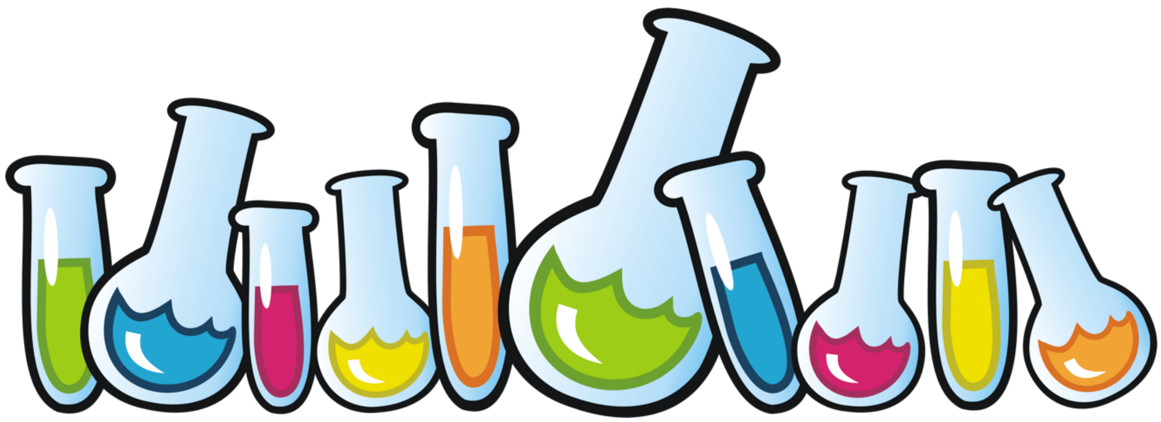
Hamburg School
Science
Curriculum Content Standards



Adopted: May 2020

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Science Philosophy: Nature of Science

Scientists and science teachers agree that science is a way of explaining the natural world. In common parlance, science is both a set of practices and the historical accumulation of knowledge. An essential part of science education is learning science and engineering practices and developing knowledge of the concepts that are foundational to science disciplines. Further, students should develop an understanding of the enterprise of science as a whole—the wondering, investigating, questioning, data collecting and analyzing

The integration of scientific and engineering practices, disciplinary core ideas, and crosscutting concepts sets the stage for teaching and learning about the nature of science. This said, learning about the nature of science requires more than engaging in activities and conducting investigations.

When the three dimensions of the science standards are combined, one can ask what is central to the intersection of the scientific and engineering practices, disciplinary core ideas, and crosscutting concepts? Or, what is the relationship among the three basic elements of A Framework for K-12 Science Education? Humans have a need to know and understand the world around them. And they have the need to change their environment using technology in order to accommodate what they understand or desire. In some cases, the need to know originates in satisfying basic needs in the face of potential dangers. Sometimes it is a natural curiosity and, in other cases, the promise of a better, more comfortable life. Science is the pursuit of explanations of the natural world, and technology and engineering are means of accommodating human needs, intellectual curiosity and aspirations.

One fundamental goal for K-12 science education is a scientifically literate person who can understand the nature of scientific knowledge. Indeed, the only consistent characteristic of scientific knowledge across the disciplines is that scientific knowledge itself is open to revision in light of new evidence.

In K-12 classrooms, the issue is how to explain both the natural world and what constitutes the formation of adequate, evidence-based scientific explanations. To be clear, this perspective complements but is distinct from students engaging in scientific and engineering practices in order to enhance their knowledge and understanding of the natural world.

Kindergarten

Content Area: Science **Grade Level: Kindergarten**
First Marking Period - Pacing Guide **Unit 1: Engineering and Technology** **Pacing: Core-12 days (24 days-Traditional Route)** **NJ-SLS: ETS1-1, ETS1-2 & ETS1-2** **Unit 2: Forces of Motion** **Pacing: Core-12 days (24 days-Traditional Route)** **NJ-SLS: PS2-1 & PS2-2**
Second Marking Period - Pacing Guide **Unit 3: Plants and Animals** **Pacing: Core-22 days (38 days-Traditional Route)** **NJ-SLS: K-LS1-1, K-ESS3-1, K-ESS2-2**
Third Marking Period - Pacing Guide **Unit 4: Sun Warms the Earth** **Pacing: Core-12 days (24 days-Traditional Route)** **NJ-SLS: PS3-1 & PS3-2** **First ½ Unit 5: Weather** **Pacing: Core-11 days (19 days-Traditional Route)** **NJ-SLS-S:** K-ESS2-1, K-ESS3-2, & K-2-ETS1-1
Fourth Marking Period - Pacing Guide **Second ½ Unit 5: Weather** **Pacing: Core-11 days (19 days-Traditional Route)** **NJ-SLS-S:** K-ESS2-1, K-ESS3-2, & K-2-ETS1-1 **Unit 6: Earth's Resources** **Pacing: Core-12 days (24 days-Traditional Route)** **NJ-SLS:** K-ESS3-1 & K-ESS3-3

Content Area: Kindergarten Science
Unit Title: Engineering and Technology
Target Course/Grade Level: Unit 1 Kindergarten

Unit Summary

In the unit children will learn the following:

- Define a simple problem that can be solved by developing a new or improved tool.
- Ask questions, make observation, and gather information helpful in thinking about a problem.
- Create a model based on evidence to represent a tool that solves a problem.
- Use sketches and models to communicate a solution to a problem.

Lesson 1: Children explore the work of an engineer. Children make observations, ask questions, and gather information about a simple problem, such as a broken pencil or an unorganized box of craft supplies. They define the problem and design a solution to the problem. Children investigate how engineers go about finding solutions to everyday problems, and technology is involved in solving problems.

Lesson 2: Children will observe and ask questions based on their observations to define a problem concerning an overcrowded desk. They will make sketches and drawings to design a solution and then make a model to test their design to determine whether its shape and stability achieve it intended purpose. Children will analyze their data and revise their design and retest it as needed.

Primary interdisciplinary connections:

English Language Arts

W.K.6: With guidance and support from adults, explore a variety of digital tools to produce and publish writing, including in collaboration with peers.
W.K.8: With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.
RI.K.1: With prompting…ask and answer questions about key details in a text.
SL.K.5: Add drawings…to descriptions as desired to provide additional details.

Mathematics

K.MD.A.2: Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less" the attribute, and describe the difference.
MP.4 Model with mathematics. (K-2-ETS1-1), (K-2-ETS1-3)
K.CC.A.3: Write numbers from 0 to 20. Represent a number of ……objects
K.CC.B.5: Count to answer "how many?" questions about ……objects
K.G.A.2: Correctly name shapes regardless of their orientations or overall size.
MP.2: Reason abstractly and quantitatively

21st century themes:

Global Awareness & Financial, Economic, Business, and Entrepreneurial Literacy

Civic Literacy

Unit Rationale

Prior Learning

Children should already know and be prepared to build on the following concepts:

- Identifying a problem that needs a solution
- Describing an object or action that solves a problem

Future Learning

Grade 1 Unit 1: Engineering and Technology

- In this unit children will learn the following: define and identify problem, define and identify examples of technology, describe how people understand problems and use technology to solve problems, and explore and apply a design process

Grade 2 Unit 1: Engineering Design Process

- In this Unit children will learn the following: ask questions, make observations, and gather information to define a problem, use a design process to solve a problem, & compare the strengths and weaknesses of multiple design solutions.

Grade 3 Unit 1:

- In this Unit children will define problems and design solutions to those problems & test solutions and make improvement to solutions.

Grade 4 Unit 1:

- In this unit, students will explore how engineers define problems and solutions, learn about the importance of prototypes & use models to examine how prototypes are tested and improved.

Grade 5 Unit 1:

- In this unit, students will discover how science and math are used in engineering, investigate a design process, and explore how technology decisions affect society.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-ETS1-1	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
K-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Unit Essential Question

Part A: What does an Engineer Do?

Part B: How can we use a design process?

Unit Enduring Understandings

Part A:

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observation, and gathering information are helpful in thinking about problems
- Before beginning to design a solution, it is important to clearly understand the problem

Part B:

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI Worktext

Lesson Plans

Lesson	Timeframe
Lesson 1 Engineer It: What Does an Engineer Do?	Core: 5 Days Traditional: 7 Days
Lesson 2 Engineer It: How can we use a design process?	Core: 5 Days

	Traditional: 7 Days
Lesson 3 Unit 1 Review and Unit 1 Test	Core: 2 days
Additional Traditional Activities: You Solve it Unit 1 Performance Task Performance-Based Assessment	 1 day 2 days 2 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction:

- **On Level: How can we solve problems?** This reader reinforces unit concepts, and includes response activities for your children.
- **Extra Support: How can we solve problems?** This reader shares titles, illustrations, vocabulary, and concepts with the on-level reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.
- **Enrichment: Make a Better Bird Feeder** the high-interest, non-fiction reader will extend and enrich unit concepts and vocabulary, and includes response activities.
- **ELL** Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content

Curriculum Development Resources

NSTA Web Seminar: Teaching NGSS in Elementary School—Kindergarten

The seminar was led by expert teachers Carla Zembal-Saul, Professor of Science Education, Penn State University; Mary Starr, Executive Director, Michigan Mathematics and Science Centers Network; and Kathy Renfrew, K-5 Science Coordinator, VT Agency of Education. Carla, Mary and Kathy engaged with participants to gauge their familiarity with *NGSS* for kindergarten, and provided a number of example activities and videos on how to implement it, e.g., different approaches to teaching weather and climate core ideas. The web seminar was then wrapped up by Ted Willard, who suggested a number of resources and events for participants to further develop their understanding of *NGSS* for kindergarten, as well as other grade levels.

View the resource collection.

Continue discussing this topic in the community forums.

NSTA Web Seminar: Teaching NGSS in K-5: Constructing Explanations from Evidence

Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three-dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena. To view related resources, visit the resource collection. Continue discussing this topic in the community forums.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1
Content Area: Engineering and Technology

Lesson Title: Lesson 1: **Engineer It**: What Does an Engineer Do?							**Timeframe:** 5 days
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: Worktext, cardboard, books, masking tape, and a toy car.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: • User observations and questions to identify engineers as workers who find solutions to problems.	1. About this Image: Invite children to describe the shape and overall appearance of the structure. **Ask:** How is this building different from the buildings we see in our town? 2. Can you Solve it: The video shows what happens during a game when a flying disc gets caught high in a tree. 3. What is a Problem? Children explore how to ask questions about a situation. 4. What is Solution? 5. Ask Questions 6. Engineer it: Problem and Solution 7. Engineers: Children explore how engineers use math and science to approach a situation as a problem to be solved. 8. Use Technology 9. Take it Further 10. Design a Toy	• Read, Write, Share! Encourage children to ask questions using questions words, such as what, why, or how. Suggest they draw or write about the problem and a possible solution. • Evidence Notebook: Have small groups of children discuss and draw a particular kind of technology that has helped them solve a problem. Shoelaces, pencil sharpeners, and cell phone are some examples. Encourage children to use evidence to support their explanation of how the technology solved a problem.

	11. Lesson Check 12. Self Check	● Lesson Check ● Self Check

Differentiation

Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.

- **Lesson Vocabulary:** Problem, Solution, engineer, technology
- **Reinforcing Vocabulary:** Have children fold a sheet of paper in half, and draw and label a picture of a problem on the top part and a solution on the bottom part. On another sheet, have them illustrate the other two vocabulary words. Remind children to look for these highlighted words as they proceed through the lesson.
- **RTI/Extra Support:** Guide children in a discussion that frames everyday tasks as problems and solutions. Examples of simple problems might be remembering to water a plant or put away toys. Discuss possible solutions to each problem.
- **Extension:** Children who are interested in learning more can choose to research a specific problem in the area where they live. They can use books, the internet, or other resources to look up additional information. Children can also research how engineers are solving challenging problems such as space travel.
- **ELL:** Pause to discuss each highlighted word. Encourage children to use the words in sentences that summarize the content in that part of the lesson. Discuss real-life connections to the content, and provide examples of objects mentioned in the lesson to aid children in remembering the word associated with the object.

Resources Provided: TCI work text, teacher online access, and equipment kits.

Content Area: Kindergarten Science

Unit Title: Forces of Motion

Target Course/Grade Level: Unit 2 Kindergarten

Unit Summary

In the unit, children will do the following: plan and conduct an investigation about the speed of objects, gather evidence to support or refute ideas about what causes motion, analyze data from tests to determine if a tool works as intended, and explore pushes and pulls of different strengths and their effect on objects.

What does science have to do with playing sports?

During this unit of study, students apply an understanding of the effects of different strengths or different directions of pushes and pulls on the motion of an object to analyze a design solution. The crosscutting concept of cause and effect is called out as the organizing concept for this disciplinary core idea. Students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations and analyzing and interpreting data. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Primary interdisciplinary connections:

English Language Arts

In order to integrate English Language Arts into this unit, students need the opportunity to participate in shared research that will enhance their understanding of the effect of forces (pushes and pulls) on objects. This could include exploring simple books and other media or digital resources. With prompting and support, students should ask and answer questions about key details in texts in order to seek help, get information, or clarify something that they do not understand. With support from adults, students will also recall information from experiences to answer questions and clarify their thinking. With support and/or collaboration, they can use digital tools to produce and publish simple informative writing or to document their observations of the simple force and motion systems they design and build.

With prompting and support, ask and answer questions about key details in a text. (K-PS2-2) **RI.K.1**
Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1) **W.K.7**
Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2) **SL.K.3**

Mathematics

During this unit of study, students will make connections to Mathematics in a number of ways. Kindergartners can use simple nonstandard units to measure the distances that two different objects travel when pushed or pulled or the distances that an object travels when varying the strength of a push or a pull. If using two objects, students can compare them using a measurable attribute, such as weight, to see which object has "more of" or "less of" the attribute, and describe the effect that increased weight has on the distance that an object travels. As students conduct multiple trials with the two objects (or with a single object, varying the strength of the push or pull), they can document the distance traveled in a simple graph. Then they can analyze the data in order to describe the cause-and-effect relationship between forces and motion of objects. As students collect and analyze data, they are learning to reason abstractly and quantitatively and use appropriate tools strategically.

Reason abstractly and quantitatively. (K-PS2-1), (K-2-ETS1-1), (K-2-ETS1-3) **MP.2**
Model with mathematics. (K-2-ETS1-1), (K-2-ETS1-3) **MP.4**
Use appropriate tools strategically. (K-2-ETS1-1), (K-2-ETS1-3) **MP.5**
Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. (K-PS2-1) **K.MD.A.1**

Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1) **K.MD.A.2**

21st century themes

Global Awareness

Unit Rationale

Prior Learning

N/A

Future Learning

By the end of the 3–5 grade span, students will know that:

- Possible solutions to a problem are limited by the available materials and resources (constraints) identified. The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Learning Targets

Standards

NJSLS-S#	Performance Expectation
K-PS2-1	**Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.** *[Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]*

K-PS2-2	**Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.** *[Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.]*
K-2-ETS1-3	**Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**

Unit Essential Question

Part A: Why do scientists like to play soccer?

Part B: How can you design a simple way to change the speed or direction of an object using a push or pull from another object?

Unit Enduring Understandings

Part A:

- People use different ways to study the world.
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- When objects touch or collide, they push on one another and can change motion.
- A bigger push or pull makes things speed up or slow down more quickly.

Part B:

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check

- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources:

- **TCI Dimensions work text**

Formative Assessments

Students who understand the concepts are able to:

- With guidance, design simple tests to gather evidence to support or refute ideas about cause-and-effect relationships.
- With guidance, plan and conduct an investigation in collaboration with peers.
- With guidance, collaboratively plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include noncontact pushes or pulls such as those produced by magnets.) Some examples of pushes and pulls on the motion of an object could include:
    - A string attached to an object being pulled.
    - A person pushing an object.
    - A person stopping a rolling ball.
    - Two objects colliding and pushing on each other.
- With guidance, design simple tests to gather evidence to support or refute ideas about cause-and-effect relationships.
- Analyze data from tests of an object or tool to determine if it works as intended.
- Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- Analyze data to determine whether a design solution works as intended to change the speed or direction of an object with a push or a pull.
- Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects.

- Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn. (Assessment does not include friction as a mechanism for change in speed.)

What it Looks Like in the Classroom

In this unit of study, students plan and carry out investigations in order to understand the effects of different strengths and different directions of pushes and pulls on the motion of an object. Students will also engage in a portion of the *engineering design process* to determine whether a design solution works as intended to change the speed or direction of an object.

Scientists often design simple tests in order to gather evidence that can be used to understand cause-and-effect relationships. In this unit's progression of learning, kindergarteners need adult guidance to collaboratively plan and conduct simple investigations to discover and compare the effects of pushes and pulls on the motion of an object. Students will need opportunities to push and pull a variety of objects, such as balls, toy cars, pull toys, cans, tops, and boxes. Students should push/pull these objects first with varying strengths, and then in a variety of directions. They should also explore the effects of pushing objects into one another, as well as into walls and other stationary objects. Students should record their observations using pictures and words, and should participate in class discussions on the effects of varying the strength or direction of a push or pull on an object.

As students engage in these types of simple force and motion investigations, they will learn that:

- ➢ Pushes and pulls can have different strengths and directions.
- ➢ Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- ➢ When objects touch or collide, the object's motion can be changed.
- ➢ The force of the push or pull will make things speed up or slow down more quickly.

To enhance students' experiences, teachers can schedule time for students to investigate these force and motion concepts using playground equipment, such as swings, seesaws, and slides. Teachers can also use trade books and multimedia resources to enrich students' understanding. As students participate in discussions, they should be encouraged to ask questions, share observations, and describe cause-and-effect relationships between forces (pushes and pulls) and the motion of objects.

As students come to understand the force and motion concepts outlined above, they should engage in the *engineering design process* as follows.

- Students are challenged to design a simple way to change the speed or direction of an object using a push or pull from another object.
- As a class, students determine what the design should be able to do (criteria). For example:\
    - An object should move a second object a certain distance;

    - An object should move a second object so that the second object follows a particular path;
    - An object should change the direction of the motion of a second object; and/or
    - An object should knock down other specified objects.
- Students determine the objects that will move/be moved (balls, ramps, blocks, poker chips) and the types of structures (ramps or barriers) and materials (rubber bands, paper tubes, cardboard, foam, wooden blocks) that can be used to meet this challenge.
- Groups of students then develop a simple drawing or diagram and use given materials to build their design. Groups should be given a predetermined amount of time to draw and build their designs.
- Groups share their designs with the class, using their drawings or diagrams, and then test their designs.
- Students make and use observations to determine which of the designs worked as intended, based on the criteria determined by the class.

While engaging in this process, students should use evidence from their observations to describe how forces (pushes and pulls) cause changes in the speed or direction of an object.

In this unit of study, students learn that problem situations can be solved through engineering, and that because there is always more than one possible solution to a problem, it is useful to compare and test designs. Students will use what they have learned about the effect of pushes and pulls of varying strength and direction on the motion of an object to determine whether a design solution works as intended. This process is outlined in greater detail in the previous section.

Lesson Plans

Lesson	Timeframe
Lesson 1 Engineer It: What is Motion?	Core: 5 Days Traditional: 7 Days
Lesson 2 Engineer It: How can we Change the Way Things Move?	Core: 5 Days Traditional: 7 Days
Lesson 3 Unit 2 Review and Unit 2 Test	Core: 2 days
Additional Traditional Activities: You Solve it Unit 2 Performance Task Performance-Based Assessment	 1 day 2 days 2 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction:

- On-Level: How can objects Move? This reader reinforces unit concepts, and includes response activities for your children.
- Extra Support: How can objects move? This reader shares title, illustrations, vocabulary, and concepts with the on-level reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.
- Enrichment: Magnets Help us Every Day. This high-interest, non-fiction reader will extend and enrich unit concepts and vocabulary and includes response activities.
- **ELL** Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content

Curriculum Development Resources

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Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena.

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Continue discussing this topic in the community forums.

NSTA Web Seminar: Motion and Stability: Forces and Interactions

The presenters were Alicia Alonzo from Michigan State University and Alex Robinson, a teacher at Thornapple Kellogg High School in Middleville, Michigan. This was the fourth web seminar in a series focused on the disciplinary core ideas that are part of the *Next Generation Science Standards (NGSS)*. The program featured strategies for teaching about physical science concepts that answer questions such as "How can one explain and predict interactions between objects and within systems of objects?"

Dr. Alonzo began the presentation by providing an overview of how disciplinary core ideas fit into the overall structure of *NGSS*. Then she and Mr. Robinson discussed common student preconceptions related to Motion and Stability: Forces and Interactions. They also showed how this disciplinary core idea progresses across grade bands. Participants had the opportunity to ask questions and discuss ideas for classroom application with other participating teachers.

View the resource collection.

Continue discussing this topic in the community forums.

Push Pull-Changing Direction: Students investigate the interactions between colliding objects using pushes and pulls. Students play a game of kickball and observe how the ball is pushed, pulled, started, stopped, or collided with other objects and how it changed position and speed. As a group, students will then brainstorm about other objects being pushed, pulled or colliding and then choose one of those objects to investigate.

Marble Roll: This is an assessment probe from the book Uncovering Student Ideas in Primary Science Vol. 1 that is used to elicit children's descriptions of motion. The probe is designed to reveal how students describe the path of a moving object as it leaves a winding track.

Roller Coaster: There are two parts to this lesson from the book More Picture Perfect Science Lessons. In the first part learners explore ways to change the speed and direction of a rolling object by building roller coasters out of pipe insulation after reading the book, Roller Coaster by Marla Frazee. In the second part students read I Fall Down by Vicki Cobb and then investigate the idea that gravity affects all objects equally by conducting dropping races with everyday items.

Ramps 2: Ramp Builder: This is a multi-day lesson plan that has students design, build, and test their own ramps. Students are introduced to a variety of materials and explore putting them together. Students engage in an inquiry-based learning experience to reinforce math, science, and technology. They create plans for ramps by evaluating a variety of materials provided to them.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Forces and Motion							
Lesson Title: Lesson 1: **Engineer It**: What is Motion						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology:							
Equipment needed: Worktext, cardboard, books, masking tape, and a toy car.							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: ● Plan and conduct an investigation to determine how changing the speed or direction of an object can affect its motion.	**1.** About this Image: Ask students: How does the Ferris wheel move? Does it go up and down or round and round? **2.** Can you Explain it: The video shows children dancing and making a push and pull motions with their bodies. **3.** Motion-Identifying the difference between push and pull. **4.** Speed: Identifying the difference between fast and slow **5.** Engineer it: Make a Ramp **6.** Direction: Guide students to identify the direction. **7.** Take it Further **8.** Do a Test!	● Evidence Notebook: Have small groups find things that are moving. Explain that the evidence something is moving is that its location changes. ● When children share their drawings, encourage classmates to ask questions about the speed of the object shown. ● To initiate a game of "Follow the Leader," have children line up behind you. The start hopping or walking in a straight path and ask what direction the class is moving. Call on volunteers to take turns

	9. Lesson Check	leading in different directions. Remind the leader to ask about the direction.

Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

Content Area: Kindergarten Science
Unit Title: Plants and Animals
Target Course/Grade Level: Unit 3 Kindergarten
Unit Summary In this Unit children will…. ● Use observations to describe patterns of what plants and animals need to survive. ● Analyze data by collecting recording, and sharing observations. ● Use a model to show the relationship between the needs of different plants or animals and the places they live. ● Use patterns as evidence to support claims. ● Construct an argument supported by evidence for how plants and animals change the environment to survive. ● **Lesson 1:** In this lesson children gather evidence to compare living and nonliving things. They identify patterns in what plants need to live and grow. Children use observations as evidence to establish patterns in the natural world. ● **Lesson 2:** In this lesson children focus on comparing what living things need to survive. Children identify what animals need to love and grow and use their observations as evidence to establish patterns in the natural world. They use their observations as a basis to answer scientific questions. ● **Lesson 3:** In this lesson children gather evidence concerning the needs of plants and animals. They develop an understanding that plants and animals live in places that have the things they need and that these places have systems. Children use models to show the relationship between the needs of living things and the places they live. ● **Lesson 4:** In this lesson children focus on how living things change their environment to meet their needs. Children build arguments from evidence to support a claim about the way living things change the environment and make observations to identify systems in the natural world.

Primary interdisciplinary connections:

English Language Arts

With adult support, kindergarteners use trade books (read-alouds and big books) to learn about plants and animals. With prompting and support strategies, such as Think-Pair-Share, students can discuss what they have learned and read and answer questions using key details from text.

As students learn about different types of plants, animals and the environments in which they live, they will use models, such as diagrams, drawings, physical replicas, or dioramas, to represent the relationships between the needs of living things and the places they live in the natural world. Using models in this way gives students an opportunity to use simple informative writing to provide additional detail that will enhance their visual displays.

Use a combination of drawing, dictating, and writing to compose opinion pieces in which they tell a reader the topic or the name of the book they are writing about and state an opinion or preference about the topic or book. (K-ESS2-2) **W.K.1**
Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic. (K-ESS2-2) **W.K.2**
Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-LS1-1) **W.K.7**
Add drawings or other visual displays to descriptions as desired to provide additional detail. (K-ESS3-1) **SL.K.5**
With prompting and support, ask and answer questions about key details in a text. (K-ESS2-2) **R.K.1**

Mathematics

With adult support, kindergarteners use simple measurements to describe various attributes of plants and animals. Kindergarteners can use simple, nonstandard units to measure the height of plants or the amount of water given to plants. For example, they might use Unfix cubes to measure height or count the number of scoops of water given to a plant on a daily or weekly basis. Students should work in groups to measure and record their data. They also measurements to describe various attributes of animals. Kindergarteners can use simple, nonstandard units to measure such attributes as height, length, or weight. They can also count numbers of appendages or other body parts. They might use Unfix cubes to measure height or length and wooden blocks to measure weight. Students should work in groups to measure and record their data.

With adult guidance and questioning, students can then learn to analyze their data. As students use data to compare the amount of growth that occurs in plants that get varying amounts of water or sunlight, they are given the opportunity to reason abstractly and quantitatively. For example, students can measure and compare the height of a sunflower grown in the shade compared to the height of a sunflower grown in the sun, or they can count and compare the number of leaves on bean plants that receive different amounts of water daily. These investigations will give students evidence to support claims about the needs of plants.

Students should also have opportunities to solve one-step addition/subtraction word problems based on their collected data.

Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-LS1-1) **K.MD.A.2**
Reason abstractly and quantitatively. (K-ESS3-1) **MP.2**
Model with mathematics. (K-ESS3-1) **MP.4**
Counting and Cardinality (K-ESS3-1) **K.CC**

21st century themes (Pick All that apply):

Global Awareness

<u>Unit Rationale</u>

Prior Learning

N/A

Future Learning

Grade 1 Unit 4: Plant and Animal Structures

The learning experience in this unit prepare children for mastery of use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

Grade 1 Unit 5: Living things and their Young

The learning experiences in this unit prepare children for mastery of read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. They will also make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their, parents.

Grade 2 Unit 3: Environments for Living things

The learning experiences in this unit prepare children for mastery of: plan and conduct an investigation to determine if plants need sunlight and water to grow. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. Make observation of plants and animals to compare the diversity of life in different habitats.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-LS1-1	**Use observations to describe patterns of what plants and animals (including humans) need to survive.** *[Clarification Statement: Examples of patterns could include that*

	animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]
K-ESS3-1	**Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.** *[Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.]*
K-ESS2-2	**Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.** *[Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.]*

Unit Essential Question

Part A: What do plants need to live and grow?

Part B: What is the relationship between what plants need and where they live?

Unit Enduring Understandings

Part A:

- Scientists look for patterns and order when making observations about the world.
- Patterns in the natural and human-designed world can be observed and used as evidence.
- Plants need water and light to live and grow.

Part B:

- Systems in the natural and designed world have parts that work together.
- Living things need water, air, and resources from the land, and they live in places that have the things they need

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.

3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources:

TCI Dimensions work text

Formative Assessments

Students who understand the concepts are able to:

- Observe and use patterns in the natural world as evidence.
- Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.
- Use observations to describe patterns in what plants need to survive. Examples of patterns could include:
  - Plants do not need to take in food.
  - All plants require light.
  - All living things need water.
- Use observations to describe patterns in what animals need to survive. Examples of patterns could include:
  - Animals need to take in food, but plants do not.
  - Different kinds of food are needed by different types of animals.
  - All living things need water.
- Observe that systems in the natural and designed world have parts that work together.
- Use a model to represent relationships between the needs of different plants and the places they live in the natural world. (Plants, animals, and their surroundings make up a system.)
  - Examples of relationships could include that grasses need sunlight, so they often grow in meadows.
  - Examples of models include diagrams, drawings, physical replicas, dioramas, dramatizations, or storyboards.
- Use a model to represent the relationships between the needs of different animals and the places they live in the natural world. (Plants, animals, and their surroundings make up a system.)
  - Examples of relationships could include that deer eat buds and leaves and therefore usually live in forested areas.
  - Examples of models include diagrams, drawings, physical replica, dioramas, dramatizations, and storyboards.

What it Looks Like in the Classroom

<u>“Kid Questions”</u>

- ➢ *How can you tell if something is alive?*
- ➢ *What do living things need to survive?*
- ➢ *Where do organisms live and why do they live there?*

The unit should begin with observable phenomena. The purpose of presenting phenomena to students is to start them thinking and wondering about what they observe. After students have observed the event, they can work individually, with partners, or in a small group to develop questions about what they saw. The questions will lead them into investigational opportunities throughout the unit that will help them answer their questions.

The questions students share about this unit will be used to guide them in identifying patterns of what plants and animals need to survive. For example, a pattern may include the types of food that specific organisms eat or that animals consume food but plants do not. Furthermore, students’ questions and investigations will also guide them in developing models that reflect their understanding of the inter-relationship between an organism and its environment.

- Prior to starting the unit, display pictures of living and non-living things. Direct students to sort the pictures into two groups: living and non-living. Ask students to explain how they decided which pictures represented living things and which represented non-living things.
- Watch the PBS video “<u>Is It Alive?</u>” Stop after each picture and ask students if it’s alive or not. Ask them to explain how they can tell. (This activity will also provide an opportunity to pre-assess students’ understandings and/or misconceptions. It will also provide an opportunity for students to think about what having life means.)
- Watch the TeacherTube video “<u>Living or Non-Living?”</u> (This activity provides similar experiences for students as the PBS video. The difference is that after each picture and question, the narrator provides the answer with reasoning.)

In this unit’s progression of learning, students first learn that scientists look for patterns and order when making observations about the world and those patterns in the natural world can be observed and used as evidence. Students conduct firsthand and media-based observations of a variety living things and use their observations as evidence to support the concepts

- ➢ Plants do not need to take in food, but do need water and light to live and grow.
- ➢ All animals need food in order to live and grow, that they obtain their food from plants or from other animals, that different kinds of food are needed by different kinds of animals, and that all animals need water.

After determining what plants need to survive, kindergarteners learn that plants are systems, with parts, or structures, that work together, enabling plants to meet their needs in a variety of environments. The vast majority of plants have similar structures, such as roots, stems, and leaves, but the structures may look different depending on the type or variety of plant. Although there are many varieties of plants, their structures function in similar ways, allowing the plants to obtain the water and light they need to survive. In other words, each variety of plant has structures that are well-suited to the environment in which it lives. As students learn about different types of plants and the environments in which they live, they use models, such as diagrams, drawings, physical replicas, or dioramas, to represent the relationships between the needs of plants and the places they live in the natural world. For example, grasses need sunlight, so they often grow in meadows. Cacti, which live in places subject to drought, have thick, wide stems and modified leaves (spines) that keep water within the plant during long periods without rain.

After determining what animals need to survive, kindergarteners learn that animals are systems that have parts, or structures, that work together, enabling animals to meet their needs in a variety of environments. Many animals have similar structures, such as mouths or mouthparts, eyes, legs, wings, or fins, but the structures may look different, depending on the type or species of animal. Although there are many types of animals, their structures function in similar ways, allowing them to obtain the water and food they need to survive. In other words, each type of animal has structures that are well-suited to the environment in which they live. As students learn about different types of animals and the environments in which they live, they use models, such as diagrams, drawings, physical replicas, or dioramas, to represent the relationships between the needs of animals and the places they live in the natural world. For example, deer eat buds and leaves; therefore, they usually live in forested areas; pelicans eat fish, therefore they live near the shorelines of oceans or seas.

The final portion of the learning progression focuses on the understanding that plants and animals are system with parts, or structures, that work together. Students use what they have learned about plants and animals to make further observations to determine ways in which plants and animals change their environment to meet their needs. For example:

- Tree roots can break rocks and concrete in order to continue to grow, plants will expand their root systems in search of water that might be found deeper in the earth, and plants can be found growing around and through man-made structures in search of light.
- A squirrel digs in the ground to hide food, and birds collect small twigs to build nests in trees. Students need opportunities to make observations, and then, with adult guidance, to use their observations as evidence to support a claim for how an animal can change its environment to meet its needs.
- Students need opportunities make observations; then, with adult guidance, they can use their observations as evidence to support a claim about how living things can change its environment to meet its needs.

Lesson Plans

Lesson	**Timeframe**
Lesson 1	

What Do Plants Needs?	5 days-Core Route 7 days-Traditional Route
Lesson 2 What Do Animals Needs?	5 days-Core Route 7 days-Traditional Route
Lesson 3 Where do Plants and Animals Live?	5 days-Core Route 7 days-Traditional Route
Lesson 4 How do Plants and Animals Change Their Environment?	5 days-Core Route 7 days-Traditional Route
Unit 3 Review and Unit 3 Test	2 days
Additional Traditional Lessons ● You solve it ● Unit 3 Performance Task ● Performance-Based Assessment	 1 days 2 days 2 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction:
On Level: What Can We Learn About Animals? What are Plants? These readers reinforce unit concepts, and include response
Extra Support: What Can We Learn About Animals? What are Plants? These readers share title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids, and includes response activities.
Enrichment: Animal Groups Inside Seeds? These high-interest, nonfiction readers will extend and enrich unit concepts and vocabulary, and include response activities.

ELL
Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences)
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Unit 3: Plants and Animals							
Lesson Title: What Do Plants Need?						Timeframe: 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology:							
Equipment needed: two plants of the same size and type, two labels, and water.							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: • Students will use observations as	1. About this Image: Ask the students how do you think these plants grew in this field?	• Evidence Notebook- Children work with a partner to identify and cut out pictures of living and nonliving things in magazines. Children should sort

evidence to explain what plants need to live and grow.	2. Can you Solve it: The time-lapse video show how a plants changes when its needs are not met. 3. Living and Nonliving Things: students make observation about living and nonliving things. 4. Sunlight, Water, and Soil: Students make observations about what plants need to live and grow. 5. Plant Needs: 6. Do the Math! Comparing: Discuss with children how to compare two plants by height, or by how tall they are. 7. Air and Space to Grow 8. Take it Further 9. Lesson Check	the pictures and glue them into their evidence notebook. ● Children should write or draw these three things plants need to live and grow. They should write or draw how these things are part of a pattern, using words or pictures as evidence. ● Read, Write, Share: Direct children to draw a picture of plants getting all the things they need to live and grow. Have children share their drawings and cite evidence to explain their drawings. ● Lesson Check ● Summative Check.

Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided TCI online and work text and classroom materials kit and grade level safety kits.

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Make observations (firsthand or from media) to collect data that can be used to make comparisons. (K-PS3-1) **Analyzing and Interpreting Data** Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-LS1-1)	**LS1.C: Organization for Matter and Energy Flow in Organisms** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1) **ESS3.A: Natural Resources** Living things need water, air, and resources from the land, and they live in places that have the	**Patterns** Patterns in the natural and human designed world can be observed and used as evidence. (K-LS1-1) **Systems and System Models** Systems in the natural and designed world have parts that work together. (K-ESS3-1), (K-ESS2-2) -

Developing and Using Models Use a model to represent relationships in the natural world. (K-ESS3-1) **Engaging in Argument from Evidence** Construct an argument with evidence to support a claim. (K-ESS2-2)	things they need. Humans use natural resources for everything they do. (K-ESS3-1) **ESS2.E: Biology** Plants and animals can change their environment. (K-ESS2-2)	***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** Scientists look for patterns and order when making observations about the world. (K-LS1-1)

Content Area: Kindergarten Science
Unit Title: Sun Warms Earth
Target Course/Grade Level: Unit 4 Kindergarten

Unit Summary

In this unit, children will…

- Make observations to construct an evidence-based account of the effect of sunlight on Earth's surface.
- Make observations to collect data that can be used to make comparisons.
- Use tools and materials provided to design and build a device that protects people from the sun
- Describe the causes that create observable patterns associated with the effect of sunlight on Earth's surface.

In **Lesson 1,** children focus on how sunlight affects Earth's surface. The lesson begins with children making observations about how water, soil, sand, and rocks are affected by sunlight, and continues with exploring more about the sun's light and heat. Children investigate the effect of the sun's light and heat through data analysis and hands-on investigations.

In **Lesson 2,** children focus on making observations to explain the effects of the sun warming Earth. Children use evidence and information about the effect of the sun's warmth to design a solution that reduces the impact of warmth from the sun. They identify occurrences that illustrate how sunlight warms Earth's surface and causes observable patterns.

Primary interdisciplinary connections:

English Language Arts

With guidance and support from adults, students recall information from experiences and gather information from books (read-alouds, big books) and other resources about the warming effects of the sun. Strategies such as Think-Pair-Share can be used to encourage students to think about and use information from books to answer questions and share their thinking. Kindergartners can add drawings or other visual displays to descriptions to provide additional detail about the structures they built to reduce the warming effects of the sun. With guidance and support from adults, students produce and publish their descriptions and observations of the structures they designed and built.

Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS3-1), (K-PS3-2) **W.K.7**
Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K- PS3-1) **K.MD.A.2**
Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. (K-2-ETS1-1) **RI.2.1**
With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. (K-2-ETS1-1), (K-2-ETS1-3) **W.2.6**
Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1), (K-2-ETS1-3) **W.2.8**
Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2) **SL.2.5**

Mathematics

Students make comparisons of objects using relative temperature [hotter, colder, warmer, cooler] and describe the objects as warmer or cooler. Students can classify the objects into categories (warmer/cooler), then count and compare the number of objects in each category. Data should be organized and compared so that students understand that placing objects in the sun generates an observable pattern of change (i.e., the objects get warmer). Kindergarteners attend to the meaning of various quantities using a variety of measurement tools, such as thermometers <u>without scale markings</u>, to determine if an object has gotten warmer when placed in the sun. They mathematically represent real-world information by organizing their data into simple graphs or charts or by diagramming the situation mathematically.

Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS3-2) **K.MD.A.2**
Reason abstractly and quantitatively. (K-2-ETS1-1), (K-2-ETS1-3) **MP.2**
Model with mathematics. (K-2-ETS1-1), (K-2-ETS1-3) **MP.4**
Use appropriate tools strategically. (K-2-ETS1-1), (K-2-ETS1-3) **MP.5**
Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (K-2-ETS1-1), (K-2-ETS1-3) **2.MD.D.10**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

In Unit 2, Forces and Motion, students will use the following engineering principles:

- *A situation that people want to change or create can be approached as a problem to be solved through engineering.*
- *Asking questions, making observations, and gathering information are helpful in thinking about problems.*
- *Before beginning to design a solution, it is important to clearly understand the problem.*
- *Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.*
- *Because there is always more than one possible solution to a problem it is useful to compare and test designs.*

Future Learning

Grade 1 Unit 2 and Unit 3: Light and Sound

- Objects can be seen if light is available to illuminate them or if they give off their own light.
- Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-PS3-1	**Make observations to determine the effect of sunlight on Earth's surface.** *[Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water.]* [Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.
K-PS3-2	**Use tools and materials provided to design and build a structure that will reduce the warming effect of sunlight on Earth's surface.** **[Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.]*

Unit Essential Question

Part A: How does sunlight affect the playground?

Part B: Imagine that we have been asked to design a new playground. How would we keep the sand, soil, rocks, and water found on the playground cool during the summer?

Unit Enduring Understandings

***Part A*:**

- Scientists use different ways to study the world.
- Events have causes that generate observable patterns.
- Sunlight warms Earth’s surface.

Part B:

- Events have causes that generate observable patterns.
- The shape and stability of structures of natural and designed objects are related to their function(s).
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.
- Sunlight warms Earth’s surface.

Evidence of Learning

Summative Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children’s preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children’s work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children’s ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children’s mastery on all three dimensions of the NGSS.

Equipment needed: TCI Dimensions materials and safety kit

Teacher Resources: TCI Dimensions work text

<u>Casting Shadows Across Literacy and Science</u>: This lesson introduces shadows by taking students on a shadow walk. Ideally this should be done on a sunny day in the schoolyard or neighborhood, but it can be a simple walk around the classroom.

<u>A</u> Big Star: This reading passage that explains what the sun is and that it provides heat to the Earth. This activity comes with comprehension and critical thinking questions.

The Warmth of the Sun: This lesson helps students broaden their understanding of the sun, particularly its critical role in warming the land, air, and water around us.

The Sun Lesson Plan: This lesson plan is adaptable to several grade band levels. The adjustments are included in the lesson plan along with suggestions for extension activities.

Cooler in the Shadows: This lesson includes several activities where students observe, explore, and analyze shadows. Students will make inferences about the cause of shadows; The lesson is linked to NASA's MESSENGER spacecraft in its voyage to and around Mercury. This lesson is designed to last 4 or more days. There are four different activities within the lesson. The teacher will need to gather some materials prior to beginning the lesson.

Shadow Smile! - Part 6 | Sid the Science Kid: In this song, Miss Susie teaches the class about shadows and the necessary shade they provide for people and animals in the heat! Learn how shadows are a result of an object getting in the way of the path of the sun and that the shadow it casts over the ground provides shade.

Using the *NGSS* Practices in the Elementary Grades

- The presenters were Heidi Schweingruber from the National Research Council, Deborah Smith from Penn State University, and Jessica Jeffries from State College Area School District. In this seminar the presenters talked about applying the scientific and engineering practices described in A Framework for K–12 Science Education in elementary-level classrooms.
- Continue the discussion in the community forums.

Teaching *NGSS* in K-5: Constructing Explanations from Evidence

- Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the NGSS for K-5th grade. The web seminar focused on the three dimensional learning of the NGSS, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena.
- View the resource collection
- Continue discussing this topic in the community forums.

Appendix I – Engineering Design in the *NGSS*

- Appendix I provides important information about how engineering design plays a key role in science education. Providing students a foundation in engineering design allows them to better engage in and aspire to solve the major societal and environmental challenges they will face in the decades ahead. We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change (NRC 2012, p. 9).

***NGSS* Core Ideas: Energy**

- The presenter was Jeff Nordine of the San Antonio Children's Museum. Ramon Lopez from the University of Texas at Arlington provided supporting remarks. The program featured strategies for teaching about physical science concepts that answer questions such as "How is energy transferred between objects or systems?" and "What is meant by conservation of energy?"
- Dr. Nordine began the presentation by talking about the role of disciplinary core ideas within *NGSS* and the importance of energy as a core idea as well as a crosscutting concept. He then shared physicist

Richard Feynman's definition of energy and related it to strategies for teaching about energy. Dr. Nordine talked about the elements of the energy core idea and discussed common student preconceptions.

- Visit the resource collection.
- Continue discussing this topic in the community forums.

Formative Assessments

Students who understand the concepts are able to:

- Observe patterns in events generated by cause-and-effect relationships.
- Make observations (firsthand or from media) to collect data that can be used to make comparisons.
- Make observations to determine the effect of sunlight on Earth's surface. (Assessment of temperature is limited to relative measures such as warmer/cooler.)
- Examples of Earth's surface could include:
    - Sand
    - Soil
    - Rocks
    - Water
- Observe patterns in events generated by cause-and-effect relationships.
- Describe how the shape and stability of structures are related to their function.
- Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem.
- Use tools and materials to design and build a structure (e.g., umbrellas, canopies, tents) that will reduce the warming effect of sunlight on an area.
- Develop a simple model based on evidence to represent a proposed object or tool.
- Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- Analyze data from tests of an object or tool to determine if it works as intended.
- Analyze data from tests of two objects designed to solve the same problem to compare the strengths

What it Looks Like in the Classroom

In this unit of study, students investigate the effects of the sun on the surface of the Earth. Throughout the unit, students make observations in order to describe patterns of change. With adult support, they design and build a structure that will reduce the warming effect of sunlight, and then conduct tests to determine if the structure works as intended.

Scientists use different ways to study the world. In this unit's progression of learning, students work like scientists to investigate the warming effect of sunlight on the surface of the Earth. They will conduct simple investigations in order to make observations and collect data that can be used to make comparisons. Students should test a variety of materials that are found naturally on the surface of the Earth, including sand, soil, rocks, and water. Samples of each of these materials can be placed on two separate paper plates or shallow plastic containers; one container can be placed in direct sunlight, and the other can be placed out of direct sunlight. After a period of time, students should compare the relative temperature of each. Students should record their observations, then analyze and compare the data to determine if there is a pattern. They should draw the conclusion that the sun has the same warming effect on all the materials found on the surface of the Earth.

As students come to understand that the sun warms the surface of the Earth, they should engage in the engineering design process as follows:

- Students are challenged to design and build a structure that will reduce the warming effects of the sun.
- Students brainstorm a list of objects that reduce the warming effects of the sun (e.g., shade trees, umbrellas, large hats, canopies).
- As a class, students determine what the design should be able to do (criteria). For example:
    - The structure must reduce the warming effects of the sun.
    - The structure should be built using materials provided by the teacher.
    - The structure should be easy to carry and fit through the doorway of the classroom.
- Groups of students then use simple drawings or diagrams to design a structure, and use given tools and materials to build their design. Groups should be given a predetermined amount of time to draw and build their designs.
- Groups share their designs with the class, using their drawings or diagrams, and then test their designs outside. (Groups can place their structures in a sunny area, then compare the relative temperature of the ground under the structure and the ground in direct sunlight.).
- Students make and use observations to determine if the designs worked as intended, then compare the strengths and weaknesses of how each design performed.
- While engaging in this process, students should use evidence from their observations to describe how their structures reduced the warming effect of sunlight.
- Through this process, students learn that the shape and stability of structures of designed objects are related to their function. They will use tools and materials to design and build their structures. Because there is always more than one possible solution to a problem, students will test and compare their designs, then analyze data to determine if their structures work as intended.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 How Does the Sun Warm Earth?	**5 days-Core Route** **7 days-Traditional Route**
Lesson 2	**5 days-Core Route** **7 days-Traditional Route**

Engineer It: How Can I Protect Myself From The Sun?	
Unit 4 Review and Unit 4 Test	**2 days**
Additional Traditional Route Lessons You Solve It Unit 4 Performance Task Performance –Based Assessment	 **1 Day** **2 Days** **2 Days**

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year

Differentiate Instruction

On Level: What Can We Learn About Matter? This reader reinforces unit concepts and includes response activities for your children

Extra Support: What Can We Learn About Matter? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Patterns in the Sky: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary, and includes response activities.

ELL

Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content

Curriculum Development Resources

TCI Kits and Worktext

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Sun Warms the Earth							
Lesson Title: How Does the Sun Warm Earth?					**Timeframe:** 5		
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Can you Explain it? Video							
Equipment needed: two cups of pebbles and two paper plates							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: ● Will observe how sunlight affects land and water on Earth's surface.	1. About this image: Ask students: Where do you think the light is coming from? 2. Can You Explain it? The sun is the primary source of heat and light on earth. The video shows a beach at sunset. 3. The Sun's Light: Children make observation to collect data about how	● Do the Math! Compare: Display two flashlights, one that gives off a bright light and one that gives off a dim. ● Read, Write, Share: Have children work in small groups. Give a volunteer a small stone

	the sun is a source of light on Earth. They use their observations to identify events that result in observable patterns. 4. The Sun's Heat: Children make observations to collect data about how the sun gives off heat. They identify events with causes that result in observable patterns. 5. The Sun's Heat (Hands-On Activity) 6. Take it Further 7. Lesson Check	or other object. Have that child tell about a sunny-day activity and the pass the stone to a neighbor. Have children write about or draw a favorite sunny-day activity. ● Lesson Check ● Self Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI Dimension Series and Kits		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Make observations (firsthand or from media) to collect data that can be used to make comparisons. (K-PS3-1) **Constructing Explanations and Designing Solutions** Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem. (K-PS3-2) **Asking Questions and Defining Problems** Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1) Define a simple problem that can be	**PS3.B: Conservation of Energy and Energy Transfer** Sunlight warms Earth's surface. (K-PS3-1), (K-PS3-2) **ETS1.A: Defining and Delimiting Engineering Problems** A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)	Cause and Effect Events have causes that generate observable patterns. (K-PS3-1), (K-PS3-2) **Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2) - ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** Scientists use different ways to study the world. (K-PS3-1)

solved through the development of a new or improved object or tool. (K-2-ETS1-1) **Developing and Using Models** Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2) **Analyzing and Interpreting Data** Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)	**ETS1.B: Developing Possible Solutions** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	

Content Area: Kindergarten Science
Unit Title: Weather
Target Course/Grade Level: Unit 5 Kindergarten
Unit Summary In this unit children will learn the following: use observations to describe different kinds of weather, explore observable weather patterns, use patterns as evidence to describe weather conditions, ask questions to find out about different kinds of weather, and explore technologies meteorologist use to predict weather and severe weather conditions. *How does weather forecasting help to keep people safe?* In this unit of study, students develop an understanding of patterns and variations in local weather and the use of weather forecasting to prepare for and respond to severe weather. The crosscutting concepts of *patterns*; *cause and effect*; *interdependence of science, engineering, and technology*; and *the influence of engineering, technology, and science on society and the natural world* are called out as organizing concepts for the disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *asking questions*, *analyzing and interpreting data*, and *obtaining, evaluating, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas. **Primary interdisciplinary connections:** *English Language Arts* With adult support, students use trade books (read-alouds, big books) to learn about and discuss severe weather. Strategies, such as Think-Pair-Share, can be used to encourage students to think about

information from books and to use that information to ask and answer questions about key details. With guidance, students use online media resources to view examples of severe weather. They can ask questions in order to understand how severe weather affects people and communities and to determine how communities prepare for and respond to severe weather.

Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-ESS2-1) **W.K.7**
With prompting and support, ask and answer questions about key details in a text. (K-ESS3-2) **RI.K.1**
Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-ESS3-2) **SL.K.3**
Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. (K-2-ETS1-1) **RI.2.1**
With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. (K-2-ETS1-1) **W.2.6**
Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) **W.2.8**

Mathematics

With adult support, students measure and record various types of weather (e.g., rainfall or snow amounts, relative temperature at different times of the day and over a period of time). They mathematically represent real-world information by organizing their data into simple weather charts and graphs. Kindergarteners attend to the meaning of various quantities using a variety of units of measure and use counting to analyze data and determine patterns in charts and graphs. By using media resources, students explore how weather scientists represent real-world weather data with picture representations, charts, and graphs. They can use this information to think about how weather scientists use tools to collect and record weather data in order to determine patterns of change. Students will attend to the meaning of various quantities used in simple weather charts and graphs, both from classroom observations and from media sources, by counting and comparing severe weather data with daily weather data (e.g., relative amounts of rainfall, snowfall). By analyzing data from weather graphs and charts, young students begin to understand how severe weather affects people and communities and that weather scientists play an important role in predicting severe weather conditions.

Reason abstractly and quantitatively. (K-ESS2-1), (K-2-ETS1-1) **MP.2**
Model with mathematics. (K-ESS2-1), (K-ESS3-2), (K-2-ETS1-1) **MP.4**

Use appropriate tools strategically. (K-2-ETS1-1) **MP.5**
Counting and Cardinality (K-ESS3-2) **K.CC**
Know number names and the count sequence. (K-ESS2-1) **K.CC.A**
Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. (K-ESS2-1) **K.MD.A.1**
Classify objects into given categories; count the number of objects in each category and sort the categories by count. (K-ESS2-1) **K.MD.B.3**
Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (K-2-ETS1-1) **2.MD.D.10**

21st century themes:

Global Awareness

<u>Unit Rationale</u>

Prior Learning

N/A

Future Learning

Grade 2 Unit 5: Changes to Earth's Surface

- Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.
- Wind and water can change the shape of the land.

Grade 3 Unit 7: Weather and Climate

In this unit, students will…

1) Explore how weather is predicted and measured
2) Learn about the difference between weather and climate
3) Identify the impact of severe weather on society and nature.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-ESS2-1	Use and share observations of local weather conditions to describe patterns over time. *[Clarification Statement: Examples of qualitative observations could include descriptions*

	of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.]
K-ESS3-2	Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. * *[Clarification Statement: Emphasis is on local forms of severe weather.]*
K-2-ETS1-1	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Unit Essential Question

Part A: *What types of patterns can be observed in local weather conditions?*

Part B: *How does weather forecasting help us to prepare for and respond to severe weather?*

Unit Enduring Understandings

Part A:

- Scientists look for patterns and order when making observations about the world.
- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.
- Weather is the combination of sunlight, wind, snow, or rain and temperature in a particular region at a particular time.
- People measure these conditions to describe and record the weather and to notice patterns over time.

Part B:

- Events have causes that generate observable patterns.
- People encounter questions about the natural world every day.
- Some kinds of severe weather are more likely than others in a given region.
- Weather scientists forecast severe weather so that communities can prepare for and respond to these events.
- People depend on various technologies in their lives; human life would be very different without technology.
- Before beginning to design a solution, it is important to clearly understand the problem.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- A situation that people want to change or create can be approached as a problem to be solved through engineering.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Teacher Resources: TCI Dimensions work text

Connections Between Practices in *NGSS*, Common Core Math, and Common Core ELA

The presenter was Sarah Michaels from Clark University. In this seminar Dr. Michaels talked about connecting the scientific and engineering practices described in A Framework for K–12 Science Education with the Common Core State Standards in Mathematics and English Language Arts.

Weather and Climate Basics; This is a resource from the National Center for Atmospheric Research and the National Science Foundation that explains the basics of weather and climate. This article is designed as background information for the teacher.

Earth and Sky: Grades K-4: SciGuides are a collection of thematically aligned lesson plans, simulations, and web-based resources for teachers to use with their students centered on standards-aligned science concepts. "We all live under the same big sky." Since the beginning of time, humans have been intrigued by the objects in our sky and beyond. Take a voyage into space science where you will travel through the Internet to connect your classroom with content and activities designed to teach concepts related to these objects and changes in the sky over time.

NGSS Core Ideas: Earth's Systems

The presenter was Jill Wertheim from National Geographic Society. The program featured strategies for teaching about Earth science concepts that answer questions such as "What regulates weather and climate?" and "What causes earthquakes and volcanoes?"

Dr. Wertheim began the presentation by introducing a framework for thinking about content related to Earth systems. She then showed learning progressions for each concept within the Earth's Systems disciplinary core idea and shared resources and strategies for addressing student preconceptions. Dr.

Wertheim also talked about changes in the way *NGSS* addresses these ideas compared to previous common approaches.

Continue the discussion in the community forums.

Watching Weather: Students will make their own weather station consisting of actual and simplified versions of real weather equipment. The weather station will consist of a thermometer and a student-made weather vane. They will use that equipment to make observations about the local weather.

Weather Patterns: This lesson is the first in a two-part series on the weather. The study of the weather in these early years is important because it can help students understand that some events in nature have a repeating pattern. It also is important for students to study the earth repeatedly because they take years to acquire the knowledge that they need to complete the picture. The full picture requires the introduction of such concepts as temperature, the water cycle, and other related concepts. In the second activity, What's the Season; students identify the seasonal patterns in temperature and precipitation.

Weather Walks: Students learn about weather by taking walks during various weather conditions over the course of time. Walks take place during sunny, rainy, windy, or snowy conditions. The lesson is divided into four sections with activities assigned to each of the weather conditions being observed. Suggested activities include appropriate investigations to help students observe and describe weather phenomenon through first hand experiences.

Science- Weather: This is a free interactive learning activity designed for individual students and can easily be used as a whole class interactive whiteboard activity. This particular title explores weather in relationship to season and temperature. Students learn to use a thermometer as a tool for recording temperature and identify the four seasons through measurable changes in the thermometer readings.

About the Weather: This lesson is about using local weather to make observations, measure, collect, and record data to describe patterns over time. Students will count types of outdoor clothing worn by classmates and use the data to look for patterns in weather over months and seasons.

Formative Assessments

Students who understand the concepts are able to:

- Observe and use patterns in the natural world as evidence and to describe phenomena.
- Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.
- Use and share observations of local weather conditions to describe patterns over time. (Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.)

    - Examples of qualitative observations could include descriptions of the weather, such as sunny, cloudy, rainy, and warm.
    - Examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month.
    - Examples of patterns could include that it is usually cooler in the morning than in the afternoon.
- Observe patterns in events generated by cause-and-effect relationships.
- Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world.
- Ask questions based on observations to find more information about the designed world.
- Ask questions to obtain information about the purpose of weather forecasting to prepare for and respond to severe weather. (Emphasis is on local forms of severe weather.)
- Define a simple problem that can be solved through the development of a new or improved object or tool.
- Ask questions, make observations, and gather information about a situation people want to change in order to define a simple problem that can be solved through the development of a new or improved object or tool.

What it Looks Like in the Classroom

In this unit of study, students are expected to develop an understanding of patterns and variations in <u>local</u> weather and the use of weather forecasting to prepare for and respond to severe weather. Throughout the unit, students will look for patterns and cause-and-effect relationships as they observe and record weather events. Students will have opportunities to ask scientific questions, analyze and interpret data, and communicate their findings to others.

In this unit of study, students learn that problem situations can be solved through engineering, and that in order to design a solution, we must first define the problem. As described in the narrative above, students define problems caused by severe weather events by asking specific questions, making observations, and gathering information that will help them understand the types of problems they might face when severe weather conditions exist in and around their homes, schools, and communities.

In this unit's progression of learning, students first develop an understanding that patterns in the natural world can be observed and documented, and that, like scientists, they can use these patterns as evidence to describe phenomena and make predictions. In order to observe patterns in weather, kindergartners will learn that weather is the combination of sunlight, wind, precipitation, and temperature in a particular region at a particular time. By observing and recording daily weather events—such as sunny, cloudy, rainy, and windy— students can analyze both qualitative and quantitative data. Recording and analyzing data over time will reveal recognizable weather patterns that can be used to make predictions. Examples of weather patterns may include:

- Snow and colder temperatures generally occur in the winter.
- Clouds may bring rain or snow.
- Rain occurs more often in the spring.
- Warmer/hotter temperatures occur in the summer.
- It is generally cooler in the morning and warmer in the afternoon.

At this grade level, it is developmentally appropriate to describe temperature in relative terms; therefore, vocabulary words such as hot, warm, cool, cold, and warmer/cooler should be used to describe temperature, rather than accurately measuring and describing temperature in degrees Celsius.

Students also learn that weather events have causes that generate observable patterns over time, and that these patterns help weather scientists predict severe weather. Kindergarteners need opportunities to learn about severe weather, especially those types that tend to occur in the local region in which they live. By using a variety of media and technology, such as computers, radio, and television, and by reading grade-appropriate texts about weather and weather events, students can learn about types of severe weather that are common to their region. In addition, they come to understand that people depend on technology to help us predict and solve problems, and without it, our lives would be very different.

In order to apply their learning, students need opportunities to ask questions about weather forecasting and how it can help us prepare for and respond to different types of severe weather. When kindergartners ask questions, make observations, gather weather information, and look for patterns of change in the weather, it prepares them to think about how to best prepare for and respond to local severe weather. As part of this unit of study, students are challenged to investigate how people prepare for and solve problems caused by severe weather. With adult guidance, students should define weather problems by asking questions, making observations, and gathering information about severe weather situations. Some questions students might want to consider include the following:

- What kinds of severe weather events tend to occur in New Jersey (e.g., thunderstorms, hurricanes, flooding, snow storms)?
- What do people do in response to these types of severe weather events?
- What kinds of tools can people use to solve problems caused by severe weather conditions (e.g., umbrellas, sandbags, salt, gravel, shovels, snow blowers)?
- What other solutions might people use for problems caused by severe weather (e.g., closing schools and businesses; sending out emergency workers to restore utilities; sending out early warnings; stockpiling food, water, and other supplies; having a portable generator)?
- What kinds of problems would we face if we had a lot of rain in a short period of time?
- What problems might we have if our community experienced flooding?
- What kinds of problems might occur if strong winds caused damage (e.g., knocked over trees, damaged power lines, damaged homes and businesses)?
- What kinds of precautions do people take during a hurricane? A tornado? A Nor'easter? Why?

Lesson Plans

Lesson	Timeframe
Lesson 1 How Can We Observe Weather Patterns	Core-5 Days Traditional -7 Days
Lesson 2 How Can we Measure Weather	Core-5 Days Traditional-7 Days
Lesson 3 Engineer It-What are Kinds of Severe Weather?	Core-5 Days Traditional -7 Days
Lesson 4 Engineer It-How can Forecasts Help Us?	Core-5 days Traditional-7 days
Unit 5 Review and Unit 5 Test	2 days
Additional Traditional Lessons: You solve it Unit 5 Performance Task Performance-Based Assessment	 1 day 2 days 2 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Curriculum Development Resources
TCI Kits and Worktext

Differentiate Instruction:
RTI/Extra Support: Point to each word and pronounce it; have children repeat after you. Direct attention to the two-word words. Explain that a pace separate written words. Challenge children to fin each word within the unit content. Working in pairs, have children talk about what they think the word means based on the pictures and text.
Extension: Have teams of children play a question-and-answer game. Have one team say a meaning of a word and the other team use the word in a question, such as, "What is a season?"
ELL
Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).   - Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.   - Use project-based science learning to connect science with observable phenomena.   - Structure the learning around explaining or solving a social or community-based issue.   - Provide ELL students with multiple literacy strategies.   - Collaborate with after-school programs or clubs to extend learning opportunities.   - Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Weather							
Lesson Title: How can we observe Weather Patterns					**Timeframe: Core-5 Days**		
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilizing online access and online teacher materials							
Equipment needed: Print and Online Text, Paper, & Crayons							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: • Will observe and describe patterns in weather over time.	1. About this Image: Ask students when do you see a rainbow? 2. Can you Explain it: Show students video and allow students to discuss observations of the differences in the weather.	• Evidence notebook: Explain that the body has a constant temperature. Different clothing helps the temperature stay the

● Children explore patterns in changes in local weather conditions.	3. Different kinds of Weather activity 4. Weather Patterns During the Day Activity. 5. Weather Patterns During the Week Activity 6. Observing Patterns in Weather Activity 7. Do the Math! 8. The Season Activity 9. Take it Further 10. Lesson Check	same. Ask: How do we dress in hot weather? ● Ask: How will you know you have found a weather pattern? ● Ask children to write notes on the weather forecast they watched. Discuss the patterns and predictions made during the forecast. ● Lesson Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI online and work text and classroom materials kit and grade level safety kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-ESS2-1) **Asking Questions and Defining Problems** Ask questions based on observations to find more information about the designed world. (K-ESS3-2) Ask questions based on observations to find more information about the natural and/or designed world(s). Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) **Obtaining, Evaluating, and**	**ESS2.D: Weather and Climate** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (K-ESS2-1) **ESS3.B: Natural Hazards** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (K-ESS3-2)	**Patterns** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1) **Cause and Effect** Events have causes that generate observable patterns. (K-ESS3-2) - ***Connections to Nature of Science*** **Science Knowledge is Based on Empirical Evidence** Scientists look for patterns and order when making observations about the world. (K-ESS2-1)

<u>Communicating Information</u> Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world. (K-ESS3-2)	**<u>ETS1.A: Defining and Delimiting an Engineering Problem</u>** A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)	- ***Connections to Engineering, Technology, and Applications of Science*** **<u>Interdependence of Science, Engineering, and Technology</u>** People encounter questions about the natural world every day. (K-ESS3-2) **<u>Influence of Engineering, Technology, and Science on Society and the Natural World</u>** People depend on various technologies in their lives; human life would be very different without technology. (K-2-ETS1-1)

Content Area: Kindergarten Science
Unit Title: Earth's Resources
Target Course/Grade Level: Unit 6 Kindergarten
Unit Summary In this unit, children will… ● Identify, air, water, rocks, and soil as natural resources. ● Use evidence to explain that living things needs water, air, and resources from the land. ● Describe how natural resources work as part of a system in the natural world. ● Explain ways people use natural resources and the impact they have on the environment. ● Design and communicate solutions to overcome negative impacts on the environment. **Lesson 1:What Are Natural Resources?** Children explore natural resources including air, water, rick, and soil. Children investigate how natural resources are part of a system with parts of a system with parts that work together in the natural world and use evidence to support their ideas. Children make a model to show how humans use natural resources to meet their needs. They also use models to identify patterns in ways humans use natural resources to survive. **Lesson 2: How can we save Natural Resources?** Children obtain, evaluate, and communicate information about ways people use natural resources, and the impact people have on their environment. Children also

explore solutions and choices people can make to reduce their impact. Children evaluate the cause-and-effect relationship between the environment and the choices people make to reduce, reuse, and recycle.

Primary interdisciplinary connections:

English Language Arts

With adult support, students participate in shared research in order to find examples of ways that humans reduce their impact on the land, water, air, and other living things in the local environment. With prompting and support, students will ask and answer questions about key details in a text. Students, with adult support and/or peer collaboration, can also use simple books and media resources to gather information and then use drawings, simple informative writing (or dictation), and visual displays to represent some of the ways that people lessen their impact on the environment. With support from adults, students will recall information from experiences or gather information provided from sources to answer a question. Students can clarify their ideas, thoughts, and feelings using simple informative writing.

Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic. (K-ESS3-3) **W.K.2**
Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. (K-2-ETS1-1) **RI.2.1**
With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. (K-2-ETS1-1) **W.2.6**
Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) **W.2.8**

Mathematics

With adult support, students will classify data by one attribute, sort data into categories, and graph the data. For example, students can keep track of the amount of materials recycled over a period of time. They can classify recycled trash as paper, plastic, or glass, then count and graph these data, using bar graphs or picture graphs. Student should have opportunities to analyze and compare the data and then use the data to solve word problems. As students work with their data, they are learning to reason abstractly and quantitatively, model by diagramming the situation mathematically, and use appropriate tools strategically.

Reason abstractly and quantitatively. (K-2-ETS1-1) **MP.2**
Model with mathematics. (K-2-ETS1-1) **MP.4**
Use appropriate tools strategically. (K-2-ETS1-1) **MP.5**
Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (K-2-ETS1-1) **2.MD.D.10**

21st century themes (Pick All that apply):

Global Awareness

Unit Rationale

Prior Learning

In Unit 4, Plants and Animals, students learned that plants need sunlight and water in order to live and grow. With regard to Basic Needs of Animals, student learned that all animals need food in order to live and grow. They obtain their food from plants or from other animals.

Future Learning

Grade 3 Unit 7

Weather

In this unit, students will…

- Explore how weather is predicted and measured
- Learn about the difference between weather and climate
- Identify the impact of severe weather on society and nature

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-ESS3-1	Use a model to represent the relationship between the needs of different plants or animals and place they live
K-ESS3-3	Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. * [Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.]
K-2 ETS1-1	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Unit Essential Question

How can humans reduce their impact on the land, water, air, and other living things in the local environment?

Unit Enduring Understandings

- Events have causes that generate observable patterns.
- Things that people do to live comfortably can affect the world around them.
- People can make choices that reduce their impacts on the land, water, air, and other living things.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution, it is important to clearly understand the problem.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Teacher Resources:

Humans on Earth: This is a 3.5 minute narrated video explaining the use of natural resources to supply the needs of humans, and solutions for preserving them.
The Clean Water Book: Choices for Resource Water Protection: This book is available from the New Jersey Department of Environmental Protection
Recycling Manual for New Jersey Schools: This manual will guide school personnel through a step-by-step process of setting up a recycling program in the school. It provides all the necessary tools for designing and implementing a viable and comprehensive program in private, public and parochial institutions.
Speakers Program: The New Jersey Department of Environmental Protection (DEP) fields requests for public speakers, classroom presentations and exhibitors regarding the various environmental topics, programs and services that are administered by the agency.
Practice the 5 R's – Poster

The USGS Water Science School: Welcome to the U.S. Geological Survey's (USGS) Water Science School. We offer information on many aspects of water, along with pictures, data, maps, and an interactive center where you can give opinions and test your water knowledge.

Formative Assessments

Students who understand the concepts are able to:

- Observe patterns in events generated due to cause-and-effect relationships.
- Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas.
- Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
- Ask questions based on observations to find more information about the natural and/or designed world.
- Define a simple problem that can be solved through the development of a new or improved object or tool.
- Ask questions, make observations, and gather information about a situation that people want to change in order to define a simple problem that can be solved through the development of a new or improved object or tool.

What it Looks Like in the Classroom

In this unit of study, students will develop an understanding of the impact that humans have on the land, water, air, and other living things in the local environment and engage in a portion of the engineering design process in order to communicate solutions that can reduce these impacts.

To help students recognize the impact that humans have on the living and nonliving components of the local environment, they need opportunities to observe and think about the things that people do to live comfortably. Over a period of a few days, students can observe their families in their day-to-day lives, paying attention to what they eat, what they throw away, when and how they use water, how they warm or cool their home, what types of appliances and gadgets they use, how they maintain their home and yard, what resources are used to make the clothes they wear, how they travel from place to place, and how they communicate with others. During whole-group discussions, students can share their observations and then discuss the concept of comfortable lifestyle. This list could include:

- Plants and animals for food
- Trees, rocks, sand, and other materials for building homes and schools
- Local reserves of water for drinking, washing clothes, showering, washing dishes, watering lawns, and cooking
- Gas and oil for cars and buses
- Electricity to power the appliances in their homes
- Land for homes, schools, parks, parking lots, and landfills

Then the class can discuss how obtaining and using these types of resources affects the local environment. To help with these discussions, teachers can use books, multimedia resources, field trips, or even invite guest speakers to the classroom. As students participate in discussions, they should be encouraged to ask questions, share observations, and describe cause-and-effect relationships between human use of resources and human impact on the environment.

As students come to understand that things people do to live comfortably can affect the world around them, they are ready to engage in the engineering design process. The process should include the following steps:

- ➢ As a class or in groups, students participate in shared research to find examples of ways that people solve some of the problems created by humans' use of resources from the environment. For example, people in the community might choose to:
- ➢ Recycle plastic, glass, paper, and other materials in order to reduce the amount of trash in landfills;
- ➢ Plant trees in areas where trees have been cut down for lumber to renew regional habitats for local wildlife; or
- ➢ Set up rainwater collection systems so that rainwater can be used to maintain landscaping instead of using water from local reserves.
    - Groups of students then develop a simple sketch, drawing, diagram, or physical model to illustrate how the solution reduces the impact of humans on land, water, air and/or other living things in the local environment.
    - Groups need the opportunity to communicate their solutions with the class in oral and/or written form, using their sketches, drawings, diagrams, or models to help explain how the solution reduces the human impact on the environment.
    - While engaging in this process, students should learn that even though humans affect the environment in many ways, people could make choices that reduce their impacts on the land, water, air, and other living things in the environment.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What are Natural Resources?	5 days-core route 7 days-traditional route
Lesson 2 Engineer It: How can We Save Natural Resources?	5 days-core route 7 days-traditional route
Unit 6 Review and Unit 6 Test	2 days
Additional Traditional Route Activities You Solve it Unit 6 Performance Task Performance-Based Assessment	 1 day 2 days 2 days

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level-What are Some Natural Resources: This reader reinforces unit concepts, and includes response activities for your children.

Extra Support-What are Some Natural Resources: This reader share title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aides. It also includes response activities.

Enrichment: **Saving Water:** The high-interest, non-fiction reader will extend and enrich unit concepts and vocabulary, and includes response activities.

ELL
Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content.

Curriculum Development Resources

TCI Kits and Worktext

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Earth's Resources							
Lesson Title: What are Natural Resources						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilizing TCI online videos							
Equipment needed: TCI Worktext and kits…. ice cube tray, cooking spray, and clay. Use an air-hardening clay, such as pottery clay.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Model the relationship between natural resources and how people use them to meet their needs.	1. About this Image: Ask the students, Does this picture show an indoor place or an outdoor place? 2. Can you explain it? 3. People use natural resources in many ways. The animation shows a panorama of natural resources being used. 4. Air 3D Learning Objective: Children explore air as a natural resource. Air is part of a system with parts that work together in the natural world. 5. Water 3D Learning Objective: Children explore water as a natural resource. Water is part of a system	● Do the Math! Invite children to predict how many breaths they take in 30 seconds. ● Evidence Notebook: Remind children that animals are living things that need water. Point out that the animal they choose can be one that lives on land or in water, but that the picture should show the animal using water.

	with parts that work together in the natural world. 6. Rock 3D Learning Objective: Children explore rocks as a natural resource. Rocks are a part of a system with parts that work together in the natural world. 7. Soil 3D Learning Objective: Children explore soil as a natural resource. Soil is a part of a system with parts that work together in the natural world. Children identify soul in a model of a natural environment. 8. Clay Bricks: Hands on Activity 9. Take it Further 10. Lesson Check 11. Self Check	• Read, Write, Share! Guide children to draw something made from rocks. Allow time for children to share their drawings, and cite evidence to support the claim that people use rocks. • Have pairs pantomime ways people use a natural resource while classmates guess the natural resource being depicted. • Lesson Check • Self Check.
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI Dimensions Text and kits		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Make observations (firsthand or from media) to collect data that can be used to make comparisons. (K-PS3-1) **Obtaining, Evaluating, and Communicating Information** Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas. (K-ESS3-3)	**ESS3.C: Human Impacts on Earth Systems** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (K-ESS3-3) **ETS1.B: Developing Possible Solutions** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. *(secondary)* (K-ESS3-3)	**Cause and Effect** Events have causes that generate observable patterns. (K-ESS3-3) **Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

<u>Asking Questions and Defining Problems</u> Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1) Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1)	**<u>ETS1.A: Defining and Delimiting Engineering Problems</u>** A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)	

Grade 1

Content Area: Science **Grade Level: 1st Grade**
First Marking Period - Pacing Guide ● **Unit 1: Engineering and Technology-** **Core 12 days (Traditional Pacing 24 days)** **NJ-SLS-S: K-2-ETS1-1, K-2-ETS1-2, K-2-ETSI-3** ● **Unit 2: Sound** **Core 7 days (Traditional Pacing 24 days)** **NJ-SLS-S: PS4-1, PS4-4**
Second Marking Period - Pacing Guide ● **Unit 3: Light** **Core 17 days (Traditional Pacing-31 days)** **NJ-SLS-S-PS4-2, PS4-3, PS-4-4** ● **1st ½ Unit 4: Plant and Animal Structures** **Core 11 days day (Traditional 19 days)** **NJ-SLS-S: 1-LS1-1**
Third Marking Period - Pacing Guide ● **2nd ½ Unit 4: Plant and Animal Structures** **Core 11 days (Traditional 19 days)** **NJ-SLS-S: 1-LS1-1** ● **Unit 5: Living Things and Their Young**

Core 17 days (Traditional 31 days) **NJ-SLS-S: LS1-2 & LS3-1**
Fourth Marking Period - Pacing Guide ● **Unit 6: Objects and Patterns in the Sky** **Core 12 days (Traditional 24 days)** **NJ-SLS-S: ESS1-1 & ESS1-2**

Content Area: First Grade Science

Unit Title: Engineering and Technology

Target Course/Grade Level: First Grade: Unit 1

Unit Summary

In the unit children will learn the following:

- Define and identify problems.
- Define and identify examples of technology
- Describe how people understand problems and use technology to solve problems.
- Explore and apply a design process

Lesson 1: In this lesson children begin by exploring, identifying, and naming simple problems, and the lesson continues with children exploring how engineers make and use technology to solve everyday problems. Finally. Children will use what they have learned to define a problem. Gather information about it, and build something to solve the problem.

Lesson 2: In this lesson children focus on a design process that engineers use to solve problems. The lesson begins with children exploring simple problems in the natural world, and how they can be solved through the development of a new or improved object or tool. As they explore a design process, children compare and test the shape and stability of objects to determine if they work as intended and are related to their functions. Lastly, children develop and test simple models to solve problems through a design process, and communicate those solutions.

Primary interdisciplinary connections:

English Language Arts

W.1.2: Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.**W.1.8:** With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.
W.1.8: With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Mathematics

1.MD.C.4: Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.

21st century themes:

Global Awareness & Financial, Economic, Business, and Entrepreneurial Literacy

Civic Literacy

Unit Rationale

Prior Learning

Kindergarten Unit 1: Engineering and Technology

In the unit children will learn the follow: Define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems & Explore and apply a design process

Future Learning

Grade 2 Unit 1: Engineering Design Process

- In this Unit children will learn the following: ask questions, make observations, and gather information to define a problem, use a design process to solve a problem, & compare the strengths and weaknesses of multiple design solutions.

Grade 3 Unit 1:

- In this Unit children will define problems and design solutions to those problems & test solutions and make improvement to solutions.

Grade 4 Unit 1:

- In this unit, students will explore how engineers define problems and solutions, learn about the importance of prototypes & use models to examine how prototypes are tested and improved.

Grade 5 Unit 1:

In this unit, students will discover how science and math are used in engineering, investigate a design process, and explore how technology decisions affect society.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-2-ETS1-1	Ask questions, make observation, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Unit Essential Question

- What are some ways to keep an object in place?
- How can examining the way one object is made help to solve a different problem?
- What evidence can be collected to show a problem has been solved?

Unit Enduring Understandings

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observation, and gathering information are helpful in thinking about problems
- Before beginning to design a solution, it is important to clearly understand the problem
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI Worktext

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Engineer It: How Do Engineers Use Technology?	Core: 5 Days Traditional: 7 Days
Lesson 2 Engineer It: How Can We Solve a Problem?	Core: 5 Days Traditional: 7 Days
Lesson 3 Unit 1 Review and Unit 1 Test	Core: 2 days
Additional Traditional Activities: You Solve it Unit 1 Performance Task Performance-Based Assessment	 1 day 2 days 2 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction:

- **On Level: How Do You Investigate? How Do Engineers Solve Problems?** These readers reinforce unit concepts, and includes response activities for your children.
- **Extra Support: How Do You Investigate? How Do Engineers Solve Problems?** These readers share title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is Linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.
- **Enrichment:** These high-interest, nonfiction readers will extend and enrich unit concepts and vocabulary, and include response activities.

ELL
Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content.

Curriculum Development Resources

<u>NSTA Web Seminar: Teaching NGSS in Elementary School—Kindergarten</u>

The seminar was led by expert teachers Carla Zembal-Saul, Professor of Science Education, Penn State University; Mary Starr, Executive Director, Michigan Mathematics and Science Centers Network; and Kathy Renfrew, K-5 Science Coordinator, VT Agency of Education. Carla, Mary and Kathy engaged with participants to gauge their familiarity with *NGSS* for kindergarten, and provided a number of example activities and videos on how to implement it, e.g., different approaches to teaching weather and climate core ideas. The web seminar was then wrapped up by Ted Willard, who suggested a number of resources and events for participants to further develop their understanding of *NGSS* for kindergarten, as well as other grade levels.

View the resource collection.

Continue discussing this topic in the community forums. **NSTA Web Seminar: Teaching NGSS in K-5: Constructing Explanations from Evidence** Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena. To view related resources, visit the resource collection. Continue discussing this topic in the community forums.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1	
Content Area: Engineering and Technology	
Lesson Title: Lesson 1: **Engineer It**: How Do Engineers Use Technology?	**Timeframe:** 5 days
Lesson Components	

21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: headphones and classroom materials.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Students will go through a variety of opportunities, children explore how engineers make and use technology to solve problem.	1. About this Image? Asks Students: Can you find the objects in this garden built by people? Who do you think built them? 2. Can you Solve it: Ask children to record their initial thoughts about what happened and what problem Mia had in the video. If the video is not available, discuss the image on the page. 3. What is an Engineer? Children will explore how engineers ask questions and gather information to understand problems. 4. What is Technology? Children will explore examples of technology and how structures in the natural world can inspire technology. Children will define a problem and gather information about it to design a solution. They will identify how the shape of the solution is connected to how it works. 5. Engineer It, Solve the Headphones Problem. 6. Take it Further 7. Lesson Check 8. Self Check	● Evidence Notebook: Children will work with a group to observe and record a problem that results from walking with headphones in their pocket. Remind children to use evidence to support their observations ● Read, Write, Share-Evidence Notebook: Children will identify three kinds of technology, explain how they know each one is technology, and tell what problems they solve. ● Lesson Check ● Self Check

Differentiation Small group instruction, leveled readers. Modifications in accordance with students’ 504 plans or IEP. ● **Lesson Vocabulary:** Problem, Solution, engineer, technology ● **Reinforcing Vocabulary:** To help children remember each vocabulary word, have them draw an illustration of each word, have them draw an illustration of each word. Then have them write the word beneath the illustration, define it, and use it in a sentence. Remind children to look for these highlighted words as they proceed through the lesson. ● **RTI/Extra Support:** Supply the children with additional images of examples of common problems and technology used to solve these problems. Provide children with context of how these technologies were made to help solve each problem. ● **Extension:** Children who want to find out more can do research on different types of engineers and/or technology. Children should use their data to make a poster that illustrates the type of engineer, or the problem and technology made to solve it. ● **ELL:** Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content, and provide hands-on examples of materials when possible to best support the needs of these learners.
Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**

Asking Questions and Defining Problems Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions. • Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1) • Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) **Developing and Using Models** Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2) **Analyzing and Interpreting Data** Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)	**ETS1.A: Defining and Delimiting Engineering Problems** • A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	**Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

Content Area: First Grade Science
Unit Title: Sound
Target Course/Grade Level: Unit 2 Grade 1
Unit Summary In this unit students will… • Explore the relationships between sound and vibration. • Compare the volume and the pitch of different sounds • Investigate how sound makes materials move.

- Identify ways people communicate using sound.
- Explore how technology is used to help people communicate with sound over distances.

In Lesson 1, children begin by observing that sound can cause materials to move and that vibrating materials can make sound. Children ask questions and explore the concepts of vibration, pitch, and volume. They also plan and conduct investigations to produce data about the relationships between sound and vibration.

IN Lesson 2, children explore the different ways people communicate with sound, including devices that allow people to communicate over long distances. Children use tools and materials provided to build and modify a tool for making sound and communicating over a distance. Children investigate technologies people use to communicate with one another and how sound engineers and people in other careers make use of technology to study and modify sound.

Primary interdisciplinary connections:

English Language Arts/Literacy

Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). (1-PS4-1),(1-PS4-2),(1-PS4-3) **W.1.7**
Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. (1-PS4-1),(1-PS4-2),(1-PS4-3) **SL.1.1**

Mathematics

Compare two two-digit numbers based on the meanings of the tens and ones digits, recording the results of comparisons with the symbols >,=, and<. 1.NBT.B.#
Express the length of an object as a whole number of length of unit, by layering multiple copies of a shorter object (the length unit) end to end, understand that the length measurement of an object is the number of same-size length units that span with no gaps or overlaps. 1.MD.A.2

21st century themes

Global Awareness & Financial, Economic, Business and Entrepreneurial Literacy

<u>Unit Rationale</u>

Prior Learning

This is the first formal opportunity for students to engage with the disciplinary core ideas.

Future Learning

Grade 1: Waves and their applications in technologies for information Transfer 1-PS4-1 & 1-PS4-4.

Grade 4: Waves and their applications in technologies for information transfer 4-PS4-1, 4-PS4-2, & 4-PS4-3

Learning Targets

Standards

NJSLS-S#	Performance Expectation
1-PS4-2	Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]
1-PS4-3	Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [Assessment Boundary: Assessment does not include the speed of light.]
1-PS4-1	Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

Unit Essential Question

How Does sound affect materials?

What does a material do when it makes sound?

How do musical instruments make sound?

Unit Enduring Understandings

- Sound can make matter vibrate, and vibrating matter can make sound.
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- The object vibrates when it makes sound.
- The sound makes the materials around it vibrate.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.

3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Online Tools

Teacher Resources: TCI Worktext

<u>What's All the Noise About?</u> This is a mini-unit that is part of the NSTA Publication "Science for the Next Generation". It is a 5 E model unit with each activity ranging in time needed from 30-90 minutes. In the Explore section, students observe a thunder drum and wine glass "singing" to form questions. As they move into Explore, they have 8 "sound centers" where they look for patterns in the ways various kinds of matter vibrate and what happens when they do. In Explain, students look at waves in particular, using a salt-drum and slinky. They then make tin-can phones in the Elaborate phase and finally, in Evaluate, they make an authentic communication device using all of their knowledge. A rubric is provided for the evaluation portion.

<u>Kat and Squirrel Go Camping:</u> This is an interactive story with pauses after each 'chapter' to allow students and teachers time to research topics, conduct experiments, do demonstrations, discuss vocabulary, record observations and conclusions , and even play a fun game. All materials needed for each of these are included in the unit.

All lessons are introduced by a continuing story about Kat and Squirrel's goofy adventures while on a camping trip. The lessons are aligned with the Next Generation Science Standards for first grade. The timing will depend upon how long and how often you have science class, but would most likely take 2-3 weeks. This could also be integrated into the reading/language arts curriculum very easily with a few creative teacher additions.

The "What it Looks Like in the Classroom" section of this document describes several student sense-making tasks.

Formative Assessments

Students who understand the concepts can:

- Design simple tests to gather evidence to support or refute ideas about cause and effect relationships.
- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.
- Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question.

- Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
- Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string.
- Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.

What it Looks Like in the Classroom

In this unit of study, students describe the relationships between sound and vibrating materials and the availability of light and the ability to see objects.

Students continue to plan and conduct investigations to develop an understanding of some basic properties of sound. Students can use a variety of objects and materials to observe that vibrating materials can make sound and that sound can make materials vibrate. Students need multiple opportunities to experiment with a variety of objects that will make sound. Some opportunities could include:

➢ Gently tapping various sizes of tuning forks on a hard surface.
➢ Plucking string or rubber bands stretched across an open box.
➢ Cutting and stretching a balloon over an open can to make a drum that can be tapped.
➢ Holding the end of a ruler on the edge of a table, leaving the opposite end of the ruler hanging over the edge, and then plucking the hanging end of the ruler.
➢ Touching a vibrating tuning fork to the surface of water in a bowl.
➢ Placing dry rice grains on a drum's surface and then touching the drum with a vibrating tuning fork or placing the drum near the speaker of a portable sound system.
➢ Holding a piece of paper near the speaker of a portable sound system.

As students conduct these simple investigations, they will notice that when objects vibrate (tuning forks that have been tapped and string, rubber bands, and rulers that have been plucked), sound is created. They will also notice that sound will cause objects to vibrate (sound from a speaker causes rice grains to vibrate on the surface of a drum, the vibrating tuning fork causes ripples on the surface of water, and sound from the speaker also causes paper to move). Students should use these types of observations as evidence when explaining the cause and effect relationship between sound and vibrating materials.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What is Sound?	Core: 5 Days Traditional: 7 Days
Lesson 2	Core: 5 Days

Engineer It-How Can We Communicate With Sound?	Traditional: 7 Days
Lesson 3 Unit 2 Review and Unit 2 Test	 2 Days
Additional Traditional Lessons: You Solve it Unit 2 Performance Task Performance-Based Assessment	 1 Day 2 Days 2 Days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction

- **On Level: What are Forces and Energy?** This reader reinforces unit concepts, and includes response activities for your children.
- **Extra Support: What are Forces and Energy?** This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.
- **Enrichments: Soccer Moves!** This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary, and includes response activities.

ELL
Lesson 1: Help children identify the key words in captions and headings throughout the lesson, and encourage children to refer to those key words as they explore the activities in the lesson.
Lesson 2: Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.

• Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Sound							
Lesson Title: What is Sound?						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness	X	Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of online tools							
Equipment needed: TCI text							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: • Plan and conduct an investigation in order to gather evidence of how sound and vibration are related	1. About this Image? Students will be asked what do they think might be making the drops move? 2. Can you Explain It? Sound has some interesting effects. Play the video to see how placing the water over the speaker can make the water move. 3. Make a Sound: 3D Learning: Children investigate to answer a question about the nature of sound. 4. Volume and Pitch: 3D Learning: Children gather evidence that helps them answer questions about volume and pitch.	• Children work with a group to perform a simple test to gather evidence about the effect of causing a metal ruler to vibrate and to answer questions about what causes the sound to change. Remind children that everyone in the group should have a turn holding and plucking the ruler. • Read, Write, Share: Children will work with a partner to list objects in the classroom that make sounds with a high pitch

	5. Do the Math! Compare Numbers: Children should indicate that 32 is less than < 62. If children indicate that 32 is equal to 62 or is greater than 62, have them use base ten blocks or counters to represent the numbers and compare them. 6. What Makes it Move? 3D Learning: Children ask questions and observe pictures to find out more about how sound makes the balloon move. 7. Make Something Move with Sound-Hands-on Activity 8. Take it Further 9. Lesson Check 10. Summative –Self Check	and objects that make sounds with a low pitch. Have each pair of children compare their list with another pair. Have them provide evidence of why they organized objects the way they did. ● Evidence Notebook: Children should write a plan with a list of steps and materials. They should include their observations, conclusions, and evidence to support their findings in their evidence notebook. ● Lesson Check ● Summative –Self Check

Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, online access, and kits

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> Plan and conduct investigations collaboratively to produce evidence to answer a question. (1-PS4-1),(1-PS4-3) **<u>Constructing Explanations and Designing Solutions</u>** Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-PS4-2) Use tools and materials provided to	**<u>PS4.A: Wave Properties</u>** Sound can make matter vibrate, and vibrating matter can make sound. (1-PS4-1) **<u>PS4.B: Electromagnetic Radiation</u>** Objects can be seen if light is available to illuminate them or if they give off their own light. (1-PS4-2) Some materials allow light to pass through them, others allow only some light through and	**<u>Cause and Effect</u>** Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS4-1),(1-PS4-2),(1-PS4-3) - **Connections to Engineering, Technology, and Applications of Science** **<u>Influence of Engineering, Technology, and Science, on</u>**

design a device that solves a specific problem. (1-PS4-4)	others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3) **<u>PS4.C: Information Technologies and Instrumentation</u>** People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	**<u>Society and the Natural World</u>** People depend on various technologies in their lives; human life would be very different without technology. (1-PS4-4) - ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** Science investigations begin with a question. (1-PS4-1) Scientists use different ways to study the world. (1-PS4-1)

Content Area: First Grade Science
Unit Title: Light
Target Course/Grade Level: Unit 3 Grade 1
Unit Summary In this unit children will… ● Provide evidence, based on observations, of the relationship between the amount of light and how an object is seen. ● Explain, using evidence based on observations, why objects that give off their own light can be seen in the dark. ● Explain and demonstrate how different materials can allow different amounts of light to pass through ● Explain how shadows are made. ● Observe that light shines in a straight line until it hits an object. ● Explore how reflection can be used to redirect light ● Explore how technology is used to send and receive information using light. **Primary interdisciplinary connections:** *Language Arts* Participate in shared research and writing projects (e.g., explore a number of “how-to” books on a

given topic and use them to write a sequence of instructions). (1-PS4-1),(1-PS4-2),(1-PS4-3) **W.1.7**
Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. (1-PS4-1),(1-PS4-2),(1-PS4-3) **SL.1.1**

Mathematics

Tell and write time in hours and half-hours using analog clocks. **1.MD.B.3**
Count to 120, starting at any number less than 120. In this range, read and write numerals and represent a number of objects with a written numeral. **1.NBT.A.1**
Solve word problems that call for addition of three whole numbers whose sum is less than or equal to 20, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem. **1.OA.A.2**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

This is the first formal opportunity for students to engage with the disciplinary core ideas.

Future Learning

Grade 1: Waves and their Applications in Technologies for Information Transfer 1-PS4-2, 1-PS4-3, & 1-PS4-4

Grade 4: Waves and their Applications in Technologies for Information Transfer 4-PS4-1, 4-PS4-2, & 4-PS4-3

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
1-PS4-2	Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]
1-PS4-3	Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [Assessment Boundary: Assessment does not include the speed of light.]
1-PS4-1	Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched

	string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

Unit Essential Question

Part A: How can you prove that you can only see something when someone shines a light on it or if the object gives off its own light?

Part B: What happens to a beam of light when you put different kinds of things in front of it? How would you design an experiment to prove your thinking?

Unit Enduring Understandings

Part A:

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Objects can be seen if light is available to illuminate them or if they give off their own light.

Part B:

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach.
- Mirrors can be used to redirect a light beam. *(Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)*

Evidence of Learning

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Online Tools

Teacher Resources: TCI work text, TCI teacher resources, and TCI Kits

What's All the Noise About? This is a mini-unit that is part of the NSTA Publication "Science for the Next Generation". It is a 5 E model unit with each activity ranging in time needed from 30-90 minutes. In the Explore section, students observe a thunder drum and wine glass "singing" to form questions. As they move into Explore, they have 8 "sound centers" where they look for patterns in the ways various kinds of matter vibrate and what happens when they do. In Explain, students look at waves in particular, using a salt-drum and slinky. They then make tin-can phones in the Elaborate phase and finally, in Evaluate, they make an authentic communication device using all of their knowledge. A rubric is provided for the evaluation portion.

Kat and Squirrel Go Camping: This is an interactive story with pauses after each 'chapter' to allow students and teachers time to research topics, conduct experiments, do demonstrations, discuss vocabulary, record observations and conclusions , and even play a fun game. All materials needed for each of these are included in the unit.

All lessons are introduced by a continuing story about Kat and Squirrel's goofy adventures while on a camping trip. The lessons are aligned with the Next Generation Science Standards for first grade. The timing will depend upon how long and how often you have science class, but would most likely take 2-3 weeks. This could also be integrated into the reading/language arts curriculum very easily with a few creative teacher additions.

The "What it Looks Like in the Classroom" section of this document describes several student sense-making tasks.

Formative Assessments

Students who understand the concepts can:

- Design simple tests to gather evidence to support or refute ideas about cause and effect relationships.
- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.
- Make observations (e.g., in a completely dark room, using a pinhole box, using video of a cave explorer with a flashlight) to construct an evidence-based account that objects can be seen only when illuminated (from an external light source or by an object giving off its own light).
- Design simple tests to gather evidence to support or refute ideas about cause and effect relationships.
- Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question.
- Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. Materials can be
    - Transparent (clear plastic, glass)

    - Translucent (wax paper, thin cloth)
    - Opaque (cardboard, construction paper)
    - Reflective (a mirror, a shiny metal spoon)
- Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
- Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string.
- Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.

What it Looks Like in the Classroom

In this unit of study, students plan and conduct investigations and make observations as they explore sound and light energy. Students describe the relationships between sound and vibrating materials and the availability of light and the ability to see objects. They also investigate the effect on a beam of light when objects made of different materials are placed in its path. Throughout the unit, students will use their observations and data as evidence to determine cause-and-effect relationships in the natural world.

Students begin this unit by observing objects with and without available light. They need opportunities to observe a variety of objects in both illuminated and non-illuminated settings. For example, observations could be made in a completely dark room, or students can use a pinhole box to observe objects. Students can also watch videos of cave explorers deep in the earth, using light from a single flashlight. With experiences such as these, they will come to understand that objects can be seen only when illuminated, either from an external light source or by when they give off their own light.

Next, students plan and conduct simple investigations to determine what happens to a beam of light when objects made of various materials are placed in its path. Students need the opportunity to explore the interaction of light with a variety of materials, and they should record what they observe with each one. When selecting materials to use, teachers should choose some that allow all light to pass through (transparent), some that allow only a portion of the light to pass through (translucent), some that do not allow any light to pass through (opaque), and some that redirect the beam of light (reflective). Examples could include clear plastic, glass, wax paper, thin cloth, cardboard, construction paper, shiny metal spoons, and mirrors.

As students observe the interaction between light and various materials, they should notice that when some or all of the light is blocked, a shadow is created beyond the object. If only a portion of light is blocked (translucent materials), a dim shadow will form, and some light will pass through the object. If all the light is blocked (opaque materials), students will see only see a dark shadow beyond the object. They will also observe that shiny materials reflect light, redirecting the beam of light in a different direction. Students should use their observations as evidence to support their explanations of how light interacts with various objects.

After investigating light energy, students continue to plan and conduct investigations to develop an understanding of some basic properties of sound. Students can use a variety of objects and materials to observe that vibrating materials can make sound and that sound can make materials vibrate. Students need multiple opportunities to experiment with a variety of objects that will make sound. Some opportunities could include:

- Gently tapping various sizes of tuning forks on a hard surface.
- Plucking string or rubber bands stretched across an open box.
- Cutting and stretching a balloon over an open can to make a drum that can be tapped.
- Holding the end of a ruler on the edge of a table, leaving the opposite end of the ruler hanging over the edge, and then plucking the hanging end of the ruler.
- Touching a vibrating tuning fork to the surface of water in a bowl.
- Placing dry rice grains on a drum's surface and then touching the drum with a vibrating tuning fork or placing the drum near the speaker of a portable sound system.
- Holding a piece of paper near the speaker of a portable sound system.

As students conduct these simple investigations, they will notice that when objects vibrate (tuning forks that have been tapped and string, rubber bands, and rulers that have been plucked), sound is created. They will also notice that sound will cause objects to vibrate (sound from a speaker causes rice grains to vibrate on the surface of a drum, the vibrating tuning fork causes ripples on the surface of water, and sound from the speaker also causes paper to move). Students should use these types of observations as evidence when explaining the cause and effect relationship between sound and vibrating materials.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 How does Light help Us See?	5 Days-Core Route 7 Days- Traditional Route
Lesson 2 How Do Materials Block Light?	5 Days-Core Route 7 Days-Traditional Route
Lesson 3 How Does Light Travel?	5 Days-Core Route 7 Days-Traditional Route
Unit 3 Review and Unit 3 Test	2 days
Additional Traditional Route Lessons You Solve It Unit 3 Performance Task Performance-Based Assessment	 1 Day 2 Days 2 Days

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.
Differentiate Instruction **On Level: What are Forces and Energy?** This reader reinforces unit concepts and includes response activities for your children. **Extra Support: What are Forces and Energy?** This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities. **Enrichment: Soccer Moves!** This high-interest, non-fiction reader will extend and enrich unit concepts vocabulary and includes response activities. **ELL** **Lesson 1, 2, & 3:** Bes sure to point out all labels, pictures, captions and headings throughout the lesson to assist children with strategies to summarize chunks of content. **Lesson 3: B**
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

<table>
<tr><th colspan="8">Lesson Plan 1</th></tr>
<tr><td colspan="8">Content Area: Light</td></tr>
<tr><td colspan="6">Lesson Title: How Does Light Help Us See?</td><td colspan="2">Timeframe: 5 days</td></tr>
<tr><td colspan="8">Lesson Components</td></tr>
<tr><td colspan="8"><u>21st Century Themes</u></td></tr>
<tr><td>X</td><td>Global Awareness</td><td></td><td>Financial, Economic, Business, and Entrepreneurial Literacy</td><td></td><td>Civic Literacy</td><td></td><td>Health Literacy</td></tr>
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<tr><td></td><td>Creativity and Innovation</td><td>X</td><td>Critical Thinking and Problem Solving</td><td></td><td>Communication and Collaboration</td><td></td><td>Information Literacy</td></tr>
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<tr><td colspan="8">Interdisciplinary Connections: Science: Technology</td></tr>
<tr><td colspan="8">Integration of Technology: Utilization of online tools</td></tr>
<tr><td colspan="8">Equipment needed: TCI Text, photos of rainbows, tall drinking glasses, water, white paper, light source, such as a bright window.</td></tr>
</table>

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Students will make observations to explain how objects can be seen if the objects give off their own light or light is available to shine on them.	1. About this Image: Ask what time of day was this picture taken? What do you see? Which of these things can you see best? Where is light coming from in the photograph? 2. Can you Explain it? *Light in Darkness,* Some things are easier to see in the dark. Go online to watch a video showing fireworks. 3. Let There Be Light: Children will observe how light affects whether an object can be seen and how that object looks. They will use these observations to provide evidence of a relationship between the amount of light and how an object is seen. 4. Do the Math! Tell and Write Time: Guide children as they read and discuss the word problem. Ask: What do you need to find out?	● Read, Write Share: Collaborate with Groups ● Evidence Notebook: Ask small groups of children to design a simple test that will answer the questions, “How can we see some objects in the dark? ● Lesson Check ● Summative Assessment

	5. Make Observations in Different Light: Children will make observation in different amounts of light. 6. See in the Dark: 3D Learning Objective: Children will observe objects that give off their own light and use their observations to explain why these objects can be seen in the dark. 7. Take It Further 8. Lesson Check 9. Summative Assessment	

Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, online access, and kits

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> Plan and conduct investigations collaboratively to produce evidence to answer a question. (1-PS4-1),(1-PS4-3) **<u>Constructing Explanations and Designing Solutions</u>** Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-PS4-2) Use tools and materials provided to design a device that solves a specific problem. (1-PS4-4)	**<u>PS4.A: Wave Properties</u>** Sound can make matter vibrate, and vibrating matter can make sound. (1-PS4-1) **<u>PS4.B: Electromagnetic Radiation</u>** Objects can be seen if light is available to illuminate them or if they give off their own light. (1-PS4-2) Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light	**<u>Cause and Effect</u>** Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS4-1),(1-PS4-2),(1-PS4-3) - **Connections to Engineering, Technology, and Applications of Science** **<u>Influence of Engineering, Technology, and Science, on Society and the Natural World</u>** People depend on various technologies in their lives; human life would be very different without technology. (1-PS4-4)

	travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3) **<u>PS4.C: Information Technologies and Instrumentation</u>** People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** Science investigations begin with a question. (1-PS4-1) Scientists use different ways to study the world. (1-PS4-1)

Content Area: First Grade Science
Unit Title: Plant and Animal Structures
Target Course/Grade Level: Unit 4 Grade 1
Unit Summary In this unit of study, students develop an understanding of how plants and animals use their parts to help them survive, grow, and meet their needs. Students also need opportunities to develop possible solutions. As students develop possible solutions, one challenge will be to keep them from immediately implementing the first solution they think of and to instead think through the problem carefully before acting. Having students sketch their ideas or make a physical model is a good way to engage them in shaping their ideas to meet the requirements of the problem. The crosscutting concept of structure and function is called out as an organizing concept for the disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in constructing explanations, designing solutions, and in developing and using models. Students are expected to use these practices to demonstrate understanding of the core ideas. **Lesson 1: Engineer It: What Parts Help Plants Live?** Children explore how the external parts of plants allow them to survive and grow. Children will explore how people design solutions by mimicking how plants parts function. Finally, children will build a solution to a human problem. **Lesson 2: Engineer It: What Body Parts Help Animals Stay Safe?** Children mimic animal parts to construct a solution to a human problem. Children explore how the structure of animal parts is related to their function **Lesson 3: Engineer It: What Body Parts Help Animals Meet their Needs?** Children will explore how the body parts of animals allow them to meet their needs. Children will explore how people design solutions to problems by mimicking animal parts. Finally, children mimic animal body parts and function to build a solution.

Lesson 4: How Do Plants and Animals Respond to Their Environment? Children will explore how plants and animals respond to their environments, carry out an investigation about the effects of light on plant growth, and explore how animal senses help them process information.

Primary interdisciplinary connections:

English Language Arts

Students participate in shared research and writing projects. Engaging in engineering design provides a perfect opportunity for students to conduct shared research and complete writing projects. Students can use text and media resources to gather information about how the shape and stability of external structures of organisms are related to their functions. In addition, students can conduct simple research to find examples of how humans solve problems using an understanding of the natural world. Examples of writing projects could include creating a book that includes examples of how humans mimic the characteristics of organisms to design solutions to human problems. Students can also use drawings or other visual displays to accompany their design solutions. Students will need support from teachers to conduct shared research and complete writing projects.

Participate in share research and writing projects (e.g. explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). **W.1.7**
Ask and answer questions about key details in a text. **R.1.1**

Mathematics:

Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another **1.MD.C.4**
Express the length of an object as a whole number of length units, by layering multiple copies of a shorter object (length and unit) end to end understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. **1.MD.A.2**

21st century themes (Pick All that apply):

Global Awareness

<u>Unit Rationale</u>

Prior Learning

Kindergarten Unit 5: Weather

Asking questions, making observations, and gathering information are helpful in thinking about problems.

Future Learning

Grade 4 Unit 4: Plant Structure and Function

In this unit students will: explore the functions of internal and external plant structures and how they aid in growth, survival, behavior and reproduction & learn how different plant structures work together as a system. Grade 4 Unit 5: Animal Structure and Function In this unit children will: explore the internal and external structures of animals & learn about how different senses work.
Learning Targets
Standards

NJSLS-S#	**Performance Expectation**
1-LS1-1	**Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.*** *[Clarification Statement: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and, detecting intruders by mimicking eyes and ears.]*
K-2-ETS1	**Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.**

Unit Essential Question Part A: How can humans mimic how plants and animals use their external parts to help them survive and grow?
Unit Enduring Understandings Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. ● The shape and stability of structures of natural and designed objects are related to their function(s). ● All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. ● Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs. ● Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
Evidence of Learning

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI work text, TCI teacher resources, and TCI Kits

<u>Eat Like a Bird! January</u>: This lesson and activity is one of several lessons about birds. In this lesson, students learn that bird beaks come in many different sizes and shape. Each beak has a specific shape and function to help the bird to get and eat food.

<u>Why So Yummy</u>: In this lesson students will investigate how fruits help some plants survive. The background information is important to the overall goals of this lesson. It states, "fruit-bearing plants can be distinguished from other plants, because they contain a reproductive structure that develops into an edible fruit. This reproductive structure is the shelter that protects the seeds until they are mature. This is important, because seeds are not distributed to the earth for germination until they are ripe." The teacher will need to purchase some fruits ahead of time for this lesson. Identifying a variety of fruits and especially fruits children might have less experience with will enhance the experience.

Formative Assessments

Students who understand the concepts are able to:

- Observe and describe how the shape and stability of structures of natural and designed objects are related to their functions.
- Use materials to design a device that solves a specific problem or [design] a solution to a specific problem.

- Use materials to design a solution to a human problem that mimics how plants and/or animals use their external parts to help them survive, grow, and meet their needs: Examples of human problems that can be solved by mimicking plant or animal solutions could include:
    - Designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales.
    - Stabilizing structures by mimicking animal tails and roots on plants.
    - Keeping out intruders by mimicking thorns on branches and animal quills.
    - Detecting intruders by mimicking eyes and ears.
- Develop a simple model based on evidence to represent a proposed object or tool.
- Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

What it Looks Like in the Classroom

In this unit of study, students investigate how plants and animals use their external structures to help them survive, grow, and meet their needs. Then students are challenged to apply their learning to design a solution to a human problem that mimics how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

In order to recognize ways in which animals and plants use their external structures, students need opportunities to observe and describe how the shape and stability of organisms' structures are related to their functions. Students can make direct observations and use media resources to find relevant examples for both plants and animals. They should observe that different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. In addition, animals have body parts that capture and convey different kinds of information from the environment, enabling them to respond to these inputs in ways that aid in survival. Plants, like animals, have different parts (roots, stems, leaves, flowers, fruits) that each serve specific functions in survival and growth, and plants also respond to external inputs. For each structure that students observe, they should describe how the shape and stability of that structure is related to its function.

The next step in this unit is to engage in engineering design. Students need opportunities to use materials to design a device that solves a specific human problem. Designs should mimic how plants and/or animals use their external parts to help them survive and grow. The engineering design process students engage in should include the following steps:

- As a class or in small groups, students participate in shared research to find examples of human-made products that have been designed and built by applying knowledge of the natural world. For each example, students identify the human problem(s) that the product solves and how that solution was designed using an understanding of the natural world.
- Students brainstorm possible human problems that can be solved by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs. Examples could include:
    - Designing clothing or equipment to protect bicyclists that mimics turtle shells, acorn shells, and animal scales.
    - Stabilizing structures that mimic animal tails and plant roots.
    - Keeping out intruders by mimicking thorns on branches and animal quills.
    - Detecting intruders by mimicking eyes and ears.

- In small groups, students use sketches, drawings, or physical models to convey a design that solves a problem by mimicking one or more external structures of plants and/or animals.
- Use materials to create the design solution.
- Share the design solution with others in the class.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Engineer It: What Parts Help Plants Live?	5 days-Core Route 7 Days- Traditional Route
Lesson 2 Engineer It: What Body Parts Help Animals Stay Safe?	5 days-Core Route 7 Days- Traditional Route
Lesson 3 Engineer It: What Body Parts Help Animals Meet Their Needs?	5 days-Core Route 7 Days- Traditional Route
Lesson 4 How Do Plants and Animals Respond to Their Environment	5 days-Core Route 7 Days- Traditional Route
Lesson 5 Unit Review and Unit 4 Test	2 days
Additional Traditional Route Lessons You Solve it Unit 4 Performance Task Performance-Based Assessment	1 day 2 days 2 days

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction

On Level: What Can We Learn About Animals? What Is a Plant? These readers reinforce unit concepts and include response activities for your children.

Extra Support: What Can We Learn About Animals? What is a Plant? These readers share titles, illustrations, vocabulary, and concepts with the On-Level Reader; however, these texts are linguistically accommodated to provide simplified sentence structures and comprehension aids. They also include response activities.

Enrichments: Amazing Animals Weird and Wacky Plants: These high-interest, nonfiction readers will extend and enrich unit concepts, vocabulary and include response activities.

ELL

Lesson 1: Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content, and provide hands-on examples of materials when possible to best support the needs of these learners.

Lesson 2: As children view the photographs of animals in the lesson, encourage them to find the name of the animal on the page with the photograph and say it aloud together.

Lesson 3: Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content.

Lesson 4: Work with children to label a diagram of key plants parts involved in adaptations and a diagram of animal parts involved in gathering information.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Plants and Animal Structures							
Lesson Title: Engineer It: What Parts Help Plants Live?						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of online tools							
Equipment needed: Books and appropriate websites about animals including the characteristics of the environments they live in and how the animals meet their needs in that environment.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Design a solution to a human problem by mimicking how plants use their parts survive and grow.	1. About this Image: Ask the students Have you ever seen a tree like this one? What parts does it have? What do you notice about the trunk? What about the roots? 2. Can you Solve It? From Seed to Design: The natural world can give people ideas to solve problems. Watch the video to learn more. 3. Plant Parts: 3D Learning: Children will identify parts of flowering plants and construct explanations of how the parts help plants survive. Grow, and meet their needs. 4. Do the Math! Represent Data: Children should fill in one rectangle for each person's choice. 5. Shape Up: 3D Learning: Children will construct explanations of how the shape and stability of structure of plant parts are related to their functions.	● Evidence Notebook: Children will need to observe and sketch a real plant. Plan to have several types of plants available in the classroom, or take children outside to observe plants in nature. ● Evidence Notebook: Children predict and record what will happen to a leaf when it is covered with aluminum foil. Have children record not only their prediction, but also their reasoning behind it. Remind children to use evidence to support their reasoning.

	6. Looking to Nature: 3D Learning: Children will explore how the shape and functions of plants parts give people ideas for designs. 7. Plants Give Ideas: 3D Learning: Children will construct explanations of how the shape and stability of the structure of plants parts are related to their functions. 8. Engineer It: Use Ideas from Plants to Design a Solution. 9. Take it Further 10. Lesson Check 11. Self Check	● Read, Write, Share! In pairs, children will research both plants and human designs that are similar in structure and function. ● In small groups, children will observe plant parts and make connections between their structure and function. ● Lesson Check ● Self Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided TCI work text, online access, and kits		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS3-1) **Constructing Explanations and Designing Solutions** Use materials to design a device that solves a specific problem or a solution to a specific problem.	**LS1.A: Structure and Function** All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1-1) **LS1.B: Growth and Development of Organisms** Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)	**Patterns** Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. (1-LS1-2) **Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (1-LS1-1) The shape and stability of structures of natural and designed objects are related to

(1-LS1-1) **<u>Developing and Using Models</u>** Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2)	**<u>LS1.D: Information Processing</u>** Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs. (1-LS1-1) **<u>ETS1.B: Developing Possible Solutions</u>** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)	their function(s). (K-2-ETS1-2) - ***Connections to Engineering, Technology, and Applications of Science*** **<u>Influence of Science, Engineering and Technology on Society and the Natural World</u>** Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. (1-LS1-1)

Content Area: First Grade Science
Unit Title: Living Things and Their Young
Target Course/Grade Level: Unit 5 Grade 1
Unit Summary In this unit of study, students develop an understanding of how plants and animals use their external parts to help them survive, grow, and meet their needs, as well as how the behaviors of parents and offspring help offspring survive. The understanding that young plants and animals are like, but not exactly the same as, their parents is developed. The crosscutting concept of *patterns* is called out as an organizing concept for the disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *obtaining, evaluating, and communicating information* and *constructing explanations*. Students are also expected to use these practices to demonstrate understanding of the core ideas. Student will: ● Compare young plants with parent plants ● Observe patterns to explain how plants of the same kind are alike and different. ● Compare young animals with parent animals ● Observe patterns to explain how animals of the same kind are alike and different ● Describe how plants and animals respond to their environments to meet their environments to meet their needs. ● Describe how behavior patterns of parents and offspring help offspring survive. **Lesson 1: How Do Plants Look Like Their Parents?** Children focus on the similarities and differences between adult plants and their young. Children investigate these phenomena by classifying plants based on shared traits. They discuss how the transfer of traits from parent plants to their young results in plants of

the same kind. During a hands-on activity, children make observations about how plants of the same kind grow to construct evidence.

Lesson 2: How Do Animals Look like their Parents? Children focus on the similarities and differences between animals and their offspring. Children explore how animals change as they grow and observe patterns in these changes. Children compare parts of young animals and their parents through a hands-on activity. Children compare and contrast coverings of young and adult animals. They explore variations among animals of the same kind.

Lesson 3: How Do Animals Take Care of Their Young? Children focus on patterns in behavior of parents and offspring that help them survive. Children explore how animals take care of their young. They describe behavioral patterns of parents and offspring that help offspring get food. They discover how animals teach their offspring to get food and stay safe.

Primary interdisciplinary connections:

English Language Arts

To integrate English Language Arts into this unit, students need opportunities to read informational texts to gather information about traits and behaviors of organisms. With adult guidance, they identify the main topic, retell key details from texts, and ask and answer questions about key details. Students should also participate in shared research and writing projects. They can gather information from a variety of preselected, grade-level-appropriate texts and resources and use that information to answer questions about traits and behaviors of organisms. In pairs or small groups, students can use pictures and words to create simple books that describe features that parents and offspring share or behaviors that parents and offspring exhibit that help offspring survive.

Ask and answer questions about key details **RI.1.1**
Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). (1-LS1-1) **W.1.7**
With guidance and support from adults, recall information from experiences or gather information from provided sources to answer questions.

Mathematics

To integrate mathematics into this unit, students reason abstractly and quantitatively and use appropriate tools strategically as they collect and organize data, and use it to solve problems. For example, when students gather information about the shape, size, color, and number of leaves on plants, they can:

- ➢ Use grade-level-appropriate tools and strategies to measure, compare, and order leaves by length.
- ➢ Organize data (e.g., number of leaves) into simple graphs or tables, and then use strategies based on place value, properties of operations, and/or the relationship between addition and subtraction to make comparisons.

➢ Use drawings and equations as they solve problems (e.g., more or less, total amount, how many in each).

Order three objects by length; compare the lengths of two objects indirectly by using a third object. **1.MD.A.1**
Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object end to end; understand that the length measurement of an object is the number of size length units that span it with no gaps or overlaps. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps **1.MD.A.2**
Compare two two-digit numbers based on the meanings of the tens and one digits, recording the results of comparisons with the symbols >, =, and<. **1.NBT.B.3**
Given a two digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used. **1.NBT.C.5**
Use appropriate tools strategically **MP.5**

21st century themes :

Global Awareness

Unit Rationale

Prior Learning

From Molecules to Organisms: Structures and Processes (K-LS1-1): Use observations to describe patterns of what plants and animals need to survive.

Future Learning

Grade 3 Unit 5: Life Cycles and Inherited Traits

- In this unit, students will explore the life cycles of plants and animals & discover inherited plant and animal traits.

Grade 4 Unit 4: Plant Structure and Function

- In this unit students will explore the functions of internal and external plant structures and how they aid growth, survival, behavior and reproduction & learn how different plant structures work together as a system.

Grade 4 Unit 5: Animal Structure and Function

- In this unit students will explore the internal and external structures of animals & learn about how different senses work.

Learning Targets

Standards

NJSLS-S#	Performance Expectation
1-LS3-1	**Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** *[Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.]* [Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.*]*
1-LS1-2	**Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.** *[Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).]*

Unit Essential Question

Part A: How are young plants and animals alike and different from their parents?

Part B: What types (patterns) of behavior can be observed among parents that help offspring survive?

Unit Enduring Understandings

Part A:

- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.
- Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.
- Young animals are very much, but not exactly, like their parents. Plants also are very much, but not exactly, like their parents.

Part B:

- Scientists look for patterns and order when making observations about the world.
- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.
- Adult plants and animals can have young.
- In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring survive.

Evidence of Learning

Summative Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**

1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI work text, TCI teacher resources, and TCI Kits

Chip Off the Old Block: In this lesson students compare adult plants with young plants and then match pictures of adult animals with their young. They then are asked to identify specific physical traits of plants and animals that can be used to identify them. Note: The Parent/Offspring photo collection on page three incorrectly states the offspring of a horse is a pony.

Eat Like a Bird! January: This lesson and activity is one of several lessons about birds. In this lesson, students learn that bird beaks come in many different sizes and shape. Each beak has a specific shape and function to help the bird to get and eat food.

Why So Yummy? In this lesson students will investigate how fruits help some plants survive. The background information is important to the overall goals of this lesson. It states, "fruit-bearing plants can be distinguished from other plants, because they contain a reproductive structure that develops into an edible fruit. This reproductive structure is the shelter that protects the seeds until they are mature. This is important, because seeds are not distributed to the earth for germination until they are ripe." The teacher will need to purchase some fruits ahead of time for this lesson. Identifying a variety of fruits and especially fruits children might have less experience with will enhance the experience.

Formative Assessments

Students who understand the concepts are able to:

- Observe and use patterns in the natural world as evidence and to describe phenomena.
- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.
- Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.
    - Examples of patterns could include features plants or animals share.

- Examples of observations could include that leaves from the same kind of plant are the same shape but can differ in size and that a particular breed of puppy looks like its parents but is not exactly the same.

[Note: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.]

- Observe and use patterns in the natural world as evidence and to describe phenomena.
- Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world.
- Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. Examples of patterns of behaviors could include:
    - The signals that offspring make, such as crying, cheeping, and other vocalizations.
    - The responses of the parents, such as feeding, comforting, and protecting the offspring.

What it Looks Like in the Classroom

In this unit of study, students observe organisms in order to recognize that many types of young plants and animals are like, but not exactly the same as, their parents. Students also observe how organisms use their external parts to help them survive, grow, and meet their needs, and how the behaviors of parents and offspring help offspring survive. Throughout the unit, students will look for patterns; obtain, evaluate, and communicate information; and construct explanations.

People look for patterns in the natural world and use these patterns as evidence to describe phenomena. Students begin this unit by observing and comparing external features of organisms, looking for patterns in what they observe. They will need opportunities to observe a variety of plants and animals in order to look for similarities and differences in their features. For example, when comparing the shape, size, color, or number of leaves on plants, students begin to notice that plants of the same kind have leaves that are the same shape and color, but the leaves of one plant may differ from another in size or number. When comparing body coverings; number, size, and type of external features (legs, tail, eyes, mouth parts); body size, body coloring, or eye color of animals, students learn that animals of the same kind have the same type of body covering and the same number and types of external features, but the size of the body, the size of external features, body color, and/or eye color of individuals might differ. Making observations like these helps students recognize that young plants and animals look very much, but not exactly, like their parents, and that even though individuals of the same kind of plant or animal are recognizable as similar, they can also vary in many ways.

In addition to observing and documenting similarities and differences in the external features of organisms, students also need opportunities to make direct observations, read texts, or use multimedia resources to determine patterns in the behaviors of parents and offspring that help offspring survive. While both plants and animals can have young, it is the parents of young animals who might engage in behaviors that help their young survive. Some examples of these patterns of behaviors could include the signals that offspring make, such as crying, cheeping, and other vocalizations, and the responses of parents, such as feeding, comforting, and protecting their young.

Lesson Plans

Lesson	Timeframe

Lesson 1 How Do Plants Look their Parents?	Core Route: 5 days Traditional Route: 7 Days
Lesson 2 How Do Animals Look Like Their Parents?	Core Route: 5 Days Traditional Route: 7 Days
Lesson 3 How Do Animals Take Care of Their Young?	Core Route: 5 Days Traditional Route: 7 Days
Unit 5 Review and Unite 5 Test	2 days
Additional Traditional Route Lessons Unit 5 Project You Solve It Unit 5 Performance Task Performance-Based Assessment	 3 Days 1 Day 2 Days 2 Days

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On Level: What Can We Learn About Animals? What is a Plant?

These readers reinforce unit concepts and include response activities for your children

Extra Support: What Can We Learn About Animals? What is a Plant?

These readers share title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. They also include response activities.

Enrichment: Amazing Animals-Weird and Wacky Plants

These high-interest, nonfiction readers will extend and enrich unit concepts and vocabulary and include response activities.

ELL

Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content and provide hands-on examples of materials when possible to best support the needs of these learners.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Living Things and Their Young							
Lesson Title: How Do Plants Look Like Their Parents?3					**Timeframe:** 5 Days		
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of online tools							
Equipment needed: carrot tops, small bowls of water							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will make observations to	1. About this Image: Guide students to look at the field of flowers in the photograph. What do you see in the	● Evidence notebook: Have children think about what happens when a young plant becomes an adult,

explain the differences and similarities between plant parents and their offspring.	picture? Which of those things are living? 2. Can you Explain it: We can make observations to determine whether plants are the same kind. 3. Young and Old: 3D Learning Objective: Children observe a pattern of difference between young trees and parent trees to gather evidence of how offspring may start life with different features than their parent plant. 4. Compare Parts:3d Learning: Children compare patterns between a young plant and a parent plant to explain how they are alike and different 5. Compare Adult Plants: Children observe and gather evidence of how plants of the same kind can have similarities and differences. 6. Take it Further 7. Lesson Check 8. Summative Assessment: Self Check	and draw pictures to represent differences between adult and young plants. ● Read, Write, Share! Children work in small groups to research how an adult plant looks when it is young. Provide access to resources such as books, magazines, or digital sources. ● Evidence notebook: Children work in groups to sort pictures of plants by kind. Provide photographs of several varieties of the same kind of plants. Encourage children to discuss their observations about each plant as they decide which ones should be sorted together and to justify their decisions with evidence. ● Lesson Check ● Summative Assessment: Self Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, online access, and kits		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS3-1) **Obtaining, Evaluating, and Communicating Information**	**LS3.A: Inheritance of Traits** Many characteristics of organisms are inherited from their parents. (3-LS3-1) **LS1.B: Growth and Development of Organisms**	**Patterns** Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1) Patterns in the natural and

Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world. (1-LS1-2)	Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)	human designed world can be observed, used to describe phenomena, and used as evidence. (1-LS1-2) - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** Scientists look for patterns and order when making observations about the world. (1-LS1-2)

Content Area: First Grade Science
Unit Title: Objects and Patterns in the Sky
Target Course/Grade Level: Unit 6 Grade 1
Unit Summary In this Unit, students will be exposed to the following: ● Identify and describe objects in the sky ● Use evidence to describe predictable patterns of the sun, moon and stars ● Observe and model patterns of the moon's phases. ● Use observations to describe characteristics of each season ● Predict patterns of change that take place from season to season ● Use observations to compare the amount of daylight from season to season. ● Explore how seasons affect people and animals **Lesson 1:** Children focus observing, describing, and predicting patterns in the way the sun, moon, and stars appear to move across the sky. Children make observations of objects in the daytime sky and the nighttime sky and use those observations to answer questions about the motion of the objects they see in the sky. In the process, children explore the apparent motion of these objects as examples of natural events that are repeated through time, and learn to make assumptions about phenomena using observed repetitions as evidence. **Lesson 2:** Children focus on how the amount of daylight in a day is related to the time of year. After an introduction to the seasons, children observe, describe, and predict seasonal patterns of sunrise and sunset. They observe how seasonal changes affect plants and animals. Children explore these patterns through a variety of interaction and one hands-on activity.

Primary interdisciplinary connections:

English Language Arts/Literacy

In this unit of study, students need opportunities to participate in shared research and writing projects about patterns of change in the sky. For example, students can use online resources or books to research the patterns of change that are visible over time when we observe the objects in the sky. With guidance from adults, students could create books that describe and illustrate the different patterns of change observed in objects in the sky. They could also describe and illustrate the relative amount of daylight in relation to the season using a sequenced set of journal entries or in a sequence-of-events foldable.

Participate in shared research and writing projects (e.g., explore a number of “how-to” books on a given topic and use them to write a sequence of instructions). (1-ESS1-1),(1-ESS1-2) **W.1.7**
With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. (1-ESS1-1),(1-ESS1-2) **W.1.8**

Mathematic

Students need opportunities to represent and interpret data and to use addition and subtraction. The following examples from NGSS Appendix L could provide guidance for instruction and should be done with teacher support:

- ➢ Science example 1: There were 16 hours of daylight yesterday. On December 21, there were 8 hours of daylight. How many more hours of daylight were there yesterday than on December 21?
- ➢ Science example 2: Based on the data collected and posted on the bulletin board so far, which day has been the longest of the year so far? Which day has been the shortest?

Partition circles and rectangles into two and four equal shares, describe the shares using the words halves, fourths, and quarters, and use the phrases half of, fourth of, and quarter of. Describe the whole as two of, or four of the shares. Understand for these examples that decomposing into more equal shares creates smaller shares. **1.G.A.3**
Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations to represent the problem. *(1-ESS1-2)* **1.OA.A.1**
Reason abstractly and quantitatively. *(1-ESS1-2)* **MP.2**

21st century themes (Pick All that apply):

Global Awareness

Unit Rationale

Prior Learning

Children should already know and be prepared to build on the following concepts: ● The sun and other objects in the sky seem to change ● The sun seems to move across the sky throughout the day. It leaves our sight, or sets, each night. It reappears, or rises, in the sky each morning. ● The sun gives earth light and warmth. ● Living things need sunlight to live. ***Future Learning*** *Grade 3 Unit 2: Forces* In this unit, students will explore how forces work, discover different types of forces, and learn about forces that act from a distance. *Grade 3 Unit 3: Motion* In this unit, students will explore types of forces and motion, learn about the relationship between forces and motion, & identify patterns in motion. *Grade 5 Unit 6: Earth's Systems* In this unit, students will explore the hydrosphere, geosphere, biosphere, and atmosphere, and learn how Earth's systems interact.
Learning Targets

Standards	
NJSLS-S#	**Performance Expectation**
1-ESS1-1	Use observations of the sun, moon, and stars to describe patterns that can be predicted. [Clarification Statement: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.] [Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.]
1-ESS1-2	Make observations at different times of year to relate the amount of daylight to the time of year. [Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.] [Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.]

Unit Essential Question **Part A:** What patterns of change can be predicted when observing the sun, moon, and stars? **Part B:** What is the relationship between the amount of daylight and the time of year?
Unit Enduring Understandings **Part A:** ● Science assumes that natural events happen today as they happened in the past. ● Many events are repeated.

- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.
- Patterns in the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.

Part B:

- **Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.**
- **Seasonal patterns of sunrise and sunset can be observed, described, and predicted.**

Evidence of Learning

Summative Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI work text, TCI teacher resources, and TCI Kits

<u>The Dynamic Trio:</u> In this lesson, students will learn about the stars, planets, and moons found in our solar system and how they relate to one another. The video segment enhances the learning. After a non-fiction read aloud, students work in groups to create models of the Solar System.

<u>Our Super Star:</u> This is a three part lesson where students use observations, activities, and videos to learn basic facts about the Sun. Students also model the mechanics of day and night

and use solar energy to make a tasty treat. One of the videos is a time-lapse video of a sunrise and a sunset.

Keep a Moon Journal: The National Wildlife Federation's "Keep a Moon Journal" page allows students to get acquainted with the phases of the moon by keeping a moon journal to record their nightly observations for one month. The page has links to diagrams, a student printable, and activities connecting the journal to other content. The page is set up as a "family activity" and could be used as nightly homework for students then discussed weekly in class.

Patterns of Daylight: This is a mini-unit that can be taught directly after Space Part 1or independently. The author chose to teach the Space Part 1 unit (also available on Better Lesson! at http://betterlesson.com/lesson/613469/introduction-and-pre-assessment) during January, and follows up at the end of the year in a recap in May. This lesson uses prior student knowledge and a video simulation.

Observing the Sun: This lesson is an activity where students create a sun tracker and monitor the sun's position over the course of a day. Examples of student journals and connections within a larger unit are provided.

Formative Assessments

Students who understand the concepts can:

- Observe and use patterns in the natural world as evidence and to describe phenomena.
- Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.
- Use observations of the sun, moon, and stars to describe patterns that can be predicted. Examples of patterns could include:
    - The sun and moon appear to rise in one part of the sky, move across the sky, and set.

Stars other than our sun are visible at night but not during the day. (Assessment of star patterns is limited to stars being seen at night and not during the day.)

- Observe and use patterns in the natural world as evidence and to describe phenomena.
- Make observations (firsthand or from media) to collect data that can be used to make comparisons.
- Make observations at different times of the year to relate the amount of daylight to the time of year. (Note: The emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall; assessment is limited to relative amounts of daylight, not to quantifying the hours or time of daylight.)

What it Looks Like in the Classroom

In this unit of study, students observe, describe, and predict some patterns of the movement of objects in the sky. Throughout the unit students look for patterns as they plan and carry out investigations and analyze and interpret data.

In this unit's progression of learning, students develop the understanding that natural events happen today as they happened in the past, and that many events are repeated. In addition, they observe and use patterns in the natural world as evidence and to describe phenomena. First graders ask questions and use observations of the sun, moon, and stars to describe apparent patterns of change in each. These patterns are then used to answer questions and make predictions. Some examples of patterns include:

- ➢ The sun and moon appear to rise in one part of the sky, move across the sky, and set.
- ➢ The shape of the moon appears to change over a period of time in a predictable pattern.
- ➢ Stars, other than our sun, are visible at night but not during the day.

After students observe and document these types of patterns over a period of time, they need opportunities to describe the patterns and to make predictions about the changes that occur in the objects in the sky. It is important that they use observed patterns as evidence to support predictions they might make about the sun, moon, and stars.

In this unit, students also learn that seasonal patterns of sunrise and sunset can be observed, described, and predicted. They relate the amount of daylight to the time of year by making observations at different times of the year. Over time, they collect and use data in order to identify the relationship between the amount of sunlight and the season. Grade 1 students are expected to make relative comparisons of the amount of daylight from one season to the next, and assessment should be limited to relative amounts of daylight, not quantifying the hours or time of daylight.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Ho Do Objects in the Sky Seem to Change?	Core Route: 5 Days Traditional Route: 7 Days
Lesson 2 What are Patterns of Daylight?	Core Route: 5 Days Traditional Route: 7 Days
Unit 6 Review and Unit 6 Test	2 days
Addition Traditional Route Lessons Unit 6 Project You Solve It Unit 6 Performance Task Performance-Based Assessment	3 days 1 day 2 days 2 days

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On Level: How Can We Observe and Record Weather? How Does the Sky Seem to Change: These readers reinforce unit concepts, and include response activities for your children.

Extra Support: How Can We Observe and Record Weather? How Does the Sky Seem to Change: These readers share title, illustrations, vocabulary, and concepts with the On-Level Reader; however the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. They also include response activities.

ELL:

Lesson 1: Point out and reinforce words associated with times of day including daytime, nighttime, early morning, noon, and late afternoon. To help children put these words into context, talk with children about what they might be doing at each time of day.

Lesson 2: Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content and provide hands-on examples of materials when possible to best support the needs of these learners.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Objects and Patterns in the Sky							
Lesson Title: How Do Objects in the Sky Seem to Change						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of online tools							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: • Will identify and describe objects in the sky and observe and describe predictable patterns of the sun, moon, and stars.	1. About this image: Ask: What do you see in this photograph? Use the discussion as an opportunity for children to share their knowledge about the sky and the objects we see in it. 2. Can You Explains It? The objects we see in the sky seem to move. Play the video to see how objects appear to move in the sky. 3. The Daytime Sky: Children observe the daytime sky and describe the pattern of the appearance of the sun. 4. Patterns in the Daytime Sky: Children observe the movement of the sun in the daytime sky and use their observations as evidence to support a claim about the pattern of the sun's movement from day to day.	• Evidence Notebook: Children work with a partner to describe what they know about the sun in the daytime sky. They will include evidence based on their reading and firsthand observations. • Read, Write, Share: Children will work with a partner to build model of the sun. Children record their observations and use them as evidence to explain the pattern of the sun's apparent movement. • Children work in small groups to make a picture dictionary that includes pictures and descriptions of objects in the nighttime sky. • Evidence Notebook: Children work in small groups to make a model of the phases of the

	5. The Nighttime Sky: Children observe the nighttime sky and describe the pattern of appearance of objects in the nighttime sky. 6. Patterns in the Nighttime Sky: Children observe the pattern of the moon in the nighttime sky and the patterns of stars in the sky and use their observations to describe the pattern. 7. Take It Further 8. Lesson Check 9. Summative Assessment-Self Check	moon, and use their models to tell about the pattern of the phases of the moon. They will explain, using evidence, how the moon seems to change. ● Lesson Check ● Summative Assessment-Self Check

Differentiation

Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.

Resources Provided

- TCI work text, online access, and kits

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
<u>Planning and Carrying Out Investigations</u> Plan and conduct investigations collaboratively to produce evidence to answer a question. (1-PS4-1),(1-PS4-3) **<u>Planning and Carrying Out Investigations</u>** Make observations (firsthand or from media) to collect data that can be used to make comparisons. (1-ESS1-2) <u>Analyzing and Interpreting Data</u>	**<u>ESS1.A: The Universe and its Stars</u>** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1) **<u>ESS1.B: Earth and the Solar System</u>** Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1-ESS1-2)	**<u>Patterns</u>** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-ESS1-1),(1-ESS1-2) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (1-ESS1-1)		Science assumes natural events happen today as they happened in the past. (1-ESS1-1) Many events are repeated. (1-ESS1-1)

Grade 2

Content Area: Science **Grade Level: Second Grade**
First Marking Period - Pacing Guide ● **Unit 1: Engineering and Technology-** **Core 12 days (Traditional Pacing 24 days)** **NJ-SLS-S:** K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3 ● **First ½ Unit 2: Matter** **Core 11 days (Traditional Pacing 19 days)** **NJ-SLS-S:** 2-PS1-1, 2-PS1-2, 2-PS1-3, 2-PS1-4
Second Marking Period - Pacing Guide ● **Second ½ Unit 2: Matter** **Core 11 days (Traditional Pacing 19 days)** **NJ-SLS-S:** 2-PS1-1, 2-PS1-2, 2-PS1-3, 2-PS1-4 ● **First ½ Unit 3: Environment for Living Things** **Core 11 days (Traditional Pacing 19 days)** **NJ-SLS-S:** 2-LS2-1, 2-LS2-2. 2-LS4-1
Third Marking Period - Pacing Guide ● **First ½ Unit 3: Environment for Living Things** **Core 11 days (Traditional Pacing 19 days)** **NJ-SLS-S:** 2-LS2-1, 2-LS2-2. 2-LS4-1 ● **Unit 4 Earth's Surface** **Core 12 days (Traditional Pacing 24 days)** **NJ-SLS-S:** 2-ESS2-2 & 2-ESS2-3

Fourth Marking Period - Pacing Guide

- **Unit 5: Changes to Earth's Surface**
- **Core 17 days (Traditional Pacing 31 days)**

NJ-SLS-S: 2-ESS1-1 & 2-ESS2-1

Content Area: Second Grade Science

Unit Title: Engineering and Technology

Target Course/Grade Level: Second Grade: Unit 1

Unit Summary

In the unit children will learn the following:

- Ask questions, make observations, and gather information to define a problem.
- Use a design process to solve a problem
- Compare the strengths and weaknesses of multiple design solutions.

Lesson 1: Children focus on how to define and solve a problem. The lesson begins with children exploring the five steps of a design process engineers use to solve problems. Children will ask questions, make observations, and gather information. The lesson continues with children using drawings and models to solve a real-life problem.

Lesson 2: Children focus on comparing solutions to a problem. Children first analyze the strengths and weaknesses of a design for a stop sign. Then children follow the steps of a design process as a child who has a backpack with uncomfortable straps identifies it as a problem and then builds, tests, and compares the strengths and weaknesses of four possible design solutions

Primary interdisciplinary connections:

English Language Arts

Ask and answer such questions as…….understanding of key details in a text. **RI.2.1**
With guidance….use a variety of digital tools…in collaboration with peers. **W.2.6**
Create….add drawings or other visual displays…..to clarify ideas…feelings. **SL.2.5**
Recall information from experiences or gather information from provided sources to answer a question. **W.2.8**

Mathematics

Reason abstractly and quantitatively **MP.2**
Model with mathematics **MP.4**
Use appropriate tools strategically **MP.5**
Draw a …bar graph…up to four categories. Solve simple….problems.. 2.**MD.D.10**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Kindergarten Unit 1: Engineering and Technology

- In the unit children will learn the follow: Define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems & Explore and apply a design process

Grade 1 Unit 1: Engineering Design Process

- In this Unit children will define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems, and explore and apply a design process.

Future Learning

Grade 3 Unit 1:

- In this Unit children will define problems and design solutions to those problems & test solutions and make improvement to solutions.

Grade 4 Unit 1:

- In this unit, students will explore how engineers define problems and solutions, learn about the importance of prototypes & use models to examine how prototypes are tested and improved.

Grade 5 Unit 1:

- In this unit, students will discover how science and math are used in engineering, investigate a design process, and explore how technology decisions affect society.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
K-2-ETS1-1	Ask questions, make observation, and gather information about a situation people want to change to define a simple problem that can solved through the development of a new or improved object or tool.

K-2-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Unit Essential Questions

- What is a design process?
- What are the steps of a design process?
- What evidence can you observe to show that a solution is effective?

Unit Enduring Understandings

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observation, and gathering information are helpful in thinking about problems
- Before beginning to design a solution, it is important to clearly understand the problem
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI Worktext

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Engineer It: What is a Design Process	Core: 5 Days Traditional: 7 Days
Lesson 2 Engineer It: How Can We Compare Design Solutions?	Core: 5 Days Traditional: 7 Days
Lesson 3 Unit 1 Review and Unit 1 Test	Core: 2 days
Additional Traditional Activities: Unit 1 Project You Solve it Unit 1 Performance Task Performance-Based Assessment	 3 days 1 day 2 days 2 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction:

- **On Level: How Do You Investigate? How Do Engineers Solve Problems?** These readers reinforce unit concepts , and includes response activities for your children.
- **Extra Support: How Do You Investigate? How Do Engineers Solve Problems?** These readers share title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.
- **Enrichment:** These high-interest, nonfiction readers will extend and enrich unit concepts and vocabulary, and include response activities.

ELL
Lesson 1: Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content, and provide hands-on examples of materials when possible to best support the needs of these learners.
Lesson 2: Make use of labeled diagrams to clarify content in this lesson. This will reinforce the core idea that drawings and models are useful to convey designs and will also help children understand the content and develop vocabulary in context.

Curriculum Development Resources

NSTA Web Seminar: Teaching NGSS in Elementary School—Kindergarten

The seminar was led by expert teachers Carla Zembal-Saul, Professor of Science Education, Penn State University; Mary Starr, Executive Director, Michigan Mathematics and Science Centers Network; and Kathy Renfrew, K-5 Science Coordinator, VT Agency of Education. Carla, Mary and Kathy engaged with participants to gauge their familiarity with *NGSS* for kindergarten, and provided a number of example activities and videos on how to implement it, e.g., different approaches to teaching weather and climate core ideas. The web seminar was then wrapped up by Ted Willard, who suggested a number of resources and events for participants to further develop their understanding of *NGSS* for kindergarten, as well as other grade levels.

View the resource collection.

Continue discussing this topic in the community forums.

NSTA Web Seminar: Teaching NGSS in K-5: Constructing Explanations from Evidence

Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena.

To view related resources, visit the resource collection.

Continue discussing this topic in the community forums.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Engineering and Technology							
Lesson Title: Lesson 1: **Engineer It**: What is a Design Process					**Timeframe:** 5 days		
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: headphones and classroom materials.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Students will ask questions, make observations, and gather information to define a problem to be solved through a design process.	1. About this Image? Asks Students: What do you think is happening in this picture? How do you think these robots were built? 2. Can you Solve it: Ramps can be used to solve problems. These videos show some different ramps and how they are used. 3. What Engineers Do? Children will explore how an engineer defines a problem and solves it by using steps in a design process. 4. Define a Problem: Children explore how to observe a situation in order to define a problem. 5. Plan and Build: Children explore how drawings and models help when planning and building solutions. 6. Test and Improve: Children explore how to test and improve upon models in order to see if their solution is viable.	● Evidence Notebook: Children identify a problem in the classroom. Make sure children use evidence to support the problem they observe. ● Evidence Notebook: Have children work through the first two steps of a design process. Make sure they use evidence to support the problem they observe and their plan to solve the problem. ● Evidence Notebook: Children review the information in their evidence notebook about the classroom problem they defined earlier. Allow children to work with a

	7. Redesign: Children explore how redesigning a model can make for a better solution to a problem. 8. Communicate: Children explore the importance of communicating their design solutions to others. 9. Take it Further 10. Lesson Check 11. Self Check	partner to complete Steps 2 and 3 of a design process. ● Monitor children and provide support as needed. ● Lesson Check ● Self Check

Differentiation

Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.

- **Lesson Vocabulary:** engineer, design process, and solution
- **Reinforcing Vocabulary:** To help children remember each vocabulary word, have them draw an illustration of each word, have them draw an illustration of each word. Then have them write the word beneath the illustration, define it, and use it in a sentence. Remind children to look for these highlighted words as they proceed through the lesson.
- **RTI/Extra Support:** Supply the children with flash cards that identify each step of a design process. Have children place the steps in order. Next, provide children with illustrations that align with the steps of a design process. Ask children to connect the correct step with each illustration.
- **Extension:** Challenge children to apply a design process to a problem in their own lives. Children should choose a problem in their own loves. Children should choose a problem that can reasonably be solved using materials that are available in the classroom. Have them make a poster or slide show to communicate their results.
- **ELL:** Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content, and provide hands-on examples of materials when possible to best support the needs of these learners.

Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**

Asking Questions and Defining Problems Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions. • Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1) • Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) **Developing and Using Models** Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2) **Analyzing and Interpreting Data** Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)	**ETS1.A: Defining and Delimiting Engineering Problems** • A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	**Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

Content Area: Second Grade Science
Unit Title: Matter
Target Course/Grade Level: Unit 2 Grade 2
Unit Summary In this unit of study, students will develop an understanding of observable properties of materials through analysis and classification of different materials. They will further learn the following: describe and classify materials by their observable properties, select and use materials based on these properties, use evidence to describe how heating and cooling cause changes to matter, use evidence to describe reversible and

irreversible changes to matter, and explore how an object can be taken apart and its pieces used to make another object.

Lesson 1: Children explore properties of matter as they discover that matter can be described and classified by their properties and that these properties have patterns. Children plan and conduct an investigation to determine which materials are best suited to a purpose based on these properties.

Lesson 2: Children explore how heating and cooling can cause changes to matter and that those changes generate observable patterns. Children use evidence to support their claim about matter.

Lesson 3: Children deepen their understanding of matter by exploring that some changes to matter are reversible and some are not. As they explore, children observe patterns in reversible and irreversible changes caused by heating and cooling. Children use evidence in order to support their claim about matter.

Lesson 4: Children explore how objects can be put together from a small set of pieces. They will deepen their understanding of matter by exploring how those pieces can be taken apart and reused to make another object.

Primary interdisciplinary connections:

English Language Arts

Students need opportunities to read texts that give information about matter and the changes that can happen to matter. With adult support, students can identify the main idea and details in informational text in order to answer questions about matter. With teacher support and modeling, students can ask and answer who, what, where, when, why, and how questions to demonstrate their understanding of key details in informational text.

As students investigate reversible and irreversible changes to matter, they should record observations in science journals, using drawings or other visual displays, when appropriate, to help clarify their thinking. To further support their learning, students can conduct shared research using trade books and online resources in order to learn more about physical changes to matter.

After reading informational texts and conducting investigations, students should be able to write opinion pieces in which they state an opinion, supply evidence to support their opinion, use linking words to connect opinion to evidence (reasons), and provide a concluding statement. For example, students can be presented with an example of matter that has been changed in some way, then asked to write an opinion piece in which they state whether or not they think the change is reversible or irreversible, and supply evidence to support their thinking. Evidence can include information recalled from experiences or information gathered from informational texts or other resources. Some possible changes that can be used are:

- ➢ Tearing paper
- ➢ Bending a spoon
- ➢ Baking a cake
- ➢ Hammering a nail into a piece of wood
- ➢ Getting grass stains on a pair of jeans

➢ Cutting your hair.

Recall information from experiences or gather information from provided sources to answer a question. **W.2.8**
Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. (2-PS1-4) **RI.2.1**
Describe how reasons support specific points the author makes in a text. (2-PS1-4) **RI.2.8**

Mathematics

Model with mathematics **MP.4**
Draw a picture graph and a bar graph…with up to four categories. Solve simple put-together, take-apart, and compare problems using…a bar graph. **2.MD.D.10**
Compare two three-digit numbers based on meanings of the hundreds, teens, and ones digits, using >,=, and < symbols to record the results of comparisons. **2.NBT.A.4**
Use addition and subtraction within 100 to solve one- and two-step word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g. by using drawings and equations with a symbol for the unknown number to represent the problem. **2.OA.A.1**

21st century themes (Pick All that apply):

Global Awareness

Unit Rationale

Prior Learning

Students should already know and be prepared to build on the following concepts: objects can be classified by shape, objects can classified by color, and objects can be made of different materials.

Future Learning

Grade 4 Unit 1: Weathering and Erosion

- Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

Grade 5 Unit 2: Properties of Matter

- Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)
- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many

observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.

Grade 5 Unit 2: Matter

- In this unit students will focus on discovering the different states of matter and how to measure matter, explore the different properties of matter along with dissolving rates of certain matter, & compare and contrast physical and chemical changes of matter

Grade 5 Unit 3: Energy and Matter in Organisms

- In this unit student will investigate how living organisms get energy & explore how living organisms use energy and how they interact in their environments.

Grade 5 Unit 4: Energy and Matter in Ecosystems

- In this unit student will explore phenomena of predator-prey population interactions and native and invasive species interactions & use models to develop explanations of the energy inputs and energy and matter flows within ecosystems.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
2-PS1-1	Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
2-PS1-2	Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
2-PS1-3	Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. *[Clarification Statement: Examples of pieces could include blocks, building bricks, or other assorted small objects.]*
2-PS1-4	Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. *[Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.]*

Unit Essential Question

Part A:

- How can we sort objects into groups that have similar patterns?
- Can some materials be a solid or a liquid?
- In what ways can an object made of a small set of pieces be disassembled and made into a new object?

Part B:

- What should the three little pigs have used to build their houses?
- Can all changes caused by heating or cooling be reversed?

Unit Enduring Understandings

Part A:

- Patterns in the natural and human-designed world can be observed.
- Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature.
- Matter can be described and classified by its observable properties.
- Objects may break into smaller pieces and be put together into larger pieces or change shapes.
- Different properties are suited to different purposes.
- A great variety of objects can be built up from a small set of pieces

P**art B:**

- Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Different properties are suited to different purposes.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.
- People search for cause-and-effect relationships to explain natural events.
- Events have causes that generate observable patterns.
- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.

Evidence of Learning

Summative Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response

items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI Worktext

What it Looks Like in the Classroom

In this unit of study, students investigate cause-and-effect relationships between matter and energy as they analyze and classify materials that undergo change. Throughout the unit, students will construct explanations and engage in argument from evidence as they investigate the ways in which matter can change and determine whether or not a change is reversible.

In Unit 2, Properties of Matter, students engaged in the engineering design process in order to understand that different properties are suited to different purposes. Students use this understanding as they construct evidence-based accounts of how an object made of small pieces can be disassembled and made into new objects. In order to do this, they need multiple opportunities to take apart and reassemble objects that are made of small pieces. For example, using blocks, building bricks, and other small objects such as Legos, small groups of students can build an object, and then a second group of students can take the object apart and build another object using those same small blocks or bricks. As students construct and deconstruct objects, then reconstruct the pieces into new objects, they should document the process in their science journals, explaining how they went about reconstructing the pieces into a new object.

After students have worked through and documented this process, ask them, "Are the changes you made to each of the original objects reversible? Can we disassemble the new objects and use the pieces to reconstruct the original object? After class discussion, ask students, "Are all changes reversible?" This should lead to opportunities for students to observe changes caused by heating or cooling. With close supervision and guidance by teachers, students can investigate such changes as heating or cooling butter, chocolate chips, or pieces of crayon, freezing water, and melting ice. They can observe an egg before and after cooking or a small piece of paper or cardboard before and after burning. As they attempt to reverse changes, they will also notice that all events have causes that generate patterns of change that can be observed and predicted. Through these types of experiences, students will recognize that some changes caused by heating or cooling can be reversed and some cannot, and they can use evidence from their investigations to support their thinking.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Engineer It-What are Properties of Matter?	5 days Core Route 7 Days Traditional Route

Lesson 2 How Do Heating and Cooling Change Matter?	5 days Core Route 7 Days Traditional Route
Lesson 3 How Does Matter Change?	5 days Core Route 7 Days Traditional Route
Lesson 4 How Are Objects Put Together?	5 days Core Route 7 Days Traditional Route
Unit 2 Review and Unit 2 Test	2 days
Additional Traditional Route Lessons Unit 2 Project Unit 2 Performance Task Performance-Based Assessment	3 Days 2 Days 2 Days

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate

On-Level: What Can We Learn About Matter? This reader reinforces unit concepts and includes response activities for your children.

Extra Support: What Can We Learn About Matter? This reader shares title, illustrations, vocabulary, and concepts with the on-level reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Making Coins This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content and provide hands-on examples of materials when possible to best support the needs of these learners.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

<table>
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<tr><td colspan="8">Equipment needed: TCI Kits, cotton, foam, feathers, tissues, zippered pillow case</td></tr>
</table>

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will use evidence to describe an classify materials based on their observable properties	1. About this Image: What properties does each ball? Are the balls alike or different? 2. Can you Solve it? The videos show how bicycle tires are used. If the videos are not available, direct children's attention to the picture. 3. Properties of Matter: Children observe the pattern that matter takes up space and has properties. They will make observations about different materials and describe their properties. 4. States of Matter-Solids: Children will observe the pattern that a solid is a state of matter that keeps in shape. 5. States of Matter-Liquids: Children will observe the pattern that a liquid does not have its own shape. 6. Which Materials are Best? Children will determine which materials are best suited for a purpose based on their properties of matter. 7. Take it Further 8. Lesson Check-Can You Solve It? 9. Summative Assessment-Self Check?	● Evidence Notebook: Encourage children to make an organized list of properties by adding headings that name the senses. Children may need guidance to list properties that cannot be observed using sight. ● Children observe properties of solid objects as they identify examples of soft solids. ● Children ● Lesson Check-Can You Solve It? ● Summative Assessment-Self Check?
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical	**PS1.A: Structure and Properties of Matter** Different properties are suited to	**Cause and Effect** Events have causes that generate observable patterns.

reasoning. (3-LS3-1) **<u>Constructing Explanations and Designing Solutions</u>** Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (2-PS1-3) **<u>Engaging in Argument from Evidence</u>** Construct an argument with evidence to support a claim. (2-PS1-4)	different purposes. (2-PS1-3) A great variety of objects can be built up from a small set of pieces. (2-PS1-3) **<u>PS1.B: Chemical Reactions</u>** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)	(2-PS1-4) **<u>Energy and Matter</u>** Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3) - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Science searches for cause and effect relationships to explain natural events. (2-PS1-4)

Content Area: Second Grade Science
Unit Title: Environments for Living Things
Target Course/Grade Level: Unit 3 Grade 2
Unit Summary In this unit students will do the following: ● Investigate what plants and animals need to live and grow. ● Develop models to show how plants depend on animals. ● Explore environments to identify observable patterns. ● Observe plants and animals to compare diversity of life in water habitats ● Observe plants and animals to compare diversity of life in land habitats. **Lesson 1: What DO Plants Need?** Children focus on what plants need to be healthy and grow. Children explore the basic needs of a plant (water, sunlight, air, nutrients, and space) and why plants need these elements. Finally, children investigate how a plant uses water to meet it needs. **Lesson 2: Engineer It-How Do Pants Depend on Animals?** Children focus on how plants depend on animals to help move seeds and pollen. The lesson begins with children exploring ways that animals move plant seeds based on their shape an structure. As they explore, children plan and build a model tool to move seeds, too. Finally, children explore how animals move pollen so new plants may grow. **Lesson 3: What Plants and Animals Live in Water Habitats?** Children focus on living things found in the habitats within a pond, a river delta, and a tide pool. Children explore why specific plants and animals live

in each habitat. Children find out how plants and animals meet their needs in each habitat. Children compare the diversity of life found both within each habitat and across different habitats.

Lesson 4: What Plants and Animals Live in Land Habitats? Children explore living things found in land habitats within a rain forest, a forest, and a savanna. Children explore the relationships and characteristics of plants and animals that live in each habitat. Finally, children will compare plants and animals across the habitats.

Primary interdisciplinary connections:

English Language Arts/Literacy

English Language Arts can be leveraged in this unit in a number of ways. Students can participate in shared research using trade books and online resources to learn about the diversity of life in different habitats or to discover ways in which animals help pollinate plants or distribute seeds. Students can record their findings in science journals or use the research to write and illustrate their own books. Students can also learn to take notes in their journals order to help them recall information from experiences or gather information from provided sources. They can add drawings or other visual displays to their work, when appropriate, to clarify ideas, thoughts, and feelings.

Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-LS2-1) **W.2.7**
Recall information from experiences or gather information from provided sources to answer a question. (2-LS2-1),(K-2-ETS1-1) **W.2.8**
Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (2-LS2-2) **SL.2.5**

Mathematics

Throughout this unit of study, students need opportunities to represent and interpret categorical data by drawing picture graphs and/or bar graphs (with a single-unit scale) to represent a data set with up to four categories. This will lead to opportunities to solve simple put-together, take-apart, and compare problems using information presented in these types of graphs. For example, students could create bar graphs that show the number of seedlings that sprout with and without watering or that document plant growth. They could also create a picture graph showing the number of plant species, vertebrate animal species, and invertebrate animal species observed during a field trip or in a nature photograph. As students analyze the data in these types of graphs, they can use the data to answer simple put-together, take apart, and compare problems. This unit also presents opportunities for students to model with mathematics. They can diagram situations mathematically or solve a one-step addition or subtraction word problems. Data collected in bar graphs and picture graphs can easily be used for this purpose.

Reason abstractly and quantitatively. (2-LS2-1),(K-2-ETS1-1) **MP.2**

Model with mathematics. (2-LS2-1),(2-LS2-2),(K-2-ETS1-1) **MP.4**
Use addition to find the total number of objects arranged in rectangular arrays with up to 5 rows and up to 5 columns; write an equation to express the total as a sum of equal addends. **2.OA.C.4**
Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (2-LS2-2) **2.MD.D.10**

21st century themes

Global Awareness

Unit Rationale

Prior Learning

Kindergarten Unit 2: Forces and Motion

- In this Unit students will plan and conduct an investigation about the speed of objects, gather evidence to support or refute ideas about what causes motion, analyze data from tests to determine if a tool works as intended, & explore pushes and pulls of different strengths.

Future Learning

Grade 3 Unit 4: Life Cycles and Inherited Traits

- In this unit, children will explore the life cycles of plants and animals & discover inherited plants and animal traits.

Grade 3 Unit 5: Organisms and Their Environments

- In this unit, children will do the following: explore inheritance and variation of traits in organisms, discover how different organisms adapt to their environment, & identify the cause and effect of how organisms change when environments change.

Grade 5 Unit 4: Energy and Matter in Ecosystems

- In this unit students will learn to explore phenomena of predator-prey population interactions and native and invasive species interactions & use models to develop explanations of the energy inputs and energy and matter flows within ecosystems.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
2-LS4-1	Make observations of plants and animals to compare the diversity of life in different habitats. [Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.] [Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.]

2-LS2-1	Plan and conduct an investigation to determine if plants need sunlight and water to grow. [Assessment Boundary: Assessment is limited to testing one variable at a time.]
2-LS2-2	Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.*
K-2-ETS1-1	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Unit Essential Question

Part A: How does the diversity of plants and animals compare among different habitats?

Part B: What do plants need to live and grow?

Part C: Why do some plants rely on animals for reproduction?

Unit Enduring Understandings

Part A:

- People look for patterns and order when making observations about the world.
- There are many different kinds of living things in any area, and they exist in different places on land and in water.

Part B:

- Events have causes that generate observable patterns.
- Plants depend on water and light to grow.

Part C:

- The shape and stability of structures of natural and designed objects are related to their function.
- Plants depend on animals for pollination or to move their seeds around.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

Evidence of Learning

Summative Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.

3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI worktexts

<u>Do Plants Need Sunlight?</u> Students will explore the importance sunlight for a plant's survival by conducting an investigation. Each group of students will cover parts of plants' leaves with black construction paper and make observations of the plant's leaves over several days. This lesson serves to model the process of investigation. The investigation will take 7 days to complete. Then students can remove the black paper, place the plants back in the sunlight, and view the leaves in a second investigation. *(Note: Chlorophyll is not a necessary concept/vocabulary term to address in this lesson.)*

<u>Who Needs What?</u> Students identify the physical needs of animals. Through classroom discussion, students speculate on the needs of plants. With teacher guidance, students then design an experiment that can take place in the classroom to test whether or not plants need light and water in order to grow. Students conduct the associated activity in which sunflower seeds are planted in plastic cups, and once germinated, are exposed to different conditions. In the classroom setting, students test for the effects of light versus darkness, and watered versus non-watered conditions. During exposure of the plants to these different conditions, students measure growth of the seedlings every few days using non-standard measurement. After a few weeks, students compare the growth of plants exposed to the different conditions, and make pictorial bar graphs that demonstrate these comparisons. I In this lesson students design a vanilla plant pollinator. This is an end-of-the-unit task, taking about 3 days to complete. The students will view an amazing video that tells about the problems with pollinating vanilla by hand. The students pretend to be employees of Ben and Jerry's ice cream company and help to plan and design a pollinator for the vanilla plant so that the great vanilla flavored ice cream can continue to be produced. (This is the first of several lessons created by Jeri Faber on plant pollination at: betterlessons.com/)

<u>Building and Testing Our Vanilla Plant Pollinator</u>: In previous lessons designed by Jeri Faber, students have learned about how animals help pollinate flowers. The students have also planned and designed their own vanilla plant pollinator. In this lesson, students use the engineering design process to build and test the plant pollinator they planned the day before in class.

<u>Two Scoops Are Better Than One</u>: This lesson is the second day of an end of the unit task to address the Performance Expectation: Develop a simple model that mimics the function of an animal in dispersing seeds

or pollinating plants. This end of unit task is expected to take 3-4 days to complete. In the previous lesson (http://betterlesson.com/lesson/628130/i-scream-you-scream-we-all-scream-for-vanilla-ice-cream), the students were challenged to brainstorm their version of a vanilla flower pollinator. For this lesson, students work with a partner to choose and develop their engineering plans by drawing a diagram for a vanilla plant pollinator. They also create a list of materials needed for the task.

Improving Our Vanilla Bean Pollinators: This lesson is part of a series of lessons created by Jeri Faber on using the engineering design process to solve a problem. In the Ice Scream, You Scream We All Scream for Vanilla Ice Cream, the students were challenged to design a vanilla flower plant pollinator. For day 2, Two Scoops Are Better Than One, students worked with a partner to determine which design to build for their vanilla plant pollinator. For day 3, Building and Testing Our Vanilla Pollinators, the students constructed and tested the effectiveness of their pollinators based on the design plans. In this lesson, students improve their plant pollinator models and retest the pollinator's effectiveness.

The Bug Chicks-Mission: Pollination (Episode 5): The Bug Chicks' five minute video provides a fun, animated way of learning about the fascinating world of pollination and insects. In this video, the students observe interesting museums and habitats to look at lesser known insect pollinators. The student challenge at the end leads students into their environment to look for other pollinators and encourages them to bring their observations back to the classroom to discuss.

Formative Assessments

Students who understand the concepts can:

- Look for patterns and order when making observations about the world.
- Make observations (firsthand or from media) to collect data that can be used to make comparisons.
- Make observations of plants and animals to compare the diversity of life in different habitats. (Note: The emphasis is on the diversity of living things in each of a variety of different habitats; assessment does not include specific animal and plant names in specific habitats.)
- Observe patterns in events generated by cause-and-effect relationships.
- Plan and conduct an investigation collaboratively to produce data to serve as a basis for evidence to answer a question.

Plan and conduct an investigation to determine whether plants need sunlight and water to grow. (Note: Assessment is limited to one variable at a time.)

- Describe how the shape and stability of structures are related to their function.
- Develop a simple model based on evidence to represent a proposed object or tool.
- Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.
- Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

What it Looks Like in the Classroom

In this unit of study, students explore and compare the diversity of life in different habitats. They develop an understanding of what plants need to grow and how plants depend on animals for seed dispersal and pollination. Students learn about cause-and-effect relationships and how an organism's structures are related to the function that each structure performs. Developing and using models plays an important role in students' understanding of structure/function relationships.

To begin this unit's progression of learning, students observe a variety of plants and animals from a variety of habitats in order to compare the diversity of life. Using firsthand observations and media resources, students explore and collect data about different habitats that exist in the world and how plants and animals have structures that help them survive in their habitats. Students need many opportunities to observe many different kinds of living things, whether they live on land, in water, or both. As students learn about the diversity of life, they begin to look for patterns and order in the natural world. As scientists, students will begin to notice patterns in the structures that enable organisms to support their existence in specific habitats. For example, webbed feet enable survival in wetlands; gills enable survival in rivers, lakes, and oceans; and blubber enables survival in polar regions.

The learning progresses as students' focus changes from diversity to commonalities among plants—what plants need in order to grow. Students need opportunities to observe that plants depend on water and light to grow. As they begin to understand that changes in the amount of water and light can affect the growth of plants, they begin to understand that all cause-and-effect relationships generate observable patterns. For example, some plants require very little water to survive, most plants will not grow without sunlight, and most plants need an adequate amount of water to thrive. Students might also observe patterns such as the effects of too much or too little water on a plant and too much or too little light on a plant. In order for students to develop these understandings, they should plan and conduct investigations and collect data, which should be used as evidence to support the idea that all events have causes that generate observable patterns.

Finally, students investigate the roles that animals play in plant reproduction. Students learn that many types of plants depend on animals for pollination and/or for the dispersal of seeds. As students begin to explore the interdependent relationships among plants and animals, they learn that the shape and stability of the structures of organisms are related to their function. For example,

- As bees collect nectar, portions of their body are designed to collect and then carry pollen from plant to plant.
- Some seeds are designed to stick to animal fur so that animals can carry them from place to place.
- Animals eat fruits containing seeds, which are then dispersed through animals' body waste.

Second graders will need multiple opportunities to develop an understanding of the important relationship between structure and function, because they are expected to use engineering design to plan and develop simple models that mimic the function of an animal in dispersing seeds or pollinating plants. Students can use sketches, drawings or physical models to illustrate how the shape of the model helps it function as needed, and they should use evidence to support their design choices. Some common examples of models could include the following:

- ➢ Using Velcro “seeds” and furry material to model how seeds with hooks adhere to animal fur.
- ➢ Using pipe cleaners to gather and distribute “pollen” in a way similar to bees pollinate flowers.

In this unit of study, students learn that designs can be conveyed through sketches, drawings, or physical models, and that these representations are useful in communicating ideas for a problem’s solutions to other people. As described in the narrative above, students develop simple sketches, drawings, or models that mimic the function of an animal in dispersing seeds or pollinating plants in order to illustrate how the shape of an object helps it function as needed to solve a given problem.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What Do Plants Need?	5 Days Core Route 7 Days Traditional Route
Lesson 2 Engineer It-How Do Plants Depend on Animals	5 Days Core Route 7 Days Traditional Route
Lesson 3 What Plants and Animals Live In Water Habitats?	5 Days Core Route 7 Days Traditional Route
Lesson 4 What Plants and Animals Live in Land Habitats?	5 Days Core Route 7 Days Traditional Route
Unit 3 Review and Unit 3 Test	2 days
Additional Traditional Route Lessons Unit 3 Project You Solve It Unit 3 Performance Task Performance-Based Assessment	 3 Days 1 Day 2 Days 2 Days

Teacher Notes: Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On Level: How Do Living Things Survive in Their Environment? This reader reinforces unit concepts and includes response activities for your children.

Extra Support-How Do Living Things Survive in Their Environment? This reader shares, title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities. **Enrichment: Meet the Amazing Monarch Butterfly** This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities. **ELL:** Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content and provide hands-on examples of materials when possible to best support the needs of these learners.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1	
Content Area: Environments for Living Things	
Lesson Title: What Do Plants Need	**Timeframe:** 5 days
Lesson Components	

21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: 2 large clear plastic containers, measuring cup, water, red food coloring, 2 celery stalks with leaves, and a red crayon per group.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will construct an argument with evidence that plants are living things that need certain things to grow and to stay healthy.	1. About this Image: Have children observe the flowers in the picture. Ask: What are some things plants need to grow. 2. Can You Explain it? Plants grow and change over time when they are able to meet their needs. Play the video to see what a need plant needs to live and stay healthy. 3. What Plants Need: Children explore what a plant needs to stay healthy and the effects when a plant does not get the things it needs. 4. Taking it In: Children explore the effects and observe patterns when a plant uses it parts to meet it needs. 5. Take it Further 6. Lesson Check: Can you Explain It 7. Summative Assessment: Self Check	● Read, Write, Share: Remind children what plants need to live and grow. Discuss how both healthful and unhealthful plants look. ● Evidence Notebook: With a partner, have children observe and describe how each plant looks in the picture. Remind children to think about the needs of a plant and what could happen if a plant gets too much or too little of a particular need. ● Lesson Check: Can you Explain It ● Summative Assessment: Self Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

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<tr><td colspan="3">The Student Learning Objectives above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td><u>Planning and Carrying Out Investigations</u>
Plan and conduct investigations collaboratively to produce evidence to answer a question. (1-PS4-1),(2-LS2-1)
<u>Planning and Carrying Out Investigations</u>
Make observations (firsthand or from media) to collect data that can be used to make comparisons. (2-LS4-1)
Developing and Using Models
Develop a simple model based on evidence to represent a proposed object or tool. (2-LS2-2)
<u>Asking Questions and Defining Problems</u>
Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1)
Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1)</td><td><u>LS4.D: Biodiversity and Humans</u>
· There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)
<u>LS2.A: Interdependent Relationships in Ecosystems</u>
Plants depend on water and light to grow. (2-LS2-1)
Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)
<u>ETS1.B: Developing Possible Solutions</u>
Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.(secondary to 2-LS2-2)
<u>ETS1.A: Defining and Delimiting Engineering Problems</u>
A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1)
Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1)
Before beginning to design a solution, it is important to clearly</td><td><u>Cause and Effect</u>
Events have causes that generate observable patterns. (2-LS2-1)
<u>Structure and Function</u>
The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2), (K-2-ETS1-2)
- -
Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
Scientists look for patterns and order when making observations about the world. (2-LS4-1)</td></tr>
</table>

	understand the problem. (K-2-ETS1-1)	

Content Area: Second Grade Science
Unit Title: Earth's Surface
Target Course/Grade Level: Unit 4 Grade 2

Unit Summary

In this unit, children will learn the following: gather information to identify where water is located on Earth & develop maps to represent locations of land and water on Earth.

Lesson 1: Where is Water Found on Earth? Children begin exploring the concept that water can be found on Earth. The lesson begins with children exploring some of the different bodies of water. Then, children explore the concept that water exists in solid and liquid forms. Finally, children explore the topic of conserving and protecting Earth's water and observe bodies of water near where they live.

Lesson 2: Engineer It-How Can We Map Land and Water? Children explore maps as drawings or models that show where things are located. The lesson begins with children exploring how a map shows different types of land and bodies of water. Then, children explore the parts of a map, including the map title, map key, and compass rose, and use a map key to interpret a map of the United States. Finally, children extend their exploration in a hands-on activity in which they make a map of their school playground.

Primary interdisciplinary connections:

English Language Arts

Students gather information about the types of landforms and bodies of water from experiences or from text and digital resources. They can use this information to answer questions such as, "Where can water be found as solid ice or snow year round?" Students should also have the opportunity to use their research to publish a writing piece, with guidance and support from adults or collaboratively with peers, based on their findings about various landforms and bodies of water. Diagrams, drawings, photographs, audio or video recordings, poems, dioramas, models, or other visual displays can accompany students' writing to help recount experiences or clarify thoughts and ideas.

Recall information from experiences or gather information from provided sources to answer a question. (2-ESS2-3) **W.2.8**

Mathematics

As students collect data about the size of landforms and bodies of water, these numbers can be used to answer questions, make comparisons, or solve problems. For example,

- ➢ If students know that a mountain is 996 feet in height, a lake is 550 feet deep, a river is 687 miles long, and a forest began growing about 200 years ago, have students show each number in three ways using base-ten blocks, number words, and expanded form.
- ➢ A stream was 17 inches deep before a rainstorm and 33 inches deep after a rainstorm. How much deeper did it get during the rainstorm?

As students engage in these types of mathematical connections, they are also modeling with mathematics and reasoning abstractly and quantitatively. When modeling with mathematics, students diagram situations mathematically (using equations, for example) and/or solve addition or subtraction word problems. When students reason abstractly and quantitatively, they manipulate symbols (numbers and other math symbols) abstractly and attend to the meaning of those symbols while doing so.

Reason abstractly and quantitatively. (2-ESS2-2) **MP.2**
Model with mathematics. (2-ESS2-2) **MP.4**
Compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using >,=, and < symbols to record the results of comparisons. **2.NBT.A.4**
Draw a picture graph and a bar graph (with single unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. **2.MD.D.10**

21st century themes

Global Awareness & Civic Literacy

<u>Unit Rationale</u>

Prior Learning

Kindergarten Unit 2: Forces and Motion

- This unit students learned how to plan and conduct an investigation about the speed of object, gather evidence to support or refute ideas about what causes motion, analyze data from tests to determine if a tool works as intended, & explore pushes and pulls of different strengths and their effect on objects.

Future Learning

Grade 4 Unit 6: Changes to Earth's Surface

- In this unit students will explore Earth has been shaped by water and other factors, discover how people map Earth's surface, & learn about the patterns we can see from maps.

Grade 5 Unit 6: Water on the Earth

- In this unit students will explore the hydrosphere, geosphere, biosphere, and atmosphere & learn how Earth's systems interact.

Learning Targets

Standards	
NJSLS-S#	**Performance Expectation**
2-ESS2-3	Obtain information to identify where water is found on Earth and that it can be solid or liquid
2-ESS2-2	Develop a model to represent the shapes and kinds of land and bodies of water in an area. [Assessment Boundary: Assessment does not include quantitative scaling in models.]

Unit Essential Question

Part A: How can we identify where water is found on Earth and if it is solid or liquid?

Part B: In what ways can you represent the shapes and kinds of land and bodies of water in an area?

Unit Enduring Understandings

Part A:

- Patterns in the natural world can be observed.
- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

Part B:

- Patterns in the natural world can be observed.
- Maps show where things are located. One can map the shapes and kinds of land and water in any area.

Evidence of Learning

Summative Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this

test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI worktexts

Teaching NGSS in K-5: Making Meaning through Discourse

Presenters were Carla Zembal-Saul, (Penn State University), Mary Starr, (Michigan Mathematics and Science Centers Network), and Kathy Renfrew (Vermont Agency of Education).
After a brief introduction by NSTA's Ted Willard about the Next Generation Science Standards (NGSS), Zembal-Saul, Starr, and Renfrew gave context to the NGSS specifically for K-5 teachers, discussing three-dimensional learning, performance expectations, and background information on the NGSS framework for K-5. The presenters also gave a number of examples and tips on how to approach NGSS with students, and took participants' questions. The web seminar ended with the presentation of a number of recommended NSTA resources for participants to explore.
View the resource collection.
Continue discussing this topic in the community forums.

Evaluating Resources for NGSS: The EQuIP Rubric

The presenters were Brian J. Reiser, Professor of Learning Sciences in the School of Education and Social Policy at Northwestern University, and Joe Krajcik, Director of the CREATE for STEM Institute.
Ted Willard, NSTA's NGSS Director, introduced the web seminar by providing an overview of the Next Generation Science Standards, including how the standards were developed, which states have adopted them and which organization, including the NSTA, have been instrumental in providing assistance in the development of the NGSS. Ted also discussed the NSTA's commitment to helping teachers and educators understand the NGSS, so that teachers can begin implementing the new standards in their instructional practices. After this brief overview, Brian Reiser, Professor of Learning Sciences, School of Education at Northwestern University and Joe Krajcik, Director of CREATE for STEM Institute of Michigan State University introduced the Educators Evaluating Quality Instructional Products (EQuIP) Rubric.
The web seminar focused on how explaining how the EQuIP rubric can be used to evaluate curriculum materials, including individual lessons, to determine alignment of the lesson and/or materials with the NGSS. Three-dimensional learning was defined, highlighted and discussed in relation to the rubric and the NGSS. An emphasis was placed on how to achieve the conceptual shifts expectations of NGSS and three-dimensional learning using the rubric as a guide. Links to the lesson plans presented and hard copies of materials discussed, including the EQuIP rubric, were provided to participants. The web seminar concluded with an overview of NSTA resources on the NGSS available to teachers by Ted, and a Q & A with Brian Reiser and Joe Krajcik.
View the resource collection.
Continue discussing this topic in the community forums.

NGSS Crosscutting Concepts: Systems and System Models

The presenter was Ramon Lopez from the University of Texas at Arlington. This was the seventh web seminar in a series of seven focused on the crosscutting concepts that are part of the Next Generation Science Standards (NGSS).
Continue the discussion in the community forums.

Formative Assessments

Students who understand the concepts are able to:

- Observe patterns in the natural world.
- Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons) and other media that will be useful in answering a scientific question.
- Obtain information to identify where water is found on Earth and to communicate that it can be a solid or liquid.
- Develop a model to represent patterns in the natural world.
- Develop a model to represent the shapes and kinds of land and bodies of water in an area. (Assessment does not include quantitative scaling in models.)

What it Looks Like in the Classroom

Students look for patterns as they identify where water is found on Earth and explore the shapes and kinds of land and bodies of water found in an area. Students also develop models to identify and represent the shapes and kinds of land and bodies of water in an area.

To begin this unit's progression of learning, students identify where water is found on Earth and whether it is solid or liquid. Using texts, maps, globes, and other resources (including appropriate online resources), students will observe that water is found in liquid form in oceans, rivers, lakes, and ponds. They also discover that water exists as a solid in the Earth's snowcaps and glaciers.

After students identify where water is found on the Earth, they take a closer look at bodies of water and landforms that can be found in the natural world. Using firsthand observations and media resources, students should look for patterns among the types of landforms and bodies of water. For example, students should notice that mountains are much taller and more rugged than hills, lakes are an enclosed body of water surrounded by land, and streams flow across land and generally end at a larger body of water, such as a lake or the ocean.

Students should also have opportunities to use maps to determine where landforms and bodies of water are located. As students become more familiar with the types and shapes of landforms and bodies of water, they develop models to represent the landforms and bodies of water found in an area. For example, students can draw/create a map of the area of the state in which they live, showing various landforms (e.g., hills, coastlines, and islands) and bodies of water (e.g., rivers, lakes, ponds, and the ocean). Teachers should keep in mind that assessment does not include quantitative scaling of models (an accurate proportional relationship with the real world).

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Where is Water Found on Earth?	5 Days Core Route 7 Days Traditional Route
Lesson 2 Engineer It: How Can We Map Land and Water	5 Days Core Route 7 Days Traditional Route
Unit 4 Review and Unit 4 Test	2 days
Additional Traditional Route Lessons Unit 4 Project You Solve It! Unit 4 Performance Task Performance-Based Assessment	 3 days 1 day 2 days 2 days

Teacher Notes: Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.
Differentiate Instruction: **On Level-Why Are Resources Important?** This reader reinforces unit concepts and includes response activities for your children **Extra Support-Why are Resources Important?** This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities. **Enrichment-All About Rocks** This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities **ELL** **Lesson 1:** Help children connect bodies of water to their own experiences by providing specific examples of ponds, lakes, rivers, and oceans with which they may be familiar. Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. **Lesson 2:** Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies.

• Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Earth's Surface							
Lesson Title: Where is Water Found on Earth?						**Timeframe:** 5 Days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy	X	Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: Resources about are where you live, poster board, art materials							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: • Will gather information to identify the water is found in ponds, lakes, rivers, and oceans on Earth	1. About This Image? Ask the students what do you see in this picture. Where else would you find water on earth 2. Can You Explain It? Water can be found in different places on Earth. Allow children time to watch the video to find out more about bodies of water. 3. Lakes and Ponds: Children obtain information to identify patterns in where lakes and ponds are found on Earth. 4. River and Oceans: Children obtain information to identify patterns in where rivers and oceans are found on Earth.	• Children measure water to make a concrete model with which to compare the total amount of water on Earth to the amount of water that people can drink. Children may use words and pictures to answer the question. • Evidence Notebook: Children explain how a world map shows that most water on Earth is Salt water. They use evidence to support their answers, and

	5. Liquid or Solid: Children obtain information that water exists in solid and liquid forms on Earth, and identify patterns in these forms. 6. Water Through the Seasons: Children obtain information that water on Earth exists in solid and liquid forms during different seasons, and identify patterns in these forms. 7. Take it Further 8. Lesson Check-Can you explain it 9. Summative Assessment: Self Check	compare their answers with a partner. ● Children use a thermometer to measure the temperature at the same time each day for one school week, and then use the data to make a bar graph. ● Lesson Check-Can you explain it ● Summative Assessment: Self Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Obtaining, Evaluating, and Communicating Information Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question. (2-ESS2-3) **Developing and Using Models** Develop a model to represent patterns in the natural world. (2-ESS2-2)	**ESS2.C: The Roles of Water in Earth's Surface Processes** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (2-ESS2-3) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** Maps show where things are located. One can map the shapes and kinds of land and water in any area. (2-ESS2-2)	**Patterns** Patterns in the natural world can be observed. (2-ESS2-2),(2-ESS2-3)

Content Area: Second Grade Science
Unit Title: Changes to Earth's Surface
Target Course/Grade Level: Unit 5 Grade 2

Unit Summary

In this unit students will learn the following:

- Use evidence to explain that some changes to Earth happen slowly
- Use evidence to explain that some changes to Earth happen quickly
- Find solutions to prevent wind from changing the land
- Find solutions to prevent water from changing the land.

Lesson 1: What Changes on Earth Happen Slowly? Children will observe how weathering by wind, water, ice, and plants causes Earth's surface to change slowly. Then children observe how erosion by wind, water, and ice causes slow changes to Earth. Finally, children extend their exploration in a hands-on activity in which they model erosion by water.

Lesson 2: What Changes on Earth Happen Quickly? Children will explore how earthquakes, volcanoes, and landslides, hurricanes, and floods cause Earth's surface to change quickly. Then, children will extend their exploration by modeling how a flood can cause Earth's surface to change quickly.

Lesson 3: Engineer It-How Can We Prevent Wind and Water from Changing Land? Children explore how wind and water cause the land to change over time. Next children explore ways to prevent changes to land through the use of different types of technology. Finally, children will design, test, and compare possible solutions that will prevent water from changing the land.

Primary interdisciplinary connections:

English Language Arts

Students participate in shared research to gather information about Earth events from texts and other media and digital resources. They will use this information to answer questions and describe key ideas and details about ways in which the land can change and what causes these changes. Students should also have opportunities to compose a writing piece, either independently or collaboratively with peers, using digital tools to produce and publish their writing. Students should describe connections between Earth events and the changes they cause, and they should include photographs, videos, poems, dioramas, models, drawings, or other visual displays of their work, when appropriate, to clarify ideas, thoughts, and feelings.

Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. (2-ESS1-1), (K-2-ETS1-1) **RI.2.1**
Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-ESS1-1) **W.2.7**

Recall information from experiences or gather information from provided sources to answer a question. (2-ESS1-1), (K-2-ETS1-1) **W.2.8**
Recount or describe key ideas or details from a text read aloud or information presented orally or through other media. (2-ESS1-1) **SL.2.2**

Mathematics

Students have multiple opportunities to reason abstractly and quantitatively as they gather information from media sources. Students can organize data into picture graphs or bar graphs in order to make comparisons. For example, students can graph rainfall amounts. Students can use the data to solve simple addition and subtraction problems using information from the graphs to determine the amount of change that has occurred to local landforms. For example, a gulley was 17 inches deep before a rainstorm and 32 inches deep after a rainstorm. How much deeper is it after the rainstorm? Students must also have an understanding of place value as they encounter the varying timescales on which Earth events can occur. For example, students understand that a period of thousands of years is much longer than a period of hundreds of years, which in turn is much longer than a period of tens of years. In addition, teachers should give students opportunities to work with large numbers as they describe length, height, size, and distance when learning about Earth events and the changes they cause. For example, students might write about a canyon that is 550 feet deep, a river that is 687 miles long, or a forest that began growing about 200 years ago.

Reason abstractly and quantitatively. (2-ESS1-1), (2-ESS2-1), (K-2-ETS1-1) **MP.2**
Model with mathematics. (2-ESS1-1), (2-ESS2-1) **MP.4**
Use appropriate tools strategically. (2-ESS2-1, (K-2-ETS1-1) **MP.5**
Understand place value. (2-ESS1-1) **2.NBT.A**

21st century themes

Global Awareness & Civic Literacy

<u>Unit Rationale</u>

Prior Learning

Kindergarten Unit 2: Forces and Motion

- This unit students learned how to plan and conduct an investigation about the speed of object, gather evidence to support or refute ideas about what causes motion, analyze data from tests to determine if a tool works as intended, & explore pushes and pulls of different strengths and their effect on objects.

Future Learning

Grade 3 Unit 5: Organisms and Their Environments

- In this unit, children will explore inheritance and variation of traits in organisms, discover how different organisms adapt to their environment & identify the cause and effect of how organisms change when environment changes.

Grade 4 Unit 6: Changes to Earth's Surface

- In this unit students will explore Earth has been shaped by water and other factors, discover how people map Earth's surface, & learn about the patterns we can see from maps.

Grade 5 Unit 6: Water on the Earth

- In this unit students will explore the hydrosphere, geosphere, biosphere, and atmosphere & learn how Earth's systems interact.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
2-ESS1-1	Use information from several sources to provide evidence that Earth events can occur quickly or slowly. *[Clarification Statement: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly.]* [Assessment Boundary: Assessment does not include quantitative measurements of timescales.*]*
2-ESS2-1	Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.***[Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.]*

Unit Essential Question

Part A: What evidence can we find to prove that Earth events can occur quickly or slowly?

Part B: In what ways do humans slow or prevent wind or water from changing the shape of the land?

Unit Enduring Understandings

Part A:

- Some events happen very quickly; others occur very slowly over a time period much longer than one can observe.
- Things may change slowly or rapidly.

Part B:

- Things may change slowly or rapidly.
- Developing and using technology has impacts on the natural world.
- Scientists study the natural and material world.
- The shape and stability of structures of natural and designed objects are related to their function(s).
- Wind and water can change the shape of the land.

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.
- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution, it is important to clearly understand the problem.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: Equipment needed: TCI Kits

Teacher Resources: TCI Worktexts

<u>How Can Water Change the Shape of the Land?</u>

In this lesson plan children investigate water erosion. Students make a sand tower and observe the erosion as they drop water on it. Students observe, illustrate, and record notes about the process. Short videos and a read aloud also further support understanding of the Performance Expectation.

How Can Wind Change the Shape of the Land?

This lesson builds on another lesson created by Jeri Faber in which students discovered how water changes the earth. For this lesson, students take part in a teacher-led investigation to show how wind changes the land. The children use straws to blow on a small mound or hill of sand. As each child takes a turn, the other students record their detailed observations that will later be used to draw conclusions. Students also watch a short video on wind erosion and discuss the new learning with partners.

Finding Erosion at Our School

In this lesson, students walk around the school grounds, neighborhood, or another area of their community to locate evidence of erosion. Various problems caused by erosion are discussed and a solution is developed for one of the problems. This lesson is one in a series on erosion by Jeri Faber. A follow-up lesson is available where students compare their erosion design solutions.

Formative Assessments

Students who understand the concepts are able to:

- Make observations from several sources to construct an evidence-based account for natural phenomena.
- Use information from several sources to provide evidence that Earth events can occur quickly or slowly. (Assessment does not include quantitative measurements of timescales.) Some examples of these events include:
    - Volcanic explosions
    - Earthquakes
    - Erosion of rocks.
- Compare multiple solutions to a problem.
- Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. Examples of solutions could include:
    - Different designs of dikes and windbreaks to hold back wind and water
    - Different designs for using shrubs, grass, and trees to hold back the land.
- Ask questions based on observations to find more information about the natural and/or designed world.
- Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- Define a simple problem that can be solved through the development of a new or improved object or tool.
- Develop a simple model based on evidence to represent a proposed object or tool.

- Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

What it Looks Like in the Classroom

In this unit of study, students learn that a situation that people want to change or create can be approached as a problem to be solved through engineering. Before beginning to design a solution, it is important to clearly understand the problem, and asking questions, making observations and gathering information are helpful in thinking about and clarifying problems. Students learn that designs can be conveyed through sketches, drawings, or physical models, and that these representations are useful in communicating ideas for a problem's solutions to other people. As outlined in the narrative above, students will develop simple sketches or drawings showing how humans have helped minimized the effects of a chosen Earth event.

Students use evidence from several sources to develop an understanding that Earth events can occur quickly or slowly. Because some events happen too quickly too observe, and others too slowly, we often rely on models and simulations to help us understand how changes to the surface of the Earth are caused by a number of different Earth events. For example,

➢ Volcanic eruptions are Earth events that happen very quickly. As volcanic eruptions occur, ash and lava are quickly emitted from the volcano. The flow of lava from the volcano causes immediate changes to the landscape as it flows and cools.
➢ Flooding can happen quickly during events such as hurricanes and tsunamis. Flooding can cause rapid changes to the surface of the Earth.
➢ Rainfall is an event that recurs often over long periods of time and will gradually lead to the weathering and erosion of rocks and soil.

In order to gather information to use as evidence, students need to make observations. They can easily look for evidence of changes caused by rain, flooding, or drought. However, actually observing Earth events as they happen is often not possible; therefore, students will need opportunities to observe different types of Earth events using models, simulations, video, and other media and online sources. At this grade level, quantitative measurements of timescales are not important. Students do need to see the kinds of changes that Earth events cause, and whether the changes are rapid or slow.

Engaging in engineering design helps students understand that a situation that people want to change or create can be approached as a problem to be solved through engineering. Asking questions, making observations, and gathering information are helpful in clearly understanding the problem. Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. In this unit of study, students need the opportunity to engage in the engineering design process in order to generate and compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. Students are not expected to come up with original solutions, although original solutions are always welcome. The emphasis is on asking questions, making observations, and gathering information in order to compare multiple solutions designed to slow or prevent wind or water from changing the land. This process should include the following steps:

- As a class, with teacher guidance, students brainstorm a list of natural Earth events, such as a volcanoes, earthquakes, tsunamis, or floods. The class selects one Earth event to research in order to gather more information.
- As a class or in small groups, with guidance, students conduct research on the selected Earth event using books and other reliable sources. They gather information about the problems that are caused by the selected event, and gather information on the ways in which humans have minimized the effects of the chosen earth event. For example,
    - Different designs of dikes or dams to hold back water,
    - Different designs of windbreaks to hold back wind, or
    - Different designs for using plants (shrubs, grass, and/or trees) to hold back the land.
- Next, students look for examples in their community of ways that humans have minimized the effect of natural Earth events. This can be accomplished through a nature walk or short hike around the schoolyard, during a field trip, or students can make observations around their own neighborhoods. If available, students can carry digital cameras (or other technology that allows them to take pictures) in order to document any examples they find.
- Groups select one solution they have found through research and develop a simple sketch, drawing, or physical model to illustrate how it minimizes the effects of the selected Earth event.
- Groups should prepare a presentation using their sketches, drawings, or models, and present them to the class.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 How Changes on Earth Happen Slowly?	5 Days Core Route 7 Days Traditional Route
Lesson 2 What Changes on Earth Happen Quickly?	5 Days Core Route 7 Days Traditional Route
Lesson 3 Engineer It-How Can We Prevent Wind and Water From Changing Land?	5 Days Core Route 7 Days Traditional Route
Lesson 4 Unit 5 Review and Unit 5 Test	2 Days
Additional Traditional Route Lessons Unit 5 Project You Solve It Unit 5 Performance Task	 3 Days 1 Day 2 Days

Performance-Based Assessment	2 Days
Teacher Notes: Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.	

Differentiation
On Level-Why Are Resources Important? This reader reinforces unit concepts and includes response activities for children
Extra Support Why Are Resources Important? This reader shares the title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.
Enrichment-All About Rocks; This high interest, non-fiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL
Be sure to point out all labels, pictures, captions, and headings throughout the lesson to assist children with strategies to summarize chunks of content. Discuss with children real-life connections to content, and provide hands-on examples of materials when possible to best support the needs of these learners.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Changes to Earth's Surface							
Lesson Title: What Changes on Earth Happen Slowly						**Timeframe:** 5 Days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy	X	Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: Disposable plastic gloves, small rocks, soil, sand, foil tray or plastic tub, small book, container of water, plastic cup, safety glasses.							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will use information from several sources to provide evidence that some changes to Earth happen slowly over time.	1. About this Image: explain to the students that this was once a solid, round piece of rock Ask: What do you think happened to make this rock look like an arch. 2. Can You Explain It? Changes to Earth can be made through slow events or fast events. The rocks shown in the video make up part of Bryce Canyon and have slowly formed over time. 3. Weathering: Children observe and describe what happens during weathering by wind. 4. Weathering by Water and Ice: Children observe and describe what happens during weathering by water and ice.	● Evidence Notebook: Children use sandpaper to change a rock, and relate their observation to the weathering process. Guide children to make a connection between what they observe happening to the rock to what happens during the weathering process. ● Guide children to connect that the water freezing in the cup is similar to what happens when water freezes in the cracks of rocks. Be sure they use evidence to support their claims. ● Guide children to think about areas they have observe that are examples of how a plant can weather Earth's surface.

	5. Weathering by Plants? Children observe and describe what happens during weathering by plants. 6. Erosion: Children observe and describe what happens during erosion by wind. 7. Erosion by Water: Children make observations and use examples to explore the slow process of erosion by water and ice. 8. Take It Further 9. Lesson Check-Can you Explain It? 10. Summative Assessment: Self Check	Encourage children to use labels and captions to explain their drawing. Remind children to use evidence to support their observations. • Guide children to set up and explore erosion through a simulation. Monitor children for safety as they blow through the straws. • Guide children to apply the information they have gained from the sections on Erosion by Wind and Erosion by Water in order to help them answer the questions. • Take It Further • Lesson Check-Can you Explain It? • Summative Assessment: Self Check
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Make observations from several sources to construct an evidence-based account for natural phenomena. (2-ESS1-1) Compare multiple solutions to a problem. (2-ESS2-1) **Asking Questions and Defining Problems** Ask questions based on	**ESS1.C: The History of Planet Earth** · Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2-ESS1-1) **ESS2.A: Earth Materials and Systems** Wind and water can change the shape of the land. (2-ESS2-1) **ETS1.A: Defining and Delimiting**	**Stability and Change** Things may change slowly or rapidly. (2-ESS1-1) Things may change slowly or rapidly. (2-ESS2-1) **Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2) -

observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1) Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) **<u>Developing and Using Models</u>** Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2)	**<u>Engineering Problems</u>** A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **<u>ETS1.B: Developing Possible Solutions</u>** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)	***Connections to Engineering, Technology, and Applications of Science*** **<u>Influence of Engineering, Technology, and Science on Society and the Natural World</u>** Developing and using technology has impacts on the natural world. (2-ESS2-1) - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** Scientists study the natural and material world. (2-ESS2-1)

Grade 3

Content Area: Science Grade Level: Third Grade
First Marking Period - Pacing Guide ● **Unit 1: Engineering Processes** **14 Days Core Route (22 Days Traditional Route)** **NJ-SLS-S: 3-5-ETS1-1, 3-5-ETS1-3, & 3-5-ETS1-3** ● **Unit 2: Forces** **14 Days Core Route (22 Days Traditional Route)** **NJ-SLS-S: 3-PS2-1, 3-PS2-3, & 3-PS2-4**
Second Marking Period - Pacing Guide ● **Unit 3: Motion** **10 Day Core Route (22 Days Traditional Route)** **NJ-SLS-S: 3-PS2-1 & 3-PS2-2** ● **Unit 4: Life Cycles and Inherited Traits** **14 Days Core Route (22 Days Traditional Route)** **NJ-SLS-S: 3-LS1-1 & 3-LS3-1**
Third Marking Period - Pacing Guide ● **Unit 5: Organisms and Their Environments** **18 Days Core Route (27 Traditional Route)** **NJ-SLS-S: 3-LS2-1, 3-LS3-2, 3-LS4-3, & 3-LS4-4** ● **1st ½ Unit 6: Fossils** **5 Days Core Route (8 Days Traditional Route)** **NJ-SLS-S: 3-LS4-1**
Fourth Marking Period - Pacing Guide ● **Unit 6: Fossils** **5 Days Core Route (8 Days Traditional Route)** **NJ-SLS-S: 3-LS4-1** ● **Unit 7: Weather and Patterns** **18 Days Core Router (27 Traditional Route)** **NJ-SLS-S: 3-ESS2-1 & 3-ESS2-2**

Content Area: Third Grade Science
Unit Title: Engineering Processes
Target Course/Grade Level: Third Grade: Unit 1

Unit Summary

In the unit children will do the following:

- Define problems and design solutions to those problems
- Test solutions and make improvements to solutions.

Lesson 1: How Do We Define Problem? Students are exposed to a problem scenario. They integrate prior problem-solving experience with the engineering concepts of criteria and constraints. After exploring real-world examples and the needs they fulfill, students write a detailed description of a problem that they wish to solve.

Lesson 2: How Can We Design a Solution? Students research and develop possible solutions to a problem, then communicate and compare those solutions with other, and develop testing criteria based on how the solution will be used. Students will also examine the ways engineering can be used to solve practical problems.

Lesson 3: How Do We Test and Improve a Solution? Students continue their exploration of the design process by investigating options and refinements of a solution to increase benefits, decrease known risks, or meet societal demands. Students utilize the prototype irrigation system that was developed over the previous two lessons. Here, students refine their solution by brainstorming and testing possible improvements.

Primary interdisciplinary connections:

English Language Arts

Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **W.3.2**
Develop the topic with facts, definitions, and details. **W.3.2.B**
Recall information from experiences. **W.3.8**
Draw evidence from literary or informational texts to support analysis reflection, and research. **W.5.9**
Report on a topic. **SL.3.4**
Ask and answer questions **RL.3.2**
Explain the functions of adjectives **RL.3.1**
Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.1**

Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g. where, when, why, and how key events occur). **RI.3.7**

Mathematics

Solve problems involving measurement and estimation. **MC.3.MD.A.2**
Reason abstractly and quantitatively. **MP.2**
Model with mathematics **MP.4**
Use appropriate tools strategically **MP.5**
Operations and Algebraic Thinking **3-5.OA**
Measure and estimate liquid volumes and masses of objects using standard units of grams, kilograms, and liters. Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings to represent the problem. **3.MD.A.2**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Kindergarten Unit 1: Engineering and Technology

In the unit children will learn the follow: Define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems & Explore and apply a design process

Grade 1 Unit 1: Engineering Design Process

- In this Unit children will define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems, and explore and apply a design process.

Grade 2 Unit 1: Engineering and Technology

In the unit children will learn the follow:

- Ask questions, make observations, and gather information to define a problem.
- Use a design process to solve a problem
- Compare the strengths and weaknesses of multiple design solutions.

Future Learning

Grade 4 Unit 1:

- In this unit, students will explore how engineers define problems and solutions, learn about the importance of prototypes & use models to examine how prototypes are tested and improved.

Grade 5 Unit 1:

- In this unit, students will discover how science and math are used in engineering, investigate a design process, and explore how technology decisions affect society.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Unit Essential Questions

- How do we define a problem?
- How do we design a solution?
- How do we test and improve a solution?

Unit Enduring Understandings

- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. Ask questions and integrate prior problem-solving experience with the engineering concepts of criteria and constraints and explore real-world examples and the needs that they fulfill. Use this information to define a simple design problem that students can solve.
- To research and design possible solutions to a problem, communicate and compare those solutions with others, and develop testing criteria based on likely conditions in which the solution will be used.
- Plan and conduct investigations that test solutions and identify problems and improvements in order to increase benefits or decrease risks associated with a device or solution.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check

- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI Worktext

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Engineer It: How Do We Define a Problem?	Core: 4 Days Traditional: 5 Days
Lesson 2 Engineer It: How Can We Design a Solution?	Core: 4 Days Traditional: 5 Days
Lesson 3 Engineer It: How Do We Test and Improve a Solution?	Core: 4 Days Traditional: 5 Days
Lesson Unit 1 Review and Unit 1 Test	Core: 2 days
Additional Traditional Activities: Unit 1 Project You Solve it Unit 1 Performance Task Performance-Based Assessment	 2 days 1 day 1 days 1 days

Teacher Notes:
Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiate Instruction:

- **On Level: How Does the Design Process Help Us?** These readers reinforce unit concepts , and includes response activities for the students.
- **Extra Support: How Does the Design Process Help Us?** These readers share title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

- **Enrichment: Designing Amusement Park Rides** These high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary, and include response activities.

ELL
Lesson 1: In typical usage, criteria are the rules used to measure something. In engineering, criteria are the desired features of a solution. Constraints are limits on which solutions can be considered. For example, a solution that costs $20 when you have only $10 is not possible. The budget of $10 is a constraint.
Lesson 3: Have students make vocabulary cards for both terms to keep handy as they work through Lesson 3.

Curriculum Development Resources

NSTA Web Seminar: Teaching NGSS in Elementary School—Kindergarten

The seminar was led by expert teachers Carla Zembal-Saul, Professor of Science Education, Penn State University; Mary Starr, Executive Director, Michigan Mathematics and Science Centers Network; and Kathy Renfrew, K-5 Science Coordinator, VT Agency of Education. Carla, Mary and Kathy engaged with participants to gauge their familiarity with *NGSS* for kindergarten, and provided a number of example activities and videos on how to implement it, e.g., different approaches to teaching weather and climate core ideas. The web seminar was then wrapped up by Ted Willard, who suggested a number of resources and events for participants to further develop their understanding of *NGSS* for kindergarten, as well as other grade levels.

View the resource collection.

Continue discussing this topic in the community forums.

NSTA Web Seminar: Teaching NGSS in K-5: Constructing Explanations from Evidence

Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena.

To view related resources, visit the resource collection.

Continue discussing this topic in the community forums.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Engineering Processes							
Lesson Title: How Do We Define a Problem?						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Using online access to text series							
Equipment needed: headphones and classroom materials.							

<table>
<tr><th>Goals/Objectives</th><th>Learning Activities/Instructional Strategies</th><th>Formative Assessment Tasks</th></tr>
<tr><td>Students:
● Will define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. Ask questions and integrate prior problem-solving experience with the engineering concepts of criteria and constraints and explore real-world examples and the needs that they fulfill. Use this information to define a simple design problem that students can solve.</td><td>1. About this Image? The plants shown here are all edible plants. As students work through this lesson, the problem they will tasked with includes: keeping the plants watered, avoiding water damage, and using only available materials.
2. Can you Solve it: Students are asked to record their initial thoughts about how indoor plants survive.
3. Exploration 1-Defining Engineering Problems
4. What's in the Way?
5. Exploration 2: Exploring the Limits on Problem-Solving.
6. Take it Further
7. Lesson Check-Can You Solve it
8. Lesson Roundup</td><td>● Asking Questions and Defining Problems: Ask: How does defining a problem help you find a solution? Ask: What are criteria?
● As students work through their experience with a limit to a problem, ask them to think about a requirement that made them discard and idea for solution or limited their ability to make the solution they wanted.
● Lesson Check-Can You Solve it</td></tr>
<tr><td colspan="3">Differentiation
Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
● Lesson Vocabulary: constraint, criteria, design, engineer, and engineering.
● ELL/ELD Strategy: In typical usage, criteria are the rules used to measure something. In engineering, criteria are the desired features of a solution. Constraints are limits on which solutions can be considered. For example, a solution that costs $20 when you have only $10 is not possible. The budget of $10 is a constraint.</td></tr>
<tr><td colspan="3">Resources Provided: TCI work text, teacher online access, and equipment kits.</td></tr>
</table>

Appendix: NJSLS and Foundations for the Unit

<table>
<tr><td colspan="3">The Student Learning Objectives above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
</table>

Asking Questions and Defining Problems Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions. ● Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1) ● Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) **Developing and Using Models** Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. ● Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2) **Analyzing and Interpreting Data** Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)	**ETS1.A: Defining and Delimiting Engineering Problems** ● A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) ● Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) ● Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions** ● Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	**Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

Content Area: Third Grade Science
Unit Title: Forces
Target Course/Grade Level: Unit 2 Grade 3
Unit Summary In the unit students will: ● explore how forces work. ● Discover different types of forces. ● Learn about forces that act from a distance

Lesson 1: Students will evaluate cause-and-effect relationship between forces and objects. They will ask questions and define problems related to real-world applications of force and make observations and collect evidence to determine how a dogsled team makes its way across a snowy landscape.

Lesson 2: Students will explore net force as well as balanced and unbalanced forces by planning and conducting and investigation to observe and measure contact forces using a variety of methods and tools. By exploring balanced and unbalanced forces, students will recognize the cause-and-effect relationship. Between force and motion

Lesson 3: Students will gather and analyze evidence that forces such as magnetism and electricity can act on objects without touching them. Students use what they learn to build an electromagnet in which electricity is used to cause magnetic attraction. As a result, students learn about attractive forces and observe how they work.

Primary interdisciplinary connections:

English Language Arts

- In order to integrate the SLS for ELA into this unit, students need opportunities to read content-specific texts to deepen their understanding of force and motion. As they read, teachers should pose questions such as, "What interactions can you identify between the objects in the text?" and "What patterns of motion are described in the text?" Students should be encouraged to answer questions and cite evidence from the text to support their thinking.
- To further support the integration of the ELA standards, students can also conduct short research projects about simple force-and-motion systems and the interactions that occur among forces and objects within the systems. For example, students could be asked to conduct a short study by bouncing a ball 10 times and identifying the patterns they observe. Next students could predict, based on the patterns they saw, what would happen if they bounced the ball 10 more times. Students then could draw a model of the force and motion system, identifying the structures and forces that interact within the system. This would also give students the opportunity to develop note-taking skills and use multiple sources to collect information about force and motion.

Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.1** (3-PS2-1)
Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence and cause/effect. **RI.3.3**
Describe the logical connection between particular sentences and paragraphs in a text (e.g. comparison, cause/effect, and first/second/third in a sequence. **RI.3.8**
Conduct short research projects that build knowledge about a topic. **W.3.7** (3-PS2-1),(3-PS2-2)
Recall information from experiences or gather information from print and digital sources; take brief

notes on sources and sort evidence into provided categories. **W.3.8** (3-PS2-1),(3-PS2-2)

Mathematics

In order to integrate the SLS for Mathematics, students can use measurement tools in a variety of ways to conduct investigations. Students could find the mass of an object in order to understand that the heavier something is, the greater the force needed to cause a change in its motion. Students could use rulers or tape measures to measure the distance an object moves. Student can then record and analyze their data to determine patterns of change and explain cause-and-effect relationships, while reasoning abstractly and quantitatively.

Reason abstractly and quantitatively. **MP.2** (3-PS2-1)
Use appropriate tools strategically. **MP.5** (3-PS2-1)
Explain equivalence of fractions in special case, and compare fractions by reasoning about their size. **3.NF.A.3**
Solve problems involving the four operations, and identify and explain patterns in arithmetic. Solve two-step word problems using the four operations. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. **2.OA.D.8**
Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. **3.MD.A.2** (3-PS2-1)

21st century themes

Global Awareness

<u>Unit Rationale</u>

Prior Learning

Kindergarten Unit 2: Forces of Motion

- In this unit, children will do the following: plan and conduct an investigation about the speed of objects, gather evidence to support or refute ideas about what causes motion, analyze data from tests to determine if a tool works as intended, and explore pushes and pulls of different strengths and their effect on objects

Grade 1 Unit 6: Objects and Patterns in the Sky

- In this unit, children will learning the following: identify and describe objects in the sky, use evidence to describe predictable patterns of the sun, moon, and stars, observe and model patterns of the moon's phases, use observations to describe characteristics of each season, predict patterns of change that take place from season to season, user observations to compare the amount of daylight from season to season, & explore how seasons affect people and animals.

Future Learning

Grade 4 Unit 3: Waves and Information Transfer

- In this unit, students will learn to discover the different parts of waves, explore how light can be reflected, & examine and describe how information is transferred from place to place.

Grade 4 Unit 6: Changes to Earth's Surface

- In this unit, students will explore how Earth has been shaped by water and other factors, discover how people map Earth's surface, & learn about the patterns we can see from maps.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
3-PS2-1	Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]
3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]
3-PS2-4	Define a simple design problem that can be solved by applying scientific ideas about magnets.

Unit Essential Question

Part A: What are Forces?

Part B: What are Some Types of Forces?

Part C: What Forces Act From a Distance?

Unit Enduring Understandings

Part A:

- Recognize a force as a push and pull. Demonstrate how the strength and direction of a force can be changed. Ask questions about force that can be investigated. Identify the cause-and-effect relationship between the speed and direction of an object and the strength and direction of the force applied to it.

Part B:

- Develop and understanding of how contact forces, including friction, and non-contact forces, such as gravity, act on objects and that objects often have multiple forces acting on them. Plan and carry out an investigation of balanced result in zero net force and no motion change, and recognize causes and effects between forces and changes in motion.

Part C:

- Identify magnetism and static electricity as forces that can act on objects without touching them.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI Worktext

Puffing Forces: Students will predict and observe what happens when a force is applied to an object, and compare the relative effects of a force of the same strength on objects of different weights by using a straw to gently puff air at a ping pong ball then a golf ball and measuring the distance the ball travels with a ruler. Students will repeat this procedure using a harder puff. This lesson was adapted from the Utah Education Network
http://www.uen.org/Lessonplan/preview?LPid=14858

Robo Arm: This fun activity is one of five in a series of space based engineering challenges developed by NASA and Design Squad where students are engaged in implementing the Engineering Design process to build a robotic arm that can lift a cup off a table using cardboard strips, brass fasteners, paper clips, straw, string, tape and a cup. The activity includes an instructor's guide, questioning techniques, discussion questions, extension activity, a rubric, and 3 short video clips that enhance the purpose of the activity and its relevance to NASA.

Formative Assessments

Students who understand the concepts are able to:

- Identify cause-and-effect relationships.
- Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence.
- Use fair tests in which variables are controlled and the number of trials considered.
- Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is also limited to gravity being addressed as a force that pulls objects down.) Examples could include:
    - An unbalanced force on one side of a ball can make it start moving.
    - Balanced forces pushing on a box from both sides
- Make predictions using patterns of change.
- Make observations and/or measurements to produce data to serve as the basis of evidence for an explanation of a phenomenon.
- Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. (Assessment does not include technical terms such as period and frequency.) Examples of motion with a predictable pattern could include:
    - A child swinging in a swing.
    - A ball rolling back and forth in a bowl.
    - Two children on a seesaw.

What it Looks Like in the Classroom

In this unit of study, students look for cause-and-effect relationships as they investigate the effects of balanced and unbalanced forces on the motion of an object. They learn that objects in contact exert forces on each other, and these forces have both strength and direction. When forces are balanced, there is no change in the motion or the position of an object. In other words, an object at rest typically has multiple forces acting on it, but the forces balance out to equal a zero net force on the object. For example, if two children stand with their hands together and push against each other, the pushing force each exerts balances to a net zero effect if neither child moves. Pushing a box from both sides also demonstrates a balanced force if the forces do not produce any change in motion or position of the box.

When forces are unbalanced, however, there is a change in the motion and/or position of the object the forces are acting on. If the same two children from the example above were pushing against each other, and one child moves his/her hands, arms, or feet forward while the other child moves backward, this would demonstrate an unbalanced force. The first child is pushing with greater force than the second.

Through planning and conducting investigations, students will come to understand that forces that result in changes in an object's speed or direction of motion are unbalanced. Students can observe everyday examples on the playground, with seesaws and swings and by kicking and throwing soccer balls. As they conduct investigations and make observations, students should identify the cause-and-effect relationships at work and identify the objects that are exerting forces on one another. They should also use qualitative descriptions when identifying the relative strength (greater than, less than, equal) and direction of the forces, even if an object is at rest.

Investigating the effects of forces on objects will also give students opportunities to observe that patterns exist everywhere. Patterns are found in shapes, structures, natural environments, and recurring events. Scientists and engineers analyze patterns to make predictions, develop questions, and create solutions. As students have opportunities to observe forces interacting with objects, they will ask questions and analyze and interpret data in order to identify patterns of change in the motion of objects and to make predictions about an object's future motion. When students are on the playground, they can observe multiple patterns of change in the back-and-forth motion of a child swinging on a swing or in the up-and-down motion of a seesaw. In the classroom, students can observe a variety of objects, such as marbles rolling back and forth in bowls or tops spinning across the floor.

Throughout this unit, as students plan and carry out investigations, it is extremely important that they routinely identify cause-and-effect relationships and look for patterns of change as objects interact. As students interact with objects, such as when they push a door closed, bounce a ball, or roll a ball down a ramp, they may ask, "What caused the changes that I observed? How can I change the way in which the object moved?" Students need to have many experiences in order to deepen their understanding of the cause-and-effect relationships between balanced and unbalanced forces on the motion of an object, and they should be guided to plan and conduct fair tests, testing only one variable at a time.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What are Forces	4 Days (Core Route) 5 Days (Traditional Route)
Lesson 2 What are Some Types of Forces?	4 Days (Core Route) 5 Days (Traditional Route)
Lesson 3 Engineer It-What are Forces Act from a Distance?	4 Days (Core Route) 5 Days (Traditional Route)
Lesson	

Unit 2 Review and Unit 2 Test	2 days
Additional Traditional Route Lessons Unit 2 Project You Solve It Unit 2 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On-Level Reader: How Do We Use Machines? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do We Use Machines? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Building With Machines? This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL/ELD Strategy:

Lesson 1: This lesson features many examples of forces causing effects. Students will need to identify sequence of events and cause-effect relationships. Warm up by having them analyze some simple causes and effects.

Lesson 2: Have students demonstrate balanced and unbalanced forces by balancing a pencil on a finger or edge of a table or desk.

Lesson 3: Ask: What else do you know that has a North and a South pole? Answer: Earth Ask: How is Earth like a magnet? Answer: It has a north and south pole and a magnetic field around it.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Forces							
Lesson Title: What Are Forces?						**Timeframe:** 4 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of the online tools for both students and teachers.							
Equipment needed: TCI Worktext, TCI Lab Kit							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: • Will recognize a force as a push or pull. Demonstrate how the strength	1. About this Image: Forces are an important part of sports, such as soccer. A force, such as a kick, changes the motion of an object. 2. Can You Explain It? Students are asked to describe the force applied by sled	• Forming an explanation: Tell students to focus on how their selected technology affects dog sled racing's goal: pulling the sled and driver over a

and direction of a force can be changed. Ask questions about force that can be investigated. Identify the cause-and effect relationship between the speed and direction of an object and the strength and direction of the force applied to it.	dogs to the sled as strong or weak. Their answer will be subjective, and most will likely say "strong" because to them the force required to move a sled is considerable. 3. Exploration 1: Forces Everywhere-Plan investigations about how a force will have an effect on motion and the explore how those relationships inform the engineering and design process to improve technologies. 4. Exploration 2: Strong Enough-Explore how the strength of a force is related to the amount of weight that can be moved. 5. Exploration 3: Which way? Plane an investigation about how the strength and direction of a force can be changed. Identify the cause-and effect relationship between the speed and direction of an object and the strength and direction of the force applied to it. 6. Take It Further: Discover More 7. Lesson Check: Can you Explain It? 8. Lesson Roundup	long distance in the least amount of time. ● Cause and Effect: Ask: What is the relationship between doubling the load on the sled and the number of dogs required to pull that load? ● Compare and Contrast: Students may better remember the distinction between compare and contrast if they define the terms in their own words. To compare means to "look for similarities." Contrast means "look for differences." Have students describe the terms in their own words. ● Lesson Check: Can you Explain It? ● Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
<u>Planning and Carrying Out Investigations</u> Plan and conduct an	**<u>PS2.A: Forces and Motion</u>** Each force acts on one particular object and has both strength and a	**<u>Cause and Effect</u>** Cause and effect relationships are routinely identified. (3-PS2-1)

investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1) Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)	direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1) The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2) **PS2.B: Types of Interactions** Objects in contact exert forces on each other. (3-PS2-1)	**Patterns** Patterns of change can be used to make predictions. (3-PS2-2) - ***Connections to Nature of Science*** **Science Knowledge is Based on Empirical Evidence** Science findings are based on recognizing patterns. (3-PS2-2) **Scientific Investigations Use a Variety of Methods** Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)

Content Area: Third Grade Science
Unit Title: Motion
Target Course/Grade Level: Unit 3 Grade 3
Unit Summary In this unit, students will: ● Explore types of forces and motion ● Learn about the relationship between forces and motion. ● Identify patterns in motion. **Lesson 1:** Students will examine how balanced and unbalanced forces affect the motion of an object. Students will begin by asking questions and defining problems related to forces and motion. They will

then investigate forces and the effects they have on motion. Student will identify specific reasons why motion changes as a result of the forces acting on them.

Lesson 2: Students will observe types of motions and measure objects' motions in various situations. Students will investigate different variables that affect the speed and direction of a pendulum to find patterns and use those patterns and use those patterns to make predictions about future movements.

Primary interdisciplinary connections:

English Language Arts

- In order to integrate the SLS for ELA into this unit, students need opportunities to read content-specific texts to deepen their understanding of force and motion. As they read, teachers should pose questions such as, "What interactions can you identify between the objects in the text?" and "What patterns of motion are described in the text?" Students should be encouraged to answer questions and cite evidence from the text to support their thinking.
- To further support the integration of the ELA standards, students can also conduct short research projects about simple force-and-motion systems and the interactions that occur among forces and objects within the systems. For example, students could be asked to conduct a short study by bouncing a ball 10 times and identifying the patterns they observe. Next students could predict, based on the patterns they saw, what would happen if they bounced the ball 10 more times. Students then could draw a model of the force and motion system, identifying the structures and forces that interact within the system. This would also give students the opportunity to develop note-taking skills and use multiple sources to collect information about force and motion.

Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.1** (3-PS2-1)
Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **W.3.2**
Conduct short research projects that build knowledge about a topic. **W.3.7** (3-PS2-1),(3-PS2-2)
Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. **W.3.8** (3-PS2-1),(3-PS2-2)
Ask and answer questions about information from a speaker. **SL.3.3**

Mathematics

In order to integrate the Common Core State Standards for Mathematics, students can use measurement tools in a variety of ways to conduct investigations. Students could find the mass of an object in order to understand that the heavier something is, the greater the force needed to cause a change in its motion. Students could use rulers or tape measures to measure the distance an object moves. Student can then record and analyze their data to determine patterns of change and explain cause-and-effect relationships, while reasoning abstractly and quantitatively.

Reason abstractly and quantitatively. **MP.2** (3-PS2-1)
Use appropriate tools strategically. **MP.5** (3-PS2-1)
Solve two-step word problems using the four operations. Represent these problems using equations with a letter for the unknown quantity. Assess the reasonableness of answers using mental computation and estimations strategies including rounding. **3.OA.D.8**
Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses objects. **3.MD.A.1**

21st century themes

Global Awareness

<u>Unit Rationale</u>

Prior Learning

Kindergarten Unit 2: Forces of Motion

- In this unit, children will do the following: plan and conduct an investigation about the speed of objects, gather evidence to support or refute ideas about what causes motion, analyze data from tests to determine if a tool works as intended, and explore pushes and pulls of different strengths and their effect on objects

Grade 1 Unit 6: Objects and Patterns in the Sky

- In this unit, children will learning the following: identify and describe objects in the sky, use evidence to describe predictable patterns of the sun, moon, and stars, observe and model patterns of the moon's phases, use observations to describe characteristics of each season, predict patterns of change that take place from season to season, user observations to compare the amount of daylight from season to season, & explore how seasons affect people and animals.

Future Learning

Grade 4 Unit 3: Waves and Information Transfer

- In this unit, students will learn to discover the different parts of waves, explore how light can be reflected, & examine and describe how information is transferred from place to place.

Grade 4 Unit 6: Changes to Earth's Surface

- In this unit, students will explore how Earth has been shaped by water and other factors, discover how people map Earth's surface, & learn about the patterns we can see from maps.

Learning Targets	
Standards	
NJSLS-S#	**Performance Expectation**
3-PS2-1	Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]
3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]

Unit Essential Question

Part A: What is Motion?

Part B: What are some patterns in Motion?

Unit Enduring Understandings

Part A:

- Determine whether an object is in motion, explain how the speed of an object is determined, and describe how unbalanced forces affect the motion of an object (speed up, slow down, change direction).

Part B:

- Develop an understanding of regular patterns of motion and how future motion can be predicted from them. Plan and carry out an investigation to predict the motion of a pendulum, and use this to discover patterns of change and how these can be used to make predictions.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.

2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI work text and teacher editions

Puffing Forces: Students will predict and observe what happens when a force is applied to an object, and compare the relative effects of a force of the same strength on objects of different weights by using a straw to gently puff air at a ping pong ball then a golf ball and measuring the distance the ball travels with a ruler. Students will repeat this procedure using a harder puff. This lesson was adapted from the Utah Education Network http://www.uen.org/Lessonplan/preview?LPid=14858

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Formative Assessments

Students who understand the concepts are able to:

- Identify cause-and-effect relationships.
- Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence.
- Use fair tests in which variables are controlled and the number of trials considered.
- Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is also limited to gravity being addressed as a force that pulls objects down.) Examples could include:
  - An unbalanced force on one side of a ball can make it start moving.
  - Balanced forces pushing on a box from both sides
- Make predictions using patterns of change.

- Make observations and/or measurements to produce data to serve as the basis of evidence for an explanation of a phenomenon.
- Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. (Assessment does not include technical terms such as period and frequency.) Examples of motion with a predictable pattern could include:
    - A child swinging in a swing.
    - A ball rolling back and forth in a bowl.
    - Two children on a seesaw.

What it Looks Like in the Classroom

In this unit of study, students look for cause-and-effect relationships as they investigate the effects of balanced and unbalanced forces on the motion of an object. They learn that objects in contact exert forces on each other, and these forces have both strength and direction. When forces are balanced, there is no change in the motion or the position of an object. In other words, an object at rest typically has multiple forces acting on it, but the forces balance out to equal a zero net force on the object. For example, if two children stand with their hands together and push against each other, the pushing force each exerts balances to a net zero effect if neither child moves. Pushing a box from both sides also demonstrates a balanced force if the forces do not produce any change in motion or position of the box.

When forces are unbalanced, however, there is a change in the motion and/or position of the object the forces are acting on. If the same two children from the example above were pushing against each other, and one child moves his/her hands, arms, or feet forward while the other child moves backward, this would demonstrate an unbalanced force. The first child is pushing with greater force than the second.

Through planning and conducting investigations, students will come to understand that forces that result in changes in an object's speed or direction of motion are unbalanced. Students can observe everyday examples on the playground, with seesaws and swings and by kicking and throwing soccer balls. As they conduct investigations and make observations, students should identify the cause-and-effect relationships at work and identify the objects that are exerting forces on one another. They should also use qualitative descriptions when identifying the relative strength (greater than, less than, equal) and direction of the forces, even if an object is at rest.

Investigating the effects of forces on objects will also give students opportunities to observe that patterns exist everywhere. Patterns are found in shapes, structures, natural environments, and recurring events. Scientists and engineers analyze patterns to make predictions, develop questions, and create solutions. As students have opportunities to observe forces interacting with objects, they will ask questions and analyze and interpret data in order to identify patterns of change in the motion of objects and to make predictions about an object's future motion. When students are on the playground, they can observe multiple patterns of change in the back-and-forth motion of a child swinging on a swing or in the up-and-down motion of a seesaw. In the classroom, students can observe a variety of objects, such as marbles rolling back and forth in bowls or tops spinning across the floor.

Throughout this unit, as students plan and carry out investigations, it is extremely important that they routinely identify cause-and-effect relationships and look for patterns of change as objects interact. As students interact with objects, such as when they push a door closed, bounce a ball, or roll a ball down a ramp, they may ask, "What caused the changes that I observed? How can I change the way in which the object moved?" Students need to have many experiences in order to deepen their understanding of the cause-and-effect relationships between balanced and unbalanced forces on the motion of an object, and they should be guided to plan and conduct fair tests, testing only one variable at a time.

Lesson Plans	
Lesson	**Timeframe**
Lesson 1 What is Motion?	4 Days-Core Route 5 Days- Traditional Route
Lesson 2 What are Some Patterns in Motion?	4 Days-Core Route 5 Days- Traditional Route
Unit 3 Review and Unit 3 Test	2 Days
Additional Traditional Route Activities Unit 3 Project You Solve It Unit 3 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On-Level Reader: How Do We Use Machines? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do We Use Machines? This reader shares title, illustrations, vocabulary, and concepts with the on-level reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Building With Machine: The high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

- Ask students to stand in specific place that have designated. Mark each position with a number, beginning with 1. Tell students that their position is the place where they are standing, which is marked by their number. Ask each student which position he or she is in. Have them change positions, and ask them again.
- Draw lines on the board and use arrows to show students one pattern of motion. Draw a vertical line with arrows on both ends that shows something move up and down. Encourage students to think of an object that moves up and down. Encourage students to think of an object that move up and down. The motion up and down is a pattern of motion. That motion repeats itself.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

<table>
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</table>

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Determine whether an object is in motion, explain how the speed of an object is determined, and describe how unbalanced forces affect the motion of an object (speed up, slow down, change direction).	1. About this image: The cheetah's speed helps it pursue and capture fast prey on grasslands of eastern and southwestern Africa. There are fewer than 10,000 cheetahs in the wild. 2. Can you Explain It? Students are asked to record their initial thoughts about what forces are acting on the Bloodhound SSC car to make it speed up or slow down. 3. Exploration 1 Here or There: Develop and understanding of how to use a change in position to determine the motion of a person or object. 4. Exploration 2: Speed It Up! Plan and carry out investigations into the nature of speed and it relation to forces and motions. 5. Take It Further: Discover More 6. Lesson Check: Can you Explain it? 7. Lesson Roundup	● Cause and Effect: Remind students that they cannot infer the answers to the questions until they have place the pictures in the correct order. ● Ask: How do measurements of distance, time, and direction contribute to descriptions of motion? Answer: Measurements of distance and time can be expressed as measurements of speed. Speed can be combined with expressions of direction to describe motion. ● Lesson Check: Can you Explain it? ● Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce	**PS2.A: Forces and Motion** Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give	**Cause and Effect** Cause and effect relationships are routinely identified. (3-PS2-1) **Patterns**

data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1) Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)	zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1) The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2) **PS2.B: Types of Interactions** Objects in contact exert forces on each other. (3-PS2-1)	Patterns of change can be used to make predictions. (3-PS2-2) - ***Connections to Nature of Science*** **Science Knowledge is Based on Empirical Evidence** Science findings are based on recognizing patterns. (3-PS2-2) **Scientific Investigations Use a Variety of Methods** Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)

Content Area: Third Grade Science
Unit Title: Life Cycles and Inherited Traits
Target Course/Grade Level: Unit 4 Grade 3
Unit Summary In this unit, children will learn the following: ● Explore the life cycles of plants and animals ● Discover inherited plant and animal traits **Lesson 1:** Students will explore plant life cycles and how a plant depends on its environment to live and reproduce. They will use data and information they gather as evidence to support explanations. By exploring the effect of the environment on plant life cycles, they will learn what plants need to reproduce. **Lesson 2:** Students explore patterns of change in animal life cycles, and use those patterns to make predictions. Students will investigate technology used to track patterns of animal movement in order to understand reproductive behavior. Students will compare and contrast the life cycles of several different animals. Students will use models to describe phenomena and develop a nest and a zoo.

Lesson 3: Students learn about offspring and parents of plants and animals. The study images to interpret data about inherited traits. They not similarities and differences in organisms that can be understood in terms of inheritance. They find patterns in inherited traits, and simulate inheritance in a hands-on project.

Primary interdisciplinary connections:

English Language Arts

In order to integrate the SLS for English language arts, students will need opportunities to read about inherited traits of animals and plants in a variety of texts and resources. During discussions, teachers might pose questions such as "What kinds of traits are passed on from parent to offspring?" or "What environmental factors might influence the traits of a specific organism?" Students should be able to refer specifically to the text when answering questions, articulate the main idea, and describe the key ideas using supporting details in their explanations. Additionally, they should describe the relationship between scientific ideas or concepts, using language that pertains to time, sequence, and cause and effect.

During this unit, students also need opportunities to write informative/explanatory texts to convey ideas and information gathered through investigations and from other resources. For example, after reading texts about a given organism, students should be expected to use key details and appropriate facts about that organism to compose an informative piece of writing. This piece should list some of the organism's traits that were passed on from its parents, describe how those traits enable the organism to interact in its environment to meet its needs, and describe any influence the environment has on the organism's traits. Students should also have the opportunity to report orally on a given topic related to traits and the way they are influenced by the environment. They should share relevant facts, details, and information while speaking clearly and at an understandable pace.

Determine the main idea of a text; recount the key details and explain how they support the main idea. **RI.3.2**
Compare and contrast the most important points and key details presented in two texts on the same topic. **RI.3.9**
Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when why, and how key events occur). **RI.3.7**
Describe the logical connection between particular sentence and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence). **RI.3.8**
Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS3-1),(3-LS3-2) **RI.3.2**
Conduct short research projects that build knowledge about a topic. **W.3.7**
Decode multi-syllable words **RF.3.3.C**

Mathematics

This unit also has connections to the CCSS for mathematics. Students can use rulers to measure the growth of organisms, then generate and plot the data they collected on line plots, making sure the horizontal scale is marked off in appropriate units (whole numbers, halves, or quarters). For example, students might chart out data in line plots to document the growth (over time) of each of a number of plants grown from a single parent. As students analyze their data, they will observe that the offspring are not the same exact height as each other or as the parent, but that the height of all plants is very similar when the plants are grown under the same conditions. Students might also make similar line plots to compare the same type of plants grown with varying amounts of water or sunlight, then compare these data to the growth data of the parent plant. Analyzing this data will help students understand that environmental factors influence/affect the traits of organisms. As students collect, organize, and analyze their data, they have opportunities to reason abstractly and model with mathematics.

Number and Operations in Base Ten **3.NBT**
Number and Operation-Fractions **3.NF**
Reason abstractly and quantitatively. (3-LS3-1),(3-LS3-2) **MP.2**
Model with mathematics. (3-LS3-1),(3-LS3-2) **MP.4**
Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. (3-LS3-1),(3-LS3-2) **3.MD.B.4**

21st century themes

Global Awareness & Financial, Economic, Business and Entrepreneurial Literacy

<u>Unit Rationale</u>

Prior Learning

By the end of Grade 1, students understand that:

- Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents.
- Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

Future Learning

By the end of middle school, students will understand that:

- Animals engage in characteristic behaviors that increase the odds of reproduction.
- Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.
- Genetic factors as well as local conditions affect the growth of the adult plant.
- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.

● Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affect the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. ● Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. ● In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. ● In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others are harmful, and some are neutral to the organism.
Learning Targets

Standards	
NJSLS-S#	**Performance Expectation**
3-LS1-1	Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.
3-LS3-1	Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. *[Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.] [Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.]*

Unit Essential Question

Part A: What are some plant life cycles?

Part B: What are some animal life cycles?

Part C: What are inherited plant and animal traits?

Unit Enduring Understandings

Part A:

- Identify and recognize the common patterns in various life cycles of plants, and build models of a plant cycle. Understand that a given plant's life cycle always happens in the same order, and can be disrupted.

Part B:

- Identify and recognize patterns in the various stages of the life cycles of different animals. Develop and use models to describe the unique and diverse life cycles of different animals. Learn about technology that enables scientists to find patterns in data to show how reproduction is essential to the continued existence of every organism.

Part C:

- To study images of organisms to collect and interpret data and find patterns in inherited traits. Note similarities and differences in the organisms.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI worktexts

Teacher Resources: TCI Kits

Guppies Galore: parents.

Formative Assessments

Students who understand the concepts are able to:

- Sort and classify natural phenomena using similarities and differences. (Clarification: Patterns are the similarities and differences in traits shared between offspring and their parents or among siblings, with an emphasis on organisms other than humans).
- Analyze and interpret data to make sense of phenomena using logical reasoning.
- Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. (Assessment does not include genetic mechanisms of inheritance and prediction of traits, and is limited to nonhumans.)
- Identify cause-and-effect relationships in order to explain change.
- Use evidence (e.g., observations, patterns) to support an explanation.

- Use evidence to support the explanation that traits can be influenced by the environment. Examples of the environment's affect on traits could include:
    - Normally tall plants that grow with insufficient water are stunted.
    - A pet dog that is given too much food and little exercise may become overweight.

What it Looks Like in the Classroom

Scientists sort and classify organisms based on similarities and differences in characteristics or traits. Students can easily observe external traits of animals such as body coverings; type, shape, and number of external features; and type, shape, and color of eyes. Similarly, they can observe external traits of plants such as the type of root system or the shape, color, and average size of leaves. The characteristics that organisms inherit influence how they look and how they function within their environment. As students observe parents and their offspring, they will notice that parents and offspring share many traits. As they observe a larger number of organisms from the same group, they will notice similarities and differences in the traits of individuals within a group. Students can observe similarities and differences in the traits of organisms and use these observations as evidence to support the idea that offspring inherit traits from parents, but these traits do vary within a group of similar organisms.

Sometimes, variations among organisms within a group are due to fact that individuals inherit traits from different parents. However, traits can also be influenced by an individuals' interaction with the environment. For example, all lions have the necessary inherited traits that allow them to hunt, such as sharp claws, sharp teeth, muscular body type, and speed. However, being a successful hunter also depends on the interaction that individual lions have with their parents and their environment. A lion cub raised in captivity without parents will have the same type of claws, teeth, and muscular body as all other lions, but it may never have the opportunity to learn to use its traits to hunt. Additionally, the environment can affect an organism's physical development. For example, any plant that lacks sufficient nutrients or water will not thrive and grow as it should. It will most likely be smaller in size, have fewer leaves, and may even look sickly. Likewise, too much food and lack of exercise can result in an overweight dog.

To investigate how the environment influences traits, students can plant the same type of seedling in different locations, which will provide variations of light, water, or soil. Data can be collected about rates of growth, height, and heartiness of the plant. The information gathered can be analyzed to provide evidence as to how the environment influenced the traits of the plant. As students read about, observe, and discuss these ideas, they learn that even though every organism inherits particular traits from its parents, the environment can have a marked effect on those traits and the development of others.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What are some plant life cycles?	4 days Core Route 5 Day Traditional Route
Lesson 2 What are some animal life cycles?	4 days Core Route 5 Day Traditional Route
Lesson 3 What are Inherited Traits?	4 days Core Route 5 Day Traditional Route
Unit 4 Review and Unit 4 Test	2 days
Additional Traditional Route Activities Unit 4 Project	2 days

You Solve It Unit 4 Performance Task Performance-Based Assessment	1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On-Level Reader: How do Living Things Change and Grow? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do Living Things Change and Grow? This reader shares the title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence and comprehension aids. It also includes response activities.

Enrichment: Surprising Adaptions: This high interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL:

Lesson 1: Help students identify cognates for the following words from the lesson: plant/planta, flow/flor, and fruit/fruta.

Lesson 2: Make a picture flashcard. Have students create a flashcard with the word metamorphosis on one side and a picture of an animal going through metamorphosis on one side and a picture of an animal going through metamorphosis on the back.

Lesson 3: A trait is a quality of something. You can use it to describe something. Have students describe a common classroom object (for example, chair).

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Lesson Plan 1							
Content Area: Life Cycles and Inherited Traits							
Lesson Title: What are some Plant Life Cycle						**Timeframe:**	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and digital text							
Equipment needed: TCI Kits							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: • Identify and recognize the common patterns in various life cycles of plants, and build models of a plant cycle. Understand that a given plant life cycle. Understand that a given plant's life	1. About this Image: Bess help pollinate plants and produce honey. They are critical to our ecosystems by helping keep plants alive. 2. Can You Explain It? Students are asked observe a field with a single dandelion that eventually turns into a field of multiple dandelions. 3. Exploration 1: So Many Stages: Identify and observe common patterns in the life cycle of flowering plants. Use this	• Say: Think about your daily routine. Order three things you have done so far in sequence. Discuss how the sequence of students daily events can be mostly similar, but vary slightly. • As students write an explanation to share with their friend, remind them to use language the shows

cycle always happens in the same order, and can be disrupted.	to build a flipbook model of a plant life cycle. 4. Exploration 2: How Do Life Cycle Differ? Examine and identify examples of differences to construct explanations about life cycles of different plants types, including patterns among different plant types, including patterns among different plant groups. 5. Exploration 3: Broken Cycles: Examine and discuss the kinds of impacts that can affect plant life cycles, analyzing what they learn to show clear patterns about the negative effect of interrupting plant life cycles. 6. Take it Further: Discover More 7. Lesson Check: Can you Explain It 8. Lesson Check: Lesson Roundup	they understand the difference between the life cycles of flowering and non-flowering plants. ● As students work to answer item 20, remind them to think about what information they already know. ● Have students think about flowering plants that make cones and their life stages. ● Lesson Check: Can you Explain It ● Lesson Check: Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS3-1) **Constructing Explanations and Designing Solutions** Use evidence (e.g., observations, patterns) to support an explanation. (3-LS3-2)	**LS3.A: Inheritance of Traits** Many characteristics of organisms are inherited from their parents. (3-LS3-1) Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2) **LS3.B: Variation of Traits**	**Patterns** Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1) **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (3-LS3-2)

	Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1) The environment also affects the traits that an organism develops. (3-LS3-2)	

Content Area: Third Grade Science
Unit Title: Organisms and Their Environment
Target Course/Grade Level: Unit 5 Grade 3
Unit Summary In this unit students will ● Explore inheritance and variation of traits in organisms. ● Discover how different organisms adapt to their environment. ● Identify the cause and effect of how organisms change when environments change. **Lesson 1: How Does the Environment Affect Traits** Students will explore cause-and-effect relationships between the environment and the traits of living things. They will use data and information they gather as evidence to support explanations. **Lesson 2: What are Adaptations** Students will recognize and explain that some organisms survive well in environments and other do not. They will analyze and interpret evidence to support the claim that any environment meets the needs of organisms to different degrees. **Lesson 3: How Can Organisms Succeed in Their Environments?** Students will investigate cause-and effect relationships about individual traits and the benefits of being a member of a group. Students will gather data to support a claim about the relationship between body color and survival. **Lesson 4: What Happens When Environments Changes?** Students will recognize that changes to habitats affect populations. They will examine changes that happen on different scales of time and construct explanations about how environmental changes affect organisms in an ecosystem. **Primary interdisciplinary connections:** *English Language Arts* Students need opportunities use informational text and other resources to gather information about organisms and the environments in which they live. Students should be able to ask and answer questions to demonstrate understanding of content-specific text and be able to cite evidence from the text to

support their thinking. For example, after reading an article about wolves, students ask and answer questions such as:

- ➢ How does being a member of a pack help wolves survive?
- ➢ What characteristics do wolves have that enable them to survive in their environment?
- ➢ What characteristics and resources does the environment have that allow wolves to survive and reproduce in that environment?

Students should be able to refer specifically to the text when answering questions, articulating the main idea and describing key details in their explanations. Students also need opportunities to write informative/explanatory texts and opinion pieces with supporting evidence to convey their ideas and understanding of cause-and-effect relationships between the environment and an organism's ability to survive and reproduce. For example, after reading text about a given animal, students should be expected to use key details and appropriate facts about that animal to compose an informative piece of writing that describes the animal's characteristics and behaviors that aid in its survival. Students should also have the opportunity to orally report on a given topic, sharing relevant facts and details while speaking clearly and at a reasonable pace.

Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-LS2-1), (3-LS4-3) **RI.3.1**
Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS4-3) **RI.3.2**
Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS2-1),(3-LS4-3) **RI.3.3**
Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-LS2-1), (3-LS4-3) **W.3.1**
Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (3-LS4-3) **W.3.2**
Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-LS4-3) **SL.3.4**

Mathematics

Students can model with mathematics by graphing the average number of organisms that make up a group among a variety of species. For example, some species live in small groups of six to eight members, while others live in groups that include thousands of organisms. Students will also reason abstractly and quantitatively as they describe and compare these groups and their ability to survive and reproduce in a given environment.

Reason abstractly and quantitatively **MP.2**

Model with mathematics. (3-LS2-1),(3-LS4-3) **MP.4**
Draw a scaled bar graph to represent a data set. **3.MD.B.3**
Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units- whole numbers, halves, or quarters. **3.MD.B.4**
Number and Operations in Base Ten. (3-LS2-1) **3.NBT**

21st century themes :

Global Awareness

Unit Rationale

Prior Learning

Kindergarten Unit 6: Earth's Resources

- In this unit, children will: identify air, water, rocks, and soil as natural resources; Use evidence to explain that living things need water, air, and resources from the land; describe how natural resources work as part of a system in the natural world; explain ways people use natural resources and the impact they have on the environment; design and communicate solutions to overcome negative impacts on the environment.

Grade 1 Unit 5: Living Things and Their Young:

- In this unit children will: compare young plants with parent plants; observe patterns to explain how plants of the same kind are alike and different; compare young animals with parent animals; observe patterns to explain how animals of the same kind are alike and different; describe how plants and animals respond to their environments to meet their needs; describe how behavior patterns of parents and offspring help offspring survive.

Grade 2 Unit 1: Relationships in Habitats

- In this unit children will: investigate what plats and animals need to live and grow; develop models to show how plants depend on animals; explore environments to identify observable patterns; observe plants and animals to compare diversity of life in water habitats; observe plants and animals to compare diversity of life in land habitats.

Future Learning

Grade 6 Unit 2: Matter and Energy in Organisms and Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

- Growth of organisms and population increases are limited by access to resources.
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Grade 7 Unit 8: Earth systems

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

Grade 8 Unit 2: Selection and Adaptation

- Natural selection leads to the predominance of certain traits in a population, and the suppression of others.
- In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.
- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
3-LS2-1	Construct an argument that some animals form groups that help members survive.
3-LS4-3	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. *[Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]*

Unit Essential Question

Part A: In a particular habitat, why do some organisms survive well, some survive less well, and some not survive at all?

Unit Enduring Understandings

Part A:

- Cause-and-effect relationships are routinely identified and used to explain change.
- Knowledge of relevant scientific concepts and research findings is important in engineering.

- For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.
- Organisms and their habitat make up a system in which the parts depend on each other.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI teacher edition & work text

Maneuvers: In this activity, students create a physical model showing how muskoxen work together as a group to protect their young from predators (wolves).

Video: In this short video, Arctic wolves attack a musk ox calf on Canada's Ellesmere Island, but the herd rushes to its defense by forming a defensive circle around the calves.

<u>Insects That Work Together</u>: This nonfiction book summarizes how some insects work together to increase their chances of survival. Details are provided on four types of insects: honeybees, hive wasps (hornets, yellow jackets, and paper wasps), termites, and ants. A short section on insect migration and building a hive model are also included.

<u>Battle at Kruger: Water Buffalo Save Calf from Lions Video</u>: This short video captures student imagination and elicits ideas about how groups of organisms work together for survival. The video contains real footage of a pack of lions attack on a water buffalo calf. The footage filmed by

amateur tourists features a surprising plot twist (featuring a crocodile), and exciting finale with the water buffalo herd rescues the calf and chases off the lions.http://ngss.nsta.org/Resource.aspx?ResourceID=273

A Walk in the Desert (Biomes of North America):This nonfiction text describes the climate, soil, plants and animals of the North American deserts. It provides detailed information on how plants and animals adapt and survive there.

A Walk in the Deciduous Forest (Biomes of North America): This nonfiction text describes the climate, soil, plants and animals of the North American deciduous forests. It provides detailed information on how plants and animals adapt and survive there.

A Walk in the Rain Forest (Biomes of North America): This nonfiction text describes the climate, soil, plants and animals of the North American rain forests. It provides detailed information on how plants and animals adapt and survive there.

A Walk in the Prairie (Biomes of North America) :This nonfiction text describes the climate, soil, plants and animals of the North American prairies. It provides detailed information on how plants and animals adapt and survive there.

A Walk in the Tundra (Biomes of North America): This nonfiction text describes the climate, soil, plants and animals of the North American tundra. It provides detailed information on how plants and animals adapt and survive there.

A Walk in the Boreal Forest (Biomes of North America): This nonfiction text describes the climate, soil, plants and animals of the North American boreal forests. It provides detailed information on how plants and animals adapt and survive there.

A Journey into the Ocean (Biomes of North America):This nonfiction text describes the organisms and features of the ocean environment. It provides detailed information on how plants and animals adapt and survive there.

Journey Into an Estuary (Biomes of North America):

This nonfiction text describes the features and plants and animals of North American estuaries. It provides detailed information on how plants and animals adapt and survive there

Formative Assessments

Students who understand the concepts are able to:

- Identify cause-and-effect relationships in order to explain change.
- Construct an argument with evidence.

- Construct an argument with evidence (e.g., needs and characteristics of the organisms and habitats involved) that in a particular habitat, some organisms can survive well, some can survive less well, and some cannot survive at all.

What it Looks Like in the Classroom

Organisms and their habitats make up a system in which they are interdependent. Environmental factors affect the growth and survival of every type of organism, and organisms in turn affect the environment. The focus of this unit of study is identifying cause-and-effect relationships between the environment and organisms' ability to survive and reproduce.

In this unit, students first learn that all organisms have a variety of behaviors and traits that enable them to survive. One of these behaviors includes forming groups. Groups serve different functions and can vary dramatically in size. Animals may form groups to obtain food, to defend themselves, and/or to cope with changes in their environment. Students should have opportunities to conduct research on animals that form groups in order to understand how being part of a group is beneficial to survival and reproduction. Students might begin with studying animals that are indigenous to the local environment (e.g., squirrels, coyotes, deer, birds, or fish), and then investigate other animals of interest, such as (but not limited to) lions, sea turtles, or penguins. For each animal that is studied, students should identify the social structure of the group and how this structure supports individuals in their need to obtain food, defend themselves, and reproduce.

Topics to focus on might be the roles of males and females within a group as well as the interactions between parents and offspring. For example, within some groups of animals, the offspring leave the nest or pack early while others remain for longer periods of time. Those that stay within the group for longer periods of time may do so because of the benefits provided by the group structure. As students compare group structures of different animals and the functions that define each, they should also think about how the size of the group and the roles of individuals within the group affect the animals' overall ability to obtain food, defend themselves, and reproduce. Students will construct arguments with evidence, using cause-and-effect relationships to show why some animals form groups and how this is advantageous to survival and reproduction.

In this unit, students also learn that for any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. As students explore the components of a given environment, they learn that each environment has a particular climate as well as finite sources of water and space. Each environment will support organisms (both plants and animals) with structures and behaviors that are best suited to the climate and resources available. Students will need opportunities to investigate the organisms (plants and animals) that live in certain environments and determine what traits and behaviors allow these organisms to survive and reproduce in that environment. In addition, students should identify some examples of organisms that would survive less well, or not at all, in that environment, and give evidence to support their thinking. Students construct arguments with evidence, using cause-and-effect relationships, to show how the needs and characteristics of the organisms are not well suited for the given environment.

Lesson Plans

Lesson	Timeframe
Lesson 1 How Does the Environment Affect Traits?	4 Days Core Route 5 Days Traditional Route
Lesson 2	4 Days Core Route

What Are Adaptations?	5 Days Traditional Route
Lesson 3 How Can Organisms Succeed in Their Environment?	4 Days Core Route 5 Days Traditional Route
Lesson 4 Engineer It: What Happens when Environments Change?	4 Days Core Route 5 Days Traditional Route
Unit 5 Review and Unit 5 Test	2 Days
Additional Traditional Route Activities Unit 5 Project You Solve it Unit 5 Performance Tasks Performance-Based Assessment	 2 Days 1 Day 1 Day 1 Day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On-Level Reader: How Are Living Things Connected to Their Ecosystems: This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Are Living Things Connected to Their Ecosystems: This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the test is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Rainforest Adventure: This high interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes responses activities.

ELL

Lesson 1: Remind students that an environment includes everything that affects a living thing. Have them look ahead at the images in this lesson to identify some parts of an environment and ways the environment affects living things.

Lesson 2: Tell students that a habitat can be thought of as an organism's home. It is the place that meets an organism's needs.

Lesson 3: Have students make a vocabulary card on which they record the definition of the term adaptation in their primary language. Encourage them to refer to the card as needed.

Lesson 4: Ask: What kind of plant populations are found in your area? What kind of animal populations are found in your area?

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: <u>All Standards, All Students</u>/<u>Case Studies</u> for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Lesson Plan 1							
Content Area: Organisms and Their Environments							
Lesson Title: How Does the Environment Affect Traits?						**Timeframe:** 4 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI Online Tools							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will user evidence to construct an explanation of cause-and-effect relationship between the environment and the inheritance and variation of traits of living things.	1. About this Image: The zebra finch is native to Australia and islands of Southeast Asia. This particular zebra finch is a male. 2. Can you Explain It? Students are asked to record their initial thoughts about the differences between the pictures trees. 3. Exploration 1 Plants and he Environment: Examine and identify examples of cause-and-effect relationships to construct explanations from obtaining information about characteristics and variation of traits of plants that are affected by the environment. 4. Exploration 2 Animals and the Environment: Examine and identify examples of cause-and effect relationships to construct explanations about characteristics and traits of animals that are affected by the environment. 5. Take it Further: Discover More 6. Lesson Check: Can you explain it? 7. Lesson Roundup	● As students write an explanation to share with their friend, remind them to use language that describes cause and effect relationships. Encourage them to use words and phrases such as results in, leads to, causes and effects. ● Cause and Effect-Probing Question: Tell students to imagine that scientists find a group of green-feathered flamingos on a remote island. Ask: How could the scientists find out if this trait is inherited or due to the environment, or affected by both? ● Lesson Check: Can you explain it? ● Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Construct an argument with evidence, data, and/or a model. (3-	**LS2.D: Social Interactions and Group Behavior** Being part of a group helps animals obtain food, defend	**Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (3-LS2-1),(3-

LS2-1) Construct an argument with evidence. (3-LS4-3)	themselves, and cope with changes. Groups may serve different functions and vary dramatically in size *(Note: Moved from K–2)*. (3-LS2-1) **LS4.C: Adaptation** For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (3-LS4-3)	LS4-3)

Content Area: Third Grade Science
Unit Title: Fossils
Target Course/Grade Level: Unit 6 Grade 3

Unit Summary

In this Unit, students will:

- Explore Fossils
- Discover what fossils can tell us about animals that lived long ago

Lesson 1: What is A Fossil: Students will analyze and interpret data to make sense of phenomena and identify some types of fossils. By observing phenomena and consistent patterns in nature, they will explain that fossils represent plants and animals from the past. Students use evidence provided by fossils represent plants and animals from the past. Students use evidence provided by fossils to determine what types of organisms and habitats existed long ago.

Lesson 2: What Do Fossils Tell Us About the Past? Students are expected to analyze fossils to discover patterns among different organisms, such as organisms, such as organisms that live in water and those that live on land. Students will also be required to identify fossils from organisms that no longer exist on Earth to modern-day animals.

Primary interdisciplinary connections:

English Language Arts

Students use content-specific print and digital sources such as books, articles, and other reliable media to observe and analyze fossils, and they use their observations to describe the types of organisms that lived in the past and characteristics of the environments in which they lived. When using these types of resources, students should determine the main idea and key details and use this information as evidence to support their thinking. They should take notes as they read and observe and use their notes as they write opinion and/or informational/explanatory pieces that convey information and ideas about organisms, both past and present, and their environments. As students discuss and write about the effects of a changing environment on organisms, they should ask and answer questions to demonstrate understanding and should cite evidence from their observations or from texts to support their thinking. Third graders should also have the opportunity to use their work to report on their findings about the effects of a changing environment on organisms living today, as well as those that lived in the past. Students should use appropriate facts and relevant descriptive details as they report out, speaking clearly at an understandable pace.

Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-LS4-4) RI.3.1
Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS4-1),(3-LS4-4) RI.3.2
Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS4-1),(3-LS4-4) RI.3.3
Conduct short research projects that build knowledge about a topic. **W.3.7**
Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-LS4-1) **W.3.8**
Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-LS4-4) **SL.3.4**

Mathematics

In order to connect the CCSS for mathematics, students generate measurement data using appropriate tools, such as rulers marked with halves and fourths of an inch, and show the data by making a line plot where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. For example, students could make a line plot to show the length of a variety of fossils, then use that data, as well as other observational data, to make comparisons to modern-day organisms and to support their thinking. Questions such as the ones below might be used to guide students' analysis of data.

ü Do any of the fossilized organisms resemble organisms that we see today? In what ways?

Can you make any inferences about a fossilized organism's way of life based on size, body style, external features, or other similarities to modern-day organisms? (Where might it have lived? What might it have eaten? How might it have moved? Could it have been part of a group?)

Reason abstractly and quantitatively. (3-LS4-1),(3-LS4-4), (3-5-ETS1-1) MP.2
Model with mathematics. (3-LS4-1),(3-LS4-4), (3-5-ETS1-1) MP.4
Use appropriate tools strategically. (3-LS4-1), (3-5-ETS1-1) MP.5
Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch.

Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. (3-LS4-1) 3.MD.B.4

21st century themes

Global Awareness

Unit Rationale

Prior Learning

Kindergarten Unit 6: Earth's Resources

- In this unit, children will: identify air, water, rocks, and soil as natural resources; Use evidence to explain that living things need water, air, and resources from the land; describe how natural resources work as part of a system in the natural world; explain ways people use natural resources and the impact they have on the environment; design and communicate solutions to overcome negative impacts on the environment.

Grade 2 Unit 1: Relationships in Habitats

- In this unit children will: investigate what plats and animals need to live and grow; develop models to show how plants depend on animals; explore environments to identify observable patterns; observe plants and animals to compare diversity of life in water habitats; observe plants and animals to compare diversity of life in land habitats.

Future Learning

Grade 4 Unit 6: Changes to Earth's Surface

- In this unit, children will: explore how Earth has been shaped by water and other factors; discover how people map Earth's surface; learn about the patterns we can see from maps.

Grade 6 Unit 2: Matter and Energy in Organisms and Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Grade 6 Unit 3: Interdependent Relationships in Ecosystems

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

Grade 7 Unit 8: Earth Systems

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.
- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

Grade 8 Unit 1: Evidence of Common Ancestry and Diversity

- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.
- Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

Grade 8 Unit 2: Selection and Adaptation

- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Grade 8 Unit 4: Human Impacts

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Learning Targets

Standards

NJSLS-S#	Performance Expectation
3-LS4-1	Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. *[Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.]* [Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.]

3-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* *[Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.]* [Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]*
3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Unit Essential Question

Part A: What do fossils tell us about the organisms and the environments in which they lived?

Part B: What happens to the plants and animals when the environment changes?

Unit Enduring Understandings

Part A:

- Observable phenomena exist from very short to very long periods of time.
- Science assumes consistent patterns in natural systems.
- Some kinds of plants and animals that once lived on Earth are no longer found anywhere.
- Fossils provide evidence about the types of organisms that lived long ago, and also about the nature of their environments

Part B:

- A system can be described in terms of its components and their interactions.
- People's needs and wants change over time, as do their demands for new and improved technologies.
- Populations live in a variety of habitats, and change in those habitats affects the organisms living there.
- When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, others move into the transformed environment, and some die.
- Possible solutions to a problem are limited by available materials and resources (constraints).
- The success of a designed solution is determined by considering the desired features of a solution (criteria).
- Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit

- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS.

Equipment needed: TCI Kits

Teacher Resources: TCI teacher edition and work text

<u>Mass Environmental Change</u>: In this lesson, students explore what happens to organisms when they cannot meet their needs due to changes in the environment. They categorize scenario cards representing different changes to an environment, then discuss in a whole group. Using what they have learned, they write about how changes to the environment can affect organisms. The resource link takes you to a full unit titled Effects of Changes in an Environment on the Survival of Organisms, of which Mass Environmental Change is a lesson.

Formative Assessments

Students who understand the concepts are able to:

- Observe that phenomena exist from very short to very long periods of time.
- Analyze and interpret data to make sense of phenomena using logical reasoning.
- Analyze and interpret data from fossils (e.g., type, size, distributions of fossil organisms) to provide evidence of the organisms and the environments in which they lived long ago. (Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.) Examples of fossils and environments could include:
    - Marine fossils found on dry land;
    - Tropical plant fossils found in Arctic areas; or
    - Fossils of extinct organisms.
- Describe a system in terms of its components and interactions.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of a problem.
- Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (Assessment is limited to a single environmental change and does not include the greenhouse effect or climate change.) Examples of environmental changes could include changes in
    - Land characteristics,

    - Water distribution,
    - Temperature,
    - Food, or
    - Other organisms.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and that includes several criteria for success and constraints on materials, time, or cost.
- Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.

What it Looks Like in the Classroom

In this unit, students will study fossils or organisms that lived long ago. Students will use that understanding to make a claim about the merit of a solution to problem created by some environmental change. (Assessment is limited to one change.) Additionally, they will learn that solutions are limited by available resources (constraints), and that the success of a solution is determined by considering the desired features of a solution (criteria). This process is outlined in greater detail in the previous section.

Students gather evidence from fossils to learn about the types of organisms that lived long ago and the nature of their environments. As they learn about organisms from long ago, they come to understand that when the environment changes, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.

To begin the progression of learning in this unit, students need multiple opportunities to study fossils. If actual fossils are not available, pictures and diagrams found in books and other media sources can be used. Students should observe fossils of a variety of organisms, both plant and animal, and they should observe diagrams of fossils within layers of rock. As students examine each fossil, they should be asked to identify whether the organism lived on land or in water and to give evidence to support their thinking. As students examine diagrams of fossils in layers of rock, they should be asked to identify the type of environment that existed when the layers of rock were formed. Students should consider the types of organisms that are fossilized in the rock layers in order to provide evidence to support their thinking.

If the type of environment in which the fossil was found is different from the type of environment that might have existed when the organism lived (e.g., marine fossils found on dry land, or tropical plant fossils found in Arctic areas), this would provide the opportunity to ask students to think about the types of changes that might have occurred in the environment and what effects these changes might have had on the organisms that lived in the environment as it changed over time. As students observe and analyze fossils, they learn that fossils provide evidence about the types of organisms that lived long ago and the nature of their environments. They also learn that some kinds of plants and animals that once lived on Earth are no longer found anywhere, and that this could be a result of changes that occurred in the environment.

During this unit, students also learn that populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms will survive and reproduce, some will move to new locations, others will move into the transformed environment, and others will die.

Students will need the opportunity to engage in a portion of the engineering design process in order to investigate the merit of solutions to problems caused when the environment changes. This process should include the following steps:

- ➢ Students brainstorm a list of environmental changes that might affect the organisms that live in the environment. This could include changes in

- Land characteristics,
  - Water distribution,
  - Temperature,
  - Food,
  - Other organisms.
- ➢ As a class or in small groups, students define a problem that occurs when the environment changes. For example, if the distribution of water changes, the available water may no longer support the types of organisms that are found in the environment.
- ➢ As a class, determine criteria that can be used to weigh a possible solution's viability. For example, the response (solution) to the problem should not result in the extinction of a species.
- ➢ Small groups conduct research, using books and other reliable media sources, to determine possible solutions/ways in which organisms can solve the problem. For example, if the available water supply is no longer adequate for the organisms in the environment, there are a number of ways in which organisms respond (i.e., solve the problem); these include:
  - Plants do not grow as large as before (shorter plant, smaller or fewer leaves);
  - Fewer seeds germinate, thereby resulting in a smaller population;
  - Herd animals may move to another environment where the water supply is adequate;
  - Populations of some species may decrease, either through lower rate of reproduction or death;
  - Some populations completely die out; or
  - Other organisms (plants and animals) that require less water to survive may move into the environment.
- ➢ Students make claims about the merit of each of the various responses (solutions) by organisms based on how well the responses meet criteria; students use research data as evidence to support their thinking.

At every stage, communicating with peers is an important part of the design process. Students should identify cause-and-effect relationships throughout the process and use these relationships to explain the changes that might occur in the environment and in the populations of organisms that live there.

Lesson Plans

Lesson	Timeframe
Lesson 1 What is a Fossil?	4 Days Core Route 5 Days Traditional Route
Lesson 2 What Do Fossils Tell Us About the Past?	4 Days Core Route 5 Days Traditional Route
Unit 6 Review and Unit 6 Test	2 days
Additional Traditional Route Lessons Unit 6 Project You Solve It Unit 6 Performance Task Unit 6 Performance-Based Assessment	 2 days 1 day 1day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On-Level Reader: How are Living Things Connected to their Ecosystems? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Are Living Things Connected to Their Ecosystems? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

ELL

Lesson 1: If one or more animals in a species still exist, that species is not extinct. How can you remember the difference? Look for the word is inside the word exist. If it is, it exists.

Lesson 2: The word aquatic is the same in both Spanish and English. Translations of other languages include: Armenian jrayin; Croatian: vodeni; Vietnamese thuy san.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Lesson Plan 1							
Content Area: Fossils							
Lesson Title: What is a Fossils?						**Timeframe:** 4 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they live long ago. Students will be able to do the following: define fossil, identify some types of fossils, explain that fossils represent plants and animals from the past, & recognize that fossils take substantial time to form, this, are very old.	1. About this Image: Hundreds of millions of years ago, the oceans teemed with life that was different from and yet similar to the life that exists in the oceans today. 2. Can you Explain It? Students are asked to record their initial inferences of how C. Megalodon lived long ago. Many students will recognize the jaws and teeth as belonging to a shark. 3. Exploration 1: What are Fossils? Analyze and interpret evidence of organisms that lived long ago and look for patterns in their fossils. 4. Exploration 2: Clues from Fossils: Analyze and interpret fossil evidence of organism that love long ago that shows the patterns of life in the past. 5. Take it Further: Discover More 6. Lesson Check: Can you explain it? 7. Lesson Check: Lesson Roundup	● Analyzing and Interpreting Data: Help students distinguish between individual organisms that once were living and species that have gone extinct. ● Constructing Explanations: Ask: How do scientists know they have discovered a fossil from a plant or animal that is now extinct. ● Lesson Check: Can you explain it? ● Lesson Check: Lesson Roundup

Differentiation
Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS4-1) **Engaging in Argument from Evidence** Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (3-LS4-4) **Asking Questions and Defining Problems** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)	**LS4.A: Evidence of Common Ancestry and Diversity** Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (3-LS4-1) Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. (3-LS4-1) **LS4.D: Biodiversity and Humans** Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** · When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.*(secondary to 3-LS4-4)* **ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the	**Scale, Proportion, and Quantity** Observable phenomena exist from very short to very long time periods. (3-LS4-1) **Systems and System Models** A system can be described in terms of its components and their interactions. (3-LS4-4) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Engineering, Technology, and Science on Society and the Natural World** Knowledge of relevant scientific concepts and research findings is important in engineering. (3-LS4-4)**Influence of Science, Engineering, and Technology on Society and the Natural World** · People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) ***Connections to Nature of Science*** **Scientific Knowledge Assumes**

	desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)	**an Order and Consistency in Natural Systems** Science assumes consistent patterns in natural systems. (3-LS4-1)

Content Area: Third Grade Science
Unit Title: Weather and Patterns
Target Course/Grade Level: Unit 7 Grade 3

Unit Summary

In this unit, students will…

- Explore how weather is predicted and measured
- Learn about the difference between weather and climate
- Identify the impact of severe weather on society and nature

Lesson 1: How Can we Predict the Weather? Students will learn how scientists measure and record data about weather. They will learn to interpret weather maps and graphs of weather data and examine patterns of weather.

Lesson 2: How is Weather Measured? Students will analyze and interpret data by recording patterns of the weather to make weather predictions. They will represent weather data tables and bard graphs to reveal patterns that indicate relationships.

Lesson 3: What are Some Severe Weather Impacts? Students will see cause and effect patterns of weather and learn how humans can use that data and technology to lessen the impacts of weather-related hazards. Students will analyze and interpret data to make a claim about a solution against criteria and constraints. They use this learn the important of improving existing technologies to lessen the impacts of severe weather.

Lesson 4: What are Some Types of Climates? Students will obtain and analyze information about weather patterns in several climates zones and investigate how patterns help scientists understand Earth's climate and make predictions.

Primary interdisciplinary connections:

English Language Arts/Literacy

As students engage in the science described in this unit of study, they use books and other reliable media resources to collect weather and climate information for a given region. They compare information found in two different texts and use information to answer questions about weather and climate. To integrate writing, students can take brief notes as they conduct research and sort evidence into provided categories. Opinion pieces and short research projects should be included to build knowledge about weather and climate.

Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-ESS2-2) **RI.3.1**
Use information from Illustrations **RI.3.7**
Describe Logical Connections **RI.3.8**
Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-ESS3-1) **W.3.1**
Conduct short research projects that build knowledge about a topic. (3-ESS3-1) **W.3.7**
Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. **W.3.8**
Presentation of knowledge and Ideas Report on a topic or text, tell a story, or recount an experience with appropriate facts or relevant, descriptive details, speaking clearly at an understandable pace. **SL.3.4**

Mathematics

Like literacy, mathematics is integrated in a variety of ways. Students use appropriate tools and units of measure when collecting and recording weather and climate data. They model with mathematics when organizing data into scaled bar graphs, pictographs, and tables. Throughout the unit, students reason abstractly and quantitatively as they analyze and compare weather data. They will use that information to answer questions and solve multistep problems.

Reason abstractly and quantitatively. (3-ESS2-1),(3-ESS2-2),(3-ESS3-1) **MP.2**
Model with mathematics. (3-ESS2-1),(3-ESS2-2), (3-ESS3-1) **MP.4**
Use appropriate tools strategically. (3-ESS2-1) **MP.5**
Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. (3-ESS2-1) **3.MD.A.2**
Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step “how many more” and “how many less” problems using information

presented in bar graphs. (3-ESS2-1) **3.MD.B.3**

21st century themes:

Global Awareness & Civic Literacy

<u>Unit Rationale</u>

Prior Learning

Kindergarten Unit 5: Weather

- In this unit children will: use observations to describe different kinds of weather; explore observable weather patterns; use patterns as evidence to describe weather conditions; ask questions to find out about different kinds of weather; & explore technologies meteorologists use to predict weather and severe weather conditions.

Future Learning

Grade 5 Unit 6: Earth Systems

- In this unit students will: explore the hydrosphere, geosphere, biosphere, and atmosphere, & learn how Earth's systems interact.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
3-ESS2-1	Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. *[Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.]*
3-ESS2-2	Obtain and combine information to describe climates in different regions of the world.
3-ESS3-1	Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. *[Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]*

Unit Essential Question

Part A: *Can we predict the kind of weather that we will see in the spring, summer, autumn, or winter?*

Part B: *How can climates in different regions of the world be described?*

Part C: *How can we protect people from natural hazards such as flooding, fast wind, or lightening*

Unit Enduring Understandings

Part A:

- Patterns of change can be used to make predictions.
- People record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.

Part B:

- Patterns of change can be used to make predictions.
- Climate describes the range of an area's typical weather conditions and the extent to which those conditions vary over years.

Part C:

- Cause-and-effect relationships are routinely identified, tested, and used to explain change.
- Science affects everyday life.
- People's needs and wants change over time, as do their demands for new and improved technologies.
- A variety of natural hazards result from natural processes (e.g., *flooding, fast wind, or lightening).*
- Humans cannot eliminate natural hazards but can take steps to reduce their impacts.
- Engineers improve technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones).
- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria).
- Different proposals for solutions can be compared on the basis of how well each one meets the criteria for success or how well each takes the constraints into account.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response

items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

Weather Science content for Kids and Teens: The National Weather Service has several education resources available at this website.

NOAA Education Resources: The National Oceanic and Atmospheric Administration (NOAA) provides education resources at this website.

(Note: Students in grades Kindergarten, 4, and 5 make sense of weather and climate. Each model science unit related to Weather and Climate will include these two websites. Therefore, it is important that teachers of science in these grades to collaborate to prevent redundancy in the K-5 weather and climate curriculum.)

Formative Assessments

Students who understand the concepts can:

- Make predictions using patterns of change.
- Represent data in tables, bar graphs, and pictographs to reveal patterns that indicate relationships.
- Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. (Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.) Examples of data could include:
  - Average temperature
  - Precipitation
  - Wind direction
- Make predictions using patterns of change.
- Obtain and combine information from books and other reliable media to explain phenomena.
- Identify and test cause-and-effect relationships to explain change.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.
- Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. Examples of design solutions to weather-related hazards could include:
  - Barriers to prevent flooding
  - Wind-resistant roofs
  - Lightning rods
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and include several criteria for success and constraints on materials, time, or cost.
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

What it Looks Like in the Classroom

In this unit of study, students organize and use data to describe typical weather conditions expected during a particular season. They notice patterns as they analyze and interpret weather data, and they use this data to determine cause-and-effect relationships. By applying their understanding of weather-related hazards, students make claims about the merit of a design solution that reduces the impacts of such hazards, using evidence to support their claims.

Initially, students learn that scientists record patterns of weather across different times and locations in order to make predictions about future weather conditions. To understand how scientists use weather data, students need time, tools, and resources (both print and digital) to collect weather data. They can use a variety of tools (e.g., thermometers, anemometers, rain gauges) to collect firsthand data and multiple resources (e.g., Weather Bug, NOAA) to gather weather data that has been collected over longer periods of time. Multiple units of measurement (e.g., m, cm, °C, km/hr) should be used when recording weather conditions such as temperature, types and amounts of precipitation, and wind direction and speed. To organize the data they collect, students create graphical displays (bar graphs and pictographs) and tables. Once a sufficient amount of data is collected, students need opportunities to analyze data, looking for patterns of change that can be used to make predictions about typical weather conditions for a particular region and time of year. As they collect and analyze data over time, students learn that certain types of weather tend to occur in a given area and that combinations of weather conditions lead to certain types of weather (e.g., it is always cloudy when it rains or snows, but not all types of clouds bring precipitation).

Weather is a combination of sunlight, wind, precipitation, and temperature in a particular region at a particular time. Climate describes the range of an area's typical weather conditions and the extent to which those conditions vary over the years. After learning to analyze and use data to make weather predictions, students use long-term patterns in weather to describe climates in a variety of regions around the world. To accomplish this, students use books and other reliable media to obtain information and weather data collected over a long period of time for a variety of regions. With guidance, students analyze the available data and information in order to describe the climate (e.g., average temperatures, average precipitation, average amount of sunlight) in each region.

Science affects everyday life. Whenever people encounter problems, engineers use scientific knowledge to develop new technologies or improve existing ones to solve our day-to-day problems.

After studying weather and climate, students investigate how weather-related hazards can be reduced. Students learn that there are a variety of natural hazards that result from severe weather. Severe weather, such as high winds, flooding, severe thunderstorms, tornados, hurricanes, ice or snowstorms, dust storms, or drought, has the potential to disrupt normal day-to-day routines and cause damage or even loss of life. While humans cannot eliminate natural hazards, they can take steps to reduce their impact. Students can use trade books and media resources to research types of severe weather hazards and their effects on communities and find examples of how communities solve problems caused by severe weather. As a class, students determine the types of severe weather that are common to the local area and discuss the effects on the community. (Define the problem.) In pairs or small groups, students can research ways that the community reduces the effects of severe weather. (Determine ways in which the problem is solved.) Given criteria, groups can determine how well each solution reduces the effects of severe weather. Groups can also prepare a presentation that

- Describes the solution that the group thinks is best for reducing the effects of a given type of weather hazard,
- Lists evidence to support their thinking, and
- Lists at least one possible constraint, such as materials, time, or cost.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 How is Weather Measured?	4 Days Core Route 5 Days Traditional Route
Lesson 2 How Can We Predict Weather?	4 Days Core Route 5 Days Traditional Route
Lesson 3 Engineer It-What are Some Severe Weather Impacts?	4 Days Core Route 5 Days Traditional Route
Lesson 4 What are Some Types of Climates?	4 Days Core Route 5 Days Traditional Route
Unit 7 Review and Unit 7 Test	2 days
Additional Traditional Route Activities Unit 7 Project You Solve It Unit 7 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: How Can We Describe Weather? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Can We Describe Weather? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Double Danger: Thunderstorms and Tornadoes: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities. **ELL** **Lesson 1:** Have students think or words related to the weather tools. For instance, thermos is similar to the word thermometer **Lesson 2:** Have students describe daily weather conditions with prompting. **Lesson 3:** Bring in various photos of severe weather damages and encourage students to identify and discuss the hazards. **Lesson 4:** Remind students that climate refers to usual weather patterns over a period of time. For students to understand climate, they will need to understand weather.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1	
Content Area: Weather and Patterns	
Lesson Title: How Is Weather Measured	**Timeframe:** 4 days

Lesson Components							
<u>21st Century Themes</u>							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy	X	Civic Literacy		Health Literacy
<u>21st Century Skills</u>							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● To observe and measure weather to obtain information about expected weather patterns; analyze weather data to draw conclusions about and to predict weather.	1. About this Image: Lightning is generated in the same way static electricity is generated. 2. Can you Explain It? Students may need prompting to think about different ways of finding a weather forecast. 3. Exploration 1 What's It Like Out? Students analyze aspects of weather that can be observed and recorded, including temperature, rain or snow, wind, and clouds. They learn that weather follows patterns. 4. Exploration 2 Weather Gadgets: Study instruments used to record weather conditions in a table. Analyze and interpret the measurements and describe patterns. 5. Exploration 3: Weather Everywhere: Learn that satellites record weather conditions. Study weather maps to analyze and interpret data and find patterns in the weather. 6. Take it Further: Discover More 7. Lesson Check: Can You explain it? 8. Lesson Check: Lesson roundup	● Describing: It may help to remind students that weather is in the atmosphere. ● Students need to identify the information they need to acquire and summarize here. ● Analyzing and Interpreting Data: ask: How is comparing bars on bar graphs similar and different to comparing number ● Lesson Check: Can You explain it? ● Lesson Check: Lesson roundup

Differentiation
Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided TCI work text, teacher online access, and equipment kits. •

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> Plan and conduct investigations collaboratively to produce evidence to answer a question. (1-PS4-1),(2-LS2-1) **Analyzing and Interpreting Data** Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships. (3-ESS2-1) **Engaging in Argument from Evidence** Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (3-ESS3-1) **Obtaining, Evaluating, and Communicating Information** Obtain and combine information from books and other reliable media to explain phenomena. (3-ESS2-2)	**ESS2.D: Weather and Climate** Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1) Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2) **ESS3.B: Natural Hazards** A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) *(Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)*	**Patterns** Patterns of change can be used to make predictions. (3-ESS2-1),(3-ESS2-2) **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1) -------------------------------------- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones). (3-ESS3-1) -------------------------------------- ***Connections to Nature of***

		Science **Science is a Human Endeavor** Science affects everyday life. (3-ESS3-1)

Grade 4

Content Area: Science **Grade Level: 4th Grade**
First Marking Period - Pacing Guide ● **Unit 1: Engineering and Technology** **Core Route 11 days (19 days traditional Route)** **NJ-SLS-S: 3-5-ETS1-1, 3-5-ETS1-2, & 3-5-ETS1-3** ● **Unit 2: Energy** **Core Route 11 days (19 days Traditional Route** **NJ-SLS-S: 4-PS3-1, 4-PS3-2, & 4-PS3-3, & 4-PS3-4**
Second Marking Period - Pacing Guide ● **Unit 3: Waves and Information Transfer** **Core Route 11 days (19 days traditional Route)** **NJ-SLS-S: 4-PS4-1, 4-PS4-2, & 4-PS4-3** ● **Unit 4: Plant Structure and Function** **Core Route 8 days (15 days traditional Route)** **NJ-SLS-S: 4-LS1-1**
Third Marking Period - Pacing Guide ● **Unit 5: Animal Structure and Function** **Core Route 11 days (19 days traditional Route)** **NJ-SLS-S: 4-LS1-1 & 4-LS1-2** ● **Unit 6: Changes to Earth's Surface** **Core Route 14 days (23 days traditional Route)** **NJ-SLS-S: 4-ESS2-1 & 4-ESS2-2**
Fourth Marking Period - Pacing Guide ● **Unit 7: Rock and Fossils** **Core Route 11 days (19 days traditional Route)**

NJ-SLS-S: 4-ESS1-1

Unit 8: Natural Resources and Hazards
Core Route 14 days (23 days traditional Route)
NJ-SLS-S: 4-ESS3-1 & 4-ESS3-2

Content Area: Fourth Grade Science
Unit Title: Engineering and Technology
Target Course/Grade Level: Unit 1 Grade 4

Unit Summary

In this unit students will….

- Explore how engineers define problems and solutions.
- Learn about the importance of prototypes.
- Use models to examine how prototypes are tested and improved.

Lesson 1: Students will learn introductory concepts of engineering and technology. They will explore engineering problems and develop solutions based on criteria and constraints. By investigating problems and solutions, students will gain deeper understanding of engineering and technology's impacts on society.

Lesson 2: Students will explore the ways engineers come up with solutions to problems. They will learn about how these solutions are then integrated into technology that affects society ad the environment. They will come up with explanations and design solutions of their own and learn about the processes that engineers go through, including using constraints and criteria.

Lesson 3: Students will plan, design, and test possible solutions for a prototype to determine which design best solves a problem within the given criteria and constraints. Students will then identify failure points or difficulties with a design and suggest and implement changes that improve it. Students learn that engineers must communicate in order to share observations, gain insight, and optimize future solutions and designs.

Primary interdisciplinary connections:

English Language Arts

Students conduct research that builds their understanding of energy transfers. They will gather relevant information from their investigations and from multiple print or digital sources, take notes, and categorize their findings. They should use this information to construct explanations and support their thinking.

Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2) **RI.5.1**
Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently **RI.5.7**

Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2) **RI.5.9**
Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1),(3-5-ETS1-3) **W.5.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-1),(3-5-ETS1-3) **W.5.8**
Draw evidence from literary or informational texts to support analysis, reflection, and research. (3-5-ETS1-1),(3-5-ETS1-3) **W.5.9**

Mathematics

Students can:

- Solve multistep word problems, using the four operations.
- Represent these problems using equations with a letter standing for the unknown quantity.
- Assess the reasonableness of answers using mental computation and estimating strategies, including rounding.

For example, “The class has 144 rubber bands with which to make rubber band cars. If each car uses 6 rubber bands, how many cars can be made? If there are 28 students in the class, how many rubber bands can each car have (if every car has the same number of rubber bands)?”

Students can also analyze constraints on materials, time, or cost to determine what implications the constraints have for design solutions. For example, if a design calls for 20 screws and screws are sold in boxes of 150, how many copies of the design can be made?

Reason abstractly and quantitatively. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3) **MP.2**
Model with mathematics. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3) **MP.4**
Use appropriate tools strategically. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3) MP.5
Operations and Algebraic Thinking (3-ETS1-1),(3-ETS1-2) **3-5.OA**

21st century themes :

Global Awareness & Financial, Economic, Business and Entrepreneurial Literacy

Unit Rationale

Prior Learning

Kindergarten Unit 1: Engineering and Technology

In the unit children will learn the follow: Define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems & Explore and apply a design process

Grade 1 Unit 1: Engineering Design Process

- In this Unit children will define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems, and explore and apply a design process.

Grade 2 Unit 1: Engineering and Technology

In the unit children will learn the follow:

- Ask questions, make observations, and gather information to define a problem.
- Use a design process to solve a problem
- Compare the strengths and weaknesses of multiple design solutions.

Grade 3 Unit 1:

In the unit children will do the follow:

- Define problems and design solutions to those problems
- Test solutions and make improvements to solutions.

Future Learning

Grade 5 Unit 1:

- In this unit, students will discover how science and math are used in engineering, investigate a design process, and explore how technology decisions affect society.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Unit Essential Question

Part A: How Do Engineers Define a Problem?

Part B: How Do Engineers Design Solutions?

Part C: How Do Engineers Test and Improve Prototypes?

Unit Enduring Understandings

Part A: To define a design problem and identify the constraints and criteria for a design solution.

Part B: Research and design possible solutions to a problem, and investigate how well your solution performs.

Part C: Plan, design, and test possible solutions for a prototype to determine which design best solves a problem within given criteria and constraints; identify failure points or difficulties with a design and suggest and implement changes that improve it; communicate in order to share observations, gain insight, and optimize future solutions and designs.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>The Sound of Science</u>: Students are given a scenario/problem that needs to be solved: Their school is on a field trip to the city to listen to a rock band concert. After arriving at the concert, the students find out that the band's instruments were damaged during travel. The band needs help to design and build a stringed instrument with the available materials, satisfying the following criteria and constraints: 1) Produce three different pitched sounds. 2) Include at least one string. 3) Use only available materials. 4) Be no longer than 30 cm / 1 foot. The challenge is divided into 4 activities. Each activity is designed to build on students' understanding of the characteristics and properties of sound. By using what they learn about sound from these activities, students are then encouraged to apply what they know about sound to complete the engineering design challenge.

<u>Energy Makes Things Happen: The Boy Who Harnessed the Wind</u>: This article from Science and Children provides ideas for using the trade book, The Boy Who Harnessed the Wind, as a

foundation for a lesson on generators. This beautiful book is the inspiring true story of a teenager in Malawi who built a generator from found materials to create much-needed electricity. The lesson allows students to explore the concept of energy transfer using crank generators. Students then design improvements to the crank mechanism on the generator. The lesson may be extended by having students build their own generators.

Light Your Way: Using the engineering design process, students will be designing and building a lantern that they will hypothetically be taking with them as they explore a newly discovered cave. The criteria of the completed lantern will include: hands need to be free for climbing, the lantern must have an on/off switch, it must point ahead when they are walking so they can see in the dark, and the lantern must be able to stay lit for at least 15 minutes. The constraints of the activity will be limited materials with which to build. At the completion of the activity, the students will present their final lantern to the class explaining how they revised and adapted the lantern to meet the criteria of the project. Students will include in the presentation the sketch of the model they created prior to building showing the labeled circuit they designed. This activity was one of numerous engineering lessons from the Virginia Children's Engineering Council geared towards Grades 1-5. http://www.childrensengineering.org/technology/designbriefs.php.

Formative Assessments

Students who understand the concepts are able to:

- Describe the various ways that energy can be transferred between objects.
- Apply scientific ideas to solve design problems.
- Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.)
- Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound or passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.
- Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

What it Looks Like in the Classroom

Note: In the prior unit of study, students observed objects in motion in order to understand the relationship between the speed of an object and its energy, and they investigated the transfer of energy from one object to another, as well as from one form to another. In this unit, students will apply scientific ideas about force, motion, and energy in order to design, test, and refine a device that converts energy from one form to another. Through this process, students will learn that science affects everyday life and that engineers often work in teams, using scientific ideas, in order to meet people's needs for new or improved technologies.

To begin the engineering design process, students must be presented with the problem of designing a device that converts energy from one form to another. This process should include the following steps:

- As a class, students should create a list of all the concepts that they have learned about force, motion, and energy.
    - The faster a given object is moving, the more energy it possesses.
    - Energy is present whenever there are moving objects, sound, light, or heat.
    - Energy can be transferred in various ways and between objects.
    - Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
    - When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
    - When objects collide, the contact forces transfer energy so as to change the objects' motions.

- Have students brainstorm examples of simple devices that convert energy from one form to another. As students give examples, the teacher should draw one or two and have students describe how each device converts energy from one form to another.
- Next, the teacher can present a "Design Challenge" to students: Design and build a simple device that converts energy from one form to another. Please note that teachers should limit the devices to those that convert motion energy to electric energy or that use stored energy to cause motion or produce light or sound.
- Small groups of students should conduct research, using several sources of information, to build understanding of "stored energy." Students can look for examples of objects that have stored energy. Stretched rubber bands, compressed springs, wound or twisted rubber bands, batteries, wind-up toys, and objects at the top of a ramp or held at a height above the ground all have stored energy.
- As a class, determine criteria and possible constraints on the design solutions. For example, devices are only required to perform a single energy conversion (i.e., transfer energy from one form to another), and devices must transfer stored energy to motion, light, or sound. Constraints could include the use of materials readily available in the classroom or provided by the teacher. (An assortment of materials can be provided, including batteries, wires, bulbs, buzzers, springs, string,

tape, cardboard, balls, rubber tubing, suction cups, rubber bands of various sizes, construction paper, craft sticks, wooden dowels or skewers, buttons, spools, glue, brads, paper clips, plastic cups, paper plates, plastic spoons, straws, Styrofoam, and cloth.) A time constraint could also be set, if desired. All criteria and constraints should be posted on chart paper so that groups can refer to them as needed.

- Students should work in small, collaborative groups to design and build their device. Examples of possible devices could include:
  - A simple rubber band car that converts the stored energy in a twisted rubber band into motion energy.
  - A simple roller coaster that converts the stored energy in a marble held at the top of the roller coaster into motion energy.
  - A whirly bird that converts stored energy (in a student's muscles) into motion energy.
  - A ball launcher that converts stored energy in a compressed spring, compressed suction cup, or stretched rubber band into motion energy when the ball is launched.
- Students should create a poster that includes a diagram of the device and a description of how the device transfers energy from one form to another. Every group should have the opportunity to present their device and explain how it works.
- As a class, students compare each of the design solutions based on how well they meet criteria and constraints, giving evidence to support their thinking. When giving feedback to the groups, students should identify which criteria were/were not met, and how the design might be improved.
- Small groups should then have the opportunity to refine their designs based on the feedback from the class.
- At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. It is also important that students describe the ways in which energy is transferred between objects and from one form to another.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 Engineer It: How Do Engineers Define Problems?	3 Days Core Route 4 Days Traditional Route
Lesson 2 Engineer It: How DO Engineers Design Solutions?	3 Days Core Route 4 Days Traditional Route
Lesson 3 Engineer It: How Do Engineers Test and Improve Prototypes?	3 Days Core Route 4 Days Traditional Route
Unit 1 Review and Unit 1 Test	2 Days

Additional Traditional Route Activities Unit 1 Project You Solve It Unit 1 Performance Task Performance –Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes: Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation

On-Level Reader: What is the Engineering Process? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: What is the Engineering Process? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: City Water Tunnel 3: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Give students series of scenarios that involve problems.

Lesson 2: Demonstrate a fair test to find which toy car is fastest (same test conditions, same timer, test more than once).

Lesson 3: Provide additional assistance to ELL students by demonstrating how to optimize something, such as the design of an object. The object can be something simple, such as a al or a paperweight.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Engineering and Technology							
Lesson Title: How do Engineers Define Problems?					**Timeframe:** 4 days		
Lesson Components							
21st Century Themes							
X	Global Awareness	X	Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online resources and tools							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: • To define a design problem and identify the constraints and criteria for a design solution	1. About this Image: Animals in the wild, such as rabbits, need to find or hunt for their own food. Some animals use tools or strategies for gathering and hunting. 2. Can You Solve It? Students are asked to record their observations of the vole and owl from the images. They must think of a solution to the problem of “noise.” To do so, students must understand what batteries are and what kinds of alternatives there are to using them.	• Cite Evidence for Criteria: This activity is an opportunity for students to observe everyday objects and apply engineering practices to them to better understand the process of defining problems and coming up with criteria for

	3. Exploration 1 What is Technology? Learn how to identify an engineering problem by asking questions about possible solutions based on constraints and criteria. Use the collected data to analyze lists of needs and wants according to society and the natural world. 4. Exploration 2: Real-World Limits: Develop a deeper understanding of how to identify constraints. Learn how to ask questions to identify constraints, which is how engineering problems are defined and delimited. 5. Take it Further: Discover More 6. Lesson Check: Can You Solve It? 7. Lesson Check: Lesson Roundup	solutions or improvements. ● Give students an opportunity to go back through their print and digital sources to find information that will help them describe a classroom object that could be improved. ● Lesson Check: Can You Solve It? ● Lesson Check: Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Apply scientific ideas to solve design problems. (4-PS3-4) Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) **Asking Questions and Defining Problems** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and	**PS3.B: Conservation of Energy and Energy Transfer** Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-4) **PS3.C: Relationship Between Energy and Forces** When objects collide, the contact forces transfer energy so	**Energy and Matter** Energy can be transferred in various ways and between objects. (4-PS3-4) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers improve existing technologies or develop new ones. (4-PS3-4) -

constraints on materials, time, or cost. (3-5-ETS1-1) **Planning and Carrying Out Investigations** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	as to change the objects' motions. (4-PS3-3) **PS3.D: Energy in Chemical Processes and Everyday Life** The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) **ETS1.B: Developing Possible Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need	***Connections to Nature of Science*** **Science is a Human Endeavor** Most scientists and engineers work in teams. (4-PS3-4) Science affects everyday life. (4-PS3-4) **Influence of Science, Engineering, and Technology on Society and the Natural World** People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

	to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	

Content Area: Fourth Grade Science
Unit Title: Energy
Target Course/Grade Level: Unit 2 Grade 4
Unit Summary In this unit, students will… ● Discover what energy is an how it is transferred. ● Explore how collisions show energy. **Lesson 1:** Students define energy and explore ways it can be transferred between objects. They recognize ways people use energy and the impact it has on society and nature. They observe and participate in activities requiring strategic thinking about design solutions to problems. **Lesson 2:** Students collect evidence for energy storage, learn ways energy moves in waves and how it transfers through the addition or subtraction of hear. They plan and build a cooker to transfer the sun's energy into food. By looking at how energy transfers, students develop a greater understanding of how it can be used to effect changes in matter. **Lesson 3:** Students learn that every object contains energy. When objects collide, they transfer that energy. They observe this by experimenting with rubber bands and toys. They visualize how potential energy can become stored energy and can be transferred through impacts. **Primary interdisciplinary connections:** *English Language Arts* Students will conduct research to build their understanding of energy, transfer of energy, and natural sources of energy. Students will recall relevant information from in-class investigations and experiences and gather relevant information from print and digital sources. They should take notes and categorize information and provide a list of sources. Students also draw evidence from literary and information texts in order to analyze and reflect on their findings. Students can also read, take notes, and construct responses

using text and digital resources such as Scholastic News, Nat Geo Kids, Study Jams (Scholastic), Reading A–Z.com, NREL.com, switchenergyproject.com, and NOVA Labs by PBS.

Describe the overall structure of events, ideas, concepts, or information in a text or part of a text **RI.4.5**
Draw on information form multiple …sources. **RI.5.7**
Write informative/explanatory texts…**W.4.2**
Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-ESS3-1) **W.4.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-2),(4-ESS3-1) **W.4.8**

Mathematics

Students reason abstractly and quantitatively as they gather and analyze data during investigations and while conducting research about transfer of energy and energy sources. Students model with mathematics as they represent and/or solve word problems. As students research the environmental effects of obtaining fossil fuels, they might be asked to represent a verbal statement of multiplicative comparison as a multiplication equation. For example, students might find information about a spill that was 5 million gallons of oil and was 40 times larger that a previous oil spill in the same location. They can be asked to represent this mathematically using an equation to determine the number of gallons of oils that were spilled in the previous event.

Reason abstractly and quantitatively. (4-ESS3-1) **MP.2**
Model with mathematics. (4-ESS3-1) **MP.4**
Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. **4.OA.A.3**
Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were no explicit in the rule itself. **4.OA.C.5**
Know relative sizes of measurement units within one system of units. Express measurements in a larger unit in terms of a smaller unit. **4.MD.A.1**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Students should already know and be prepared to build on the following concepts:

- In science and engineering, there are often problems that need to be solved (solutions), which lead to inventions and discoveries.
- Scientists and engineers work with criteria and constraints to come up with design solutions.

Future Learning

Grade 5 Unit 6: Earth Systems

- In this unit, students will: explore the hydrosphere, geosphere, biosphere, and atmosphere & learn how Earth's systems interact.

Grade 7 Unit 7: Organization for Matter and Energy in Organisms

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.(secondary)
- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)

Grade 7 Unit 8: Earth Systems

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Grade 8 Unit 3: Stability and Change on Earth

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

Grade 8 Unit 4: Human Impact

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Grade 8 Unit 5: Relationships among Forms of Energy

● Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. ● A system of objects may also contain stored (potential) energy, depending on their relative positions. ● When the motion energy of an object changes, there is inevitably some other change in energy at the same time. Grade 8 Unit 6: Thermal Energy ● Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. ● The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. ● Energy is spontaneously transferred out of hotter regions or objects and into colder ones. Grade 8 Unit 7: Electromagnetic Radiation ● When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. ● The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. ● However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Learning Targets	
Standards	
NJSLS-S#	**Performance Expectation**
4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]
4-PS3-3	Ask questions and predict outcomes about changes in energy that occur when object collide.
4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
Unit Essential Question **Part A:** What is Energy? **Part B:** How is Energy Transferred/ **Part C:** How Do Collisions Show Energy?	
Unit Enduring Understandings	

Part A:

- Recognize common transformations of electrical energy.

Part B:

- To understand and observe energy transfer involving light, sound, and heat, and provide evidence illustrating the changes that results

Part C:

- Observe energy transfers and recognize the correlations between speed and the amount of energy and object possesses, and identify collisions as a form of motion energy transfer.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

Switch Energy Project: The Educator Portal provides free access to a documentary, energy labs, videos, and study guides.

Wind Generator: Windmills have been used for hundreds of years to collect energy from the wind in order to pump water, grind grain, and more recently generate electricity. There are many possible designs for the blades of a wind generator and engineers are always trying new ones. Design and test your own wind generator, then try to improve it by running a small electric motor connected to a voltage sensor.

Thermal Energy Transfer: Explore the three methods of thermal energy transfer: conduction, convection, and radiation, in this interactive from WGBH, through animations and real-life examples in Earth and space science, physical science, life science, and technology.

Formative Assessments

Students who understand the concepts are able to:

- Make observations to produce data that can serve as the basis for evidence for an explanation of a phenomenon or for a test of a design solution.
- Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- Identify cause-and-effect relationships in order to explain change.
- Obtain and combine information from books and other reliable media to explain phenomena.
- Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
    - Examples of renewable energy resources could include:
        - Wind energy,
        - Water behind dams, and
        - Sunlight.
    - Examples of nonrenewable energy resources are:
        - Fossil fuels,
        - Fissile materials
    - Examples of environmental effects could include:
        - Loss of habitat due to dams
        - Loss of habitat due to surface mining
        - Air pollution from burning of fossil fuels.

What it Looks Like in the Classroom

Students conduct investigations to observe that energy can be transferred from place to place by sound, light, heat, and electrical currents. They describe that energy and fuels are derived from natural resources and that their uses affect the environment. Throughout this unit, students obtain, evaluate, and communicate information as they examine cause-and-effect relationships between energy and matter.

To begin the unit of study's progression of learning, students need opportunities to observe the transfer of heat energy. They can conduct simple investigations, using thermometers to measure changes in temperature as heat energy is transferred from a warmer object to a colder one. For example, hot water can be poured into a large Styrofoam cup, and then a smaller plastic cup of cold water can be placed inside the larger cup of water. A thermometer can be placed in each cup, and students can observe and record changes in the temperature of the water in each cup every minute over the course of about 10–15 minutes, or until the temperatures are the same. Students can use their data as evidence to explain that some of the heat energy from the hot water transferred to the cold water. This transfer of heat caused the cold water to become gradually warmer and the hot water to cool. This process continued until the cups of water reached the same temperature.

Students can also place a thermometer in the palm of their hands, close their hands around it, and measure the temperature. They can then place a piece or two of ice into their palms and close their fists around the ice until it melts. When they again measure the temperature of their palms, they will observe a change. Students can use these data to describe how some of the heat from their hands transferred to the ice, causing it to melt, while the ice also decreased the temperature of their hand. It is important that students understand that heat is transferred from warmer to colder objects. When an object cools, it loses heat energy. When an object gets warmer, it gains heat energy.

To continue learning about energy transfer, students can build simple electric circuits. As students work in small groups to build circuits, they should add a bulb and/or a buzzer to the circuit in order to observe and describe the ways in which energy is transferred in the circuit. (The word "transfer" can refer to a change in the type of energy or a change in the location of energy.) For example, stored energy in a battery is transferred into electrical energy, which is then transferred into light energy if a bulb is added to the circuit. The energy transfers from the battery to the wire and then to the bulb. The same holds true if a buzzer is added to the circuit. The stored energy in the battery is transferred into electrical energy, which is then transferred into sound energy. (Keep in mind that energy is not actually produced. When we say that energy is "produced," this typically refers to the conversion of stored energy into a desired form for practical use. Students should be encouraged to use the term "transferred" rather than "produced").

After conducting these types of investigations, the class can create a list of events in which energy is transferred. For example, when a ball is thrown against a wall, some of the motion energy is transferred to sound energy; when water boils on the stove top, heat energy from the stove is transferred to the pot and to the water in the pot; and when a doorbell is rung, electrical energy is transferred into sound energy.

Next, students learn about fuels and energy, and conduct research using books and other reliable media to determine which natural resources are sources of energy. Light, heat, sound, and electricity are all forms of energy. Energy is not matter. Fuels, however, are matter. For example, fossil fuels, such as coal, oil, and natural gas, are matter. When fossil fuels are burned, energy stored in the fuel can be transferred from stored energy to heat, light, electrical, and/or motion energy. Therefore, fuels are considered to be a source of energy.

Energy can also be obtained from other sources, such as wind, water, and sunlight. Air and water are both matter, but when they are moving, they have motion energy. Energy from wind (moving air) and from moving water can be transferred into electrical energy. Light energy from the sun can also be transferred to heat energy or electrical energy. In addition, energy can be released through nuclear fission using materials known as fissile materials.

As students learn about fuels and other sources of energy, they should determine which sources are renewable and which are nonrenewable. Generally, a fuel or source of energy is considered nonrenewable if that source is limited in supply and cannot be replenished by natural means within a reasonable amount of time. Renewable sources of energy are those that are replenished constantly by natural means. Using this general description, all fossil fuels are considered nonrenewable, because these resources were naturally created over millions of years. Fissile materials are also nonrenewable. On the other hand, wind, moving water, and sunlight are renewable sources of energy.

As the population continues to grow, so does the demand for energy. Human use of natural resources for energy, however, has multiple effects on the environment. Students should conduct further research to determine how the use of renewable and nonrenewable resources affects the environment. Some examples include:

- ü Changes in and loss of natural habitat due to the building of dams and the change in the flow of water;
- Changes in and loss of natural habitat due to surface mining; and
- Air pollution caused by the burning of fossil fuels in factories, cars, and homes.
- As students conduct research and gather information from a variety of reliable resources, they can take notes and use the information to describe and explain the impact that human use of natural resources has on the environment.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What is Energy?	3 Days Core Route 4 Days Traditional Route
Lesson 2 How is Energy Transferred?	3 Days Core Route 4 Days Traditional Route
Lesson 3 How Do Collisions Show Energy?	3 Days Core Route 4 Days Traditional Route
Unit 2 Review and Unit 2 Test	2 days
Additional Traditional Route Activities Unit 2 Project You Solve It Unit 2 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: How Do We Generate and Use Electricity? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do We Generate and Use Electricity? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Energy on Demand: Making Electricity: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL:

Point out the word vibrate comes from a Latin word (vibrate) meaning “wave.”

Ask: What is something that makes a wave?

Explain to students that waves are how energy travels. Water waves happen when energy travels. Water waves happen when energy moves through water. Energy also moves through other material waves.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students’ interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

<table>
<tr><th colspan="8">Lesson Plan 1</th></tr>
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<table>
<tr><th>Goals/Objectives</th><th>Learning Activities/Instructional Strategies</th><th>Formative Assessment Tasks</th></tr>
<tr><td>Students:
• Recognize common transformations of electrical energy.</td><td>1. About this Image: This is an image of something students see on a daily basis. In fact, students can probably point out an electrical cord in the classroom.
2. Can You Explain It? Students are asked to study the image and explain where the energy comes from. To do so, students must pay close attention to the details.
3. Exploration 1: Energy is All Around: Learn the definition of energy and how it can be moved through electric currents. Ask questions about how energy can be transferred from on object to another.
4. Exploration 2-Energy Transfer: Develop a deeper understanding of how energy transfers and changes forms.
5. Take it Further-Discover More
6. Lesson Check: Can you explain it?
7. Lesson Check: Lesson Roundup</td><td>• Putting it Together: Before student work on completing the sentence, Ask: What is energy?
• Putting it Together: Before students work on completing the sentences, ask: What senses could you use to detect motion energy.
• Lesson Check: Can you explain it?
• Lesson check: Lesson Roundup</td></tr>
<tr><td colspan="3">Differentiation</td></tr>
</table>

Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2) **Obtaining, Evaluating, and Communicating Information** Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)	**PS3.A: Definitions of Energy** Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2) Light also transfers energy from place to place. (4-PS3-2) Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2) **ESS3.A: Natural Resources**	**Energy and Matter** Energy can be transferred in various ways and between objects. (4-PS3-2) **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1) **Influence of Engineering, Technology, and Science on Society and the Natural World** Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)

	Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)	

Content Area: Fourth Grade Science
Unit Title: Waves and Information Transfer
Target Course/Grade Level: Unit 3 Grade 4

Unit Summary

In this unit, students…

- Discover the different parts of waves.
- Explore how light can be reflected
- Examine and describe how information is transferred from place to place.

Lesson 1: Students will explore the properties and characteristics of waves and the patterns they create. They will use models to learn about the ways in which waves create motion through the transfer of energy. Through the use of these diagrams, students will be able to visualize transverse waves and differentiate between wavelength and amplitude. This information will help deepen their understanding of the movement of energy.

Lesson 2: Students will investigate how light interacts with the surface of objects to form an image that we can see. Students will develop and use models to manipulate a variety of objects to observe how the behavior of light changes the images sent to our eyes and perceived by our brains. By investigating how light interacts with mirrors and lenses, students will deepen their understanding of the development of many useful tools and technologies that utilize light.

Lesson 3: Students will explore variety of communication devices that are result of science, engineering, and technology working together to meet people's needs and decide how well each device solves a problem. Students will also design their own devices to communicate information over a distance.

Primary interdisciplinary connections:

English Language Arts/Literacy

To support integration of English language arts into this unit, students conduct short research projects, using both print and digital sources, to build their understanding of wave properties and of the use of waves to communicate over a distance. Students should take notes, categorize information collected, and document a list of the sources used. Using the information they collect during research, as well as information from their experiences with waves, sound, and light, students integrate the information and use it to design a device or process that can be used to communicate over a distance using patterns. As students create presentations that detail how their design solutions can be used to communicate, they should use details and examples from both their research and experiences to explain how patterns are used in their design to communicate over a distance. They can include audio or video recordings and visual displays to enhance their presentations.

Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word (e.g. telegraph, photograph, autograph). **L.4.4.B**
Consult reference materials (e.g. dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation and determine or clarify the precise meaning of key words and phrases. **L.4.4.C**
Determine the main idea of a text and explain how it is supported by key details; summarize the text. **RI.4.2**
Determine the overall structure of events, ideas, concepts, or information **RI.4.5**
Use precise language and domain-specific vocabulary to inform about or explain the topic. **W.4.2.D**
Conduct short research projects that build knowledge.. **W.4.7**
Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-1)* **SL.4.5**

Mathematics

To support the integration of the CCSS for mathematics into this unit of study, students should have opportunities to draw points, lines, line segments, rays, angles, and perpendicular and parallel lines, and identify these in two-dimensional drawings as they identify rays and angles in drawings of the ways in which waves move. Students should also have opportunities to use the four operations to solve problems. Students can analyze constraints on materials, time, or cost to draw implications for design solutions. For example, if a design calls for 20 screws and screws are sold in boxes of 150, how many copies of the design could be made?

As students represent and solve word problems, such as these, they reason abstractly and quantitatively and model with mathematics. As students create models of waves and engage in engineering design, they have opportunities to use tools strategically while measuring, drawing, and building.

Model with mathematics. (4-PS4-2),(3-5-ETS1-2),(3-5-ETS1-3) **MP.4**
Know relative sizes of measurement units within one system of figures. **4.MD.A.1**

Generate and analyze patterns. **4.OA.C.5**
Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. (4-PS4-2) **4.G.A.1**

21st century themes

Global Awareness

Unit Rationale

Prior Learning

By the end of Grade 1, students know that:

- People also use a variety of devices to communicate (send and receive information) over long distances.

By the end of Grade 2, students know that:

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution it is important to clearly understand the problem.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

By the end of Grade 3, students know that:

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces is used at this level).
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

Future Learning

In middle school, students will know that:

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.
- A sound wave needs a medium through which it is transmitted.

- Digitized signals (sent as wave impulses) are a more reliable way to encode and transmit information.
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important for testing solutions.
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process— that is, some of those characteristics may be incorporated into the new design.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
4-PS4-1	Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. *[Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]*
4-PS4-2	Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
4-PS4-3	Generate and compare multiple solutions that use patterns to transfer information. *[Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]*

Unit Essential Question

Part A: If a beach ball lands in the surf, beyond the breakers, what will happen to it?

Part B: Which team can design a way to use patterns to communicate with someone across the room?

Unit Enduring Understandings

Part A:

- Science findings are based on recognizing patterns.
- Similarities and differences in patterns can be used to sort and classify natural phenomena.
- Waves, which are regular patterns of motion, can be made in water by disturbing the surface.
- When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.

- Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks)

Part B:

- Similarities and differences in patterns can be used to sort and classify designed products.
- Knowledge of relevant scientific concepts and research findings is important in engineering.
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.
- Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—that is, convert it from digitized form to voice and vice versa.
- Different solutions need to be tested in order to determine which of them best solve the problem, given the criteria and the constraints.
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

The "What it Looks Like in the Classroom" section of this document describes several student sense-making and engineering tasks.

The Utah Education Network has created several resources for fourth grade science teachers.

Michigan NGSS Moodle: The purpose of this website to provide K-5 Science teachers with resources, lessons, and activities based on the NGSS which were created by teachers in our region.

Formative Assessments

Students who understand the concepts can:

- Sort and classify natural phenomena using similarities and differences in patterns.
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle.
- Develop a model (e.g., diagram, analogy, or physical model) of waves to describe patterns in terms of amplitude and wavelength, and that waves can cause objects to move. (Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength).
- Sort and classify designed products using similarities and differences in patterns.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.
- Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- Generate and compare multiple solutions that use patterns to transfer information. Examples of solutions could include:
    - Drums sending coded information through sound waves;
    - Using a grid of ones and zeroes representing black and white to send
    - information about a picture;
    - Using Morse code to send text.
- Plan and conduct an investigation collaboratively to produce data that can serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

What it Looks Like in the Classroom

In this unit of study, students plan and carry out investigations, analyze and interpret data, and construct explanations. They also develop and use models to describe patterns of waves in terms of amplitude and wavelength and to show that waves can cause objects to move.

Waves, which are regular patterns of motion, can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). Students can model the properties of waves by disturbing the surface of water in a variety of pans and buckets. Students should make observations as they strike the surface of the water with small and large objects, such as marbles and rocks. In addition, smaller pans can be tilted in different directions in order to observe the effect on the wave patterns created on the surface of the water. Students should observe and describe a number of similarities and differences in the wave patterns created, including the following:

- When an object hits the surface of water, waves move across the surface.
- Waves move up and down across the surface of the water away from the point of contact.
- Waves on the surface of the water move away from the point of contact in increasingly larger circles.
- When waves hit another surface, the waves change direction and move away from the surface with which they come into contact.
- The height of the wave (amplitude) and the distance between the peaks of waves (wavelength) varies depending upon the intensity of the disturbance, and/or the size (mass, volume) of the object disturbing the surface of the water.

When describing the properties of waves, students should also develop a model using drawings, diagrams, or physical models (such as a slinky or jump rope) to show the basic properties of waves (amplitude and wavelength). In addition, the class should discuss other real-world examples of waves, including sound and light waves, using understandings developed in prior units of study.

To begin the engineering design process, students are challenged to design a way to use patterns to transfer information. This process should include the following steps:

- As a class, brainstorm a list of ways in which patterns have been used in the past to communicate over distance. Some examples include the use of smoke signals, drums, and Morse code on a telegraph.
- Small groups collaboratively conduct research to determine other possible ways of communicating using patterns over distances.
- As a class, determine criteria and possible constraints on the design solutions.
    - Criteria might include that groups must communicate information using patterns, the design solution must communicate over a predetermined distance, and groups must be able to describe how patterns were used in the design to communicate over a distance.
    - Possible constraints might include materials available to build/create a device and the amount of time available to design and build.
- Small groups work collaboratively to design and build a device or design a process for communicating information over a distance. Some examples could include:
    - Drums sending coded information through sound waves.
    - Use a flashlight to convey information using a pattern of on and off.
    - Use Morse code to send information.
    - Build an instrument with a box and rubber bands of varying sizes that can be plucked in a pattern to communicate information.
    - Use musical patterns on a xylophone or tuning forks to convey information.
    - Use string and cups to build a simple “phone” to send information.
- After small groups finish designing and building, they should put together a presentation that includes a written description/explanation of how patterns are used to communicate information.

They can also include pictures, video or audio recordings, and/or models to support their explanation.

- Each group presents their design solution to the class. After observing each design solution, students should classify each based on the type or types of patterns used to communicate (e.g., sound, light, or both).
- Students investigate how well the solutions perform under a range of likely conditions (e.g., environmental noise or light, increases in distance). This may involve additional research, planning and conducting multiple investigations to produce data, and collecting and analyzing additional data that can be used as evidence to support conclusions. All tests that are planned and carried out should be fair tests in which variables are controlled and failure points are considered in order to identify elements of the design solution that do and do not meet criteria and constraints.
- Students compare the solutions, determining which can be used to successfully communicate information over a distance using patterns. Students should determine how well each design solution meets criteria, using data as evidence to support their thinking.

Throughout this process, communicating with peers is important, and can lead to better designs. After completing the engineering design process, students should discuss ways in which we use patterns in today's technology to communicate over long distances and how engineers have improved existing technologies over time in order to increase benefits, decrease known risks, and meet societal demands.

Integration of engineering-

Engineering design is an integral part of this unit of study. Students are expected to research a problem and communicate proposed solutions to others; define a simple design problem including specified criteria for success and constraints on materials time, or cost; and plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of the design solution that can be improved. This process is outlined in greater detail in the previous section.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What are Waves?	3 Days Core Route 4 Days Traditional Route
Lesson 2 How Does Light Reflect?	3 Days Core Route 4 Days Traditional Route
Lesson 3 How is Information Transferred from Place to Place?	3 Days Core Route 4 Days Traditional Route
Unit 3 Review and Unit 3 Test	2 days

Additional Traditional Route Activities Unit 3 Project You Solve it Unit 3 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: How Do We Use Forms of Energy? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do We Use Forms of Energy? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: What Happens Under the Hood?: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL:

- Give student ripped paper, newspaper, magazine articles and tell them to try and tape them back together as best they can so that you can't tell where they were ripped. This can only be done if the tape is transparent.
- To help bridge understanding, point out cognates of key terms in the lesson, such as: satellite/el satellite, technology/la tecnologia, pictograph/pictografia, hieroglyphics/jeroglificos, telegraph/ el telegrafo, and binary code/codigo binario. Spotlight the similarities and discuss the differences, such as including a definite article before some nouns and having the adjective following the noun it modifies. Pronounce each word in English, and have students repeat it.

Modifications

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities.

Lesson Plan 1							
Content Area: Waves and Information Transfer							
Lesson Title: What are Waves?						**Timeframe:** 4 days	
Lesson Components							
<u>21st Century Themes</u>							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
<u>21st Century Skills</u>							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: ● To differentiate between wavelength and	1. About this Image: Notice the ripples in the American Flag. Those ripples, ,or waves, are creating motion. The people who are holding the flag are responsible for	● Classifying information: As students work to classify the examples according to the type of

amplitude, and observe how waves interact.	producing the starting energy needed to wave the flag. 2. Can You Explain It? Students are asked to study the image of the surfer in the ocean and explain how the surfer knows when to catch a wave. 3. Exploration 1: How waves Transfer Energy: Students work in pairs to model how energy moves through waves. They will create waves with certain materials and measure the transfer of energy with other materials. 4. Exploration 2 Wave Parts: Explore different part of waves and the patterns they create. Review a series of model diagrams, and visualize amplitude, wavelength, and other characteristics of waves. Study patterns related to sound waves, such as volume. 5. Exploration 3: Waves Interact: Explore how waves interact with each other. Analyze diagrams that show the different ways waves can be combined, both to produce a new wave or to cancel each other out. Find patterns related to the ways that waves interact. 6. Take it Further: Discover More 7. Lesson Check: Can you explain it? 8. Lesson Check: Lesson roundup	wave, remind them that it's important to draw n what they learned from both text and images throughout the section. ● Putting it Together: Ask: What kind of information can you tell about a wave by studying its properties? ● Putting it Together: Students recall the properties of waves that they learned about in Exploration 3. Inform students that some words from the word bank will not be used as answers. ● Lesson Check: Can you explain it? ● Lesson Check: Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Develop a model using an analogy,	**PS4.A: Wave Properties** Waves, which are regular patterns of	**Patterns** Similarities and differences in

example, or abstract representation to describe a scientific principle. (4-PS4-1) **Constructing Explanations and Designing Solutions** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-PS4-3) Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** Science findings are based on recognizing patterns. (4-PS4-1) **Planning and Carrying Out Investigations** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. *(Note: This grade band endpoint was moved from K–2.)* (4-PS4-1) Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1) **PS4.C: Information Technologies and Instrumentation** Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3) **ETS1.C: Optimizing The Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. *(secondary to 4-PS4-3)* **ETS1.B: Developing Possible Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify	patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena. (4-PS4-1) Similarities and differences in patterns can be used to sort and classify designed products. (4-PS4-3) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** Knowledge of relevant scientific concepts and research findings is important in engineering. (4-PS4-3) **Influence of Science, Engineering, and Technology on Society and the Natural World** Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

	failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	

Content Area: Fourth Grade Science
Unit Title: Plant Structure and Function
Target Course/Grade Level: Unit 4 Grade 4

Unit Summary

In this unit, students will…

- Explore the functions of internal and external plant structures and how they aid in growth, survival, behavior and reproduction.
- Learn how different plant structures work together as a system

Lesson 1: Students will gather evidence about the function of internal and external plant parts to construct an argument that these parts work together to form a system used for growth, survival, reproduction, and behavior. Students also investigate how plants move, and they design and build a system to grow a plant in water rather than soil.

Lesson 2: Students develop an understanding of how the internal and external structures of both flowering and non-flowering plants function to support survival, growth, and reproduction. Students will construct arguments from evidence to explain the components and interactions of systems and how they work together to enable reproduction.

Primary interdisciplinary connections:

English Language Arts

Students use the evidence from their observations of plants and animals to support the claim that all organisms are systems with structures that function in growth, survival, behavior, and/or reproduction. Students need opportunities to observe plants and animals closely, taking notes and drawing pictures, so that they can describe various structures and their functions.

Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)

W.4.1
Draw evidence from literary or informational texts to support analysis, reflection, and research. **W.4.9**
Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **RI.4.2**
Explain how an author uses reasons and evidence to support particular points in a text. **RI.4.8**
Interpret information presented visually, orally, or quantitatively. **RI.4.7**
Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. **RI.4.9**

Mathematics

Students describe the symmetry that can be observed in an organism's structures. For example, the leaves of many plants and the bodies of many animals display bilateral symmetry. Students should be encouraged to draw each organism that they observe, pointing out any structures that are symmetrical. Students should also trace lines of symmetry in their drawings to support their thinking. In addition, students can conduct research to determine whether the symmetry serves a function in the growth, reproduction, or survival of the organism.

Reason abstractly and quantitatively **MP.2**
Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. (4-LS1-1) **4.G.A.3**

21st century themes:

Global Awareness

<u>Unit Rationale</u>

Prior Learning

Grade 1 Unit 5: Living Things and Their Young

- Compare young plants with parent plants.
- Observe patterns to explain how plants of the same kind are alike and different
- Describe how plants respond to their environments to meet their needs.

Future Learning

Grade 7 Unit 4: Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
4-LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. *[Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.]* [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]*

Unit Essential Question

Part A: What are some plant parts and how do they function?

Part B: How do plants grow and reproduce?

Unit Enduring Understandings

Part A: To gather evidence about the function and structure of plant parts in order to construct an argument that these parts are used for survival, growth, reproduction, and behavior.
Part B: Describe the process of pollination and fertilization in both flowering and non-flowering plants. Identify the basic reproductive structures of plants, and how the parts form a system for reproduction.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

Animal Mouth Structures In this lesson, students gather evidence to understand features that enable them to meet their needs. In particular, they examine the mouth structures of different animals to help them understand how animals are adapted to obtain food in their environment.

Formative Assessments

Students who understand the concepts are able to:

- Describe a system in terms of its components and their interactions.
- Construct an argument with evidence, data, and/or a model.
- Construct an argument to support the claim that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (Assessment is limited to macroscopic structures within plant and animal systems.) Examples of structures could include:

★ Thorns	★ Heart
★ Stems	★ Stomach
★ Roots	★ Lung
★ Colored petals	★ Brain
	★ Skin

What it Looks Like in the Classroom

In this unit of study, students spend time observing plants and animals in order to gather evidence that organisms are living systems. A system is made up of structures and processes that interact and enable the system to function. Every plant and animal can be described in terms of its internal and external structures and their interactions, and these structures each have specific functions that support survival, growth, behavior, and reproduction for the organism.

Using a variety of plants and animals as examples, students need multiple opportunities to:

- ➢ ü Describe the internal and external structures of a plant or animal and the function of each of those structures. Description should explain how each structure serves various functions in growth, survival, behavior, and/or reproduction. (Note: This is limited to macroscopic structures within plant and animal systems, and could include such structures as thorns, stems, roots, and colored petals for plants, and heart, stomach, lung, brain, and skin for animals.)
- ➢ Describe the interactions that occur among the structures within the plant or animal system.

➢ As students observe the structures of an animal or plant, explain the function of each, and describe how these structures help the animal grow, survive, and/or reproduce, they should use evidence from their observations to support their explanations.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What are some plant parts and how do they function?	3 Days Core Route 4 Days Traditional Route
Lesson 2 Engineer It-How Do Plants Grow and Reproduce?	3 Days Core Route 4 Days Traditional Route
Lesson Unit 4 Review and Unit 4 Test	2 Days
Additional Traditional Route Activities Unit 4 Project You Solve It Unit 4 Performance Task Performance-Based Assessment	2 days 1 day 1 day 1 day

Teacher Notes: Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: How Do Plants and Animals Reproduce and Adapt? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do Plants and Animals Reproduce and Adapt? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Exploring the Galapagos Islands This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Point out cognates of key terms from students' home languages. Such as spores/esporas, to bridge understanding. Pronounce each word in English, and have students repeat it. Ask other students to share the same words in their home languages.

Lesson 2: Show students illustrated plant life cycles diagrams and carefully explain the different steps. Help students from sentences of the various steps using the key vocabulary and write them on the board. Leave them there for the duration of the lesson.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

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Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● To gather evidence about the function and structure of plant parts in order to construct an argument that these parts are used for survival, growth, reproduction, and behavior.	1. About this Image: Plants include everything from blades of grass to cultivated flowers to giant trees. Flowers are an example of a plant part used in reproduction. 2. Can You Explain It? Students are asked to record their initial thoughts about why plants in the pictures are bending in a certain direction. To do so, students must begin to think about the different parts of plants and how they function to help the plant grow and survive. 3. Exploration 1: Plant Dissection: In this lesson, students will gather evidence about the functions of external plant parts: which specific parts of a plant's system help it grow, help it survive, and help it reproduce. The students write an argument about which is the most important part of growth. 4. Exploration 2: What's Inside? Students learn about tube structures in plants that transport water and food and make a model and argue a claim that plants have a tube system that transports water and food throughout the plant. 5. Exploration 3: Can Plants Move? Students investigate how parts of a plant system move in response to their environment, and they make a claim about how this helps the plant survive. 6. Take It Further: Discover More 7. Lesson Check: Can you explain it? 8. Lesson Check: Lesson Roundup	● Writing Opinion Pieces: Remind students that an opinion piece is a point of view supported by facts. The claim in an opinion piece should be debatable-other people may disagree with it. Using valid evidence to support the claim can help to persuade others to agree with the claim. ● Multiple Sources: As students construct their claim about how plant responses help plant survival, remind them to cite the numbers of the pages where they found the facts they used to develop their arguments.
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Construct an argument with evidence, data, and/or a model. (4-LS1-1)	**LS1**.A: **Structure and Function** Plants and animals have both internal and external structures that serve various functions in	**Systems and System Models** A system can be described in terms of its components and their interactions. (4-

	growth, survival, behavior, and reproduction. (4-LS1-1)	LS1-1)

Content Area: Fourth Grade Science
Unit Title: Animal Structure and Function
Target Course/Grade Level: Unit 5 Grade 4

Unit Summary

In this unit, students will…

- Explore the internal and external structures of animals
- Learn about how different senses work.

Lesson 1: Students will learn and understand that animals have external and internal structures. They will use evidence from the lesson to engage in arguments, and they will be able to describe the components of systems and their interactions.

Lesson 2: Students will gather evidence to support an argument regarding the importance of the internal structures of animals in growth, survival, behavior, and reproduction. They explore the components and functions of several body systems to identify similarities and differences of the body systems in different groups of animals.

Lesson 3: Students will explore the ways in which people and animals use their senses. They will learn about the physical parts and unique structures that make it possible for people and animals to analyze information through senses, though which sensory information can be processed in the brain. Students will interpret sensory systems and apply what they learn to construct intelligent explanations using evidence and date.

Primary interdisciplinary connections:

English Language Arts

Students use the evidence from their observations of plants and animals to support the claim that all organisms are systems with structures that function in growth, survival, behavior, and/or reproduction. Students need opportunities to observe plants and animals closely, taking notes and drawing pictures, so that they can describe various structures and their functions.

Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1) **W.4.1**
Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g. headings), illustrations, and multimedia when useful to aiding comprehension. **W.4.2.A**
Refer to details and examples in a text when explaining what the text says explicitly when drawing inference

from the text. **RI.4.1**
Explain…scientific, or technical text…based on specific information in the text. **RI.4.3**
Interpret information presented visually, orally, or quantitatively. **RI.4.7**
Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. **RI.4.9**
Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas of themes. **SL.4.5**

Mathematics

Students describe the symmetry that can be observed in an organism's structures. For example, the leaves of many plants and the bodies of many animals display bilateral symmetry. Students should be encouraged to draw each organism that they observe, pointing out any structures that are symmetrical. Students should also trace lines of symmetry in their drawings to support their thinking. In addition, students can conduct research to determine whether the symmetry serves a function in the growth, reproduction, or survival of the organism.

Model with mathematics **MP.4**
Solve multistep word problems posed with whole numbers and having whole-number answers using the fou operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. **4.OA.A.3**
Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. (4-LS1-1) **4.G.A.3**

Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. (4-LS1-1) **4.G.A.3**

21st century themes :

Global Awareness

Unit Rationale

Prior Learning

Grade 1 Unit 5: Living Things and Their Young

- Compare animals with parent animals

- Observe patterns to explain how animals of the same kind are alike and different.
- Describe how animals respond to their environments to meet their needs.
- Describe how behavior patterns of parents and offspring help offspring survive.

Future Learning

Grade 7 Unit 4: Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
4-LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. *[Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.]* [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]*
4-LS1-2	Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Unit Essential Question

Part A: What are some external structures of Animals?

Part B: What are some internal structures of Animals?

Part C: How do senses work?

Unit Enduring Understandings

Part A: To identify the external parts animals have and how their parts are used for growth, survival, behavior, and reproduction.
Part B: Observe and describe some of the internal structures of animals, compare similar body parts that have similar and different uses from species to species or multiple uses within a species, and recognize that some animals have modified systems or don't have them at all.
Part C: Construct an argument that animals have internal structures that support survival and behavior.

Evidence of Learning

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>Animal Mouth Structures</u> In this lesson, students gather evidence to understand features that enable them to meet their needs. In particular, they examine the mouth structures of different animals to help them understand how animals are adapted to obtain food in their environment.

Formative Assessments

Students who understand the concepts are able to:

- Describe a system in terms of its components and their interactions.
- Construct an argument with evidence, data, and/or a model.
- Construct an argument to support the claim that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (Assessment is limited to macroscopic structures within plant and animal systems.) Examples of structures could include:

★ Thorns	★ Heart
★ Stems	★ Stomach
★ Roots	★ Lung

	★ Colored petals	★ Brain	
		★ Skin	

What it Looks Like in the Classroom

In this unit of study, students spend time observing plants and animals in order to gather evidence that organisms are living systems. A system is made up of structures and processes that interact and enable the system to function. Every plant and animal can be described in terms of its internal and external structures and their interactions, and these structures each have specific functions that support survival, growth, behavior, and reproduction for the organism.

Using a variety of plants and animals as examples, students need multiple opportunities to:

- ü Describe the internal and external structures of a plant or animal and the function of each of those structures. Description should explain how each structure serves various functions in growth, survival, behavior, and/or reproduction. (Note: This is limited to macroscopic structures within plant and animal systems, and could include such structures as thorns, stems, roots, and colored petals for plants, and heart, stomach, lung, brain, and skin for animals.)
- Describe the interactions that occur among the structures within the plant or animal system.
- As students observe the structures of an animal or plant, explain the function of each, and describe how these structures help the animal grow, survive, and/or reproduce, they should use evidence from their observations to support their explanations.

Lesson Plans

Lesson	Timeframe
Lesson 1 Engineer It- What are Some External Structures of Animals?	3 Days Core Route 4 Days Traditional Route
Lesson 2 What are some Internal Structures of Animals?	3 Days Core Route 4 Days Traditional Route
Lesson 3 How do Senses Work?	3 Days Core Route 4 Days Traditional Route
Lesson Unit 5 Review and Unit 5 Test	2 Days
Additional Traditional Route Activities Unit 5 Project You Solve It Unit 5 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes: Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: How Do Plants and Animals Reproduce and Adapt? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do Plants and Animals Reproduce and Adapt? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Exploring the Galapagos Islands This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Review animal external structures with ELL/ELD students, including fur, hair, skin, feathers, shell, scales. Encourage them to translate some from English to their native language using images.

Lesson 3: Have students smell different scents, such as coffee beans, jelly-beans, and refried beans.

Ask: How would you describe the aroma of all three scents? How do you react when your receptors receive a new smell.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

• Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Animal Structure and Functions							
Lesson Title: What are some external structures of Animals?					**Timeframe:** 4 days		
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: • Will identify the external parts animals have and how their parts are used for growth, survival, behavior, and reproduction.	1. About this Image: A starfish, or sea star, isn't really a fish! It is animal called an echinoderm. Sea stars live all of Earth's oceans, but the North Pacific Ocean has the greatest variety. 2. Can you Explain It? Students are asked to explain how the gecko is climbing up the wall. 3. Exploration 1-Body Building: Students will develop an understanding that all animals have external structures that protect them from their environments and help them survive. They will engage in an argument using evidence to explain that where an animal lives and where it eats is related to	• Engaging in Argument from Evidence: Be sure students construct a meaningful arguments where they back up their points and can prove their statements. Use questions to guide them. • Applying Concepts: Have students research other examples of biomimicry, such as spider web silk, animals to explain how the

	the functions of its structures. Students will also study information to understand animal interactions in a system. 4. Exploration 2-Inspired by Nature: Students will develop an understanding that the animal world has led humans to some amazing inventions. 5. Take it Further: Discover More 6. Lesson Check: Can you explain it? 7. Lesson Check: Lesson Roundup	natural world serves as inspiration for solving human problems. ● Lesson Check: Can you explain it? ● Lesson check: Lesson Roundup.
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
<u>Engaging in Argument from Evidence</u> Construct an argument with evidence, data, and/or a model. (4-LS1-1)	**<u>LS1</u>**.A: **<u>Structure and Function</u>** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)	**<u>Systems and System Models</u>** A system can be described in terms of its components and their interactions. (4-LS1-1)

Content Area: Fourth Grade Science
Unit Title: Changes to Earth's Surface
Target Course/Grade Level: Unit 6 Grade 4
Unit Summary In this unit, children will… ● Explore how Earth has been shaped by water and other factors. ● Discover how people map Earth's surface. ● Learn about the patterns we can see from maps.

Lesson 1: Students will identify and record evidence of how water, weathering, erosion, and deposition shape Earth's surface. Students will investigate how water impacts Earth and then examine the relationships between Earth's surface and the physical forces of weathering, erosion, and deposition.

Lesson 2: Students will identify, explain, and record evidence regarding how rainfall, weathering, erosion, and deposition shape Earth's surface. Students will investigate how living things impact Earth and the examine and explain the relationship between them all.

Lesson 3: Students will make observations and analyze data about maps. Students will understand that maps can help locate the different land and water features of Earth, as shown in the patterns of mountain ranges, ocean trenches, and other natural phenomena.

Lesson 4: Students will analyze and interpret data about the locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes and use maps to identify the patterns of the locations in which they appear on land and in the oceans.

Primary interdisciplinary connections:

English Language Arts

To support integration of the CCSS for English Language Arts in this unit, students should have access to multiple sources of information about Earth's features and earth processes. Students should have opportunities to read, analyze, and interpret information from nonfiction text, charts, graphs, diagrams, timelines, and interactive elements on the Internet. Students use this information, along with data they collect during investigations, to help explain, both orally and in writing, the patterns they observe in the features of the Earth and in the natural hazards that occur on the Earth.

As students engage in the engineering design process, they need opportunities to conduct research to build their understanding of how earth processes affect humans and to find examples of ways in which engineers reduce the effect of volcanic eruptions, earthquakes, floods, and tsunamis. Students should take notes as they read and summarize or paraphrase their notes to support their work throughout the engineering design process.

In addition, students should provide a list of sources when using this type of information.

Describe the overall structure of events, ideas, concepts, or information in a text or part of text. **RI.4.5**
Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **RI.4.7**
Provide reasons supported by facts and details. **W.4.1**
Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources (3-5-ETS1-3) **W.4.8**
Add audio recordings and visual displays to presentations when appropriate to enhance the development of

main ideas of themes. **SL.4.5**

Mathematics

- Use measurements to determine how far earthquakes and volcanoes tend to occur from continental boundaries.
- Analyze data to determine patterns of change that occur in areas where volcanoes erupt, earthquakes occur, and in flood zones.
- Reason abstractly and quantitatively to draw diagrams to build scale models.
- Analyze timelines, charts, and graphs to determine patterns in Earth's features and patterns of change caused by earth processes.
- Reason abstractly and quantitatively when discussing the effects of an earth process on humans. For example, on average, 3,000 lives are lost every year due to tsunamis. When early warning systems are in place, fewer than 1,000 lives are lost annually.
- Analyze constraints on materials, time, or cost to in order to determine criteria for design solutions.

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb., oz.: l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. **4.MD.A.1**
Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. 4-ESS2-2) **4.MD.A.2**
Reason abstractly and quantitatively. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.2**
Model with mathematics. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.4**
Use appropriate tools strategically. (3-5-ETS1-2),(3-5-ETS1-3) **MP.5**

21st century themes

Global Awareness

Unit Rationale

Prior Learning

Grade 2 Unit 4: Earth's Surface

- Gather information to identify where water is located on Earth
- Develop maps to represent locations of land and water on Earth.

Future Learning

Grade 5 Unit 6: Earth's Systems

- Explore the hydrosphere, geosphere, biosphere, and atmosphere.
- Learn how Earth's systems interact.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
4-ESS2-1	Make observation and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
4-ESS2-2	Analyze and interpret data from maps to describe patterns of Earth's features. *[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]*

Unit Essential Question

Part A: How does water shape earth's surface?

Part B: What other factors shape earth's surface?

Part C: How do people map earth's surface?

Part D: What patterns do maps show us?

Unit Enduring Understandings

Part A:

- Identify, explain, and record evidence about how water shapes Earth's surface, and describe ways in which water causes weathering, erosion, and deposition to take place; identify how the speed and volume of water affect these processes.

Part B:

- Identify, explain, and record evidence about factors that shape Earth's surface, such as rainfall, organisms, wind, ice, and gravity.

Part C:

- To interpret map contents that illustrate topographical features and use maps as sources of data about Earth's features.

Part D:

- To identify and explain where on Earth's surface earthquakes, volcanoes, mountains, and ocean trenches can be found; to use maps to describe the patterns they observe in the locations of those land- and water forms.

Evidence of Learning

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit

- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>Engineering for the Three Little Pigs</u>: This activity helps to demonstrate the importance of rocks, soils, and minerals in engineering and how using the right material for the right job is important. The students build 3 different sand castles composed of varying amounts of sand, water, and glue. The 'buildings' in this lesson are made of sand and glue, sand being a soil and glue being composed of different minerals. They then test them for strength (load bearing), and resistance to weathering. The students will then compare possible solutions and discuss how well each is likely to work while meeting the criteria and constraints of the problem. The students will be the engineers who figure out which materials are best for the buildings they are making, taking into consideration all the properties of materials that are discussed in the lesson.

<u>Building for the Big One</u>: This lesson plan details a Design Challenge in which students build and test structures while learning about the earthquakes that shake them. It is designed as a review or culmination of an Earthquake unit of study. The lesson plan allows teachers to connect back to previous lessons. The Tech Museum of Innovation also suggests that the lesson might be used as a form of introduction to a unit about earthquakes. The lesson would then be used to determine students' prior knowledge to set the stage for the design challenge. This resource often mentions the effects of tectonic plates on earthquake location. Grade 4 curriculum does not include tectonic plates in their earth science curriculum. Tectonic plate information is included in the lesson as a resource for the teacher.

<u>Earthquakes in the Classroom</u>: Students investigate which building types are structured to withstand earthquake damage. They take on the role of engineers as they design their own earthquake resistant buildings, then test them in a simulated earthquake activity. Students also develop an appreciation for the job of engineers who need to know about earthquakes and their

causes in order to design resistant buildings. This lesson is one of several in the "Earthquakes Rock" unit provided by the Teach Engineering site. The unit "URL" listed here is not being reviewed for the Performance Expectation listed. It is offered as a supplemental concept and lesson background aid for teachers.
https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03.xml

Getting the Right Angle on the Story: This informational text shows students how tsunamis form and behave. It also describes how scientists are collecting data to create models that can be used to predict tsunamis. Animations/computer models are also included to enhance student knowledge of how tsunami warnings work. Models integrate new, unfamiliar vocabulary. Students could use the resource as a starting point for an earth systems unit; teachers could assign the site as a form of research where students gather data, take notes, and draw inferences from text. As students begin their study, they could generate a list of the earth's natural disasters and define their impact on human life and the environment. Their possible solutions for lessening that impact could also be incorporated as an informal formative assessment to determine student prior knowledge.

DLESE Earth Science Literacy Maps are a tool for teachers and students to find resources that relate to specific Earth science concepts. These maps illustrate connections between concepts and how they build upon one another across grade levels. Clicking on a concept within the maps will show DLESE resources related to the concept, as well as information about related AAAS Project 2061 Benchmarks and National Science Education Standards.

Formative Assessments

Students who understand the concepts are able to:

- Support an explanation using patterns as evidence.
- Analyze and interpret data to make sense of phenomena using logical reasoning.
- Analyze and interpret data from maps to describe patterns of Earth's features. Maps can include:
    - Topographic maps of Earth's land
    - Topographic maps of Earth's ocean floor
    - Locations of mountains
    - Locations of continental boundaries
    - Locations of volcanoes and earthquakes
- Identify and test cause-and-effect relationships in order to explain change.
- Generate multiple solutions to a problem and compare them based on how well they meet the criteria and constraints of the design solution.
- Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans (Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.) Examples of solutions could include:
    - Designing an earthquake-resistant building

- Improving monitoring of volcanic activity.

- Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

What it Looks Like in the Classroom

In this unit of study, students analyze and interpret data from maps to describe patterns of Earth's features. Students can use topographic maps of Earth's land and ocean floor in order to locate features such as mountains, mountain ranges, deep ocean trenches, and other ocean floor structures. As students analyze and interpret these types of maps, they begin to notice patterns in the types of structures and where these structures are found. Students learn that major mountain chains often form along or near the edge of continents. Once students locate continental boundaries, a further analysis of data can show students that there is a noticeable pattern of earth events, including volcanoes and earthquakes, which occur along these boundaries.

During this unit, students also learn that engineers develop or improve technologies to solve societal problems. A variety of hazards result from natural processes (e.g. earthquakes, floods, tsunamis, volcanic eruptions). Although we cannot eliminate the hazards, we can take steps to reduce their impacts. Students must have the opportunity to engage in the engineering design process in order to generate and compare multiple solutions that reduce the impacts of natural Earth processes on humans. This process should include the following steps:

- ➢ Students brainstorm possible problems that Earth processes can cause for humans. (Earth processes should be limited to earthquakes, volcanic eruptions, tsunamis, and floods.)
- ➢ Either as a class or in small groups, have students select one problem (such as the effects of volcanic eruptions on humans) to research.
- ➢ Small groups conduct research to determine possible solutions (such as consistent monitoring of volcanic activity and the use of early warning systems) that reduce the impacts of the chosen Earth process on humans.
- ➢ As a class, determine criteria and possible constraints on the design solutions. Criteria might include: saving lives and/or reducing property loss.
- ➢ Small groups investigate how well the solutions perform under a range of likely conditions. This may involve additional research and analysis of available data or planning and conducting investigations to produce data that will serve as the basis for evidence. During this process, students should plan and carry out fair tests in which variables are controlled and failure points are considered in order to identify elements of the design solution that do and do not meet criteria.

- ➢ Students compare the solutions based on how well they meet criteria and constraints, using data as evidence to support their thinking. At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

Engineering design performance expectations are an integral part of this unit of study. Students are expected to research a problem, generate and compare possible design solutions, and test the design solutions to determine how well each performs under a range of likely conditions. Using data as evidence, students identify elements of each design that need improvement and determine which design solution best solves the problem, given the criteria and the constraints. This process is outlined in greater detail in the previous section.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 How Does Water Shape Earth's Surface?	3 Days Core Route 4 Day Traditional Route
Lesson 2 What Other Factors Shape Earth's Surface?	3 Days Core Route 4 Day Traditional Route
Lesson 3 Engineer It-How Can Maps Help Us to Learn About Earth's Surface?	3 Days Core Route 4 Day Traditional Route
Lesson 4 What Patterns Do Maps Show Us?	3 Days Core Route 4 Day Traditional Route
Unit 6 Review and Unit 6 Test	2 days
Additional Traditional Route Activities Unit 6 Project You Solve It Unit 6 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: Earth's Changing Surface and Natural Resources This reader reinforces unit concepts and includes response activities for your students.

Extra Support: Earth's Changing Surface and Natural Resources This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Conserving Earth's Resources This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

- Point out cognates of key of key terms from students' home language, for example, canyon/canon, erosion/erosion, desert/desierto, to help bridge understanding of pertinent lesson vocabulary. Pronounce each word and spotlight the similarities. Ask other students to share the same words in their home language.
- Show a continent on a political map. Ask: What are three countries that are in the continent of North America?
- Show a picture of an ocean trench. Have students use adjectives to describe it.
- Have students draw a picture of what they think an ocean trench is. Then, have them describe their pictures.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Changes to Earth's Surface							
Lesson Title: How Does Water Shape Earth's Surface?					**Timeframe:** 4 days		
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy	X	Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Identify, explain, and record evidence about how water shapes Earth's surface, and describe ways in which water causes weathering, erosion, and deposition to take place; identify how the speed and volume of water affect these processes.	1. About this Image: The Grand Canyon is located in the Northwest corner of Arizona. It is 277 miles long and up to 18 mile wide. It was formed by the Colorado River, which lows west through the canyon and averages 300 feet wide. 2. Can you Explain It? Students are asked to record their initial thoughts about how the different rock layers they see were formed. 3. Exploration 1: Making a Move: Investigate cause-and-relationship between water and the processes of weathering, erosion, and deposition that affect the physical characteristics of Earth's surface. 4. Exploration 2-Away it Goes: Students will investigate and gather evidence to	● Putting it together: Make certain students understand the concept of Earth's river systems by asking for different volunteers to describe one step in the sequence of a river's journey from its source to its mouth. Student should also understand the positive and negative affects of flooding. ● Categorizing Information: As students fill in the table, remind them that water produces a certain outcome to shape and reshape Earth's surface

	explain the cause-and effect relationship between floods, heavy rains, ocean waves, and swift currents and the impact they have on Earth's Surface. 5. Exploration 3_Cold Stuff: Students will make observation of how forces that break down rocks have a cause-and-effect relationship with Earth's surface. 6. Take it Further: Discover More 7. Lesson Check-Can you Explain It? 8. Lesson Check-Lesson roundup.	and that outcome is the effect. ● Cause and Effect: Before students work through items 23 and 24, discuss that each sentence has only one correct answer from the word bank. ● Lesson check-Can you explain it? ● Lesson Check-Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2) **Constructing Explanations and Designing Solutions** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2),(3-5-ETS1-2) **Planning and Carrying Out Investigations** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence,	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** · The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2) **ESS3.B: Natural Hazards** A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot	**Patterns** Patterns can be used as evidence to support an explanation. (4-ESS2-2) **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on**

using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) *(Note: This Disciplinary Core Idea can also be found in 3.WC.)* **ETS1.B: Designing Solutions to Engineering Problems** Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2)* **ETS1.B: Developing Possible Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	**Society and the Natural World** Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Content Area: Fourth Grade Science
Unit Title: Rocks and Fossils
Target Course/Grade Level: Unit 7 Grade 4
Unit Summary In this unit students will… ● Explore the different layers an of rocks and how they change. ● Discover what we can learn about fossils and ancient environments ● Identify patterns in Fossils

Lesson 1: Students will model rock layers to gather evidence about how they form and what information they contain about the history of planet Earth. They will look at examples of exposed layers in different formations and come up with explanations for how these layers tells stories about the past and the Earth processes that shape and change rocks.

Lesson 2: Students examine fossils representing life from different periods in Earth's history, determine the habitats in which those fossils lived, and draw conclusions about what modern-day organisms the fossils may be related to. By looking closely at the structures of fossils and living organisms, students see repeated forms and traits that helped these organisms survive in specific environments.

Lesson 3: Students use evidence to determine what past environments were like, examine the fossils in different layers of rock to reveal the history of planet Earth, and construct explanations for how environments have changed over time. Studying patterns in rocks and fossils, students learn how changes to Earth's surface have affected and will continue to affect rock layers.

Primary interdisciplinary connections:

English Language Arts

To support integration of the NJ-SLS for English Language Arts in this unit, students should have access to multiple sources of information about Earth's features and earth processes. Students should have opportunities to read, analyze, and interpret information from nonfiction text, charts, graphs, diagrams, timelines, and interactive elements on the Internet. Students use this information, along with data they collect during investigations, to help explain, both orally and in writing, the patterns they observe in the features of the Earth and in the natural hazards that occur on the Earth.

As students engage in the engineering design process, they need opportunities to conduct research to build their understanding of how earth processes affect humans and to find examples of ways in which engineers reduce the effect of volcanic eruptions, earthquakes, floods, and tsunamis. Students should take notes as they read and summarize or paraphrase their notes to support their work throughout the engineering design process.

In addition, students should provide a list of sources when using this type of information.

Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **W.4.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list sources. **W.4.8**
Draw evidence from literary or informational texts to support analysis, reflection, and research. **W.4.9**

Mathematics

Know relative sizes of measurements units within one system of units within one system of units including Km, cm, m; kg, g,; lb., oz.; lamp,; hr, min, sec. Within a single system of measurement, express

measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. **4.MD.A.1**
Reason abstractly and quantitatively. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.2**
Model with mathematics. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.4**
Use appropriate tools strategically. (3-5-ETS1-2),(3-5-ETS1-3) **MP.5**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Grade 3 Unit 6: Fossils

- In this unit students learned how to explore fossils & discovered what fossils can tell us about animals hat lived long ago.

Future Learning

Middle School Level: MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-Billion-year-old history.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
4-ESS1-1	Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

Unit Essential Question

Part A: How Do Rock Layers Change?

Part B: What Do Fossils Tell Us About Ancient Environments?

Part C: What are Some Patterns Fossils Show Us?

Unit Enduring Understandings

Part A:

- To construct explanations for the ways in which rock layers reveal patterns and reflect the history of planet Earth.

Part B:

- Examine fossil evidence to determine how and in what environments organisms of the past lived, based on their physical traits and similarities to living organisms.

Part C:

- To examine fossils and other geologic evidence to understand what past environments were like, how they have changed over time, and how changes to Earth's surface have affected them.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

Engineering for the Three Little Pigs: This activity helps to demonstrate the importance of rocks, soils, and minerals in engineering and how using the right material for the right job is important. The students build 3 different sand castles composed of varying amounts of sand, water, and glue. The 'buildings' in this lesson are made of sand and glue, sand being a soil and glue being composed of different minerals. They then test them for strength (load bearing), and resistance to weathering. The students will then compare possible solutions and discuss how well each is likely to work while meeting the criteria and constraints of the problem. The students will be the engineers who figure out which materials are best for the buildings they are making, taking into consideration all the properties of materials that are discussed in the lesson.

DLESE Earth Science Literacy Maps are a tool for teachers and students to find resources that relate to specific Earth science concepts. These maps illustrate connections between concepts and how they build upon one another across grade levels. Clicking on a concept within the maps will show DLESE resources related to the concept, as well as information about related AAAS Project 2061 Benchmarks and National Science Education Standards.

Formative Assessments

Students who understand the concepts are able to:

- Support an explanation using patterns as evidence.
- Analyze and interpret data to make sense of phenomena using logical reasoning.
- Analyze and interpret data from maps to describe patterns of Earth's features. Maps can include:
    - Topographic maps of Earth's land
    - Topographic maps of Earth's ocean floor
    - Locations of mountains
    - Locations of continental boundaries
    - Locations of volcanoes and earthquakes
- Identify and test cause-and-effect relationships in order to explain change.
- Generate multiple solutions to a problem and compare them based on how well they meet the criteria and constraints of the design solution.
- Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans (Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.) Examples of solutions could include:
    - Designing an earthquake-resistant building
    - Improving monitoring of volcanic activity.
- Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 How Do Rock Layers Change?	3 Days Core Route 4 Days Traditional Route
Lesson 2 What Do Fossils Tell Us About Ancient Environments?	3 Days Core Route 4 Days Traditional Route
Lesson 3 What are Some Patterns Fossils Show Us?	3 Days Core Route 4 Days Traditional Route
Unit 7 Review and Unit 7 Test	2 Days
Additional Traditional Route Activities Unit 7 Project You Solve It	 2 days 1 day

Unit 7 Performance Task Performance-Based Assessment	1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: Earth's Changing Surface and Natural Resources This reader reinforces unit concepts and includes response activities for your students.

Extra Support: Earth's Changing Surface and Natural Resources This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Conserving Earth's Resources This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Show students images of people of various ages. **Ask:** How old do you think the oldest person in these images is? **Ask:** How old do you think the youngest person in these images is? Explain to students that they are comparing ages. The youngest person's age is relative to the oldest person's age/ Throughout this lesson, they will do the same thing with different layers of rock.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Rocks and Fossils							
Lesson Title: How Do Rock Layers Change?						**Timeframe:** 4 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy	X	Health Literacy
21st Century Skills							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● To construct explanations for the ways in which rock layers reveal patterns and reflect the history of planet Earth.	1. About this Image: This mountain looks the way it does because of weathering and erosion. Elemental forces have caused the surface of the mountain to break down into small particles of rock, which have been moved by water and rain. 2. Can You Explain It? Students are asked to record their initial thoughts about how the rocks of the Niobrara chalk formation formed, as well as which layers are the oldest and which are the youngest 3. Exploration 1-One Layer at a Time: Develop an understanding of how rock layers form as older layers of sediment are compacted by new layers of sediment, which press the lower layers into rock. 4. Exploration 2: Layer on Layer: Affirm understanding of rock layers through a group of exercises that show how those layers, or patterns, reveal the history of planet Earth.	● Ask: What do the layers in rock represent? ● Ask: What is one way to tell whether rock layers from different areas represent the same time period? ● Citing Evidence: Students should be reminded that when they write reports or answer science-related questions, they need to cite

	5. Exploration 3- Not What It Used to Be: Students will construct explanations of how patterns in rock layers are caused by slow or fast changes over time. 6. Take it Further-Discover More 7. Lesson Check-Can you Explain it? 8. Lesson Check-Lesson Roundup	evidence to back up their claims. ● Lesson Check-Can you explain it? ● Lesson Check-Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2) **Constructing Explanations and Designing Solutions** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2),(3-5-ETS1-2) **Planning and Carrying Out Investigations** Plan and conduct an investigation	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** · The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2) **ESS3.B: Natural Hazards** A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) *(Note: This Disciplinary Core Idea can also be found in 3.WC.)* **ETS1.B: Designing Solutions to Engineering Problems** Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2)*	**Patterns** Patterns can be used as evidence to support an explanation. (4-ESS2-2) **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers improve existing

collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	**ETS1.B: Developing Possible Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Content Area: Fourth Grade Science
Unit Title: Natural Resources and Hazards
Target Course/Grade Level: Unit 8 Grade 4

Unit Summary

In this unit, students will…

- Explore how renewable and nonrenewable resources are used for energy.
- Discover how people can reduce land- and water-based hazards and their impacts.

Lesson 1: Students will obtain, evaluate, and communicate information about nonrenewable resources, protecting and reducing the use of nonrenewable resources. They will learn how people's need and wants change over time as they demand new and better technologies.

Lesson 2: Students will learn about renewable energy resources including how we make use of them. They will evaluate the benefits and drawbacks of renewable resources.

Lesson 3: Students learn about natural hazards that take place on land, such as volcanic eruptions, earthquakes, landslides, and wildfires. They explore the causes and effects of these events and analyze information about how maps can used to assess the risk of natural hazards.

Lesson 4: Students will study a variety of water-based Earth processes that can be hazardous to humans and design and test multiple solutions to lessen the impacts of these processes on humans.

Primary interdisciplinary connections:

English Language Arts

Compare and contrast the most important points and key details presented in two texts on the same topic.

RI.3.9
Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-ESS3-2) **RI.4.1**
Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. **RI.4.9**
Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **W.4.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **W.4.8**
Draw information from literary or informational texts to support analysis. **W.4.9**

Mathematics.

Reason abstractly and quantitatively. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.2**
Model with mathematics. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.4**
Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-2) **4.OA.A.1**

21st century themes

Global Awareness & Civic Literacy

Unit Rationale

Prior Learning

Earth and Human Activity

- 3-ESS3-1

Future Learning

Earth and Human Activity

- 5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment
- MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

Learning Targets	
Standards	
NJSLS-S#	**Performance Expectation**
4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-ESS3-2	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* *[Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.]* [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

Unit Essential Question

Part A: What Nonrenewable Resources are Used for Energy?

Part B: What Renewable Resources are Used for Energy?

Part C: How Can People reduce the impact of land-based hazards?

Part D: How can people reduce the impact of water-based hazards?

Unit Enduring Understandings

Part A:

- Understand that humans use energy and fuels derived from natural resources. Rely on books and other media to explain the use and reuse of natural resources as well as gain the knowledge that human needs change over time.

Part B:

- Obtain and evaluate information about renewable resources. Apply knowledge of the interdependence of science and technology to draw conclusion about electrical energy systems.

Part C:

- Describe a variety of Earth processes on land that can be hazardous to humans and how the impact of these processes can be lessened.

Part D:

- To analyze and describe a variety of water-based processes that can be hazardous to humans and design and test multiple solutions to lessen the impacts of these natural Earth processes on humans.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check

- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work.
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>Building for the Big One</u>: This lesson plan details a Design Challenge in which students build and test structures while learning about the earthquakes that shake them. It is designed as a review or culmination of an Earthquake unit of study. The lesson plan allows teachers to connect back to previous lessons. The Tech Museum of Innovation also suggests that the lesson might be used as a form of introduction to a unit about earthquakes. The lesson would then be used to determine students' prior knowledge to set the stage for the design challenge. This resource often mentions the effects of tectonic plates on earthquake location. Grade 4 curriculum does not include tectonic plates in their earth science curriculum. Tectonic plate information is included in the lesson as a resource for the teacher.

<u>Earthquakes in the Classroom</u>: Students investigate which building types are structured to withstand earthquake damage. They take on the role of engineers as they design their own earthquake resistant buildings, then test them in a simulated earthquake activity. Students also develop an appreciation for the job of engineers who need to know about earthquakes and their causes in order to design resistant buildings. This lesson is one of several in the "Earthquakes Rock" unit provided by the Teach Engineering site. The unit "URL" listed here is not being reviewed for the Performance Expectation listed. It is offered as a supplemental concept and lesson background aid for teachers.
https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03.xml

<u>Getting the Right Angle on the Story</u>: This informational text shows students how tsunamis form and behave. It also describes how scientists are collecting data to create models that can be used to predict tsunamis. Animations/computer models are also included to enhance student knowledge of how tsunami warnings work. Models integrate new, unfamiliar vocabulary.

Students could use the resource as a starting point for an earth systems unit; teachers could assign the site as a form of research where students gather data, take notes, and draw inferences from text. As students begin their study, they could generate a list of the earth's natural disasters and define their impact on human life and the environment. Their possible solutions for lessening that impact could also be incorporated as an informal formative assessment to determine student prior knowledge.

DLESE Earth Science Literacy Maps are a tool for teachers and students to find resources that relate to specific Earth science concepts. These maps illustrate connections between concepts and how they build upon one another across grade levels. Clicking on a concept within the maps will show DLESE resources related to the concept, as well as information about related AAAS Project 2061 Benchmarks and National Science Education Standards.

Formative Assessments

Students who understand the concepts are able to:

- Support an explanation using patterns as evidence.
- Analyze and interpret data to make sense of phenomena using logical reasoning.
- Analyze and interpret data from maps to describe patterns of Earth’s features. Maps can include:
    - Topographic maps of Earth’s land
    - Topographic maps of Earth’s ocean floor
    - Locations of mountains
    - Locations of continental boundaries
    - Locations of volcanoes and earthquakes
- Identify and test cause-and-effect relationships in order to explain change.
- Generate multiple solutions to a problem and compare them based on how well they meet the criteria and constraints of the design solution.
- Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans (Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.) Examples of solutions could include:
    - Designing an earthquake-resistant building
    - Improving monitoring of volcanic activity.
- Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

What it Looks Like in the Classroom

In this unit of study, students analyze and interpret data from maps to describe patterns of Earth's features. Students can use topographic maps of Earth's land and ocean floor in order to locate features such as mountains, mountain ranges, deep ocean trenches, and other ocean floor structures. As students analyze and interpret these types of maps, they begin to notice patterns in the types of structures and where these structures are found. Students learn that major mountain chains often form along or near the edge of continents. Once students locate continental boundaries, a further analysis of data can show students that there is a noticeable pattern of earth events, including volcanoes and earthquakes, which occur along these boundaries.

During this unit, students also learn that engineers develop or improve technologies to solve societal problems. A variety of hazards result from natural processes (e.g. earthquakes, floods, tsunamis, volcanic eruptions). Although we cannot eliminate the hazards, we can take steps to reduce their impacts. Students must have the opportunity to engage in the engineering design process in order to generate and compare multiple solutions that reduce the impacts of natural Earth processes on humans. This process should include the following steps:

- ➢ Students brainstorm possible problems that Earth processes can cause for humans. (Earth processes should be limited to earthquakes, volcanic eruptions, tsunamis, and floods.)
- ➢ Either as a class or in small groups, have students select one problem (such as the effects of volcanic eruptions on humans) to research.
- ➢ Small groups conduct research to determine possible solutions (such as consistent monitoring of volcanic activity and the use of early warning systems) that reduce the impacts of the chosen Earth process on humans.
- ➢ As a class, determine criteria and possible constraints on the design solutions. Criteria might include: saving lives and/or reducing property loss.
- ➢ Small groups investigate how well the solutions perform under a range of likely conditions. This may involve additional research and analysis of available data or planning and conducting investigations to produce data that will serve as the basis for evidence. During this process, students should plan and carry out fair tests in which variables are controlled and failure points are considered in order to identify elements of the design solution that do and do not meet criteria.
- ➢ Students compare the solutions based on how well they meet criteria and constraints, using data as evidence to support their thinking. At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

Engineering design performance expectations are an integral part of this unit of study. Students are expected to research a problem, generate and compare possible design solutions, and test the design solutions to determine how well each performs under a range of likely conditions. Using data as evidence, students identify elements of each design that need improvement and determine which design solution best solves the problem, given the criteria and the constraints. This process is outlined in greater detail in the previous section.

Lesson Plans

Lesson	**Timeframe**
Lesson 1 What Non-Renewable Resources are Used for Energy?	3 days Core Route 4 days Traditional Route
Lesson 2 **Engineer it-** What Renewable Resources are used for Energy?	3 days Core Route 4 days Traditional Route
Lesson 3 How Can People Reduce the Impact of Land-Based Hazards?	3 days Core Route 4 days Traditional Route
Lesson 4 Engineer It-How Can people reduce the impact of water-based hazards.	3 days Core Route 4 days Traditional Route
Unit 8 Review and Unit 8 Test	2 days
Additional Traditional Route Activities Unit 8 Project You Solve It Unit 8 Performance Task Performance-Based Assessment	 2 days 1 day 1 day 1 day

Teacher Notes:

Core Pacing is based on sharing course time with Social Studies. Traditional Pacing is based on course time having a dedicated period for the entire year.

Differentiation:

On-Level Reader: Earth's Changing Surface and Natural Resources This reader reinforces unit concepts and includes response activities for your students.

Extra Support: Earth's Changing Surface and Natural Resources This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Conserving Earth's Resources This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL: **Lesson 1:** Point out cognates of key terms from students' home languages, for example, resource/rescurso, natural resource/rescurso natural, to help bridge understanding of pertinent lesson vocabulary. Pronounce each word, and spotlight the similarities. Ask other students to share the same word in their home languages. **Lesson 2:** Break down the vocabulary term renewable resource. Ask: What doe is mean to renew something? Ask: What is a resource? Tell students that a renewable resource is one that can be made new again, or replenished. It doesn't get totally used up. **Lesson 3:** Have students preview at the types of land-based natural hazards in exploration 1. Model how to use the captions and diagrams to define each hazard. **Lesson 4:** Have English-language learners add fourth and fifth columns to their tables. In those columns, have them add the terms and definition in their primary language.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1	
Content Area: Natural Resources and Hazards	
Lesson Title: What nonrenewable resources are used for energy?	**Timeframe:** 4 days
Lesson Components	

21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students will: ● Understand that humans use energy an fuels derived from natural resources. Rely on books and other media to explain the use and reuse of natural resources as well as gain the knowledge that human needs change over time.	1. About this Image: An oil rig is equipped to drill and service an oil well. A well provides access to an oil "field" that is underground or beneath the ocean floor. 2. Can you Explain It: Students are asked to look at cards and to observe how they have changed over the years. Have a class a discussion on the cards in the photographs. 3. Exploration 1-Material we use: Evaluate information about resources. Recognize that some resources are renewable and others are not. Analyze how people's wants and needs change due to the environment and other circumstances. 4. Exploration 2: Search and Find: After learning about nonrenewable resources, evaluate the pros and cons of using them by studying causes and effects of using nonrenewable resources. 5. Take it Further-Discover More 6. Lesson Check-Can you explain it 7. Lesson Check- Lesson Roundup	● Putting it Together: Review all the words in the box with students before they fill in the answer to item 10. Remind them that they may look back in Exploration 1 for help with the words and where they belong in the sentences. ● Collaboration: Feedback- As students answer the question, have small groups discuss any toys or household appliances that may have rechargeable batteries. ● Lesson Check-Can you explain it. ● Lesson Check-Lesson Roundup

Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

<table>
<tr><td colspan="3">The Student Learning Objectives above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr>
<td>Analyzing and Interpreting Data
Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)
Constructing Explanations and Designing Solutions
Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2),(3-5-ETS1-2)
Planning and Carrying Out Investigations
Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)</td>
<td>ESS2.B: Plate Tectonics and Large-Scale System Interactions
· The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)
ESS3.B: Natural Hazards
A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) (Note: This Disciplinary Core Idea can also be found in 3.WC.)

ETS1.B: Designing Solutions to Engineering Problems
Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)
ETS1.B: Developing Possible Solutions
Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it</td>
<td>Patterns
Patterns can be used as evidence to support an explanation. (4-ESS2-2)
Cause and Effect
Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2)
- -
Connections to Engineering, Technology, and Applications of Science
Influence of Engineering, Technology, and Science on Society and the Natural World
Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2)
Engineers improve existing</td>
</tr>
</table>

	performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Grade 5

Content Area: Science **Grade Level: 5th Grade**
First Marking Period - Pacing Guide ● **Unit 1: Engineering and Technology- 22 days** **NJ-SLS-S:** 5-ESS3-1, 3-5-ETS1-1, 3-5-ETS1.2, & 3-5-ETS1.3 ● **Unit 2: Matter-22 days** **NJ-SLS-S:** 5-PS1-1, 5-PS1-2, & 5-PS1-3
Second Marking Period - Pacing Guide ● **Unit 3: Energy and Matter in Organisms-22 days** **NJ-SLS-S:** 5-LS1-1, & 5-PS3-1 ● **Unit 4: Energy and Matter in Ecosystems -17 days** **NJ-SLS-S:** 5-LS2-1
Third Marking Period - Pacing Guide ● **Unit 5: Systems in Space-27**

NJ-SLS-S: 5-PS2-1, 5-ESS1-1, & 5-ESS1-2 ● **First ½ of Unit 6: Earth Systems-11 days** **NJ-SLS-S:** 5-ESS2-1 and 5-ESS2-2
Fourth Marking Period - Pacing Guide ● **Second ½ of Unit 6: Earth Systems-11 days** **NJ-SLS-S:** 5-ESS2-1 and 5-ESS2-2 ● **Unit 7: Earth And Human Activity-17 days** **NJ-SLS-S:** 5-ESS3-1

Content Area: Fourth Grade Science
Unit Title: Engineering and Technology
Target Course/Grade Level: Unit 1 Grade 5
Unit Summary In this unit, students will… ● Discover how science and math are used in engineering ● Investigate a design process ● Explore how technology decisions affect society. **Lesson 1:** Students will explain the purpose of engineering and technology and give examples of how engineering an technology and give examples of how engineering is used in science. They will explore models and systems that are products of engineering and recognize that technology solves a problem or meets need. They will learn that technologies change over time as needs change and investigate engineering and science practices by designing and communicating a solution to a problem. **Lesson 2:** Students will investigate and apply aspects of the design process. They will ask and answer questions, constructing explanations as they design solutions to a problem. Throughout, they develop an understanding of the influence of science, engineering, and technology on the natural world. **Lesson 3:** Students will examine the engineering of certain technologies according to human wants and needs. They will explain the relationship between technology and society, indicating how technology has bother positive and negative impacts on society and the natural world. Students will carry out investigations

that increase their awareness of engineering and technology, and learn how to identify problems and solutions.

Primary interdisciplinary connections:

English Language Arts

Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1),(3-5-ETS1-3) **W.5.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-1),(3-5-ETS1-3) **W.5.8**

Mathematics

Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane. **5.OA.B.3**
Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. **5.G.A.2**
Reason abstractly and quantitatively. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3) **MP.2**
Model with mathematics. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3) **MP.4**

21st century themes:

Global Awareness & Financial, Economic, Business and Entrepreneurial Literacy

<u>**Unit Rationale**</u>

Prior Learning

Kindergarten Unit 1: Engineering and Technology

In the unit children will learn the follow: Define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems & Explore and apply a design process

Grade 1 Unit 1: Engineering Design Process

- In this Unit children will define and identify problems, define and identify examples of technology, describe how people understand problems and use technology to solve problems, and explore and apply a design process.

Grade 2 Unit 1: Engineering and Technology

In the unit children will learn the follow:

- Ask questions, make observations, and gather information to define a problem.

- Use a design process to solve a problem
- Compare the strengths and weaknesses of multiple design solutions.

Grade 3 Unit 1:

In the unit children will do the follow:

- Define problems and design solutions to those problems
- Test solutions and make improvements to solutions.

Grade 4 unit 1:

In this unit students will….

- Explore how engineers define problems and solutions.
- Learn about the importance of prototypes.
- Use models to examine how prototypes are tested and improved.

Future Learning

Engineering Design:

MS-ETS1-1

MS-ETS1-2

MS-ETS1-3

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Unit Essential Question

Part A: How are science and math used in engineering?

Part B: What is the design process?

Part C: How does technology affect society?

Unit Enduring Understandings

Part A: Explain the purpose of engineering and technology, and give examples of how engineering and math are used in science.

Part B: Define problems seen in photographs and maps, using the engineering design process to find good solutions to the problems.

Part C: Explain how society affects the evolution and development of technology; describe positive and negative, and planned and intended, consequences of technology; and explain how tradeoffs balance opposing needs or wants.
Evidence of Learning
Assessment ● **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit ● **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check ● **Summative Assessment:** 1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson. 2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work. 3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional rubric for evaluating children's mastery on all three dimensions of the NGSS **Equipment needed:** TCI Kits **Teacher Resources:** TCI teacher editions, worktexts & assessment guide. The Sound of Science: Students are given a scenario/problem that needs to be solved: Their school is on a field trip to the city to listen to a rock band concert. After arriving at the concert, the students find out that the band's instruments were damaged during travel. The band needs help to design and build a stringed instrument with the available materials, satisfying the following criteria and constraints: 1) Produce three different pitched sounds. 2) Include at least one string. 3) Use only available materials. 4) Be no longer than 30 cm / 1 foot. The challenge is divided into 4 activities. Each activity is designed to build on students' understanding of the characteristics and properties of sound. By using what they learn about sound from these activities, students are then encouraged to apply what they know about sound to complete the engineering design challenge. Energy Makes Things Happen: The Boy Who Harnessed the Wind: This article from Science and Children provides ideas for using the trade book, The Boy Who Harnessed the Wind, as a foundation for a lesson on generators. This beautiful book is the inspiring true story of a teenager in Malawi who built a generator from found materials to create much-needed electricity. The lesson allows students to explore the concept of energy transfer using crank generators.

Students then design improvements to the crank mechanism on the generator. The lesson may be extended by having students build their own generators.

Light Your Way: Using the engineering design process, students will be designing and building a lantern that they will hypothetically be taking with them as they explore a newly discovered cave. The criteria of the completed lantern will include: hands need to be free for climbing, the lantern must have an on/off switch, it must point ahead when they are walking so they can see in the dark, and the lantern must be able to stay lit for at least 15 minutes. The constraints of the activity will be limited materials with which to build. At the completion of the activity, the students will present their final lantern to the class explaining how they revised and adapted the lantern to meet the criteria of the project. Students will include in the presentation the sketch of the model they created prior to building showing the labeled circuit they designed. This activity was one of numerous engineering lessons from the Virginia Children's Engineering Council geared towards Grades 1-5. http://www.childrensengineering.org/technology/designbriefs.php.

Formative Assessments

Students who understand the concepts are able to:

- Describe the various ways that energy can be transferred between objects.
- Apply scientific ideas to solve design problems.
- Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.)
- Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound or passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.
- Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Lesson Plans

Lesson	**Timeframe**
Unit 1 Project	2 days
Lesson 1	5 Days Comprehensive Class

Engineer It: How are science and Math used in Engineering?	
Lesson 2 What is the Design Process?	5 Days Comprehensive Class
Lesson 3 How Does Technology Affect Society?	5 Days Comprehensive Class
You Solve it	1 day
Unit 1 Performance Task	1 day
Performances-Based Assessment	1 day
Unit 1 Review and Unit 1 Test	2 Days

Teacher Notes: Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: How Do Engineers Solve Problems? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do Engineers Solve Problems? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Harnessing the Wind: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Use Realia: Help student identify technology. Hold and apple and a pencil. Ask: Which one is designed and made by people? Ask: Which one is technology?

Lesson 2: Model a short brainstorming session. Ask: What are your favorite foods? Ask: Why do we brainstorm at the start of a new project? This is a compound word made from brain and storm/storming. We use our brains to come up with many ideas, and we do it quickly like a storm.

Lesson 3: ELL students may need additional assistance understanding the vocabulary term. They may take a more literal understanding and think that the word off in tradeoff means that the trade is off. Ask: What does it mean when someone says you can have this or that?

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

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Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Explain the purpose of engineering and technology, and give examples of how engineering and math are used in science.	1. About this Image: The Hubble space telescope was the first space and remains the most famous. Since its launch in 1990, Hubble has gathered more than 1.2 million images. 2. Can You Solve It? Students are asked to infer why the Hubble Space Telescope was not able to take clear pictures and see different parts of space as well as it was built to do. They are also asked to predict how the telescope was fixed. 3. Exploration 1-What is Engineering: Learn about engineering and technology and identify items or systems that are products of engineering. Recognize that technology solves a problem or meets a need and use examples to apply this knowledge to one's own life. Research a technology of students choice and communicate the results. 4. Exploration 2-How Does Engineering Use Science: Learn how technologies change over time to meet people's wants and needs. Explore the relationship between science and technology can lead to new scientific discoveries and how new scientific discoveries can lead to new technology. Also, compare and contrast engineering practices and science practices. 5. Take it Further: Discover More 6. Lesson Check: Can You Solve It? 7. Lesson Check: Lesson Roundup	● Obtaining, Evaluating, and Communicating Information: Have students review the definition of technology. Scan through the images in the lesson and ask students to explain the purpose of each type of technology. ● Communicating Information: Have students consider all they have learned about advances in technology related to light and vision. Point out that the study of optics applies to technology, ranging from ancient spectacles to space telescopes. ● Lesson Check: Can You Solve It? ● Lesson Check: Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Apply scientific ideas to solve design problems. (4-PS3-4) Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) **Asking Questions and Defining Problems** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1) **Planning and Carrying Out Investigations** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	**PS3.B: Conservation of Energy and Energy Transfer** Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-4) **PS3.C: Relationship Between Energy and Forces** When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3) **PS3.D: Energy in Chemical Processes and Everyday Life** The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) **ETS1.B: Developing Possible Solutions** Research on a problem should be carried	**Energy and Matter** Energy can be transferred in various ways and between objects. (4-PS3-4) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers improve existing technologies or develop new ones. (4-PS3-4) - ***Connections to Nature of Science*** **Science is a Human Endeavor** Most scientists and engineers work in teams. (4-PS3-4) Science affects everyday life. (4-PS3-4) **Influence of Science, Engineering, and Technology on Society and the Natural World** People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet

	out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	societal demands. (3-5-ETS1-2)

Content Area: Fifth Grade Science
Unit Title: Matter
Target Course/Grade Level: Unit 2 Grade 5

Unit Summary

In this Unit, students will…

- Discover the different states of matter and how measure matter.
- Explore the different properties of matter along with dissolving rates of certain matter.
- Compare and contrast physical and chemical changes of matter.

Lesson 1: Students will learn to recognize that all objects are made of matter and identify the three most common states of matter: solid, liquids, and gases. Students will be able to explain that all matter is made of particles too small to be seen. Through planning and carrying out investigations, students will demonstrate how to measure matter, including length, weight, and volume.

Lesson 2: Students continue their exploration of structure and properties by focusing on the properties of matter, mixtures, and solutions. They gather evidence about the formation of solutions and analyze information about size, proportion, rate, and ratios. They will also apply math and use models in the properties of matter.

Lesson 3: Students will study a number of processes to learn which changes in properties represent physical changes and which represent chemical changes. They find that both kinds of changes are consistent with the law of conversation of matter and with the particle model of matter.

Primary interdisciplinary connections:

English Language Arts

In order to integrate literacy into this unit of study, students can conduct research by using text and media resources to build their knowledge of the physical properties of matter. In researching this topic, students can recall and gather information by summarizing or paraphrasing their research as they take notes in their science journals. Students can also draw evidence from informational texts to support their design choices as they build and share their models of matter at the particle level. They can also create foldables, charts, or PowerPoint presentations to accompany their models. In addition, if students use research to support their work, they should provide a list of the sources used.

Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-PS1-1) **RI.5.7**
Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases. **L.5.6**
Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (5-PS1-3) **W.5.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (5-PS1-3) **W.5.8**
Draw evidence from literary or informational texts to support analysis, reflection, and research. (5-PS1-3) **W.5.9**

Mathematics

Mathematics is integrated into this unit when students use appropriate tools, such as balances, thermometers, and graduated cylinders, to measure properties of matter like mass, temperature, and volume. In addition, students reason quantitatively and abstractly when analyzing and interpreting data collected when measuring physical properties of matter. Students also model with mathematics as they attempt to understand that matter exists even though it is made of particles too small to be seen. They interpret mathematical data in the context of the situation, reflect on how the data helps explain the particle nature of matter, and modify or improve their models if they do not adequately represent the phenomenon they are meant to represent.

Reason abstractly and quantitatively. (5-PS1-1) (5-PS1-3) **MP.2**

Model with mathematics. (5-PS1-1) **MP.4**
Use appropriate tools strategically. (5-PS1-3) **MP.5**
Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. (5-PS1-1) **5.NF.B.7**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Grade 2 Unit 2: Properties of Matter

- Describe and classify materials by their observable properties.
- Select and use materials based on these properties.
- Use evidence to describe how heating and cooling cause changes to matter.
- Use evidence to describe reversible and irreversible changes to matter.
- Explore how an object can be take apart and it pieces used to make another object.

Future Learning

Grade 7 Unit 1: Structure and Properties of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.)
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Grade 7 Unit 2: Interactions of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced out except when they happen to collide. In a solid, atoms are closely spaced and they vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations and temperature or pressure can be described and predicted using these models of matter

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
5-PS1-1	Develop a model to describe that matter is made of particles too small to be seen. *[Clarification Statement: Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]*
5-PS1-2	Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
5-PS1-3	Make observations and measurements to identify materials based on their properties. *[Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [Assessment Boundary: Assessment does not include density or distinguishing mass and weight.]*

Unit Essential Question

Part A: How can properties be used to identify materials?

Part B: What kind of model would best represent/describe matter as made of particles that are too small to be seen?

Unit Enduring Understandings

Part A:

- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Measurements of a variety of properties can be used to identify materials. *(At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)*

Part B:

- Natural objects exist from the very small to the immensely large.

- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by means other than seeing.
- A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>Material Properties:</u> The dangerous Androvax has crash-landed on Earth! Sabotage his escape plans by tricking him into building a spaceship out of the wrong materials.

Formative Assessments

Students who understand the concepts can:

- Measure and describe physical quantities such as weight, time, temperature, and volume.
- Make observations and measurements to produce data that can serve as the basis for evidence for an explanation of a phenomenon.
- Make observations and measurements to identify materials based on their properties. Examples of materials to be identified could include:
    - Baking soda and other powders
    - Metals
    - Minerals
    - Liquids

Examples of properties could include:

- ❖ Color
- ❖ Hardness
- ❖ Reflectivity
- ❖ Electrical conductivity
- ❖ Thermal conductivity
- ❖ Response to magnetic forces
- ❖ Solubility

- Develop a model to describe phenomena.
- Develop a model to describe that matter is made of particles too small to be seen. (Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.) Examples of evidence could include:
    - Adding air to expand a basketball
    - Compressing air in a syringe
    - Dissolving sugar in water
    - Evaporating salt water

What it Looks Like in the Classroom

The concepts and practices in this unit are foundational for understanding the relationship between changes to matter and its weight. During this unit of study, students will observe, measure, and identify materials based on their properties and begin to get a conceptual understanding of the particle nature of matter (i.e., all matter is made of particles too small to be seen).

In the first portion of the unit, students will focus on measuring and describing a variety of physical properties, including color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces and solubility. These observations and measurements are used to produce data that serves as the basis for evidence that can be used to identify materials. Students need opportunities to observe, measure, and describe a variety of types of matter, such as baking soda and other powders; metals; minerals; and liquids. Standard units should be used to measure the properties of weight, time, temperature, and volume; however, at this grade level, mass and weight are not distinguished. In addition, students are not expected to understand density as a physical property, and no attempt should be made to define unseen particles or explain the atomic-scale mechanism of evaporation and condensation.

In the second portion of the unit, students make observations, gather evidence, and develop models in order to understand that matter is made up of particles too small to be seen. Matter of any type can be subdivided into small particles. In planning and carrying out simple investigations, students will produce data to be used as evidence to support the idea that even though matter is made of particles too small to be seen, matter can still exist and can be detected by means other than seeing. This evidence will be used to support students' thinking as they develop models that depict matter. For example, a model that represents solids at the particle level would show particles tightly packed, while a model that represents gases would show particles moving freely around in space. Observing such phenomena as adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, or evaporating salt water could help students to understand matter at the particle level and to build models that represent this phenomenon.

Although engineering design is not explicitly called out in this unit, students could incorporate engineering design in a number of ways as they explore the particle nature of matter.

- ➢ Students can design ways/tools to measure a given physical property, such as hardness, reflectivity, electrical or thermal conductivity, or response to magnetic forces.
- ➢ The engineering design process can be used to analyze students' models using criteria. Then students can improve their designs based on analysis.

Lesson Plans

Lesson	**Timeframe**
Unit 2 Project	2 days
Lesson 1 What is Matter?	5 Days Comprehensive Class
Lesson 2 What are Properties of Matter?	5 Days Comprehensive Class
Lesson 3 How Does Matter Change?	5 Days Comprehensive Class
You Solve it	1 Day
Unit 2 Performance Task	1 Day
Performance-Based Assessment	1 Day
Unit 2 Review and Unit 2 Test	2 days

Teacher Notes:

Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: What are the Physical Properties of Matter? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: What are the Physical Properties of Matter ? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Clean Water: This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL:

Lesson 1: Pair up English-speaking students with students acquiring English. Challenge each pair to draw pictures to convey they understand different definitions of matter in the following sentences: Everything in the classroom is made up of matter; It may not matter to you, but it matters to me. The English-speaking student explains, and the student acquiring English explains again but in his or her own words to demonstrate understanding of the concept.

Lesson 3: Write the phrase conservation of matter on the board. Have students find related words in English equivalent words in their native language.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1	
Content Area: Matter	
Lesson Title: What is Matter?	**Timeframe: 5 Days**
Lesson Components	
21st Century Themes	

X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Recognize all objects are made of tiny particles of matter too small to be seen. Identify the most common states of matter are solids, liquids, and gases. Through investigations demonstrate how to measure matter, including length, weight, and volume.	1. About this Image: Brilliantly colored bins of spices are common sights at open-air Middle Eastern markets. Some important spices in Middle Eastern cooking are cayenne pepper, cinnamon, turmeric, ginger paprika, saffron, and curry. 2. Can you Explain It? Students are asked to write down all the different types of matter they see in the image. To do so, students must begin to think about how matter makes up all objects and living organisms. 3. Exploration 1-Matter is Everything: Students use models to describe the structure and properties of matter. They develop an understanding that objects are made up of particles too small to be seen. 4. Exploration 2-Measuring Matter: Students investigate properties of matter by using standard units to measure and describe physical quantities such as length, weight, and volume. 5. Take it Further: Discover More 6. Lesson Check: Can you Explain It? 7. Lesson Check: Lesson Roundup	● Scales, Proportion, and Quantity: Make certain that students understand that the smallest particle of a substance made from more than one particle still has the same properties of that substance. One particle of water has the same properties of that substance. One particle of water has the same properties as a glass of water. Ask for volunteers to explain how a particle of water can be very small and invisible, and a glass of water very large and visible. ● Planning and Carrying Out Investigations: Make certain students understand the structure and properties of matter by asking for volunteers to explain the difference in volume before and after the rice and beans were mixed together.

Differentiation
Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, teacher online access, and equipment kits. ●

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (5-PS1-3) **Developing and Using Models** Use models to describe phenomena. (5-PS1-1)	**PS1.A: Structure and Properties of Matter** Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (5-PS1-3) Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (5-PS1-1)	**Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-3) Natural objects exist from the very small to the immensely large. (5-PS1-1)

Content Area: Fifth Grade Science
Unit Title: Energy and Matter in Organisms
Target Course/Grade Level: Unit 3 Grade 5

Unit Summary

In this unit, students will…

- Investigate how living organisms get energy
- Explore how living organisms use energy and how they interact in their environments.

Lesson 1: Students will gather evidence that plants get energy from the sun and materials for growth from water and air and construct an argument for how matter is transported into, out of, and within an ecosystem. Students also model how well plants grow with or without water and in or out of a light source.

Lesson 2: Students will understand that animals need food for the materials necessary for body growth and repair and that they obtain gases and water from the environment and release waste matter back into the environment. Students will create a model to explore the energy animals need for body warmth and motion, which comes from the food animals eat, and will describe how energy in the food organism.

Lesson 3: Students gather evidence about food chains to make models that describe the movement of energy in ecosystem.

Primary interdisciplinary connections:

English Language/Arts

Students can conduct short research projects, using both print and digital sources, to build their understanding of physical changes to matter. While reading, they should take notes of relevant information, and summarize that information so that it can be used as evidence to explain the changes that occur as substances are heated, cooled, dissolved, or mixed. When drawing evidence from texts to support analysis, reflection, and research, students should provide a list of sources.

Interpret information presented…and explain how the information contributes to an understanding of the text in which it appears. **RI.4.7**
Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. **RI.5.7**
Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably . **RI.5.9**
Write opinion pieces on topics or texts, supporting a point of view with reasons and information. **W.5.1**
Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. **W.5.4**

Include multimedia components…and visual displays in presentation when appropriate to enhance the development of main ideas or themes. **SL.5.5**

Mathematics

- Use appropriate tools in strategic ways when measuring physical properties of substances, such as weight or volume.
- Model with mathematics when organizing data into tables or charts, and using the data as evidence to explain changes that occur.
- Convert among different-sized standard measurement units within a given measurement system and use these conversions to explain changes that occur.

Reason abstractly and quantitatively. (5-PS1-2) **MP.2**
Model with mathematics. (5-PS1-2) **MP.4**
Use appropriate tools strategically. (5-PS1-2) **MP.5**
Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems. (5-PS1-2) **5.MD.A.1**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Grade 2 Unit 2: Properties of Matter

- Describe and classify materials by their observable properties.
- Select and use materials based on these properties.
- Use evidence to describe how heating and cooling cause changes to matter.
- Use evidence to describe reversible and irreversible changes to matter.
- Explore how an object can be take apart and it pieces used to make another object.

Future Learning

Grade 7 Unit 1: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

Grade 7 Unit 2: Interactions of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Grade 7 Unit 3: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
5-LS1-1	Support an argument that plants get the materials they need for growth chiefly from air and water.
5-PS3-1	Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

Unit Essential Question

Part A: How can we make slime?

Part B: How can baking soda and vinegar burst a zip-lock bag?

Unit Enduring Understandings

Part A:

- Cause-and-effect relationships are routinely identified, tested, and used to explain change.
- When two or more different substances are mixed, a new substance with different properties may be formed.

Part B:

- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.
- No matter what reaction or change in properties occurs, the total weight of the substances does not change. *(Note: Mass and weight are not distinguished at this grade level.)*
- Science assumes consistent patterns in natural systems.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
  1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
  2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work
  3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>Time for Slime</u>: Students combine water and borax to create slime. Be sure to read and follow all of the cautions on the borax box label.

<u>Bubble Burst!</u> How can baking soda and vinegar burst a zip-lock bag?

<u>Flame Out:</u> A candle flame is actually a chemical reaction in action! Candle wax is one of the chemicals in the reaction.

Formative Assessments

Students who understand the concepts are able to:

- Identify, test, and use cause-and-effect relationships to explain change.
- Conduct an investigation collaboratively to produce data that can serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials is considered.
- Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- Measure and describe physical quantities such as weight, time, temperature, and volume.
- Measure and graph quantities such as weight to address scientific and engineering questions and problems.
- Measure and graph quantities to provide evidence that regardless of the type of change that occurs when substances are heated, cooled, or mixed, the total weight is conserved. (Note: Assessment does not include distinguishing between mass and weight.)

- Examples of reactions or changes could include:
    - Phase changes
    - Dissolving
    - Mixing

What it Looks Like in the Classroom

In this unit of study, students will use mathematical and computational thinking to understand the cause and effect relationship between physical changes in matter and conservation of weight. Throughout the unit, students need multiple opportunities to observe and document changes in matter due to physical changes, and to analyze data to explain changes that do or do not occur in the physical properties of matter.

Students begin by planning and conducting investigations to determine whether or not a new substance is made when two or more substances are mixed (see the Sample Open Education Resources). As they work with a variety of substances, they should:

- ➢ Measure, observe, and document physical properties (e.g., color, mass, volume, size, shape, hardness, reflectivity, conductivity, and response to magnetic forces) of two or three substances.
- ➢ Mix the original substances.
- ➢ Measure, observe, and document the physical properties of the substance produced when the original substances are mixed.
- ➢ Compare data from the original substances to data from the substance produced, and determine what changes, if any, have occurred.
- ➢ Use observations and data as evidence to explain whether or not a new substance was produced, and to explain any changes that occurred when the original substances were mixed.

With each set of substances that students investigate, it is important that they use balances to measure the mass of the original substances and the mass of the substance made when the original substances are mixed. These data should be documented so that students can analyze the data. As they compare the data, they should recognize that when two or more substances are mixed, the mass of the resulting substance equals the sum of the masses of the original substances. In other words, the total mass is conserved.

Conservation of mass is a critical concept that is developed over time; therefore, students need multiple opportunities to investigate this phenomenon. Students should measure the mass of each substance, document the data they collect in a table or chart, and use the data as evidence that regardless of the changes that occur when mixing substances, the total weight of matter is conserved.

In addition to observing changes that occur when substances are mixed, students should also have opportunities to investigate other types of physical changes. For example, students can observe changes in matter due to heating, cooling, melting, freezing, and/or dissolving. As before, students should measure, observe, and document the physical properties of the substance before and after a physical change, and use

the data as evidence to explain any changes that occur. The data should also provide evidence that regardless of the type of change that matter undergoes, the mass is conserved.

Lesson Plans	
Lesson	Timeframe
Unit 3 Project	2 days
Lesson 1 How Does Energy Get Transformed by Plants?	5 Days Comprehensive Class
Lesson 2 How Do Organisms Use Matter and Energy?	5 Days Comprehensive Class
Lesson 3 Ho Do Organisms Interact?	5 Days Comprehensive Class
You Solve it	1 day
Unit 3 Performance Task	1 day
Performance-Based Assessment	1 day
Unit 3 Review and Unit 3 Test	2 days

Teacher Note: Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: How Do Organisms and Their Environments Form and Ecosystem? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do Organisms and Their Environments Form and Ecosystem? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Predators of Shark River? This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL:

Lesson 1: To help student develop fluency and familiarity with English syntax, give them sentence frames to guide responses to questions.

Lesson 2: Point out cognates of key terms from students' home languages-for example, consumer/consumidor-to help bridge understanding of pertinent lesson vocabulary. Pronounce each word, and spotlight the similarities.

Lesson 3: Point out cognates of key terms from students' home languages: for example: ecosystem/ el ecisustema, habitat/ el habitat. Niche/el nicho, population/ la poblacion, and community/ la comunidad to bridge understanding of lesson vocabulary. Pronounce each word and discuss the use of articles with the nouns. Ask other students to share the same words in their home languages.
Modifications *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Energy and Matter in Organisms							
Lesson Title: How Does Energy Get Transformed by Planets						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							

X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● To Develop and use models to support an argument that plants acquire material for growth mainly from air and water	1. About This Image: Vietnam's Son Doong cave is the world's largest cave, about 8.8 km long and 200 m wide. The case was created 2-5 million years ago when river water eroded limestone under a mountain, creating huge holes that acted as skylights. 2. Can You Explain It? Students are asked to record their initial thoughts about plants growing not in a normal garden but a hydroponic one. To do so, students must think about what plants need to grow. 3. Exploration 1-Plant Growth: Students will gather evidence of where plants get the materials they need for growth from matter and form models of how plants grow, with or without air or water. 4. Exploration 2-Getting Energy from Food: Students discover how a plant store energy from the sun through a chemical process, using matter transported into and within parts of the plant. The, students model the plant parts involved in the photosynthesis process. 5. Take it Further: Discover More 6. Lesson Check: Can You Explain It? 7. Lesson Check: Lesson Roundup	● Organization for Matter and Energy Flow in Organisms: Make certain students understand the concept of how plants would fare in outer space. ● Language Smarts: as students explain how plants get what they need to make food, encourage them to make sketches to accompany their written descriptions. Point out that the visuals can assist with clarifying information and help readers better understand what they read. ● Lesson Check: Can you Explain It? ● Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

<table>
<tr><td colspan="3">The Student Learning Objectives above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Planning and Carrying Out Investigations
Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (5-PS1-4)
Using Mathematics and Computational Thinking
Measure and graph quantities such as weight to address scientific and engineering questions and problems. (5-PS1-2)</td><td>PS1.A: Structure and Properties of Matter
The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (5-PS1-2)
PS1.B: Chemical Reactions
When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)</td><td>Cause and Effect
Cause and effect relationships are routinely identified and used to explain change. (5-PS1-4)
Scale, Proportion, and Quantity
Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2)
- -
Connections to Nature of Science
Scientific Knowledge Assumes an Order and Consistency in Natural Systems
Science assumes consistent patterns in natural systems. (5-PS1-2)</td></tr>
</table>

Content Area: Fifth Grade Science
Unit Title: Energy and Matter in Ecosystems
Target Course/Grade Level: Unit 4 Grade 5
Unit Summary In this unit, students will… ● Explore phenomena of predator-prey population interactions and native and invasive species interactions. ● Use models to develop explanations of the energy inputs and energy and matter flows within ecosystems. **Lesson 1:** Students will gather evidence to help build food chains and webs and use these models to trace the movement of matter and energy within and ecosystem. Through the development and use of these models, students will visualize the relationships among the components of the system. Through the use of their

models, students will deepen their understanding of the movement of energy between each level in their model.

Lesson 2: Students will explore the ways in which organisms change their ecosystems. They will learn recognize how plants, animals, and nonliving species can adapt to learn to recognize how plants, animals, and nonliving species can adapt to new environments or become invasive after being introduced. Students will gain a deeper understanding of these concepts through observation, as well as by studying and using models to explain how these changes occur in nature and why balanced ecosystems are necessary for conserving plant and animal species.

Primary interdisciplinary connections:

English Language Arts

Students should use information from print and digital sources to build their understanding of energy and matter in ecosystems. As students read, they should use the information to answer questions, participate in discussions, solve problems, and support their thinking about movement of matter and the flow of energy through the organisms in an ecosystem. In this unit of study, students are also required to build models to describe the cycling of matter and the flow of energy in ecosystems. They can enhance their models using multimedia components, such as graphics and sound, and visual displays.

Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-LS1-1) **RI.5.1**
Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-LS2-1), (5-PS3-1) **RI.5.7**
Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-LS1-1) **RI.5.9**
Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-LS2-1), (5-PS3-1) **SL.5.5**

Mathematics

In this unit students should:

- Use appropriate tools in strategic ways when making and recording observations of the living and nonliving components of an ecosystem.
- Model with mathematics when using tables, charts, or graphs to organize observational data.
- Reason abstractly and quantitatively when analyzing data that can be used as evidence for explaining how matter cycles and energy flows in systems.
- Convert among different-sized standard measurement units within a given measurement system and use these conversions to help explain what happens to matter and energy in ecosystems.

Reason abstractly and quantitatively. (5-LS1-1), (5-LS2-1) **MP.2**

Model with mathematics. (5-LS1-1), (5-LS2-1) **MP.4**
Apply and extend previous understandings of multiplications to multiply a fraction or whole number by a fraction. **5.NF.B.4**

21st century themes

Global Awareness & Financial, Economic, Business and Entrepreneurial Literacy

Unit Rationale

Prior Learning

Kindergarten Unit 3: Plants and Animals

- During this lesson students learned the following: use observation to describe patterns of what plants and animals need to survive; Analyze data by collecting, recording, and sharing observations; Use a model to show the relationship between the needs of different plants or animals and the place they live; Use patterns as evidence to support claims; & Construct an argument supported by evidence for how plants and animals change the environment to survive.

Grade 2: Unit 3: Environments for Living Things

- During this unit students learned the following: Investigate what plants and animals need to live and grow; Develop models to show how plants depend on animals; Explore environment to identify observable patterns; Observe plants and animals to compare diversity of life in water habitats; & Observe plants and animals to compare diversity of life in land habitats.

Grade 4 Unit 2: Energy

- During this unit students learned the following: Discovered what energy is and how it is transferred;

Future Learning

LS1.C: Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

LS1.C: Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.

● Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. LS2.B: Cycle of Matter and Energy Transfer in Ecosystems ● Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. LS4.D: Biodiversity and Humans ● Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary)	
Learning Targets	
Standards	
NJSLS-S#	Performance Expectation
5-LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.[Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]
5-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
Unit Essential Question Part A: Where do plants get the materials they need for growth? Part B: How does matter move among plants, animals, decomposers, and the environment? Part C: How can energy in animals' food be traced to the sun?	
Unit Enduring Understandings Part A: ● Matter is transported into, out of, and within systems. ● Plants acquire their material for growth chiefly from air and water. Part B: ● Science explanations describe the mechanisms for natural events. ● A system can be described in terms of its components and their interactions. ● The food of almost any kind of animal can be traced back to plants.	

- Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants.
- Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as decomposers.
- Decomposition eventually restores (recycles) some materials back to the soil.
- Organisms can survive only in environments in which their particular needs are met.

Part C:

- Energy can be transferred in various ways and between objects.
- The energy released from food was once energy from the sun, which was captured by plants in the chemical process that forms plant matter (from air and water).
- Food provides animals with the materials they need for body repair and growth and the energy they need for motion and to maintain body warmth.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

<u>Bottle Biology Terrarium</u>: Students will create a terrarium, make observations of the terrarium, then develop a model to explain how matter transfers within the ecosystem. This resource describes the process of creating a terrarium (which will serve as the phenomena that the students observe), but does not include specific lesson details or instructional strategies.

<u>Biodomes Engineering Design Project</u>: This activity is a culmination of a 16 day unit of study where students explore the biosphere's environments and ecosystems. In this final activity, students apply what they learned about plants, animals, and decomposers to design and create a model biodome. Engaging in the engineering design process, students construct a closed (system) environment containing plants and animals existing in

equilibrium. Provided with a variety of materials (constraints), teams of students will use their imagination and culminating knowledge to design a biodome structure following the criteria of the activity that models how plants, insects, and decomposers work together in a system. (The activity can be conducted as a structured or open-ended design. It is recommended to allow students the opportunity to be true engineers and follow the opened-ended design.)

Formative Assessments

Students who understand the concepts are able to:

- Describe how matter is transported into, out of, and within systems.
- Support an argument with evidence, data, or a model.
- Support an argument that plants get the materials they need for growth chiefly from air and water. (Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.)
- Describe a system in terms of its components and interactions.
- Develop a model to describe phenomena.
- Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (Assessment does not include molecular explanations.)
- Emphasis is on the idea that matter that is not food—such as air, water, decomposed materials in soil—is changed into matter that is food. Examples of systems could include:
    - Organisms
    - Ecosystems
    - Earth
- Describe how energy can be transferred in various ways and between objects.
- Use models to describe phenomena.
- Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
- Examples of models could include:
    - Diagrams
    - Flowcharts

What it Looks Like in the Classroom

In every habitat and ecosystem on Earth, plants and animals survive, grow, reproduce, die, and decay. What happens to the matter and energy that are part of each organism? Where does it come from and where does it go? In this unit of study, students make observations and use models to understand how energy flows and matter cycles through organisms and ecosystems.

Students should first understand that plants acquire their material for growth chiefly from air and water. Students will need opportunities to observe a variety of plants over time. As students document plants' continual need for water and air in order to grow, they recognize that this evidence supports the argument that plants acquire their material for growth chiefly from air and water (not from soil). In addition, as students observe that plants also need sunlight, they begin to recognize that plants use energy from the sun to transform air and water into plant matter.

Once students understand that plants acquire material for growth from air and water, they need opportunities to observe animals and plants interacting within an ecosystem. Terrariums, such as those built in 3-liter bottles, are ideal for this because they are large enough for small plants and animals to survive and grow, yet easy to build and maintain. In these terrariums, students should observe plants growing and providing a source of food for small herbivores, carnivores consuming other animals, and decomposers consuming dead plant material.

All of these interactions may not be observable within a single terrarium; however, a class could use a number of 3-liter bottles to set up different ecosystems, each with a few carefully chosen plants and animals. This will give students opportunities to observe different types of interactions within a variety of enclosed systems.

When students record their observations of these small systems, it is important that students be able to:

- Identify the living and nonliving components of a system.
- Describe the interactions that occur between the living and nonliving components of each system.
- Develop models (such as food chains or food webs) that describe the movement of matter among plants, animals, decomposers, and the environment.

As students continue to observe each terrarium, they learn that:

- The food of almost any kind of animal can be traced back to plants.
- Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants.
- Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as decomposers.
- Decomposition eventually restores (recycles) some materials back to the soil.
- A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life.
- Organisms can survive only in environments in which their particular needs are met.
- Matter cycles between the air and soil and among plants and animals as these organisms live and die.
- Organisms obtain gases and water from the environment and release waste matter (gas, liquid, or solid) back into the environment.

Furthermore, students can conduct research to determine the effects of newly introduced species to an ecosystem.

After investigating the movement of matter in ecosystems, students revisit the concept of energy flow in systems. At the beginning of this unit of study, students learned that energy from the sun is transferred to plants, which then use that energy to change air and water into plant matter. After observing the interactions between the living and nonliving components of small ecosystems, students recognize that energy, like matter, is transferred from plants to animals. When animals consume plants, that food provides animals with the materials they need for body repair and growth and with the energy they need to maintain body warmth and for motion. Students can use diagrams or flowcharts to describe the flow of energy within an ecosystem, tracing the energy in animals’ food back to the energy from the sun that was captured by plants.

Lesson Plans	
Lesson	Timeframe
Unit 3 Project	2 Days
Lesson 1 How Do Energy and Matter Move Through Ecosystems?	5 Days Comprehensive Class
Lesson 2 How Do Organisms Change Their Ecosystems?	5 Days Comprehensive Class
You Solve It	1 day
Unit 4 Performance Task	1 day
Performance-Based Assessment	1 day
Unit 4 Review and Unit 4 Test	2 days

Teacher Note: Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: How Do Organisms and Their Environments Form and Ecosystem? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do Organisms and Their Environments Form and Ecosystem? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Predators of Shark River? This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL:
Lesson 1: Play a clip of contemporary music. Name the composer.
Lesson 2: Show students pictures of ecosystems, or put together a collage of various ecosystems and their organisms.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Energy and Matter Ecosystems							
Lesson Title: How Do Energy and Matter Move Through Ecosystems					**Timeframe:** 5 days		
Lesson Components							
21st Century Themes							
X	Global Awareness	X	Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	**Learning Activities/Instructional Strategies**	**Formative Assessment Tasks**
Students: • Understand that some matter that is not food is changed by plants into matter that is food and is used by other	1. About this Image: The tundra ecosystem is a treeless plain characterized by very cold temperature and little rainfall. Polar tundra is found in the Artic. 2. Can you Explain It? Students are asked to record their initial thoughts about why the owl	• Making Inferences: As students work to infer explanation, remind them that it's important to be accurate when using

organisms in the ecosystem. Describe how the flow of energy derived from the sun is transferred as matter through a food chain and food web to consumers and decomposers. Develop and use models of ecosystems to explore specific ways in which organisms are linked in their interactions. Understand and explain that only a portion of energy available at any level of a food web is available to the next higher step and how it affects population.	population decreased and to suggest a remedy. To do so, students must ultimately relate the decrease in the number of owls to the disruption of the grass-rabbit-owl food chain. 3. Exploration 1: Moving Energy and Matter- Develop an understanding of how energy and matter are transferred through a food chain to consumers and decomposers. Students use information about energy and matter in an ecosystem. They use this to develop models of food chains. 4. Exploration 2: Following Matter and Energy- Develop or use models of how energy and matter flow in an ecosystem through food chains. 5. Exploration 3: At the Top- Calculate how energy is transferred between various components of a food chain. Understand that food chains are a foundational concept that supports later development of models of ecosystem interactions, such as food webs and energy pyramids. 6. Take it Further: Discover More 7. Lesson Check: Can you explain it? 8. Lesson Check: Lesson Roundup	another person's writing. If they cite an example, it should reflect the actual wording. It's a way of being honest with readers. ● Putting it Together: Have students explain the difference between a food chain and a food web and how they are connected. ● Putting it Together: In energy pyramids, the bottom levels usually contain more organism. ● Lesson Check: Can you explain it? ● Lesson Check: Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence	**LS1.C: Organization for Matter and Energy Flow in Organisms** Plants acquire their material for growth chiefly from	**Energy and Matter** Matter is transported into, out of, and within systems. (5-LS1-1)

Support an argument with evidence, data, or a model. (5-LS1-1) **<u>Developing and Using Models</u>** Develop a model to describe phenomena. (5-S2-1) Use models to describe phenomena. (5-PS3-1)	air and water. (5-LS1-1) **<u>LS2.A: Interdependent Relationships in Ecosystems</u>** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)	Energy can be transferred in various ways and between objects. (5-PS3-1) **<u>Systems and System Models</u>** · A system can be described in terms of its components and their interactions. (5-LS2-1) - ***Connections to the Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Science explanations describe the mechanisms for natural events. (5-LS2-1)

Content Area: Fifth Grade Science
Unit Title: Systems in Space
Target Course/Grade Level: Unit 5 Grade 5
Unit Summary In this unit, students will: ● Use evidence to explain that Earth's orbit, the moon's orbit and Earth's rotation cause predictable patterns. ● Explain why the sun appears so large and bright from Earth ● Explain that Earth is a sphere and that gravity pulls objects toward Earth's center. **Lesson 1:** Students will gather evidence to explain that the gravity of Earth pulls objects toward the plant's center. Through the development and use of models, students will use evidence to explain tat Earth is a sphere and that gravity pulls objects toward Earth's center. **Lesson 2:** Students will evaluate facts about Earth and the sky and use data to find patterns caused by the interactions between Earth, the sun, and stars. BY studying patterns, students will be able to apply their understanding to other Earth processes to gain a bigger picture view of how so many processes are interconnected and work together to sustain life on Earth. **Lesson 3:** Students gather evidence to explain Earth's orbit around the sun. Through the collection and analysis of data, use evidence to explain that Earth's orbit and the moon's orbit cause predictable patterns such as the seasonal changes in sunlight and the phases of the moon.

Lesson 4: Students observe characteristics of stars and use this information to support an argument that the apparent brightness of the sun is die to distance from Earth. Using this data, understand scale, proportion, and quantity as it pertains to the sun and its place in the universe.

Primary interdisciplinary connections:

English Language Arts

Students should use information from print and digital sources to build their understanding of:

- The Earth's gravitational force on objects.
- The differences in the apparent brightness of the sun compared to that of other stars due to their relative distances from Earth.
- Patterns of change that occur due to the position and motion of the Earth, sun, moon, and stars.
- As students read and gather information from multiple sources, they should integrate and use the information to answer questions and support their thinking during discussions and in their writing

Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-ESS1-1) **RI.5.7**
Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s). (5-ESS1-1) **RI.5.8**
Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-PS2-1), (5-ESS1-1) **RI.5.9**
Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-PS2-1), (5-ESS1-1) **W.5.1**
Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. **W.5.8**
Draw evidence from literary of informational texts to support analysis, reflection, and research. **W.5.9**
Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word (photograph, photosynthesis). **L.5.4.A**

Mathematics

Students reason abstractly and quantitatively when analyzing and using data as evidence to describe phenomena, including:

- The Earth's gravitational force pulls objects "down" (toward the center of the Earth).
- The differences in the apparent brightness of the stars are due to their relative distances from Earth.
- Patterns of change, such as the day/night cycle, the change in length and direction of shadows during the day, the apparent motion of the sun across the daytime sky and the moon across the nighttime

sky, the changes in the appearance of the moon over a period of four weeks, and the seasonal changes in the position of the stars in the night sky.

Students will model with mathematics as they graphically represent data collected from direct observations and from multiple resources throughout the unit, and as they describe relative distances of the sun and other stars from the Earth. Students might also express relative distances between the Earth and stars using numbers that can be expressed using powers of 10.

Reason abstractly and quantitatively. (5-ESS1-1),(5-ESS1-2) **MP.2**
Model with mathematics. (5-ESS1-1,(5-ESS1-2)) **MP.4**
Convert among different-sized standard measurement units within a given measurement system, and use these conversions in solving multi-step, real world problems. **5.MD.A.1**
Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. (5-ESS1-1) **5.NBT.A.2**
Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. (5-ESS1-2) **5.G.A.2**

21st century themes

Global Awareness

Unit Rationale

Prior Learning

Grade 1 Unit 6: Objects and Patterns in the Sky

- In this unit students learned the following: Identify and describe objects in the sky; Use evidence to describe predictable patterns of the sun, moon, and stars; Observe and model patterns of the moon's phases; Use observations to describe characteristics of each season; predict patterns of change that take place from season to season; & Explore how seasons affect people and animals.

Grade 3 Unit 6: Forces

- In this unit students learning the following: explored how forces work; Discovered different types of forces; Learned about forces that act from a distance.

Future Learning

Grade 6 Unit 4: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Grade 6 Unit 5: Types of Interactions

- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

Grade 6 Unit 6: Astronomy

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
5-PS2-1	Support an argument that the gravitational force exerted by Earth on objects is directed down. *[Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.]
5-ESS1-1	Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]
5-ESS1-2	Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and

	motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Unit Essential Question

Part A: What effect does Earth's gravitational force have on objects?

Part B: What effect does the relative distance from Earth have on the apparent brightness of the sun and other stars?

Part C: What patterns do we notice when observing the sky?

Unit Enduring Understandings

Part A:

- Cause-and-effect relationships are routinely identified and used to explain change.
- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center

Part B:

- Natural objects exist from the very small to the immensely large.
- The sun is a star that appears larger and brighter than other stars because it is closer.
- Stars range greatly in their distance from Earth.

Part C:

- Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena.
- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its north and south poles, cause observable patterns. These include:
    - Day and night
    - Daily changes in the length and direction of shadows
    - Different positions of the sun, moon, and stars at different times of the day, month, and year.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work

3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

Gravity and Falling Objects: PBS Learning Media lesson where students investigate the force of gravity and how all objects, regardless of mass, fall to the ground at the same rate.

NASA's Solar System Exploration website contains several resources that educators and students can use to make sense of the night sky.

Our Super Star: PBS Learning Media lesson that guides students to understand the basic facts about the Sun, model the mechanics of day and night, and use solar energy to make a tasty treat.

Formative Assessments

Students who understand the concepts are able to:

- Identify cause-and-effect relationships in order to explain change.
- Support an argument with evidence, data, or a model.
- Support an argument that the gravitational force exerted by Earth on objects is directed down. ("Down" is a local description of the direction that points toward the center of the spherical Earth.) (Assessment does not include mathematical representation of gravitational force.).
- Support an argument with evidence, data, or a model.
- Support an argument that differences in the apparent brightness of the sun compared to that of other stars is due to their relative distances from Earth. (Assessment is limited to relative distances, not sizes, of stars, and does not include other factors that affect apparent brightness, such as stellar masses, age, or stage.)
- Sort, classify, communicate, and analyze simple rates of change for natural phenomena using similarities and differences in patterns.
- Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
- Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. (Assessment does not include causes of seasons.) Examples of patterns could include:
    - The position and motion of Earth with respect to the sun.
    - Selected stars that are visible only in particular months.

What it Looks Like in the Classroom

In this unit of study, students explore the effects of gravity and determine the effect that relative distance has on the apparent brightness of stars. They also collect and analyze data in order to describe patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

To begin the progression of learning in this unit, students explore the effects of gravity by holding up and releasing a variety of objects from a variety of heights and locations. Students should record and use their observations to describe the interaction that occurs between each object and the Earth. In addition, students should use their observations as evidence to support an argument that the gravitational force exerted by the Earth on objects is directed “down” (towards the center of the Earth), no matter the height or location from which an object is released.

Next, students investigate the effect of distance on the apparent brightness of stars. Using information from a variety of print or digital sources, students learn that natural objects vary in size, from very small to immensely large. Stars, which vary in size, also range greatly in their distance from the Earth. The sun, which is also a star, is much, much closer to the Earth than any other star in the universe. Once students understand these concepts, they should explore the effect of distance on the apparent brightness of the sun in relation to other stars. This can be accomplished by modeling the effect using a light source, such as a bright flashlight. As students vary the distance of the light from their eyes, they should notice that the farther away the light is, the less bright it appears. Observations should again be recorded and used as evidence to support the argument that the differences in the apparent brightness of the sun compared to that of other stars is due to their relative distances from the Earth.

To continue the progression of learning, students investigate the following observable patterns of change that occur due to the position and motion of the Earth, sun, moon, and stars.

- Day and night: This pattern of change is a daily, cyclical pattern that occurs due to the rotation of the Earth every 24 hours. Students can observe model simulations using online or digital resources, or they can create models in class of the day/night pattern caused by the daily rotation of the Earth.
- The length and direction of shadows: These two interrelated patterns of change are daily, cyclical patterns that can be observed and described through direct observation. Students need the opportunity to observe a stationary object at chosen intervals throughout the day and across a few days. They should measure and record the length of the shadow and record the direction of the shadow (using drawings and cardinal directions), then use the data to describe the patterns observed.
- The position of the sun in the daytime sky: This daily, cyclical pattern of change can also be directly observed. Students will need the opportunity to make and record observations of the position of the sun in the sky at chosen intervals throughout the day and across a few days. Data should then be analyzed in order to describe the pattern observed.
- The appearance of the moon in the night sky: This cyclical pattern of change repeats approximately every 28 days. Students can use media and online resources to find data that can be displayed

graphically (pictures in a calendar, for example), which will allow them to describe the pattern of change that occurs in the appearance of the moon every four weeks.

- The position of the moon in the night sky: This daily, cyclical pattern of change can be directly observed, but students would have to make observations of the position of the moon in the sky at chosen intervals throughout the night, which is not recommended. Instead, students can use media and online resources to learn that the moon, like the sun, appears to rise in the eastern sky and set in the western sky every night.
- The position of the stars in the night sky: Because the position of the stars changes across the seasons, students will need to use media and online resources to learn about this pattern of change.

Whether students gather information and data from direct observations or from media and online sources, they should organize all data in graphical displays so that the data can be used to describe the patterns of change.

Lesson Plans

Lesson	**Timeframe**
Unit 5 Project	2 days
Lesson 1 **How Does Gravity Affect Matter on Earth?**	5 Days Comprehensive Class
Lesson 2 **What Daily Patterns Can Be Observed?**	5 Days Comprehensive Class
Lesson 3 **What Patterns Can Be Observed in a Year?**	5 Days Comprehensive Class
Lesson 4 **What is the Sun?**	5 Days Comprehensive Class
You Solve It	1 day
Unit 5 Performance Task	1 day
Performance-Based Assessment	1 day
Unit 5 Review and Unit 5 Test	1 day

Teacher Notes: Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: How Do the Sun, Earth, and Moon Move in Space? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Do the Sun, Earth, and Moon Move in Space? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: To the Moon? This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Give students a three-dimensional model of a sphere, such as globe.

Lesson 2: Have students make a circle in the room, and ask one student to stand in the center of the circle. Next have the student to stand in the center stand still, while the other students rotate around him/her.

Lesson 3: Give students a three-dimensional globe of Earth.

Lesson 4: Have students draw the shape of a star. The show them an actual close-up image of a star in the sky. Ask students to study the image.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Systems in Space							
Lesson Title: How Does Gravity Affect Matter on Earth?						**Timeframe:** 5 Days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students will: ● Gather evidence to explain that the gravity of Earth pulls objects toward the plant's center. Through the development and use of models, use evidence to explain that Earth is a sphere and that gravity causes objects to move toward Earth's center.	1. About this Image: The gravitational pull of Earth holds the water to the surface of the planet, as well as the air ad everything in the air that surrounds the surface. The force of gravity between two objects depends on the masses of both objects. 2. Can you Explain? To answer the questions in Item 1, students must be able to describe the force of gravity, as well as Earth's gravitational pull. Students must also have background knowledge about Earth's hemispheres. 3. Exploration 1-Is Earth a Sphere? Evaluate cause and effect from different perspectives, and gather evidence to argue that Earth is a sphere. Apply this to understand how gravity pulls things toward Earth's center. 4. Exploration 2-What is Gravity? Gather evidence to explain that gravity is the force	● Supporting your point of view: As students work to create an argument, remind them that it's important to be accurate when giving evidence that supports their statement. Using evidence from the lesson is the best way to support their argument. ● Supporting your point of view: As students work to create an argument, remind them that it's important to be accurate when giving

	that pulls objects toward Earth's center. Through the development and use of models, use evidence to argue that the force of gravity effects all matter on Earth. 5. Take It Further-Discover More 6. Lesson Check-Can you Explain It? 7. Lesson Check –Lesson Roundup	evidence that supports their statement. Using evidence from the lesson is the best way to support their argument. ● Lesson Check ● Lesson Roundup

Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.
Resources Provided: TCI work text, teacher online access, and equipment kits.

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Develop a model using an example to describe a scientific principle. (5-ESS2-1) **Engaging in Argument from Evidence** Support an argument with evidence, data, or a model. (5-PS2-1), (5-ESS1-1) **Analyzing and Interpreting Data** Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	**PS2.B: Types of Interactions** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1) **ESS1.A: The Universe and its Stars** The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1) **ESS1.B: Earth and the Solar System** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily	**Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) **Scale, Proportion, and Quantity** Natural objects exist from the very small to the immensely large. (5-ESS1-1) **Patterns** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

	changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)	

Content Area: Fifth Grade Science
Unit Title: Earth Systems
Target Course/Grade Level: Unit 6 Grade 5

Unit Summary

In this unit, students will…

- Explore the hydrosphere, geosphere, biosphere, and atmosphere.
- Learn How Earth's systems interact.

Lesson 1: Students will learn about Earth's major systems: the geosphere, the hydrosphere, the atmosphere, and the biosphere and develop and use models to explore interactions among Earth's systems. Students will use math to investigate the distribution of water on Earth and evaluate the importance of Earth's limited supply of fresh water.

Lesson 2: Students will investigate the ways in which Earth's systems interact and ultimately affect each other. Students will develop and use models to investigate the water cycles. Through the use of two case studies, students learn how human actions can affect Earth's water and air. By investigating a variety of factors such as wind, rain, shadows, and the angle at which sunlight strikes Earth, students will further enhance their understanding of the interactions between Earth's systems.

Lesson 3: Students will use models to describe how the ocean is interrelated to Earth's other systems. Students will also apply mathematics to demonstrate their understanding of the distribution of Earth's water.

Primary interdisciplinary connections:

English Language Arts

In this unit, students can use information from print and digital sources to build their understanding of Earth's major systems and the interactions that occur within and between them. As students read and gather information from multiple print or digital sources, they should use the information to make inferences, answer questions, participate in discussions, solve problems, and support their thinking about the interactions that occur among Earth's systems and the impact that humans have on Earth's resources and environments. As students build models to explain the interactions between the systems and research ways in which individual communities use science ideas to protect the Earth's resources and environments, they can enhance their work with multimedia components, such as graphics and sound and visual displays.

Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text. **RI.5.2**
Explain the relationship or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text. **RI.5.3**
Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-ESS2-1),(5-ESS3-1) **RI.5.7**
Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic. **W.5.2.B**
Link ideas within and across categories of information using words, phrases, and clauses. **W.5.2.C**
Use precise language and domain-specific vocabulary to inform about or explain the topic. **W.5.2.D**
Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. **W.5.7**
Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (5-ESS3-1) **W.5.8**
Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-ESS2-2),(5-ESS2-1) **SL.5.5**

Mathematics

In this unit, students should:

- ➢ Reason abstractly and quantitatively when analyzing data used as evidence to explain how Earth's major systems interact and how human activities affect Earth's resources.
- ➢ Model with mathematics by using tables, charts, or graphs to organize data and information they collect to support explanations about the interactions that occur within and between Earth's systems.
- ➢ Represent real-world and mathematical relationships through graphing. For example, students can graph data to show the relationship between the amount of rainfall that occurs and changes in air temperature or pressure or the relationship between the types or number of organisms living at various altitudes.

Reason abstractly and quantitatively. (5-ESS2-1),(5-ESS3-1) **MP.2**

Model with mathematics. (5-ESS2-1),(5-ESS3-1) **MP.4**
Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. (5-ESS2-1) **5.G.A.2**
Extend understanding of fraction equivalence and ordering **4.NF.A.2**

21st century themes:

Global Awareness

Unit Rationale

Prior Learning

Grade 2 Unit 5: Changes to Earth's Surface

- In this unit students learned the following: To use evidence to explain that some change to Earth happen slowly; To user evidence to explain that some changes to Earth happen quickly; To fin solutions to prevent wind from changing the land; & To find solutions to prevent water form changing the land.

Grade 3 Unit 7: Weather and Climate

- In this unit students learned the following: To explore how weather is predicted and measured; Learned about the difference between weather and climate; & identified the impact of severe weather on society and nature.

Future Learning

Grade 6 Unit 7: Weather and Climate

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
- Global movements of water and its changes in form are propelled by sunlight and gravity.
- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

Grade 8 Unit 3: Stability and Change on Earth

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

Grade 7 Unit 8: Earth Systems

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

Grade 6 Unit 7: Weather and Climate

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
- Global movements of water and its changes in form are propelled by sunlight and gravity.
- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Learning Targets

Standards

NJSLS-S#	**Performance Expectation**
5-ESS2-1	Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [Assessment Boundary: Assessment is limited to the interactions of two systems at a time.]
5-ESS2-2	Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

Unit Essential Question

Part A: What are Earth's Major Systems?

Part B: Ho Do Earth's Systems Interact?

Part C: What is the Role of the Oceans in Earth's Systems?

Unit Enduring Understandings

Part A:

- Student will identify and describe each of Earth’s systems and the cycles that occur within them.

Part B:

- Students will develop and use models to investigate how Earth’s systems interact.

Part C:

- Observe and describe the distribution of water on Earth, and explore the effect of the oceans on landforms, climates, and ecosystems.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children’s preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children’s work
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children’s ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

NOAA What-a-Cycle: Through role-playing as a particle of water, students gain an understanding of the complexity of the movement of water through earth’s systems. Stations are set-up for nine different water reservoirs associated with the water cycle. On each turn, students roll the dice at each station and either stay in place or move to a different location. Students track their unique journey through the water cycle to later share and discuss the strengths and limitations of the game as a model for the movement of water through Earth's systems.

Shower Curtain Watershed: What is a watershed? How do our actions affect the health of a watershed? Students explore these questions by analyzing pictures and identifying watershed features. Students then make a watershed model using a plastic shower curtain, a spray bottle of water and themselves or classroom objects The objectives of the lesson are to: a) Identify nonliving and living features found in a watershed. b) Understand how human activities can affect watersheds.

Formative Assessments

Students who understand the concepts are able to:

- Describe a system in terms of its components and interactions.
- Develop a model using an example to describe a scientific principle.
- Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. (The geosphere, hydrosphere, atmosphere, and biosphere are each a system. Assessment is limited to the interactions of two systems at a time.)
- Examples could include:
    - The influence of oceans on ecosystems, landform shape, and climate.
    - The influence of the atmosphere on landforms and ecosystems through weather and climate.
    - The influence of mountain ranges on the wind and clouds in the atmosphere.
- Describe a system in terms of its components and interactions.
- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
- Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

What it Looks Like in the Classroom

In this unit of study, students develop models to describe the interactions that occur within and between major Earth systems and conduct research to learn how humans protect the Earth's resources.

Foundational to this unit of study is the understanding of a system, its components, and the interactions that occur within the system. Initially, students may need opportunities to review familiar examples of systems, such as plants and animals, listing external and internal structures and processes and describing the interactions that occur within the system. Students can then begin to think about Earth's major systems, identifying the components and describing the interactions that occur within each. For example:

➢ The geosphere is composed of solid and molten rock, soil, and sediments. Some processes that occur between the components of the geosphere include erosion, weathering, deposition, sedimentation, compaction heating, cooling, and flow. These processes cause continual change to rock, soil, and sediments.

➢ The hydrosphere is composed of water in all its forms. Water, unlike the vast majority of earth materials, occurs naturally on the Earth as a solid, liquid, or gas, and it can be found on, above, and below the surface of the Earth. Some processes that occur in the hydrosphere include evaporation, condensation, precipitation, run-off, percolation, freezing, thawing, and flow. These processes cause water to change from one form to another in a continuous cycle.

➢ The atmosphere is a critical system made up of the gases that surround the Earth. The atmosphere helps to regulate Earth's climate and distribute heat around the globe, and it is composed of layers with specific properties and functions. This system, composed mainly of nitrogen, oxygen, argon, and carbon dioxide, also contains small amounts of other gases, including water vapor, which is found in the lowest level of the atmosphere where weather-related processes occur. In addition to weather processes, radiation, conduction, convection, carbon cycling, and the natural greenhouse effect are processes that occur in the atmosphere.

- The biosphere comprises living things, including humans. Living organisms can be found in each of the major systems of the Earth (the atmosphere, hydrosphere, and geosphere). Some processes that occur within the biosphere include transpiration, respiration, reproduction, photosynthesis, metabolism, growth, and decomposition.

As students become more comfortable with describing each system in terms of its components and interactions, they should begin to think about and discuss the interactions that occur between systems. This should be a natural progression in their learning, since students will discover that any interactions that occur within a system affect components of other systems. Students should develop models that describe ways in which any two Earth systems interact and how these interactions affect the living and nonliving components of the Earth. Some examples include:

- The influence of oceans on ecosystems, landform shape, or climate.
- The impact of the atmosphere on landforms or ecosystems through weather and climate.
- The influence of mountain ranges on wind and clouds in the atmosphere.
- The role of living organisms (both plants and animals) in the creation of soils.

As a class, students can brainstorm additional examples. They can use any type of model, such as diagrams or physical replicas, to describe the interactions that occur between any two systems, and they can choose to enhance the model with multimedia components or visual displays.

Once students have an understanding of the components and interactions that occur within and between Earth's major systems, they should gather information about the ways in which individual communities use science ideas to protect Earth's resources and environment. Students can work individually, in pairs, or in small groups to conduct research using books and other reliable media resources. They should paraphrase and summarize information as they take notes, then use their information to support their finished work. Students' research should help them determine:

- How human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space
- What individuals and communities are doing to help protect Earth's resources and the environment.

Students can share their work in a variety of ways and should provide a list of sources for the information in their finished work.

Although engineering design is not explicitly called out in this unit, students could incorporate engineering design in a number of ways as they explore human impact on the environment.

- Students may design a way to promote local, sustainable agriculture, making healthy food available to more people in their communities while having minimizing the impact on the local environment.
- Students can design ways to capture and use rainwater throughout their community to lessen the impact on local freshwater reserves.
- Students can design and implement a variety of recycling projects that have a positive impact on the environment by increasing the reuse of materials that normally end up in landfills and decreasing our reliance on earth resources.
- Students can research and design ways to increase the use of environmentally friendly fertilizers and pesticides that do not harm the local environment. Students can create pamphlets, presentations, or even commercials that inform the local community of the impact that chemical fertilizers and pesticides have when used in and around homes and businesses and offer information on safer alternatives that are just as effective.
- Students will need time to conduct research, determine criteria for success, consider constraints on available resources, and design solutions based on the information they gather. Students will need access to reliable sources of information that will help them as they work through the design process.

Lesson Plans

Lesson	**Timeframe**
Unit 6 Project	2 days
Lesson 1 What are Earth's Major Systems?	5 Days Comprehensive Class
Lesson 2 How Do Earth's Systems Interact?	5 Days Comprehensive Class
Lesson 3 Engineer It- What is the Role of the Oceans in Earth's System's	5 Days Comprehensive Class
You Solve it	1 day
Unit 6 Performance Task	1 day
Performance –Based Assessment	1 day
Unit 6 Review and Unit 6 Test	2 days

Teacher Notes:

Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: How Are Climate and Weather Different? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Are Climate and Weather Different? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: The Coldest Place on Earth? This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Use Realia: Point out that each Earth system includes the word root sphere. Tell students that the word sphere comes from an ancient Greek word meaning "globe." Hold up a globe before the class.

Lesson 2: Have students help you make a word wall to create a visual display of all vocabulary for this lesson.

Lesson 3: Help reinforce students' understanding of these vocabulary terms by having students complete two index cars, one for each term. On their index cards, have them write the term, a definition in their own words, and a picture, diagram, or cartoon to help them remember the definition.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Earth's Systems							
Lesson Title: What are Earth's Major System?						**Timeframe: 5 days**	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation	X	Critical Thinking and Problem Solving		Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy		Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization of TCI online tools and resources							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students will be able: ● To identify and describe each of Earth's systems and the cycles that occur within them.	1. About this Image: The first Americans to record their observations of Mount Hood were Captain Meriweather Lewis and Second Lieutenant William Clark during their Corps of Discovery Exploration, which took place in the early 1800's/ 2. Can you Explain It? Students are asked to define, their own words, the term cycle. Guide students by drawing a cycle graphic organizer on the board. 3. Exploration 1-Systems and Cycles: Geosphere and Atmosphere: Students explore Earth's major systems, including the biosphere, atmosphere, geosphere, and hydrosphere. Using models and other strategies, students learn what these systems contain and how they interact. 4. Exploration 2-Atmosphere: The Big Picture: Students learn more about the	● Developing and Using Models: Make sure students understand that models can be two-dimensional diagrams, such as the one of the rock cycle shown on this page. ● Developing and Using Models: If students have trouble completing the interactivity, suggest they look back at the diagram of how energy and matter move through the biosphere. ● Can you explain it? ● Lesson roundup

	atmosphere, one of Earth's major systems. The discover the importance of the atmosphere to life and explore its different layers. 5. Exploration 3-Systems and Cycles: Hydrosphere and Biosphere: Students learn more about the hydrosphere and the biosphere. They will discover that most of Earth's surface is covered by water and use modeling and math to investigate how much of this water is available for humans to use. 6. Take It Further: Discover More 7. Lesson Check: Can you Explain it? 8. Lesson Check; Lesson Roundup	
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Develop a model using an example to describe a scientific principle. (5-ESS2-1) **Obtaining, Evaluating, and Communicating Information** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5-ESS3-1)	**ESS2.A: Earth Materials and Systems** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1) - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World.** Science findings are limited to questions that can be answered with empirical evidence. (5-ESS3-1)

	atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1) **<u>ESS3.C: Human Impacts on Earth Systems</u>** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	

Content Area: Fifth Grade Science
Unit Title: Earth and Human Activities
Target Course/Grade Level: Unit 7 Grade 5

Unit Summary

In this unit students will….

- Explore how human activity affects the Earth and its systems.
- Learn about ways to keep Earth and its systems healthy

Lesson 1: Students will gather evidence of how everyday human activity can affect Earth and combine information to explain possible solutions to the problems that arise through the interactions within Earth's system of resources and how science addresses those interactions.

Lesson 2: Students will identify and explain ways that people can help protect the environment. Students will obtain, evaluate, and communicate ideas for recycling, reusing, and rescuing objects in and around the home. Students will investigate green technologies to try to find ways to help protect the planet while making observation and forming ideas about how to conserve energy in their own homes. Finally, students will examine how cities work to reduce fossil fuel use, recycle, and improve energy efficiency.

Primary interdisciplinary connections:

English Language Arts

Students should use information from print and digital sources to build their understanding of:

- The Earth's gravitational force on objects.
- The differences in the apparent brightness of the sun compared to that of other stars due to their relative distances from Earth.
- Patterns of change that occur due to the position and motion of the Earth, sun, moon, and stars.

- As students read and gather information from multiple sources, they should integrate and use the information to answer questions and support their thinking during discussions and in their writing

Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-PS2-1), (5-ESS1-1) **RI.5.1**
Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-ESS1-1) **RI.5.7**
Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-PS2-1), (5-ESS1-1) **RI.5.9**
Recall relevant information from experience or gather relevant information from point and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources **W.5.8**
Draw evidence from literary or informational texts to support analysis, reflection, and research. **W.5.9**

Mathematics

Students reason abstractly and quantitatively when analyzing and using data as evidence to describe phenomena, including:

- The Earth's gravitational force pulls objects "down" (toward the center of the Earth).
- The differences in the apparent brightness of the stars are due to their relative distances from Earth.
- Patterns of change, such as the day/night cycle, the change in length and direction of shadows during the day, the apparent motion of the sun across the daytime sky and the moon across the nighttime sky, the changes in the appearance of the moon over a period of four weeks, and the seasonal changes in the position of the stars in the night sky.
- Students will model with mathematics as they graphically represent data collected from direct observations and from multiple resources throughout the unit, and as they describe relative distances of the sun and other stars from the Earth. Students might also express relative distances between the Earth and stars using numbers that can be expressed using powers of 10.

Reason abstractly and quantitatively. (5-ESS1-1),(5-ESS1-2) **MP.2**
Model with mathematics. (5-ESS1-1,(5-ESS1-2)) **MP.4**

21st century themes):

Global Awareness

Unit Rationale

Prior Learning

Grade 1 Unit 6: Objects and Patterns in the Sky

· In this unit students learned the following: Identify and describe objects in the sky; Use evidence to describe predictable patterns of the sun, moon, and stars; Observe and model patterns of the moon's phases; Use observations to describe characteristics of each season; predict patterns of change that take place from season to season; & Explore how seasons affect people and animals.

- http://www.nap.edu/openbook.php?record_id=13165&page=175

Grade 3 Unit 6: Forces

· In this unit students learning the following: explored how forces work; Discovered different types of forces; Learned about forces that act from a distance.

Future Learning

Grade 6 Unit 4: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Grade 6 Unit 5: Types of Interactions

- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

Grade 6 Unit 6: Astronomy

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Learning Targets	
Standards	
NJSLS-S#	**Performance Expectation**
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Unit Essential Question

Part A: How Does Resources Use Affect Earth?

Part B: How Can People Protect the Environment?

Unit Enduring Understandings

Part A:

- To use photographs and obtain information and communicate ways students see human impact on Earth and its systems, including how humans use Earth's resources and how human population affects Earth's environments.

Part B:

- Obtain, evaluate , and communicate information about the importance of reducing, reusing, and recycling and other ways people protect the environment. Students investigate technologies and ideas used to help protect Earth's resources and environments.

Evidence of Learning

Assessment

- **Pre-Assessment (1 Day)-**The unit pretest focuses on prerequisite knowledge and is composed of items that evaluate children's preparedness for the content covered within this unit
- **Formative Assessment (Throughout the lesson):** Interactive Worktext, Apply What you Know, Lesson Check, and Self Check
- **Summative Assessment:**
    1. **Assessment Guide (1 period)-**The lesson quiz provides a quick assessment of each lesson objective and of the portion of the Performance Expectation aligned to the lesson.
    2. **Interactive Worktext (1 day)-** The performance task presents the opportunity for children to collaborate with classmates in order to complete the steps of each Performance Task. Each Performance Task provides a formal Scoring Rubric for evaluating children's work
    3. **Assessment Guide (1 day)-** The unit test provides an in-depth assessment of the Performance Expectations aligned to the unit. This test evaluates children's ability to apply knowledge in order to explain phenomena and to solve problems. Within this test, Constructed Response items apply a three-dimensional

Equipment needed: TCI Kits

Teacher Resources: TCI teacher editions, worktexts & assessment guide.

Gravity and Falling Objects: PBS Learning Media lesson where students investigate the force of gravity and how all objects, regardless of mass, fall to the ground at the same rate.

NASA's Solar System Exploration website contains several resources that educators and students can use to make sense of the night sky.

Our Super Star: PBS Learning Media lesson that guides students to understand the basic facts about the Sun, model the mechanics of day and night, and use solar energy to make a tasty treat.

Formative Assessments

Students who understand the concepts are able to:

- Identify cause-and-effect relationships in order to explain change.
- Support an argument with evidence, data, or a model.
- Support an argument that the gravitational force exerted by Earth on objects is directed down. ("Down" is a local description of the direction that points toward the center of the spherical Earth.) (Assessment does not include mathematical representation of gravitational force.).
- Support an argument with evidence, data, or a model.
- Support an argument that differences in the apparent brightness of the sun compared to that of other stars is due to their relative distances from Earth. (Assessment is limited to relative distances, not sizes, of stars, and does not include other factors that affect apparent brightness, such as stellar masses, age, or stage.)
- Sort, classify, communicate, and analyze simple rates of change for natural phenomena using similarities and differences in patterns.
- Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
- Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. (Assessment does not include causes of seasons.) Examples of patterns could include:
  - The position and motion of Earth with respect to the sun.
  - Selected stars that are visible only in particular months.

What it Looks Like in the Classroom

In this unit of study, students explore the effects of gravity and determine the effect that relative distance has on the apparent brightness of stars. They also collect and analyze data in order to describe patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

To begin the progression of learning in this unit, students explore the effects of gravity by holding up and releasing a variety of objects from a variety of heights and locations. Students should record and use their observations to describe the interaction that occurs between each object and the Earth. In addition, students should use their observations as evidence to support an argument that the gravitational force exerted by the Earth on objects is directed "down" (towards the center of the Earth), no matter the height or location from which an object is released.

Next, students investigate the effect of distance on the apparent brightness of stars. Using information from a variety of print or digital sources, students learn that natural objects vary in size, from very small to immensely large. Stars, which vary in size, also range greatly in their distance from the Earth. The sun, which is also a star, is much, much closer to the Earth than any other star in the universe. Once students understand these concepts, they should explore the effect of distance on the apparent brightness of the sun in relation to other stars. This can be accomplished by modeling the effect using a light source, such as a bright flashlight. As students vary the distance of the light from their eyes, they should notice that the farther away the light is, the less bright it appears. Observations should again be recorded and used as evidence to support the argument that the differences in the apparent brightness of the sun compared to that of other stars is due to their relative distances from the Earth.

To continue the progression of learning, students investigate the following observable patterns of change that occur due to the position and motion of the Earth, sun, moon, and stars.

- Day and night: This pattern of change is a daily, cyclical pattern that occurs due to the rotation of the Earth every 24 hours. Students can observe model simulations using online or digital resources, or they can create models in class of the day/night pattern caused by the daily rotation of the Earth.
- The length and direction of shadows: These two interrelated patterns of change are daily, cyclical patterns that can be observed and described through direct observation. Students need the opportunity to observe a stationary object at chosen intervals throughout the day and across a few days. They should measure and record the length of the shadow and record the direction of the shadow (using drawings and cardinal directions), then use the data to describe the patterns observed.
- The position of the sun in the daytime sky: This daily, cyclical pattern of change can also be directly observed. Students will need the opportunity to make and record observations of the position of the sun in the sky at chosen intervals throughout the day and across a few days. Data should then be analyzed in order to describe the pattern observed.
- The appearance of the moon in the night sky: This cyclical pattern of change repeats approximately every 28 days. Students can use media and online resources to find data that can be displayed graphically (pictures in a calendar, for example), which will allow them to describe the pattern of change that occurs in the appearance of the moon every four weeks.
- The position of the moon in the night sky: This daily, cyclical pattern of change can be directly observed, but students would have to make observations of the position of the moon in the sky at chosen intervals throughout the night, which is not recommended. Instead, students can use media and online resources to learn that the moon, like the sun, appears to rise in the eastern sky and set in the western sky every night.
- The position of the stars in the night sky: Because the position of the stars changes across the seasons, students will need to use media and online resources to learn about this pattern of change.

Whether students gather information and data from direct observations or from media and online sources, they should organize all data in graphical displays so that the data can be used to describe the patterns of change.

Lesson Plans

Lesson	Timeframe
Unit 7 Project	2 days
Lesson 1 How Does Resource Use Affect Earth?	5 Days of Comprehensive Class
Lesson 2 **Engineer It-**How Can People Protect the Environment?	5 Days of Comprehensive Class
You Solve It?	1 day
Unit 7 Performance Task	1 day
Performance-Based Assessment	1 day
Unit 7 Review and Unit 7 Test	2 days

Teacher Notes:

Comprehensive Class pacing is based on meeting daily for a 45-minute class for the entire school year.

Differentiation

On-Level Reader: How Can Conservation Save Earth's Resources? This reader reinforces unit concepts and includes response activities for your students.

Extra Support: How Can Conservation Save Earth's Resources? This reader shares title, illustrations, vocabulary, and concepts with the On-Level Reader; however, the text is linguistically accommodated to provide simplified sentence structures and comprehension aids. It also includes response activities.

Enrichment: Alternative Energy Resources? This high-interest, nonfiction reader will extend and enrich unit concepts and vocabulary and includes response activities.

ELL

Lesson 1: Point out cognates of key terms from students' home languages, for example natural/recursos naturales, conserve/conserver, population/poblacion to help bridge understanding of pertinent lesson vocabulary. Pronounce each word and spotlight the similarities. Ask other students other students to share the same words in their home language

Lesson 2: Pair ELL students will bilingual students or strong English speakers. Each pair will need four index cards and two different-colored markers. Explain that bio-means "something living" and de-means "able to be broken down" and that –composer means "putting something together."

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: <u>All Standards, All Students</u>/<u>Case Studies</u> for vignettes and explanations of the modifications.)

• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Lesson Plan 1							
Content Area: Earth and Human Activities							
Lesson Title: How Does Resources Use Affect Earth?						**Timeframe:** 5 days	
Lesson Components							
21st Century Themes							
X	Global Awareness		Financial, Economic, Business, and Entrepreneurial Literacy		Civic Literacy		Health Literacy
21st Century Skills							
X	Creativity and Innovation		Critical Thinking and Problem Solving	X	Communication and Collaboration		Information Literacy
	Media Literacy		ICT Literacy	X	Life and Career Skills		
Interdisciplinary Connections: Science: Technology							
Integration of Technology: Utilization on TCI online tools and resources.							
Equipment needed: TCI Kits							

Goals/Objectives	Learning Activities/Instructional Strategies	Formative Assessment Tasks
Students: ● Will be able to use photographs and obtain information and communicate ways students see human impact on Earth and its systems, including how humans use Earth's resources and how human population affects Earth's environments.	1. About this Image: Cities with large population also use a large amount of resources. Having tall vertical buildings uses less horizontal land space. 2. Can you Explain It? Students are asked to record their initial thoughts about how a growing population, as seen in a series of pictures, affects the use of earth's resources. To do so, students must begin to think about what Earth's resources are and how we use them. 3. Exploration 1: Earth's Resources: Obtain and combine information about the natural resources in Earth's systems, how humans use these resources, and how human use affects the environment. 4. Exploration 2; Earth and Human Activity: Obtain and combine information from empirical evidence about how increased population results in increased human impact on the environment. 5. Take it Further: Discover More 6. Lesson Check: Can you explain it? 7. Lesson Check: Lesson Roundup	● Cause and Effect: Make sure students understand the concept of how human activities impact Earth's systems by asking for volunteers to explain ho increased population affects the environment. ● Lesson Check: Can you explain it? ● Lesson Check: Lesson Roundup
Differentiation Small group instruction, leveled readers. Modifications in accordance with students' 504 plans or IEP.		
Resources Provided: TCI work text, teacher online access, and equipment kits.		

Appendix: NJSLS and Foundations for the Unit

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Develop a model using an example to describe a scientific principle. (5-ESS2-1) **Engaging in Argument from Evidence** Support an argument with	**PS2.B: Types of Interactions** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1) **ESS1.A: The Universe and its Stars** The sun is a star that appears larger and	**Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) **Scale, Proportion, and Quantity**

evidence, data, or a model. (5-PS2-1), (5-ESS1-1) **Analyzing and Interpreting Data** Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1) **ESS1.B: Earth and the Solar System** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)	Natural objects exist from the very small to the immensely large. (5-ESS1-1) **Patterns** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

Curriculum: Grade 6

Unit 1: Growth, Development, and Reproduction of Organisms

Instructional Days: 25

Unit Summary
What influences the growth and development of an organism? Students use data and conceptual models to understand how the environment and genetic factors determine the growth of an individual organism. They connect this idea to the role of animal behaviors in animal reproduction and to the dependence of some plants on animal behaviors for their reproduction. Students provide evidence to support their understanding of the structures and behaviors that increase the likelihood of successful reproduction by organisms. The crosscutting concepts of *cause and effect* and *structure and function* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade-appropriate proficiency in *analyzing and interpreting data*, *using models*, *conducting investigations*, and *communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-LS1-4 and MS-LS1-5.

Student Learning Objectives
Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. *[Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]* **(MS-LS1-4)**
Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. *[Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]* **(MS-LS1-5)**

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MS-LS1-4	Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
LS1.A	All living things are made up of cells, which is the smallest unit that can be said to be alive
LS1.B	Animals engage in characteristic behaviors that increase the odds of reproduction
LS1.B	Genetic factors as well as local conditions affect the growth of the adult plant

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Unit 1: Growth, Development, and Reproduction of Organisms

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Quick Links		
Unit Sequence p. What it Looks Like in the Classroom p. Connecting ELA/Literacy and Math p. Modifications p.	Research on Learning p. Prior Learning p. Future Learning p. Connections to Other Units p.	Sample Open Education Resources p. Teacher Professional Learning Resources p. Appendix A: NGSS and Foundations p.

Enduring Understandings
• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
Essential Questions
• What are the basic structures and functions of all living organisms? • How do organisms reproduce and grow? • How does energy flow through all living organisms? • How do living organisms process environmental stimuli?

Unit 1: Growth, Development, and Reproduction of Organisms

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: How do characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>

Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.
✓ There are a variety of ways that plants reproduce.
Specialized structures for plants affect their probability of successful reproduction.
Some characteristic animal behaviors affect the probability of successful reproduction in plants.
Animals engage in characteristic behaviors that affect the probability of successful reproduction.
There are a variety of characteristic animal behaviors that affect their probability of successful reproduction.
There are a variety of animal behaviors that attract a mate.
Successful reproduction of animals and plants may have more than one cause, and some cause-and-effect

</td><td>
Students who understand the concepts are able to:

Collect empirical evidence about animal behaviors that affect the animals’ probability of successful reproduction and also affect the probability of plant reproduction.
Collect empirical evidence about plant structures that are specialized for reproductive success.
Use empirical evidence from experiments and other scientific reasoning to support oral and written arguments that explain the relationship among plant structure, animal behavior, and the reproductive success of plants.
Identify and describe possible cause-and effect relationships affecting the reproductive success of plants and animals using probability.
Support or refute an explanation of how characteristic animal behaviors and specialized plant structures affect the probability of successful plant reproduction using oral

</td></tr>
</table>

relationships in systems can only be described using probability.	and written arguments.

Unit 1: Growth, Development, and Reproduction of Organisms

Instructional Days: 25

Unit Sequence	
Part B: *How do environmental and genetic factors influence the growth of organisms?*	
Concepts	**Formative Assessment**
• Genetic factors as well as local conditions affect the growth of organisms. ✓ A variety of local environmental conditions affect the growth of organisms. • Genetic factors affect the growth of organisms (plant and animal). • The factors that influence the growth of organisms may have more than one cause. • Some cause-and-effect relationships in plant and animal systems can only be described using probability.	*Students who understand the concepts are able to:* • Conduct experiments, collect evidence, and analyze empirical data. • Use evidence from experiments and other scientific reasoning to support oral and written explanations of how environmental and genetic factors influence the growth of organisms. • Identify and describe possible causes and effects of local environmental conditions on the growth of organisms. • Identify and describe possible causes and effects of genetic conditions on the growth of organisms.

Unit 1: Growth, Development, and Reproduction of Organisms

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Three-Dimensional Teaching and Learning
Instruction should result in students being able to use arguments based on empirical evidence and scientific reasoning to support an explanation of how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants. Students may observe examples of plant structures that could affect the probability of plant reproduction, including bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract pollen-transferring insects, and hard shells on nuts that squirrels bury. Possible activities could include plant experiments (e.g., students could count the number of butterflies on brightly colored plants vs. the number of butterflies on other types of plants and record the data they collect in a table), using microscopes/magnifiers to view plant structures (e.g., dissecting a lily), going on field trips, both virtual and actual (e.g., butterfly garden/botanical garden). Students may observe examples of animal behaviors that affect the probability of plant reproduction, which could include observing how animals can transfer pollen or seeds and how animals can create conditions for seed germination and growth (e.g., students may conduct an experiment using rapid cycling Brassica rapa [Fast Plant] and collect data on how many plants produce seeds with and without the aid of a pollinator. Students could then observe examples of animal behaviors (using videos, Internet resources, books, etc.) that could affect the probability of successful animal reproduction. These behaviors could include nest building to protect young from cold, herding of animals to protect young from predators, and colorful plumage and vocalizations to attract mates for breeding. Students may be able to identify and describe possible cause-and-effect relationships in factors that contribute to the reproductive success of plants and animals by using probability data from the rapid-cycling *Brassica rapa* (Fast Plant) experiments and drawing conclusions about one relationship between animals and plants. At this point, students can present an oral and/or written argument supported by evidence and scientific reasoning that characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. Students may use evidence from experiments or other sources to identify the role of pollinators in plant reproduction. Instruction that results in students being able to construct an evidence-based scientific explanation for how environmental and genetic factors influence the growth of organisms could begin with students conducting experiments and collecting data on the environmental conditions that effect the growth of organisms (e.g., the effect of variables such as food, light, space, and water on plant growth). Students could then examine genetic factors (inherited traits) that influence the growth of organisms, including parental traits

and selective breeding. *It is important to note that at this grade level, Mendelian genetics are not a part of student learning. Mendelian genetics will be covered in future grades.* This unit of study could end with students using an oral and/or written argument, supported by evidence and scientific reasoning from their experiments, to explain how environmental conditions and genetic factors affect the growth of an organism.

Leveraging English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific, empirical, textual evidence to support analysis of how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.
- Trace and evaluate the argument and specific claims in a text about how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. Distinguish claims that are supported by empirical evidence and scientific reasoning from claims that are not.
- Write an argument focused on how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.

Mathematics

- Understand that a set of data collected to answer a statistical question about how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively, has a distribution which can be described by its center (mean), spread (range), and overall shape (shape of the distribution of data).
- Summarize numerical data sets, collected to answer a statistical question about how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively, that have a distribution that can be described by its center (mean), spread (range), and overall shape (shape of the distribution of data) in relation to their context.

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Unit 1: Growth, Development, and Reproduction of Organisms

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Future Learning
• Systems of specialized cells within organisms help perform essential functions of life. • Any one system in an organism is made up of numerous parts. • Feedback mechanisms maintain an organism's internal condition within certain limits and mediate behaviors. • Growth and division of cells in organisms occur by mitosis and differentiation for specific cell types.

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy- • Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4),(MS-LS1-5) **RST.6-8.1** • Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-LS1-5) **RST.6-8.2** • Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4) **RI.6.8** • Write arguments focused on discipline content. (MS-LS1-4) **WHST.6-8.1** • Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-5) **WHST.6-8.2** • Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5) **WHST.6-8.9** *Mathematics* • Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. (MS-LS1-4),(MS-LS1-5) **6.SP.A.2** • Summarize numerical data sets in relation to their context. (MS-LS1-4),(MS-LS1-5) **6.SP.B.4**

Unit 1: Growth, Development, and Reproduction of Organisms

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

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Research on Student Learning
Students may not believe food is a scarce resource in ecosystems, thinking that organisms can change their food at will according to the availability of particular sources. Students of all ages think that some populations of organisms are numerous in order to fulfill a demand for food by another population. Students may believe that organisms are able to effect changes in bodily structure to exploit particular habitats or that they respond to a changed environment by seeking a more favorable environment. It has been suggested that the language about adaptation used by teachers or textbooks to make biology more accessible to students may cause or reinforce these beliefs (NSDL, 2015).

Prior Learning
Life Science • Reproduction is essential to every kind of organism. • Organisms have unique and diverse life cycles. • Organisms have both internal and macroscopic structures that allow for growth, survival, behavior, and reproduction.

Unit 1: Growth, Development, and Reproduction of Organisms

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Future Learning
Life Science • In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. • The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. • As successive subdivisions of an embryo's cells occur, programmed genetic instructions and small differences in their immediate environments activate or inactivate different genes, which cause the cells to develop differently—a process called differentiation. • Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. • In sexual reproduction, a specialized type of cell division called meiosis occurs that results in the production of sex cells, such as gametes in animals (sperm and eggs), which contain only one member from each chromosome pair in the parent cell.

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Unit 1: Growth, Development, and Reproduction of Organisms

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Connections to Other Units
Grade 6 Unit 2: Matter and Energy in Organisms and Ecosystems • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)

Unit 1: Growth, Development, and Reproduction of Organisms

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Links to Free and Low Cost Instructional Resources
Note- *The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials.*
• American Association for the Advancement of Science: *http://www.aaas.org/programs* • American Association of Physics Teachers: *http://www.aapt.org/resources/* • American Chemical Society: *http://www.acs.org/content/acs/en/education.html* • Concord Consortium: Virtual Simulations: *http://concord.org/* • International Technology and Engineering Educators Association: *http://www.iteaconnect.org/* • National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php* • National Science Digital Library: *https://nsdl.oercommons.org/* • National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx • North American Association for Environmental Education: *http://www.naaee.net/* • Phet: Interactive Simulations *https://phet.colorado.edu/* • Physics Union Mathematics (PUM): *http://pum.rutgers.edu/* • Science NetLinks: *http://www.aaas.org/program/science-netlinks*

Sample of Open Education Resources

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Unit 1: Growth, Development, and Reproduction of Organisms

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<table>
<tr><th colspan="3">Appendix A: NGSS and Foundations for the Unit</th></tr>
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<tr><td colspan="3">The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Engaging in Argument from Evidence
• Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS1-4)

Constructing Explanations and</td><td>LS1.B: Growth and Development of Organisms
• Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)
• Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-4),(MS-LS1-5)
• Phenomena may have more than one cause, and some cause and effect relationships in systems can</td></tr>
</table>

Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-5)	features for reproduction. (MS-LS1-4) • Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)	only be described using probability. (MS-LS1-4),(MS-LS1-5) **Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS1-4), (MS-LS1-5)

Unit 1: Growth, Development, and Reproduction of Organisms

Instructional Days: 25

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4),(MS-LS1-5) **RST.6-8.1** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-LS1-5) **RST.6-8.2** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4) **RI.6.8** Write arguments focused on discipline content. (MS-LS1-4) **WHST.6-8.1** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-5) **WHST.6-8.2** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5) **WHST.6-8.9**	Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. (MS-LS1-4),(MS-LS1-5) **6.SP.A.2** Summarize numerical data sets in relation to their context. (MS-LS1-4),(MS-LS1-5) **6.SP.B.4**

Unit 1: Growth, Development, and Reproduction of Organisms

Instructional Days: 25

Common Vocabulary	
Breed Diverse Transfer Development Attract Characteristics of life Germination	Plant structure Plumage Reproductive system Soil fertility Vocalization fertilizer

Curriculum: Grade 6

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Unit Summary
How and why do organisms interact with their environment and what are the effects of these interactions?   Students *analyze and interpret data, develop models, construct arguments*, and demonstrate a deeper understanding of the cycling of matter, the flow of energy, and resources in ecosystems. They are able to study patterns of interactions among organisms within an ecosystem. They consider biotic and abiotic factors in an ecosystem and the effects these factors have on populations. They also understand that the limits of resources influence the growth of organisms and populations, which may result in competition for those limited resources. The crosscutting concepts of *matter and energy*, *systems and system models*, *patterns*, and *cause and effect* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade-appropriate proficiency in analyzing and interpret data, developing models, and constructing arguments. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-LS2-1, MS-LS2-2, and MS-LS2-3.
Student Learning Objectives
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. *[Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]* **(MS-LS2-1)**
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. *[Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]* **(MS-LS2-2)**
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. *[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]* **(MS-LS2-3)**

Curriculum: Grade 6

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

MS-LS2-1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-3	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem
LS2.A	Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors
LS2.B	Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem
LS2.C	Ecosystems are dynamic in nature

Curriculum: Grade 6

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Quick Links		

Enduring Understandings
• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources. (MSLS21) • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations oforganisms.
Essential Questions
• How do organisms interact within an ecosystem? • How does energy and matter cycle through ecosystems? • How can ecosystems be sustained? • How do humans adapt to changes in resources?

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Unit Sequence	
Part A: *How do changes in the availability of matter and energy effect populations in an ecosystem?*	
Concepts	**Formative Assessment**
• Organisms and populations of organisms are dependent on their environmental interactions with other living things. • Organisms and populations of organisms are dependent on their environmental interactions with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with others for limited resources. • Access to food, water, oxygen, or other resources constrain organisms' growth and reproduction.	*Students who understand the concepts are able to:* • Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. • Use cause-and-effect relationships to predict the effect of resource availability on organisms and populations in natural systems.

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Unit Sequence	
Part B: *How do relationships among organisms, in an ecosystem, effect populations?*	
Concepts	**Formative Assessment**
• Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. • Mutually beneficial interactions may become so interdependent that each organism requires the other for survival. • The patterns of interactions of organisms with their environment, both its living and nonliving components, are shared. • Interactions within ecosystems have patterns that can be used to identify cause-and-effect relationships. • Patterns of interactions among organisms across multiple ecosystems can be predicted. • Patterns of interactions can be used to make predictions about the relationships among and between organisms and abiotic components of ecosystems.	*Students who understand the concepts are able to:* • Construct an explanation about interactions within ecosystems. • Include qualitative or quantitative relationships between variables as part of explanations about interactions within ecosystems. • Make predictions about the impact within and across ecosystems of competitive, predatory, or mutually beneficial relationships as abiotic (e.g., floods, habitat loss) or biotic (e.g., predation) components change.

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Unit Sequence	
Part C: *How can you explain the stability of an ecosystem by tracing the flow of matter and energy?*	
Concepts	**Formative Assessment**
• Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. • Transfers of matter into and out of the physical environment occur at every level. • Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments. • Decomposers recycle nutrients from dead plant or animal matter back to the water in aquatic environments. • The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. • The transfer of energy can be tracked as energy flows through an ecosystem. • Science assumes that objects and events in ecosystems occur in consistent patterns that are understandable through measurement and observation.	• *Students who understand the concepts are able to:* • Develop a model to describe the cycling of matter among living and nonliving parts of an ecosystem. • Develop a model to describe the flow of energy among living and nonliving parts of ecosystem. Track the transfer of energy as energy flows through an ecosystem. • Observe and measure patterns of objects and events in ecosystems.

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

What it Looks Like in the Classroom
Instruction should result in students being able to use arguments based on empirical evidence and scientific reasoning to support an explanation of how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants. Students may observe examples of plant structures that could affect the probability of plant reproduction, including bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract pollen-transferring insects, and hard shells on nuts that squirrels bury. Possible activities could include plant experiments (e.g., students could count the number of butterflies on brightly colored plants vs. the number of butterflies on other types of plants and record the data they collect in a table), using microscopes/magnifiers to view plant structures (e.g., dissecting a lily), going on field trips, both virtual and actual (e.g., butterfly garden/botanical garden). Students may observe examples of animal behaviors that affect the probability of plant reproduction, which could include observing how animals can transfer pollen or seeds and how animals can create conditions for seed germination and growth (e.g., students may conduct an experiment using rapid cycling Brassica rapa [Fast Plant] and collect data on how many plants produce seeds with and without the aid of a pollinator. Students could then observe examples of animal behaviors (using videos, Internet resources, books, etc.) that could affect the probability of successful animal reproduction. These behaviors could include nest building to protect young from cold, herding of animals to protect young from predators, and colorful plumage and vocalizations to attract mates for breeding. Students may be able to identify and describe possible cause-and-effect relationships in factors that contribute to the reproductive success of plants and animals by using probability data from the rapid-cycling Brassica rapa (Fast Plant) experiments and drawing conclusions about one relationship between animals and plants. At this point, students can present an oral and/or written argument supported by evidence and scientific reasoning that characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. Students may use evidence from experiments or other sources to identify the role of pollinators in plant reproduction. Instruction that results in students being able to construct an evidence-based scientific explanation for how environmental and genetic factors influence the growth of organisms could begin with students conducting experiments and collecting data on the environmental conditions that effect the growth of organisms (e.g., the effect of variables such as food, light, space, and water on plant growth).

Students could then examine genetic factors (inherited traits) that influence the growth of organisms, including parental traits and selective breeding. It is important to note that at this grade level, Mendelian genetics are not a part of student learning. Mendelian genetics will be covered in future grades.

This unit of study could end with students using an oral and/or written argument, supported by evidence and scientific reasoning from their experiments, to explain how environmental conditions and genetic factors affect the growth of an organism.

Connecting English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific, empirical, textual evidence to support analysis of how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.
- Trace and evaluate the argument and specific claims in a text about how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. Distinguish claims that are supported by empirical evidence and scientific reasoning from claims that are not.
- Write an argument focused on how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.

Mathematics

- Understand that a set of data collected to answer a statistical question about how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively, has a distribution which can be described by its center (mean), spread (range), and overall shape (shape of the distribution of data).
- Summarize numerical data sets, collected to answer a statistical question about how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively, that have a distribution that can be described by its center (mean), spread (range), and overall shape (shape of the distribution of data) in relation to their context.

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Research on Student Learning
Some students have difficulty in identifying the sources of energy for plants and also for animals. Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis. Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. Careful coordination between the Physical and Life Sciences Disciplinary Core Ideas about conservation of matter and energy and the nature of energy may help alleviate these difficulties. Students of all ages see food as substances (water, air, minerals, etc.) that organisms take directly in from their environment. In addition, some students of all ages think food is a requirement for growth, rather than a source of matter for growth. They have little knowledge about food being transformed and made part of a growing organism's body. Some students of all ages hold misconceptions about plant nutrition. They think plants get their food from the environment rather than manufacturing it internally, and that food for plants is taken in from the outside. These misconceptions are particularly resistant to change. Even after traditional instruction, students have difficulty accepting that plants make food from water and air, and that this is their only source of food. Understanding that the food made by plants is very different from other nutrients such as water or minerals is a prerequisite for understanding the distinction between plants as producers and animals as consumers. Some middle-school students do not realize that the matter from dead organisms is converted into other materials in the environment. Some middle-school students see decay as a gradual, inevitable consequence of time without need of decomposing agents. Some high-school students believe that matter is conserved during decay, but do not know where it goes. Middle-school students seem to know that some kind of cyclical process takes place in ecosystems. Some students see only chains of events and pay little attention to the matter involved in processes such as plant growth or animals eating plants. They think the processes involve creating and destroying matter rather than transforming it from one substance to another. Other students recognize one form of recycling through soil minerals but fail to incorporate water, oxygen, and carbon dioxide into matter cycles. Even after specially designed instruction, students cling to their misinterpretations. Instruction that traces matter through the ecosystem as a basic pattern of thinking may help correct these difficulties (NSDL, 2015).

Curriculum: Grade 6

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Prior Learning
By the end of Grade 5, students understand that: • Populations live in a variety of habitats, and change in those habitats affects the organisms living there. • Organisms can survive only in environments in which their particular needs are met. • A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. • Newly introduced species can damage the balance of an ecosystem. • The food of almost any animal can be traced back to plants. • Organisms are related in food webs, in which some animals eat plants for food and other animals eat the animals that eat plants; eventually, decomposers restore some materials to the soil. • Matter cycles between the air and soil and among organisms as they live and die and among plants, animals, and microbes as these organisms live and die. • Organisms obtain gases and water from the environment and release waste matter (gas, liquid, or solid) back into the environment. • Adult plants and animals can have young. • In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

Future Learning
Life Science • Systems of specialized cells within organisms help perform essential functions of life. • Any one system in an organism is made up of numerous parts. • Feedback mechanisms maintain an organism’s internal condition within certain limits and mediate behaviors. • Growth and division of cells in organisms occur by mitosis and differentiation for specific cell types.

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Connections to Other Units
Grade 6 Unit 3: Interdependent Relationships in Ecosystems • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. **Grade 7 Unit 1: Structure and Properties of Matter** • Substances react chemically in characteristic ways. **Grade 7 Unit 3: Chemical Reactions** • In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. **Grade 7 Unit 8: Earth Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **Grade 8 Unit 3: Stability and Change on Earth** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for

different living things.

- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Sample of Open Education Resources
Habitable Planet Population Simulator: This ecosystem interactive will allow the user to determine the producers and consumers (primary and secondary) in a simulated ecosystem. The user can then see the outcome of including species with particular diets, including the result of how food resources can be depleted if consumers have similar diets. The accompanying lessons do have questions to guide the development of investigations, and there are data tables that are provided to gather information as it is collected.
Modeling Marine Food Webs and Human Impact: In this two-part lesson, students develop food webs and investigate human impacts on marine ecosystems. In Part I, students explore the ecological role of organisms in an ocean habitat and use information provided on Food Web Cards to develop food chains. In Part II, students model the interconnected feeding relationships in the open ocean ecosystem by developing food webs and then using their food webs to explore the impact that different scenarios have on the ecosystem.
Interactive Interdependence: This article describes an interactive lesson in which the complexity of food webs and ecosystems is explored. Students generate a list of organisms in a Pacific aquatic ecosystem, assign each organism to a student, and then link the organisms together in a food web using string. Students tug on the string to identify the connections in the food web. In response to several potential changes the teacher describes, the students tug on their strings to predict patterns of interactions. Next, they investigate the limiting factors in an ecosystem. As a concluding activity, students respond to how organisms are affected with differing "Interdependence Scenarios."
Florida's Everglades: The River of Grass utilizes a video clip of a visit to the Everglades, short articles for students to read, a series of slides and a suggested project for students to complete. Students sign up for a pbsteacherline.org account (no email required) to save their notes. As they go through the lesson, they read, watch videos, and answer questions in order to investigate the Florida Everglades ecosystem. Students investigate the biodiversity in the varying ecosystems and the human impact on this biome. Students compare the Florida Everglades to their local ecosystem. An included writing prompt helps students explain patterns of interactions between organisms and ecosystems. An eight page teacher's guide is included in support materials under "For Teachers". This guide provides lesson goals, key literacy strategies, essential background information, questions for determining students' prior knowledge, suggestions for ways to support students as they complete the lesson and a variety of assessment ideas. This lesson is grade appropriate.

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Appendix A: NGSS and Foundations for the Unit		
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. *[Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]* **(MS-LS2-1)**		
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. *[Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]* **(MS-LS2-2)**		
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. *[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]* **(MS-LS2-3)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1) **Constructing Explanations and Designing Solutions** • Construct an explanation that includes qualitative or quantitative relationships between variables that	**LS2.A: Interdependent Relationships in Ecosystems** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) • In any ecosystem, organisms and populations with similar requirements	**Patterns** • Patterns can be used to identify cause and effect relationships. (MS-LS2-2) **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

predict phenomena. (MS-LS2-2) **Developing and Using Models** • Develop a model to describe phenomena. (MS-LS2-3)	for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2) **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

	three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-1),(MS-LS2-2) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1) **RST.6-8.7** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2) **WHST.6-8.2** Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2) **WHST.6-8.9** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS2-2) **SL.8.1** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS2-2) **SL.8.4** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS2-3) **SL.8.5**	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS2-3) **6.EE.C.9** Summarize numerical data sets in relation to their context. (MS-LS2-2) **6.SP.B.5**

Unit 2: Matter and Energy in Organisms and Ecosystems

Instructional Days: 25

Common Vocabulary	
Breed Diverse Transfer Development Attract Characteristics of life Germination	Plant structure Plumage Reproductive system Soil fertility Vocalization fertilizer

Curriculum: Grade 6

Unit 3: Interdependent Relationships in Ecosystems

Instructional Days: 25

Unit Summary
What happens to ecosystems when the environment changes?   Students build on their understandings of the transfer of matter and energy as they study patterns of interactions among organisms within an ecosystem. They consider biotic and abiotic factors in an ecosystem and the effects these factors have on a population. They construct explanations for the interactions in ecosystems and the scientific, economic, political, and social justifications used in making decisions about maintaining biodiversity in ecosystems. The crosscutting concept of *stability and change* provide a framework for understanding the disciplinary core ideas.   This unit includes a two-stage engineering design process. Students first evaluate different engineering ideas that have been proposed using a systematic method, such as a tradeoff matrix, to determine which solutions are most promising. They then test different solutions, and combine the best ideas into a new solution that may be better than any of the preliminary ideas. Students demonstrate grade appropriate proficiency in *asking questions*, *designing solutions, engaging in argument from evidence, developing and using models*, and *designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-LS2-4, MS-LS2-5, MS-ETS1-1, and MS-ETS1-3.
Student Learning Objectives
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. *[Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]* **(MS-LS2-4)**
Evaluate competing design solutions for maintaining biodiversity and ecosystem services. * *[Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]* **(MS-LS2-5)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

Curriculum: Grade 6

Unit 3: Interdependent Relationships in Ecosystems

Instructional Days: 25

MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
LS4.D	Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on
ETS1.B	There are systematic process for evaluating solutions with respect to how well they meet the criteria and constraints of a problem

Curriculum: Grade 6

Unit 3: Interdependent Relationships in Ecosystems

Instructional Days: 25

Quick Links		

Enduring Understandings
• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources. (MSLS21) • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations oforganisms.
Essential Questions
• How do organisms interact within an ecosystem? • How does energy and matter cycle through ecosystems? • How can ecosystems be sustained? • How do humans adapt to changes in resources?

Unit 3: Interdependent Relationships in Ecosystems

Instructional Days: 25

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: How can a single change to an ecosystem disrupt the whole system?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>
• Ecosystems are dynamic in nature.
• The characteristics of ecosystems can vary over time.
• Disruptions to any physical or biological component of an ecosystem can lead to shifts in all the ecosystem's populations.
• Small changes in one part of an ecosystem might cause large changes in another part.
• Patterns in data about ecosystems can be recognized and used to make warranted inferences about changes in populations.
• Evaluating empirical evidence can be used to support arguments about changes to ecosystems.
</td><td>
Students who understand the concepts are able to:
• Construct an argument to support or refute an explanation for the changes to populations in an ecosystem caused by disruptions to a physical or biological component of that ecosystem. Empirical evidence and scientific reasoning must support the argument.
• Use scientific rules for obtaining and evaluating empirical evidence.
• Recognize patterns in data and make warranted inferences about changes in populations.
• Evaluate empirical evidence supporting arguments about changes to ecosystems.
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Curriculum: Grade 6

Unit 3: Interdependent Relationships in Ecosystems

Instructional Days: 25

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: What limits the number and variety of living things in an ecosystem?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
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• Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems.
• The completeness, or integrity, of an ecosystem's biodiversity is often used as a measure of its health.
• Changes in biodiversity can influence humans' resources, such as food, energy, and medicines.
• Changes in biodiversity can influence ecosystem services that humans rely on.
• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
• A solution needs to be tested and then modified on the basis of the test results, in order to improve it.
• Models of all kinds are important for testing solutions.
• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.
• Small changes in one part of a system might cause large changes in another part.
• Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.
</td><td>
Students who understand the concepts are able to:
• Construct a convincing argument that supports or refutes claims for solutions about the natural and designed world(s).
• Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
• Create design criteria for design solutions for maintaining biodiversity and ecosystem services.
• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
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Unit 3: Interdependent Relationships in Ecosystems

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What it Looks Like in the Classroom
At the beginning of this unit of study, students will begin to collect empirical evidence that will be used to argue that physical or biological components of an ecosystem affect populations. Students will evaluate existing solutions for maintaining biodiversity and ecosystem services to determine which solutions are most promising. As part of their evaluation, students will develop a probability and use it to determine the probability that designed systems, including those representing inputs and outputs, will maintain biodiversity and ecosystem services. They will develop mathematical model(s) to generate data to test the designed systems and compare probabilities from the models to observe frequencies. If the agreement is not good, they will explain possible sources of the discrepancy. Distinguish among facts, reasoned judgment based on research findings, and speculation During this process, students will distinguish among facts reasoned judgment based on research findings, and speculation while reading text about maintaining biodiversity and ecosystem services. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. After determining that ecosystems are dynamic in nature, students may construct an argument to support an explanation for how shifts (large and/or small) in populations are caused by change to physical or biological components in ecosystems (e.g., gas explosions, tornados, mining, oil spills, clear cutting, hurricanes, volcanoes, etc.). Students will study the variety of species found in terrestrial and oceanic ecosystems and use the data they gather to make decisions about the health of the ecosystem. Students may compare, through observations and data analysis, the biodiversity before and after events affecting a specific area—for examples, the Pinelands, that were lost due to the creation of the reservoir; the underground coal fires in Centralia, PA, that caused people to abandon the town; the volcanic eruption in Mt. St. Helen’s, WA; the nuclear reactor meltdown in Chernobyl, Ukraine. Students should recognize patterns in data about changes to components in ecosystems and make inferences about how these changes contribute to changes in the biodiversity of populations. Students should investigate and design investigations to test their ideas and develop possible solutions to problems caused when changes in the biodiversity of an ecosystem affect resources (food, energy, and medicine) as well as ecosystem services (water purification, nutrient recycling, soil erosion prevention) available to humans. Students can then construct arguments using evidence to support recognized patterns of change in factors such as global temperatures and their effect on populations and the environment. As part of their argument, students need to note how small changes in one part of an ecosystem might cause large changes in another part. While

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collecting evidence for their arguments about maintaining biodiversity, students will trace and evaluate specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. Students will evaluate the argument and claims in text*,* assess whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. As a culmination of this unit of study, students will take the evidence they have collected and their understanding of how changes in the biodiversity of populations can impact ecosystem services and use that evidence and understanding to evaluate competing design solutions. Students will include multimedia components and visual displays as part of their argument about competing design solutions based on jointly developed and agreed-upon design criteria to clarify evidence used in their arguments. The multimedia component and visual displays should clarify claims and findings and emphasize salient points in their argument. Students will use a systematic process for evaluating their design solutions with respect to how well they meet the criteria and constraints. Students may determine the systematic process they will use, or the teacher can determine a process for students to use to evaluate ecosystem services. Any process used should include mathematical models that generates data for the iterative testing of competing design solutions involving a proposed object, tool, or process maintaining biodiversity and ecosystem services and quantitative reasoning (with amounts, numbers, sizes) and abstract reasoning (with variables). Ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. For this unit of study, design solution constraints could include scientific, economic, and social considerations. After determining the process for evaluating the design solutions and establishing the criteria and constraints, students will compare competing design solutions to determine the optimal solution.

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Connecting English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Distinguish among facts, reasoned judgment based on research findings, and speculation when reading text about maintaining biodiversity and ecosystem services. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. • Trace and evaluate the argument and specific claims in a text *about maintaining biodiversity and ecosystem services*, distinguishing claims that are supported by reasons and evidence from claims that are not. Trace and evaluate the arguments about specific claims in a text and assess whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. • Include multimedia components and visual displays *as part of an argument about competing design solutions based on jointly developed and agreed-upon design criteria* to clarify information. Include multimedia components and visual displays. The multimedia component and visual displays should clarify claims and findings and emphasize salient points in the presentation. *Mathematics* • Model design solutions for maintaining biodiversity and ecosystem services with mathematics. Use ratio and rate reasoning to evaluate competing design solutions for maintaining biodiversity and ecosystem services. • Develop a model that generates data for the iterative testing of competing design solutions involving a proposed object, tool, or process that maintains biodiversity and ecosystem services, reasoning quantitatively (with amounts, numbers, sizes) and abstractly (with variables). • Develop a probability and use it to find the probability *that designed systems, including those representing inputs and outputs, will maintain biodiversity and ecosystem services*. Compare probabilities from the model to observe frequencies. If the agreement is not good, explain possible sources of the discrepancy.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 3: Interdependent Relationships in Ecosystems

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Research on Student Learning
Students may believe that organisms are able to effect changes in bodily structure to exploit particular habitats or that they respond to a changed environment by seeking a more favorable environment. It has been suggested that the language about adaptation used by teachers or textbooks to make biology more accessible to students may cause or reinforce these beliefs. Some students think dead organisms simply rot away. They do not realize that the matter from the dead organism is converted into other materials in the environment. Some students see decay as a gradual, inevitable consequence of time without need of decomposing agents. Some students believe that matter is conserved during decay, but do not know where it goes (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • When the environment changes in ways that affect a place's physical characteristics, temperature, or available resources, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. • Populations of organisms live in a variety of habitats. Changes in those habitats affect the organisms living there. • Research on a problem should be carried out before work to design a solution begins. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

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Future Learning
Life Science • If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem. • Biodiversity is increased by the formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on earth.

Connections to Other Units
Grade 6 Unit 3: Interdependent Relationships in Ecosystems • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. **Grade 7 Unit 1: Structure and Properties of Matter** • Substances react chemically in characteristic ways. **Grade 7 Unit 3: Chemical Reactions** • In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. **Grade 7 Unit 8: Earth Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

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- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Grade 8 Unit 3: Stability and Change on Earth

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

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Sample of Open Education Resources
In Exploring the "Systems" in Ecosystems, students are introduced to the concept of an ecosystem, and explore how to analyze ecosystems using a systems thinking approach. A class discussion brings out students' ideas about ecosystems and introduces basic information about the components and processes of ecosystems. Next, students encounter a hypothetical ecosystem and gain experience analyzing it the way scientists do. Students then select a local ecosystem and apply what they have learned to analyze it. Finally, students extend their understanding by characterizing three different types of ecosystems and describing their components and processes. The Flow of Matter and Energy in Ecosystems SciPack explores the systemic interplay and flow of matter and energy throughout ecosystems, populations and organisms. Energy from the sun is the direct or indirect source of energy for nearly all organisms, it can flow only in one direction through ecosystems: from the sun to producers, to consumers, and finally to decomposers. Unlike the unidirectional transformation of energy, matter cycles among ecosystem components. One key ecosystem function, the cycling of carbon from non-living to living components and back, serves as a primary example in this SciPack for how all nutrients cycle on Earth. Webs and pyramids are used to model and communicate about the transfer of energy and cycling of matter within an ecosystem, representing how the total living biomass stays roughly constant—cycling materials from old to new life—accompanied by an irreversible flow of energy from captured sunlight into dissipated heat. **Problem Based Learning Scenario** You are a cargo inspection agent working in Guam to prevent the introduction of non-native species to your island. People coming into your territory often do not understand why you must spend so much time checking their cargo. Working in small groups, develop a public service announcement and media campaign to explain to the public how devastating the introduction of non-native species can be to an island ecosystem. Research how the region has been affected by invasive species. Connect with experts in the field to further your understandings. Use video clips, podcasts, and other authentic media to help explain the impact. Focus your message on how non-native species can become invasive and affect the biodiversity of the island. **Resources** • Annenberg Media's Teachers' Resources offer short video courses covering essential science content for teachers. http://www.learner.org/resources/series179.html • National Invasive Species Information Center (NISIC) provides data and information regarding invasive species, including covering Federal, State, local, and international sources. This site supports the performance assessment associated with the CPI. http://www.invasivespeciesinfo.gov/

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Appendix A: NGSS and Foundations for the Unit
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. *[Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]* **(MS-LS2-4)**
Evaluate competing design solutions for maintaining biodiversity and ecosystem services. * *[Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]* **(MS-LS2-5)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4) • Evaluate competing design solutions	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Stability and Change** • Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5) -

based on jointly developed and agreed-upon design criteria. (MS-LS2-5) **Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) **Developing and Using Models** • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)	• Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5) **LS4.D: Biodiversity and Humans** • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5) **ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.*(secondary to MS-LS2-5)* **ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions**	***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-

	• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)	LS2-3) **Scientific Knowledge is Based on Empirical Evidence** • Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4) **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4) **RST.6-8.1** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5) **RST.6-8.8** Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-5) **RI.8.8** Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4),(MS-ETS1-1),(MS-ETS1-3) **WHST.6-8.1** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2) **WHST.6-8.2** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ETS1-3) **RST.6-8.7** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) **WHST.6-8.8**	Reason abstractly and quantitatively. (MS-ETS1-1),(MS-ETS1-3) **MP.2** Model with mathematics. (MS-LS2-5) **MP.4** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-3) **7.EE.3** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-LS2-5) **6.RP.A.3**

Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2),(MS-LS2-4),(MS-ETS1-3), (MS-ETS1-2) **WHST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4) **SL.8.5**	

Common Vocabulary	
Relative Disperse Ecological role Host Infection Mutualism	Mutually beneficial Parasite Evolve Genetic Interdependent Abiotic

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Unit 4: Forces and Motion

Instructional Days: 25

Unit Summary
How can we predict the motion of an object?   Students use *system and system models* and *stability and change* to understanding ideas related to why some objects will keep moving and why objects fall to the ground. Students apply Newton's third law of motion to related forces to explain the motion of objects. Students also apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of *system and system models* and *stability and change* provide a framework for understanding the disciplinary core ideas. Students demonstrate proficiency in *asking questions*, *planning and carrying out investigations, designing solutions, engaging in argument from evidence*, *developing and using models,* and *constructing explanations and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-PS2-1, MS-PS2-2, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4.
Student Learning Objectives
Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. * *[Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]* **(MS-PS2-1)**
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. *[Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]* **(MS-PS2-2)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)

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Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)

MS-PS2-1	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2	Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4)	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved

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Quick Links		

Enduring Understandings
• For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily
Essential Questions
• How can forces be used to explain the motion of objects? • How can forces help to explain why some materials attract while others repel?

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For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).
Models can be used to represent the motion of objects in colliding systems and their interactions, such as inputs, processes, and outputs, as well as energy and matter flows within systems.
The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values, by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions.
The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful.
Specification of constraints includes consideration of scientific principles and other relevant knowledge, which are likely to limit possible solutions.

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Students who understand the concepts are able to:

Apply Newton’s third law to design a solution to a problem involving the motion of two colliding objects.
Define a design problem involving the motion of two colliding objects that can be solved through the development of an object, tool, process, or system and that includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
Evaluate competing design solutions involving the motion of two colliding objects based on jointly developed and agreed-upon design criteria.
Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
Analyze and interpret data to determine similarities and differences in findings.

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Unit 4: Forces and Motion

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Unit Sequence	
Part B: *Who can build the fastest sailboat?*	
Concepts	**Formative Assessment**
• The change in an object's motion depends on balanced (Newton's first law) and unbalanced forces in a system Evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object includes qualitative comparisons of forces, mass, and changes in motion (Newton's second law); frame of reference; and specification of units • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. • The greater the mass of the object, the greater the force needed to achieve the same change in motion. • For any given object, a larger force causes a larger change in motion. • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.	*Students who understand the concepts are able to:* • Plan an investigation individually and collaboratively to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. • Design an investigation and identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. • Make logical and conceptual connections between evidence and explanations. • Examine the changes over time and forces at different scales to explain the stability and change in designed systems.

Unit 4: Forces and Motion

Instructional Days: 25

What it Looks Like in the Classroom
Throughout this unit of study, students will be examining and interacting with objects in motion. They will begin this unit by investigating Newton's third law of motion by observing the action/reaction forces involved during a collision. Students will expand their idea of collisions beyond the narrow view of collisions as being an accident in which two or more objects crash into each other. They will learn that scientists' use of the word collision does not refer to the size of the force; instead it describes any interaction between two objects. We want students to understand that a collision can be as small as an ant walking on a blade of grass—that is, that a collision is any touch between two objects, no matter how small or how large the force. Some possible observations may include the action/reaction forces involved in roller skating, skateboarding, moving boxes of different masses, etc. Students will then apply Newton's third law to possible problems and solutions. Some possible investigations could include designing and launching rockets or protecting eggs in a collision. Students then investigate Newton's first and second laws of motion through hands-on activities in which they observe the result of balanced and unbalanced forces on an object's motion. Some examples may include using a seesaw or kicking a ball. In addition, students will observe how an object's motion will change depending upon the mass of the object and the amount of force applied. Activities could include pushing objects of different masses and comparing the forces needed to accelerate the objects. Students will continue their investigation of Newton's third law by participating in an engineering and design problem that will require them to design a solution to a problem involving the motion of two colliding objects. Students could begin by observing collisions. An example of a collision could be an egg in a cart rolling down an incline and colliding with a barrier. Based on their observations of collisions, students will jointly develop and agree upon the design problem that they will focus on. Students will begin by making a clear statement of the problem they are going to attempt to solve. Once students have a clearly stated problem, the teacher will need to provide them with time and opportunity to participate in a short research project where they will gather background information that will help them come up with possible design solutions. Students will need to document their findings, making sure that they cite the resources they use. After students have collected evidence, they can then begin to brainstorm possible solutions. To begin this process, students will need to identify the constraints and criteria for a successful design solution. This would involve them identifying the limits of the design. For example, time, materials, and resources could be some constraints. Students will next identify the criteria for a

successful design. For example, one criterion could be that the egg in the collision does not break at all, or that it may crack as long as the contents do not spill out.

After the constraints and criteria have been identified, students can them generate possible solutions. Multiple solutions could be generated. Using the evidence collected during their research, as well as information they have learned as a part of their classroom experience, students can eliminate the solutions that seem least likely to be successful and focus on those that are more likely to be successful.

After students have identified the solutions that are most likely to be successful, they will evaluate their competing design solutions using a rubric, checklist, or decision tree to assist them in selecting the design solution they will take into the next phase of the process.

Students have reached the stage where they will need to create a model that can be tested. The model could be physical, graphical, mathematical, or it could be a scale model. Students will use the model to collect evidence that will help them determine which of the possible design solutions will be taken into the prototype phase. During the prototype phase, students will create their actual model. Once students have constructed their devices, they should gather necessary data from tests performed on their design solutions. They will analyze and interpret these data to determine which design best minimizes the force acting upon the egg. For example, the materials of a particular design may be superior and/or the structure of another design may be more successful. Once students have evaluated competing solutions and analyzed and interpreted data, they may then begin to modify their original designs. It is important that students consider the benefits of each design solution. This is when they are deciding whether different parts of their solutions can be combined to maximize efficiency. The final goal is for students to identify the parts of each design solution that best fit their criteria and combine these parts into a design solution that is better than any of its predecessors. Students will then translate this activity to a real world-example in which they see the influence of science, engineering, and technology on society and the natural world.

Unit 4: Forces and Motion

Instructional Days: 25

Connecting English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions of the application of Newton's third law involving the motion of two colliding objects. • Follow precisely a multistep procedure when carrying out experiments to apply Newton's third law when designing a solution to a problem involving the motion of two colliding objects, taking measurements, or performing technical tasks. • Follow precisely a multistep procedure when performing an investigation that provides evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object, taking measurements or performing technical tasks. • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading texts about the application of Newton's third law to the motion of two colliding objects Conduct a short research project to answer a question about the application of Newton's third law when designing a solution to a problem involving the motion of two colliding objects, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. • Conduct a short research project to answer a question about how the sum of the forces on the object and the mass of the object change an object's motion, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. • Gather relevant information from multiple print and digital sources that provide information about the application of Newton's third law when designing a solution to a problem involving the motion of two colliding objects; assess the credibility of each source and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. • Draw evidence from informational texts to support analysis, reflection, and research about the application of Newton's third law when designing a solution to a problem involving the motion of two colliding objects. *Mathematics* • Reason abstractly and quantitatively when collecting and analyzing data about the application of Newton's third law in the

course of designing a solution to a problem involving the motion of two colliding objects.

- Analyze data in the form of numbers and symbols to draw conclusions about how the sum of the forces on an object and the mass of an object change the object's motion.
- Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in a design that applies Newton's third law to a problem involving the motion of two colliding objects.
- When collecting and analyzing data from investigations about how the sum of the forces on an object and the mass of the object changes the object's motion, write, read, and evaluate expressions in which letters stand for numbers.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 4: Forces and Motion

Instructional Days: 25

Research on Student Learning
Students tend to think of force as a property of an object ("an object has force," or "force is within an object") rather than as a relation between objects. In addition, students tend to distinguish between active objects and objects that support or block or otherwise act passively. Students tend to call the active actions "force" but do not consider passive actions as "forces". Teaching students to integrate the concept of passive support into the broader concept of force is a challenging task even at the high-school level. Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force; that if a body is not moving, there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction -- that is, they confound inertia with friction. Students tend to hold on to these ideas even after instruction in high-school or college physics. Specially designed instruction does help high-school students change their ideas. Research has shown less success in changing middle-school students' ideas about force and motion. Nevertheless, some research indicates that middle-school students can start understanding the effect of constant forces to speed up, slow down, or change the direction of motion of an object. This research also suggests it is possible to change middle-school students' belief that a force always acts in the direction of motion. Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on the separate, interacting bodies. Instead they believe that "active" objects (like hands) can exert forces whereas "passive" objects (like tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force (NSDL, 2015).

Unit 4: Forces and Motion

Instructional Days: 25

Prior Learning
By the end of Grade 5, students understand that: • Each force acts on one particular object and has both strength and a direction. • An object at rest typically has multiple forces acting on it, but these forces add to give zero net force on the object. • Forces that do not sum to zero can cause changes in the object's speed or direction of motion. • The patterns of an object's motion in various situations can be observed and measured; when the past motion exhibits a regular pattern, future motion can be predicted from it. • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Unit 4: Forces and Motion

Instructional Days: 25

Future Learning
Physics • Newton's second law accurately predicts changes in the motion of macroscopic objects. • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.

Unit 4: Forces and Motion

Instructional Days: 25

Connections to Other Units
Grade 8 Unit 5: Relationships among Forms of Energy • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. • A system of objects may also contain stored (potential) energy, depending on their relative positions. • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **Grade 8 Unit 6: Thermal Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **Grade 6 Unit 7: Weather and Climate** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. • Global movements of water and its changes in form are propelled by sunlight and gravity. • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

Unit 4: Forces and Motion

Instructional Days: 25

Sample of Open Education Resources
Force and Motion is a teacher-submitted, NGSS-mindful lesson plan for using the PhET model "Forces and Motion - Basics". The model uses a tug-of-war with participants of different sizes and strengths, placed different distances from the center, in order to show how forces can combine in different ways to affect the motion of an object. The lesson itself includes a framing question, several investigations, and a request to back up a claim with evidence. NOTE: the web page given above is not itself the resource. The web page provides a link to a downloadable Microsoft Word document of the lesson plan, which is the resource. Seeing Motion: Students explore straight-line motion using a motion sensor to generate distance versus time graphs of your own motion. Learn how changes in speed and direction affect the graph, and gain an understanding of how motion can be represented on a graph.

Curriculum: Grade 6

Unit 4: Forces and Motion

Instructional Days: 25

Appendix A: NGSS and Foundations for the Unit
Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. * *[Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]* **(MS-PS2-1)**
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. *[Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]* **(MS-PS2-2)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)

Unit 4: Forces and Motion

Instructional Days: 25

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2) **Constructing Explanations and Designing Solutions** • Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1) **Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible	**PS2.A: Forces and Motion** • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1) **Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven

solutions. (MS-ETS1-1) **Engaging in Argument from Evidence** • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)	PS2-2) **ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2) • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)	by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1) • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

	• Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	

Curriculum: Grade 6

Unit 4: Forces and Motion

Instructional Days: 25

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS2-1),(MS-ETS1-1),(MS-ETS1-2) **RST.6-8.1** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1),(MS-PS2-2) **RST.6-8.3** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) **WHST.6-8.8** Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) **WHST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3) **RST.6-8.9** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2) **WHST.6-8.7**	Reason abstractly and quantitatively. (MS-PS2-1),(MS-PS2-2),(MS-PS2-3),(MS-ETS1-1),(MS-ETS1-2) **MP.2** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1) **6.NS.C.5** Write, read, and evaluate expressions in which letters stand for numbers. (MS-PS2-1),(MS-PS2-2) **6.EE.A.2** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-PS2-1),(MS-PS2-2) **7.EE.B.3** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-PS2-1),(MS-PS2-2) **7.EE.B.4** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-2) **7.EE.3**

Unit 4: Forces and Motion

Instructional Days: 25

Common Vocabulary	
Conservation	Economic
Electric current	Impact
Exert	Inertia
Interaction	Isaac Newton
Transfer	Law of motion
Mass	Nonlinear
Constant speed	Macroscopic
Control	Momentum
Deceleration	Net force
Direction of a force	Optimal

Curriculum: Grade 6

Unit 5: Types of Interactions

Instructional Days: 25

Unit Summary
Is it possible to exert on an object without touching it?
Students use *cause and effect*; *system and system models*; and *stability and change* to understand ideas that explain why some materials are attracted to each other while others are not. Students apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while others repel. In particular, students develop understandings that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are expected to consider the influence of science, engineering, and technology on society and the natural world. Students are expected to demonstrate proficiency in *asking questions*, *planning and carrying out investigations*, *designing solutions*, and *engaging in argument*. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-PS2-3, MS-PS2-4, and MS-PS2-5.
Student Learning Objectives
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. *[Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and is limited to qualitative evidence for the existence of fields.]* **(MS-PS2-5)**
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [*Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]* **(MS-PS2-3)**
Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. *[Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]* **(MS-PS2-4)**

Unit 5: Types of Interactions

Instructional Days: 25

MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact
MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces
MS-PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects
PS2.A	For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in opposite direction
PS2.B	Electric and magnetic forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects

Curriculum: Grade 6

Unit 5: Types of Interactions

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Quick Links		
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What it Looks Like in the Classroom p. 3	Prior Learning p. 6	Sample Open Education Resources p. 7
Connecting ELA/Literacy and Math p. 4	Future Learning p. 6	Appendix A: NGSS and Foundations p. 7
Modifications p. 5		

Enduring Understandings

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily

Essential Questions

- How can forces be used to explain the motion of objects?
- How can forces help to explain why some materials attract while others repel?

Unit 5: Types of Interactions

Instructional Days: 25

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: Can you apply a force on something without touching it?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>Fields exist between objects that exert forces on each other even though the objects are not in contact.
The interactions of magnets, electrically charged strips of tape, and electrically charged pith balls are examples of fields that exist between objects exerting forces on each other, even though the objects are not in contact.
Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).
Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.</td><td>Students who understand the concepts are able to:
Students will conduct an investigation and evaluate an experimental design to produce data that can serve as the basis for evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
Students will identify the cause-and-effect relationships between fields that exist between objects and the behavior of the objects.</td></tr>
</table>

Unit 5: Types of Interactions

Instructional Days: 25

Unit Sequence	
Part B: *How does a Maglev train work?*	
Concepts	**Formative Assessment**
• Factors affect the strength of electric and magnetic forces. • Devices that use electric and magnetic forces could include electromagnets, electric motors, and generators. • Electric and magnetic (electromagnetic) forces can be attractive or repulsive. • The size of an electric or magnetic (electromagnetic) force depends on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. • Cause-and-effect relationships may be used to predict the factors that affect the strength of electrical and magnetic forces in natural or designed systems	*Students who understand the concepts are able to:* • Students will ask questions about data to determine the effect of the strength of electric and magnetic forces that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. • Students will perform investigations using devices that use electromagnetic forces. • Students will collect and analyze data that could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor.

Unit 5: Types of Interactions

Instructional Days: 25

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: If I were able to eliminate air resistance and dropped a feather and a hammer at the same time, which would land first?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>

Gravitational interactions are always attractive and depend on the masses of interacting objects.
There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass.
Evidence supporting the claim that gravitational interactions are attractive and depend on the masses of interacting objects could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.

</td><td>
Students who understand the concepts are able to:

Students construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
Students use models to represent the gravitational interactions between two masses.

</td></tr>
</table>

Unit 5: Types of Interactions

Instructional Days: 25

What it Looks Like in the Classroom
Students will conduct investigations of fields that exist between objects exerting forces on each other, even though the objects are not in contact. Through first-hand experiences or simulations, students will observe and evaluate the behavior of objects and record evidence of fields that exist and are responsible for the observed behavior of the objects. Students can investigate the interactions between magnets, electrically charged strips of tape, and/or electrically charged pith balls. Through hands-on investigations or simulations, students will be able to observe how the motion or behavior of objects change when they are exposed to electric or magnetic fields. For example, a pith ball could be suspended from a lightweight string and students can apply a charge to a balloon, comb, or plastic rod and make observations about the motion of the pith ball when these objects are placed in close proximity to the ball. The same type of investigation could be conducted with magnets or strips of electric tape. If instruction starts with students making these observations, students could then generate questions that they could use to ask questions about the cause-and-effect relationships that could explain their observations. A short research project could be conducted to provide data that students would use to help them answer their self-generated questions. Students will investigate magnetic and electric forces to determine the nature of the force (repulsive, attractive, or both), and factors that affect the strength of the forces. Before beginning the investigations, students will generate questions that will be used to guide their investigations. Depending on the nature of their questions, students may need to cite specific textual evidence to support the generation of a hypothesis. During the investigation, students will identify cause-and-effect relationships and use their understanding of these relationships to make predictions about what would happen if a variable in the investigation were changed. They will also determine the impact of distance on the strength of a force. Investigations may include the use of electromagnets, electric motors, or generators. During these investigations, students will collect data that they will use to answer their self-generated questions. Students will investigate magnetic and electric forces to determine the nature of the force (repulsive, attractive, or both), and factors that affect the strength of the forces. Before beginning the investigations, students will generate questions that will be used to guide their investigations. Depending on the nature of their questions, students may need to cite specific textual evidence to support the generation of a hypothesis. During the investigation, students will identify cause-and-effect relationships and use their understanding of these relationships to make predictions about what would happen if a variable in the investigation were changed. They will also determine the impact of distance on the strength of a force. Investigations may include the use of electromagnets, electric motors, or generators. During these investigations, students will collect data that they will use to

answer their self-generated questions. Investigations can take place in the classroom, outdoor environment, or museums and other public facilities with available resources and when appropriate. Students will frame a hypothesis based on observations and scientific principles about the behavior of electromagnetic forces and carry out investigations to collect data about the factors that affect the strength of electric and magnetic forces. Examples of investigations could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor. Students will analyze both numerical and symbolic data and use these data to determine the factors that affect the strength of electric and magnetic fields. Students will conclude this portion of the unit by citing specific textual evidence to support the analysis of information they access while reading science and technical texts or online sources about electric and magnetic forces, attending to the precise details of explanations or descriptions.

The next portion of this unit will focus on gravitational forces. Students will construct and present oral and written arguments using evidence to support the claim that gravitational interactions are always attractive and depend on the masses of interacting objects. Students will also understand that there is gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. Because of this, gravitational fields will only be observed through the observation of simulations, the use of models, or the analysis of data. These could include simulations or digital tools and charts displaying mass, strength of interactions, distance from the sun, and orbital periods of objects within the solar system. Models used need to represent gravitational interactions between two masses within and between systems.

Connecting English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific textual evidence to support analysis of information about science and technical texts regarding *the factors that affect the strength of electric and magnetic forces,* attending to the precise details of explanations or descriptions.
- Write arguments focused on evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Mathematics

- Reason abstractly and quantitatively while using data to determine the factors that affect the strength of electric and magnetic forces.

Unit 5: Types of Interactions

Instructional Days: 25

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 5: Types of Interactions

Instructional Days: 25

Research on Student Learning
Students tend to think of force as a property of an object ("an object has force," or "force is within an object") rather than as a relation between objects. In addition, students tend to distinguish between active objects and objects that support or block or otherwise act passively. Students tend to call the active actions "force" but do not consider passive actions as "forces". Teaching students to integrate the concept of passive support into the broader concept of force is a challenging task even at the high-school level. Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force; that if a body is not moving, there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction -- that is, they confound inertia with friction. Students tend to hold on to these ideas even after instruction in high-school or college physics. Specially designed instruction does help students change their ideas. Research has shown less success in changing middle-school students' ideas about force and motion. Nevertheless, some research indicates that middle-school students can start understanding the effect of constant forces to speed up, slow down, or change the direction of motion of an object. This research also suggests it is possible to change middle-school students' belief that a force always acts in the direction of motion. Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on the separate, interacting bodies. Instead they believe that "active" objects (like hands) can exert forces whereas "passive" objects (like tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force. Teaching high-school students to seek consistent explanations for the "at rest" condition of an object can lead them to appreciate that both "active" and "passive" objects exert forces. Showing high-school students that apparently rigid or supporting objects actually deform might also lead them to appreciate that both "active" and "passive" objects exert forces (NSDL, 2015).

Unit 5: Types of Interactions

Instructional Days: 25

Prior Learning
By the end of Grade 5, students understand that: • Objects in contact exert forces on each other. • Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Future Learning
Physics and Chemistry • Newton's second law of motion (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects. • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

Unit 5: Types of Interactions

Instructional Days: 25

- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- When two objects interacting through a field change relative position, the energy stored in the field is changed.

Unit 5: Types of Interactions

Instructional Days: 25

Connections to Other Units
Grade 6 Unit 6: Astronomy • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **Grade 6 Unit 7: Weather and Climate** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. • Global movements of water and its changes in form are propelled by sunlight and gravity. • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. **Grade 7 Unit 8: Earth Systems** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. •

Unit 5: Types of Interactions

Instructional Days: 25

Sample of Open Education Resources
Electromagnetic Power! Students investigate the characteristics of electromagnetism and then use what they learn to plan and conduct an experiment on electromagnets. Inspector Detector Challenge: Students use the engineering design process to design and build magnetic-field detectors, and use them to find hidden magnets. Parallels are drawn to real-world NASA missions and how NASA scientists use magnetic field data from planets and moons. The website has video clips, teaching suggestions, a student handout, and a link to the pdf of the Teacher's Guide for Mission: Solar System. The Inspector Detector challenge is a series of activities that form a unit in the Mission: Solar System collection. * NOTE: The Teacher's Guide does not contain the lesson plan. You will need to click on the Student Handout heading of the website to download the "Inspector Detector Challenge Leader's Notes". Or you can go to the Design Squad webpage

Appendix A: NGSS and Foundations for the Unit
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. *[Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and is limited to qualitative evidence for the existence of fields.]* **(MS-PS2-5)**
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. *[Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]* **(MS-PS2-3)**
Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. *[Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]* **(MS-PS2-4)**

Unit 5: Types of Interactions

Instructional Days: 25

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena to describe explanations. (HS-PS2-4) **Constructing Explanations and Designing Solutions** • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Planning and Carrying Out Investigations** • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4) **PS2.A: Forces and Motion** • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-3) **ETS1.A: Defining and Delimiting an Engineering Problem**	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** • Systems can be designed to cause a desired effect. (HS-PS2-3) • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5) - ***Connections to Nature of Science***

	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary) (HS-PS2-3) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary HS-PS2-3)* **PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-5) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause	**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. (HS-PS2-4) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)

	magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-5) **PS3.A: Definitions of Energy** • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary HS-PS2-5)*	

Unit 5: Types of Interactions

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English Language Arts	Mathematics
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HS-PS2-5), (HS-PS2-3) **WHST.11-12.7** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS2-5) **WHST.11-12.8** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-5) **WHST.11-12.9**	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-5),(HS-PS2-4) **HSN.Q.A.1** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-5),(HS-PS2-4) **HSN.Q.A.2** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-5),(HS-PS2-4) **HSN.Q.A.3** Reason abstractly and quantitatively. (HS-PS2-4) **MP.2** Model with mathematics. (HS-PS2-4) **MP.4** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-4) **HSA.SSE.A.1** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-4) **HSA.SSE.B.3**

Unit 5: Types of Interactions

Instructional Days: 25

Common Vocabulary	
Conservation	Economic
Electric current	Impact
Exert	Inertia
Interaction	Isaac Newton
Transfer	Law of motion
Mass	Nonlinear
Constant speed	Macroscopic
Control	Momentum
Deceleration	Net force
Direction of a force	Optimal

Curriculum: Grade 6

Unit 6: Astronomy

Instructional Days: 20

Unit Summary
This unit is broken down into three sub-ideas: the universe and its stars, Earth and the solar system, and the history of planet Earth. Students examine the Earth's place in relation to the solar system, the Milky Way galaxy, and the universe. There is a strong emphasis on a systems approach and using models of the solar system to explain the cyclical patterns of eclipses, tides, and seasons. There is also a strong connection to engineering through the instruments and technologies that have allowed us to explore the objects in our solar system and obtain the data that support the theories explaining the formation and evolution of the universe. Students examine geosciences data in order to understand the processes and events in Earth's history. The crosscutting concepts of *patterns*, *scale, proportion, and quantity* and *systems and systems models* provide a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models* and *analyzing and interpreting data*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-ESS1-1, MS-ESS1-2, and MS-ESS1-3.
Student Learning Objectives
Generate and analyze evidence (through simulations or long term investigations) to explain why the Sun's apparent motion across the sky changes over the course of a year. (ESS1.B) *[Clarification Statement: This SLO is based on a disciplinary core idea found in the Framework. It is included as a scaffold to the following SLO.]*
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. *[Clarification Statement: Examples of models can be physical, graphical, or conceptual.]* **(MS-ESS1-1)**
Develop and use a model that shows how gravity causes smaller objects to orbit around larger objects at increasing scales, including the gravitational force of the sun causes the planets and other bodies to orbit around it holding together the solar system. (ESS1.A; ESS1.B) *[Clarification Statement: This SLO is based on disciplinary core ideas found in the Framework. It is included as a scaffold to the following SLO.]*
Analyze and interpret data to determine scale properties of objects in the solar system. *[Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine*

similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.] **(MS-ESS1-3)**
Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. *[Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).] [Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]* **(MS-ESS1-2)**

ESS1.B	Generate and analyze evidence (through simulations or long term investigations) to explain why the Sun's apparent motion across the sky changes over the course of a year.
MS-ESS1-1	Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons
ESS1.A; ESS1.B	Develop and use a model that shows how gravity causes smaller objects to orbit around larger objects at increasing scales, including the gravitational force of the sun causes the planets and other bodies to orbit around it holding together the solar system
MS-ESS1-3	Analyze and interpret data to determine scale properties of objects in the solar system
MS-ESS1-2	Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system

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Quick Links		
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What it Looks Like in the Classroom p. 3	Prior Learning p. 6	Sample Open Education Resources p. 7
Connecting ELA/Literacy and Math p. 5 Modifications p. 5	Future Learning p. 6	Appendix A: NGSS and Foundations p. 9

Enduring Understandings

- The formation of solar systems occurs when a disk of dust and gas is drawn together by gravity (ESS12)
- The relative size of objects and their composition in the universe (ESS13)
- We study the solar system through Earth based instruments, space based telescopes, and manned spacecraft exploration

Essential Questions

- How do forces affect objects in the universe?
- What can we learn from studying the solar system?
- What can rocks tell us about the age of Earth?

Unit 6: Astronomy

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: What pattern in the Earth–sun–moon system can be used to explain lunar phases, eclipses of the sun and moon, and seasons?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>Patterns in the apparent motion of the sun, moon, and stars in the sky can be observed, described, predicted, and explained with models.
The Earth and solar system model of the solar system can explain eclipses of the sun and the moon.
Earth’s spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun.
The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
Patterns can be used to identify cause-and-effect relationships that exist in the apparent motion of the sun, moon, and stars in the sky.
Science assumes that objects and events in the solar system systems occur in consistent patterns that are understandable through measurement and observation.</td><td>Students who understand the concepts are able to:
Students will develop and use a physical, graphical, or conceptual model to describe patterns in the apparent motion of the sun, moon, and stars in the sky.</td></tr>
</table>

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Unit Sequence	
Part B: *What is the role of gravity in the motions within galaxies and the solar system?*	
Concepts	**Formative Assessment**
• Gravity plays a role in the motions within galaxies and the solar system. • Gravity is the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids, that are held in orbit around the sun by its gravitational pull on them. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. • Models can be used to represent the role of gravity in the motions and interactions within galaxies and the solar system. • Science assumes that objects and events in the solar systems occur in consistent patterns that are understandable through measurement and observation.	*Students who understand the concepts are able to:* • Students develop and use models to explain the relationship between the tilt of Earth's axis and seasons.

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Unit Sequence	
Part C: *What are the scale properties of objects in the solar system?*	
Concepts	**Formative Assessment**
• Objects in the solar system have scale properties. • Data from Earth-based instruments, space-based telescopes, and spacecraft can be used to determine similarities and differences among solar system objects. • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • • Time, space, and energy phenomena in the solar system can be observed at various scales, using models to study systems that are too large. • • Engineering advances have led to important discoveries in space science, and scientific discoveries have led to the development of entire industries and engineered systems.	*Students who understand the concepts are able to:* • Analyze and interpret data to determine similarities and differences among objects in the solar system.

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What it Looks Like in the Classroom
At the beginning of the unit, students will develop and use mathematical, physical, graphical or conceptual models to describe the cyclical patterns of lunar phases, eclipses of the sun and moon, and seasons. Students can use mathematics to create scale models of the solar system to investigate relative distances between the planets and their orbits around the sun or to represent the distance from the sun to the Earth during different Earth seasons. Students can also use physical models to examine the phases of the moon using a light source and a moon model to view the various shapes of the moon as it orbits the earth. Students may also keep a lunar calendar for one month and analyze the results by looking for differences and patterns. Using a model of the sun, Earth, and moon, students can view the positions of these planetary objects during a solar or lunar eclipse. To investigate seasons, students can simulate the position and tilt of the Earth as it revolves around the sun, using computer simulations, hands-on models, and videos. Students will explore, through the development and use of models, the role of the force of gravity in explaining the motions within our solar system and the Milky Way Galaxy. As part of their study of the solar system and its components, including the sun, planets and their moons, and asteroids, they will use models and examine simulations to determine how gravity holds these systems together. To visualize how gravity pulls objects down towards its center, students can experiment with dropping spheres of different masses but of the same diameter as a way to determine that gravity acts on both objects and that they drop at the same rate. If technology is available, students can measure the acceleration of the objects as they fall from various heights. Students will be able to determine that the objects speed up as they fall, therefore proving that a force is acting on them. If motion detectors are not available for student use, they could observe these using simulations. After students have had opportunities to participate in the investigations, they should prepare multimedia visual displays the present their findings. As part of their presentation, students will use mathematical models or simulations that show the relationship between relative sizes of objects in the solar system and the size of the gravitational force that is being exerted on the object. They should be able to compare and contrast the weight of an object if it were on the surface of different-sized planets that have very different masses. Students will gather evidence that every object in the solar system is attracted to every other object in the solar system with a force that is related to the mass of the objects and the distance between the objects. They should extend this understanding of gravity to explain why objects in the solar system do not simply flow away from each other. Students should also make connections between their understanding of the force of gravity and the formation of the solar system from a cloud of dust and gas. As part of their mathematical model of the solar system, students will use variables to represent numbers and write expressions when solving a problem involving the role of gravity in the motions within galaxies and within the solar system. The variable can represent an unknown number or any number in a specified set.

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Students will also analyze and interpret data from Earth-based instruments to determine the scale properties of objects within our solar system. Examples of models that students could use include physical (such as the analogy of distance along a football field or computer visualization of elliptical orbits), conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Students can construct scale models of the solar system that will help them visualize relative sizes of objects in the system as well as distances between objects. Students can use graphs or tables to make comparisons between the size and gravitational pull of the planets and their moons.

Unit 6: Astronomy

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Connecting English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Include multimedia components and visual displays in presentations to describe the cyclical patterns of lunar phases, eclipses of the sun and moon, seasons, and the role of gravity in the motions within galaxies and the solar system. The presentation needs to clarify claims and findings and emphasize salient points. • Cite specific textual evidence to support analysis of science and technical text about scale properties of objects in the solar system. • Integrate quantitative or technical information expressed in words in a text about scale properties of objects in the solar system with a version of that information expressed visually in a flowchart, diagram, model, graph, or table. *Mathematics* • Reason quantitatively and abstractly about the sizes of an object's layers, surface features, and orbital radius where appropriate. • Use mathematics to model the motion of the sun, moon, and stars in the sky and the role of gravity in the motions within galaxies and the solar system. • Understand the concept of a ratio and use ratio language to describe a ratio relationship between the measurements of the cyclical motion between at least two bodies in the solar system and the relative sizes of objects and/or distances between objects and the impact of gravity on the motion of these objects. • Recognize and represent proportional relationships between the measurement of patterns in the cyclical motion of the sun, moon, and stars in the sky and mathematical proportions relative to the sizes of objects and the effect of gravity on the motion of these objects. • Use variables to represent numbers and write expressions when solving a problem involving the role of gravity in the motions within galaxies and within the solar system. Understand that a variable can represent an unknown number, or depending on the problem, any number in a specified set.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 6: Astronomy

Instructional Days: 20

Research on Student Learning
The ideas "the sun is a star" and "the earth orbits the sun" appear counter-intuitive to elementary-school students. The ideas "the sun is a star" and "the earth orbits the sun" and are not likely to be believed or even understood in elementary grades. Whether it is possible for elementary students to understand these concepts even with good teaching needs further investigation. Explanations of the day-night cycle, the phases of the moon, and the seasons are very challenging for students. To understand these phenomena, students should first master the idea of a spherical earth, itself a challenging task. Similarly, students must understand the concept of "light reflection" and how the moon gets its light from the sun before they can understand the phases of the moon. Finally, students may not be able to understand explanations of any of these phenomena before they reasonably understand the relative size, motion, and distance of the sun, moon, and the earth (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • Earth's orbit and rotation and the orbit of the moon around Earth cause observable patterns. • Certain features on Earth can be used to order events that have occurred in a landscape.

Future Learning
• Light spectra from stars are used to determine their characteristics, processes, and life cycles. • Solar activity creates the elements through nuclear fusion. • The development of technologies has provided astronomical data that provide empirical evidence for the Big Bang theory. • Kepler's Laws describe common features of the motions of orbiting objects. • Observations from astronomy and space probes provide evidence for explanations of solar system formation. • Changes in Earth's tilt and orbit cause climate changes such as ice ages.

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Connections to Other Units
Grade 6 Unit 4: Forces and Motion • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. **Grade 6 Unit 5: Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). **Grade 7 Unit 8: Earth Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

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Instructional Days: 20

Sample of Open Education Resources
NASA Solar System Exploration: This link will connect you to NASA's Solar system Exploration website. The website offers a wide variety of student activities. Seasons Interactive provides students with the opportunity to investigate how Earth's angle of inclination affects three factors: the angle of incoming sunlight, average daily temperatures and the Sun's ecliptic path. Three preset values for the angle of inclination are available (corresponding to the values of Earth, Venus and Uranus). Additionally, users may select an angle value from a sliding scale. Users can control the speed of the simulation or may pause it when needed. Students are able to compare the heights of the ecliptic paths during the course of the year by checking the "Trace Sun's Path" box. From this information, students will be able to construct an explanation for the occurrence of seasons. Exercises with solutions are included, as well as a self-assessment located below the simulation. Teachers should be aware of several weaknesses in the simulation. First, the model allows students to reverse the motion of the Earth around the Sun which could lead to misconceptions. Secondly, the model overemphasizes the elliptical path of the Earth which often leads to the misconception that seasons are caused by distance from the Sun. Lastly, while the Sun is shown moving across the sky during the day (from Earth's view), the stars are left static during the night. In Eclipse Interactive, students investigate both lunar and solar eclipses by manipulating up to three independent variables: Moon's tilt from orbit, Earth-Moon distance and size of the Moon. By viewing the effects of changes to these variables, students will be able to construct explanations for solar and lunar eclipses. The model includes both top and side views of the Earth-Moon system during the Moon's revolution. In addition, students can toggle to show outlines of the Earth and Moon. Teachers should note that the simulation has been designed as a single screen model that automatically moves between solar and lunar eclipses without any indication of time. As a result, younger students may become confused and will need to be reminded about the duration of lunar months. The simulation includes bare-bones introductory content, how-to instructions, the interactive model itself, related exercises, and solutions to the exercises. One minor inconvenience is the lack of a reset button. The Pull of the Planets is part of a thematic series of lessons highlighting the Juno mission to Jupiter. It is a traditional hands-on activity that models how gravitational forces can keep planets and asteroids in orbit within the Solar System. Using a stretchable fabric held in place with an embroidery hoop, students work with spheres of various materials to explore how mass and sizes affect the strength of gravitational forces. Background materials, including a materials sheet, aid teachers in organizing this activity.

Unit 6: Astronomy

Instructional Days: 20

Appendix A: NGSS and Foundations for the Unit
Generate and analyze evidence (through simulations or long term investigations) to explain why the Sun’s apparent motion across the sky changes over the course of a year. (ESS1.B)
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. *[Clarification Statement: Examples of models can be physical, graphical, or conceptual.]* **(MS-ESS1-1)**
Develop and use a model that shows how gravity causes smaller objects to orbit around larger objects at increasing scales, including the gravitational force of the sun causes the planets and other bodies to orbit around it holding together the solar system. (ESS1.A; ESS1.B)
Analyze and interpret data to determine scale properties of objects in the solar system. *[Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]* **(MS-ESS1-3)**
Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. *[Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).] [Assessment Boundary: Assessment does not include Kepler’s Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]* **(MS-ESS1-2)**

Unit 6: Astronomy

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The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Develop and use a model to describe phenomena. (MS-ESS1-1),(MS-ESS1-2) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)	**ESS1.A: The Universe and Its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1) • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2) **ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3) • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas	**Patterns** • Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1) **Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-3) **Systems and System Models** • Models can be used to represent systems and their interactions. (MS-ESS1-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually

	of Earth across the year. (MS-ESS1-1) • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)	every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1),(MS-ESS1-2)

Unit 6: Astronomy

Instructional Days: 20

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS1-3) **RST.6-8.7** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS1-1),(MS-ESS1-2) **SL.8.5**	Reason abstractly and quantitatively. (MS-ESS1-3) **MP.2** Model with mathematics. (MS-ESS1-1),(MS-ESS1-2) **MP.4** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3) **6.RP.A.1** Recognize and represent proportional relationships between quantities. (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3) **7.RP.A.2** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS1-2) **6.EE.B.6** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-2)* **7.EE.B.6**

Unit 6: Astronomy

Instructional Days: 20

Common Vocabulary	
Astronomical	Atomic
Astronomy	Chemical process
Microscopic	Massive
Atom	Big bang theory
Brightness	Element
Development	Galileo
Mass	Helium
Relative	Light year
Vast	
Celestial body	
Comet	

Curriculum: Grade 6

Unit 7: Weather and Climate

Instructional Days: 20

Unit Summary
What factors interact and influence weather and climate?   This unit is broken down into three sub-ideas: Earth's large-scale systems interactions, the roles of water in Earth's surface processes, and weather and climate. Students make sense of how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. A systems approach is also important here, examining the feedbacks between systems as energy from the Sun is transferred between systems and circulates though the ocean and atmosphere. The crosscutting concepts of *cause and effect*, *systems and system models*, and *energy and matter* are called out as frameworks for understanding the disciplinary core ideas. In this unit, students are expected to demonstrate proficiency in *developing and using models* and *planning and carrying out investigations* as they make sense of the disciplinary core ideas. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-ESS2-4, MS-ESS2-5, and MS-ESS2-6.
Student Learning Objectives
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]* **(MS-ESS2-4)**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. *[Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]* **(MS-ESS2-5)**
Explain how variations in density result from variations in temperature and salinity drive a global pattern of interconnected ocean currents. *[Note: This SLO is based on a disciplinary core idea found in the Framework. It is included as a scaffold to the*

following SLO.] (ESS2.C)
Use a model to explain the mechanisms that cause varying daily temperature ranges in a coastal community and in a community located in the interior of the country. *[Note: This SLO is based disciplinary core ideas found in the Framework. It is included as a scaffold to the following SLO.]* (ESS2.C; ESS2.D)
Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. *[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]* **(MS-ESS2-6)**

MS-ESS2-4	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
ESS2.C	Explain how variations in density result from variations in temperature and salinity drive a global pattern of interconnected ocean currents
ESS2.C; ESS2.D	Use a model to explain the mechanisms that cause varying daily temperature ranges in a coastal community and in a community located in the interior of the country.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates

Curriculum: Grade 6

Unit 7: Weather and Climate

Instructional Days: 20

Quick Links	
[Research on Learning p. 6]	[Connections to Other Units p. 8]
[Prior Learning p. 6]	[Sample Open Education Resources p. 10]
[Future Learning p. 7]	[Appendix A: NGSS and Foundations p. 11]

Enduring Understandings
• Human activity impacts ecosystems • The relationship between human population and the impact on natural resources
Essential Questions
• What are resources? • Why do natural disasters occur? • How do humans impact the environment? • What affects climate change?

Unit 7: Weather and Climate

Instructional Days: 20

Unit Sequence	
Part A: *What are the processes involved in the cycling of water through Earth's systems?*	
Concepts	**Formative Assessment**
• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity. • The cycling of water through Earth's systems is driven by energy from the sun and the force of gravity. • Within Earth's systems, the transfer of energy drives the motion and/or cycling of water.	*Students who understand the concepts are able to:* • Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. • Model the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle.

Unit 7: Weather and Climate

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: What is the relationship between the complex interactions of air masses and changes in weather conditions?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>The motions and complex interactions of air masses result in changes in weather conditions.
The complex patterns of the changes in and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
Examples of data that can be used to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions include weather maps, diagrams, and visualizations; other examples can be obtained through laboratory experiments.
Air masses flow from regions of high pressure to regions of low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time.
Because patterns of the changes and the movement of water in the atmosphere are so complex, weather can only be predicted probabilistically.
Sudden changes in weather can result when different air masses collide.
Weather can be predicted within probabilistic ranges.
Cause-and effect-relationships may be used to predict</td><td>Students who understand the concepts are able to:
Collect data to serve as the basis for evidence for how the motions and complex interactions of air masses result in changes in weather conditions.</td></tr>
</table>

changes in weather.	

Unit Sequence	
Part C: *What are the major factors that determine regional climates?*	
Concepts	**Formative Assessment**
• Unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. • Patterns of atmospheric and oceanic circulation that determine regional climates vary by latitude, altitude, and geographic land distribution. • Atmospheric circulation that, in part, determines regional climates is the result of sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds. • Ocean circulation that, in part, determines regional climates is the result of the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. • Models that can be used to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates can be diagrams, maps and globes, or digital representations.	*Students who understand the concepts are able to:* • Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Curriculum: Grade 6

Unit 7: Weather and Climate

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What it Looks Like in the Classroom
During this unit, students will answer the question “What factors interact and influence weather and climate?” beginning with the cycling of water in Earth’s systems. Models will be created and emphasis will be on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Students will model the continuous movement of water from land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation. Students will focus on the global movement of water and its changes in form that are driven by sunlight as it heats the Earth’s surface water. The motions and complex interactions of air masses result in changes in weather conditions. The patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. Students will collect data from weather maps, diagrams, visualizations, and laboratory experiments to explain how the movements of air masses from regions of high pressure to regions of low pressure cause weather at a fixed location. For example, students can observe the movement of colored water that simulates the movement of hot and cold air masses. Students can observe the cooler water flowing in the direction of the warmer area and equate this with wind being created from the uneven heating of the Earth. Students will compare data collected from sources such as simulations, video, or experiments to identify the patterns of change in the movement of water in the atmosphere that are used to make weather predictions, understanding that any predictions are reported within probability ranges. Students will also make predictions about the conditions that result in sudden changes in weather. Students will use models, diagrams, maps, and globes to understand atmospheric and ocean circulation patterns. Since the ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents, the ocean will be studied as a system with interactions such as inputs, outputs, processes, energy, and matter. Students will model how the unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. They will describe how the unequal heating of the global ocean produces convection currents. By examining maps, globes and digital representations of the movement of ocean currents, students will model the patterns by latitude, altitude, and geographic distribution. They will show that these patterns vary as a result of sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing wines. Digital models like NOAA videos can be used to help students visualize how variations in density due to temperature and salinity drive a global pattern of interconnected ocean currents. This can be demonstrated in the classroom using models in which colored water with different temperatures or water with different densities is added to clear tubs of water. Students can

observe that the warmer water is pushed upwards by the colder water. This same demonstration can be used with water that has different salinities. Using a turntable and drawing a straight line from the middle to the edge can model the Coriolis effect. If a turntable is not available, a Lazy Susan is a great substitute. The turntable or Lazy Susan can be painted with chalk paint, and the students can draw the line using chalk. Using chalk paint and chalk will enable the teacher to use them over and over. After the turntable is stopped, students will see that the motion of the turntable resulted in a curved line, and they will then be able to correlate how the rotation of Earth results in the movement of air.

Connecting English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Support the analysis of science and technical texts by citing specific textual evidence for how the motions and complex interactions of air masses result in changes in weather conditions.
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with information that is gained from reading text about how the complex patterns of the changes and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents are major determinants of local weather patterns.
- Gather relevant information from multiple print and digital sources about how the complex patterns of the changes and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.
- Include multimedia components and visual displays in presentations to clarify information about how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Mathematics

- Reason abstractly and quantitatively by using data such as weather maps, diagrams, and visualizations or obtained through laboratory experiments to predict weather within probabilities ranges.
- Understand that positive and negative numbers are used together to describe quantities having opposite directions or values. Use positive and negative numbers to represent changes in atmospheric and oceanic temperatures, explaining the meaning of 0 in each situation.

Unit 7: Weather and Climate

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Curriculum: Grade 6

Unit 7: Weather and Climate

Instructional Days: 20

Research on Student Learning
Students of all ages (including college students and adults) have difficulty understanding what causes the seasons. Students may not be able to understand explanations of the seasons before they reasonably understand the relative size, motion, and distance of the sun and the earth. Many students before and after instruction in earth science think that winter is colder than summer because the earth is further from the sun in winter. This idea is often related to the belief that the earth orbits the sun in an elongated elliptical path. Other students, especially after instruction, think that the distance between the northern hemisphere and the sun changes because the earth leans toward the sun in the summer and away from the sun in winter. Students' ideas about how light travels and about the earth-sun relationship, including the shape of the earth's orbit, the period of the earth's revolution around the sun, and the period of the earth's rotation around its axis, may interfere with students' understanding of the seasons. For example, some students believe that the side of the sun not facing the earth experiences winter, indicating confusion between the daily rotation of the earth and its yearly revolution around the sun. Although upper elementary students may identify air as existing even in static situations and recognize that it takes space, recognizing that air has weight may be challenging even for high-school students. Students of all ages (including college students) may believe that air exerts force or pressure only when it is moving and only downwards. Only a few middle-school students use the idea of pressure differences between regions of the atmosphere to account for wind; instead they may account for winds in terms of visible moving objects or the movement of the earth. Before students understand that water is converted to an invisible form, they may initially believe that when water evaporates it ceases to exist, or that it changes location but remains a liquid, or that it is transformed into some other perceptible form (fog, steam, droplets, etc.). With special instruction, some students in 5th grade may be able to identify the air as the final location of evaporating water Students must accept air as a permanent substance before they can identify the air as the final location of evaporating water. For many students, difficulty understanding the existence of water vapor in the atmosphere persists in middle school years. Students can understand rainfall in terms of gravity once they attribute weight to little drops of water (typically in upper elementary grades), but the mechanism through which condensation occurs may not be understood until high school. Students of all ages may confuse the ozone layer with the greenhouse effect, and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (for example, that the use of unleaded petrol reduces the risk of global warming). Students have difficulty linking relevant elements of knowledge when explaining the greenhouse

effect and may confuse the natural greenhouse effect with the enhancement of that effect (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • Most of the Earth's water is in the ocean, and much of the Earth's fresh water is in glaciers or underground. • Climate describes patterns of typical weather conditions over different scales and variations. • Historical weather patterns can be analyzed.

Future Learning
Physical science • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the

concept of conservation of energy to be used to predict and describe system behavior.

- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Earth and space science

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- The complex patterns of the changes and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
- Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface

features and create underground formations.

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Connections to Other Units

Grade 6 Unit 1: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Grade 6 Unit 2: Interactions of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

Unit 7: Weather and Climate

Instructional Days: 20

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Grade 6 Unit 4: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Grade 6 Unit 5: Types of Interactions

- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively)

Grade 8 Unit 5: Relationships among Forms of Energy

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.

- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

Grade 8 Unit 6: Thermal Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

Grade 8 Unit 7: The Electromagnetic Spectrum

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Sample of Open Education Resources
Air Masses of a set of Level 1 activities designed by the Science Center for Teaching, Outreach, and Research on Meteorology (STORM) Project. The authors suggest that previous activities in the unit be completed before Activity 12: Air Masses, including those that address pressure systems and dew point temperature. In Activity 12, the students learn about the four main types of air masses that affect weather in the United States, their characteristic temperatures, and humidity levels as it relates to dew point temperatures. The lesson plan follows the 5E format. Initially, students discuss local weather and then examine surface temperature and dew point data on maps to determine patterns and possible locations of air masses. They learn about the source regions of air masses and compare their maps to a forecast weather map with fronts and pressure

systems drawn in. During the Extension phase, students access current maps with surface and dew point temperatures at http://www.uni.edu/storm/activities/level1 and try to identify locations of air masses. They sketch in fronts and compare their results to the fronts map. Evaluation consists of collection of student papers.

Ocean Currents and Sea Surface Temperature allows students to gather data using My NASA Data microsets to investigate how differential heating of Earth results in circulation patterns in the oceans and the atmosphere that globally distribute the heat. They examine the relationship between the rotation of Earth and the circular motions of ocean currents and air. Students also make predictions based on the data to concerns about global climate change. They begin by examining the temperature of ocean's surface currents and ocean surface winds. These currents, driven by the wind, mark the movement of surface heating as monitored by satellites. Students explore the link between 1) ocean temperatures and currents, 2) uneven heating and rotation of Earth, 3) resulting climate and weather patterns, and 4) projected impacts of climate change (global warming). Using the Live Access Server, students can select data sets for various elements for different regions of the globe, at different times of the year, and for multiple years. The information is provided in maps or graphs which can be saved for future reference. Some of the data sets accessed for this lesson include Sea Surface Temperature, Cloud Coverage, and Sea Level Height for this lesson. The lesson provides directions for accessing the data as well as questions to guide discussion and learning. The estimated time for completing the activity is 50 minutes. Inclusion of the Extension activities could broaden the scope of the lesson to several days in length. Links to informative maps and text such as the deep ocean conveyor belt, upwelling, and coastal fog as needed to answer questions in the extension activities are included.

Adopt a Drifter: Do Ocean Surface Currents Influence Climate? Students construct climographs showing both precipitation and temperature for 3 coastal cities and describe how ocean surface currents affect climate on nearby land. They are provided with the research question, "Do ocean currents influence climate?" and are asked to construct a hypothesis. The students are asked to read an introductory paragraph explaining the relationship between the temperature of the ocean current and temperature and precipitation on adjacent land and examine a map of major ocean currents. They construct 3 climographs using data provided. The labels on the graphs are not directly on the lines, so the teacher would need to instruct students on the placement of their data points. Conclusion and analysis questions are provided asking students to examine the direction of flow of ocean currents, temperature of the water, source regions of the current, and impact on both temperature and precipitation on coastal regions. Extension activities include researching additional information on vegetation, culture and physical geography of the 3 cities studied, plus comparing data for 2 additional cities. The activity should take 2 class periods.

Unit 7: Weather and Climate

Instructional Days: 20

Appendix A: NGSS and Foundations for the Unit
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]* **(MS-ESS2-4)**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. *[Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]* **(MS-ESS2-5)**
Explain how variations in density result from variations in temperature and salinity drive a global pattern of interconnected ocean currents. (ESS2.C)
Use a model to explain the mechanisms that cause varying daily temperature ranges in a coastal community and in a community located in the interior of the country. (ESS2.C; ESS2.D)
Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. *[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]* **(MS-ESS2-6)**
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent*

heats of vaporization and fusion is not assessed.] **(MS-ESS2-4)**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena. (MS-ESS2-6) • Develop a model to describe unobservable mechanisms. (MS-ESS2-4) **Planning and Carrying Out Investigations** • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-5)	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5) • Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4) • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5) **Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. (MS-ESS2-6) **Energy and Matter** • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)

	ESS2.D: Weather and Climate • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6) • Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5) • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)	

Unit 7: Weather and Climate

Instructional Days: 20

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-5),(MS-ESS3-5) **RST.6-8.1** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-5) **RST.6-8.9** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS2-5) **WHST.6-8.8** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS2-6) **SL.8.5**	Reason abstractly and quantitatively. (MS-ESS2-5),(MS-ESS3-5) **MP.2** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-ESS2-5) **6.NS.C.5** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-5) **6.EE.B.6**

Unit 7: Weather and Climate

Instructional Days: 20

Common Vocabulary	
Condensation	Mass
Geographic	Orbit
Latitude	Tilt
Longitude	Air mass
Pressure	Altitude
Solar	Atmospheric
Transfer	Constrain
Accuracy	Density
Biosphere	Gradual
High pressure	Humidity
Low pressure	

Curriculum: Grade 7

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Unit Summary
How is it that everything is made of star dust?   Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide a molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of *cause and effect*, *scale, proportion and quantity*, *structure and function*, *interdependence of science, engineering, and technology*, and *the influence of science, engineering and technology on society and the natural world* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in *developing and using models*, and *obtaining, evaluating, and communicating information*. Students are also expected to use the scientific and engineering practices to demonstrate understanding of the core ideas.
Student Learning Objectives
Develop models to describe the atomic composition of simple molecules and extended structures. *[Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. The substructure of atoms and the periodic table are learned in high school chemistry.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]* **(MS-PS1-1)**
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. *[Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]* **(MS-PS1-2)**

Unit 1: Structures and Properties of Matter

Instructional Days: 20

MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred
PS1.A	Substances are made from different types of atoms, which combine with one another in various ways
PS1.B	Substances react chemically in characteristic ways
PS3.A	The term “heat” as used in everyday language refers both to thermal energy and the transfer of that thermal energy from one object to another

Curriculum: Grade 7

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Quick Links		

Enduring Understandings

- People use all of their senses to detect matter.
- Even when matter seems to vanish, it is still conserved. The amount (weight) of matter is conserved when it changes form even when it seems to vanish (such as dissolving, mixing, melting and freezing.)
- Matter can change state when external forces are applied.

Essential Questions

- How is matter structured?
- How does matter react?
- How are energy and matter connected?

Curriculum: Grade 7

Unit 1: Structures and Properties of Matter

Instructional Days: 20

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: If the universe is not made of Legos®, then what is it made of?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>
• Substances are made from different types of atoms.
 ✓ Atoms are the basic units of matter.
• Substances combine with one another in various ways.
 ✓ Molecules are two or more atoms joined together.
• Atoms form molecules that range in size from two to thousands of atoms.
 ✓ Molecules can be simple or very complex.
• Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
</td><td>
Students who understand the concepts are able to:
• Develop a model of a simple molecule.
• Use the model of the simple molecule to describe its atomic composition.
• Develop a model of an extended structure.
• Use the model of the extended structure to describe its repeating subunits.
[Boundary: The substructure of atoms and the periodic table are learned in high school chemistry.]
</td></tr>
</table>

Unit 1: Structures and Properties of Matter

Instructional Days: 20

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: Is it possible to tell if two substances mixed or if they reacted with each other?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>
• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
• Substances react chemically in characteristic ways.
• In a chemical process, the atoms that make up the original substances are regrouped into different molecules; these new substances have different properties from those of the reactants.
• The analysis of data on the properties of products and reactants can be used to determine whether a chemical process has occurred.
• Density, melting point, boiling point, solubility, flammability, and odor are characteristic properties that can be used to identify a pure substance.
• Macroscopic patterns are related to the nature of the atomic-level structure of a substance.
</td><td>
Students who understand the concepts are able to:
• Analyze and interpret data to determine similarities and differences from results of chemical reactions between substances before and after they undergo a chemical process.
• Analyze and interpret data on the properties of substances before and after they undergo a chemical process.
• Identify and describe possible correlation and causation relationships evidenced in chemical reactions.
• Make logical and conceptual connections between evidence that chemical reactions have occurred and explanations of the properties of substances before and after they undergo a chemical process.
</td></tr>
</table>

Unit 1: Structures and Properties of Matter

Instructional Days: 20

What It Looks Like in the Classroom
Within this unit, students will use informational text and models (which can include student-generated drawings, 3-D ball-and-stick structures, or computer representations) to understand that matter is composed of atoms and molecules. These models should reflect that substances are made from different types of atoms. Student models can be manipulated to show that molecules can be disassembled into their various atoms and reassembled into new substances according to chemical reactions. This scientific knowledge can be used to explain the properties of substances. Students will examine and differentiate between physical and chemical properties of matter. They are limited to the analysis of the following characteristic properties: density, melting point, boiling point, solubility, flammability, and odor. This analysis of properties serves as evidence to support that chemical reactions of substances cause a rearrangement of atoms to form different molecules. Students will also recognize that they are using models to observe phenomena too small to be seen. Students who demonstrate this understanding can develop or modify a model of simple molecules to describe the molecules' atomic composition. Examples of molecules that can be modeled include water, oxygen, carbon dioxide, ammonia, and methanol. Additionally, students will develop and modify a model that describes the atomic composition of an extended structure showing a pattern of repeating subunits. Examples may include sodium chloride and diamonds. Due to the repeating subunit patterns, models can include student-generated drawings, 3-D ball-and-stick structures, and computer representations. Building upon these experiences, students will analyze and interpret data on the properties of substances in order to provide evidence that a chemical reaction has occurred. They will also analyze and interpret data to determine similarities and differences in findings. Students will recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They will use patterns to identify cause-and-effect relationships and graphs and charts to identify patterns in data.

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Cite specific textual evidence to support analysis of science and technical texts on the characteristic properties of pure substances. Attend to precise details of explanations or descriptions about the properties of substances before and after they undergo a chemical process. • Integrate qualitative information (flowcharts, diagrams, models, graphs, or tables) about the characteristic properties of substances before and after a chemical process has occurred with a version of that information expressed visually, ***or*** integrate technical information about the characteristic properties of substances before and after a chemical process has occurred with a version of that information expressed visually. *Mathematics* • Integrate quantitative or technical information about the composition of simple molecules and extended structures that is expressed in words in a text with a version of that information expressed in a model. • Reason quantitatively (with amounts, numbers, sizes) and abstractly (with variables). • Develop a mathematical model to describe the atomic composition of simple molecules and extended structures. • Use ratio and rate reasoning to describe the atomic composition of simple molecules and extended structures. • Reason quantitatively with amounts, numbers, and sizes for properties like density, melting point, boiling point, solubility, flammability, and odor, and reason abstractly by assigning labels or symbols. • Use ratio and rate reasoning to determine whether a chemical reaction has occurred. • Display numerical data for properties such as density, melting point, solubility, flammability, and order in plots on a number line, including dot plots, histograms, and box plots. • Summarize numerical data sets on the properties of substances before and after the substances interact to determine whether a chemical reaction has occurred. The summary of the numerical data sets must be in relation to their context.

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Research on Student Learning
Middle school students may think everything that exists is matter, including heat, light, and electricity. Alternatively, they may believe that matter does not include liquids and gases or that they are weightless materials. With specially designed instruction, some middle school students can learn the scientific notion of matter. Middle-school and high-school students are deeply committed to a theory of continuous matter. Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. Students at the beginning of middle school may be at different points in their conceptualization of a "theory" of matter. Although some 5th graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight" -- something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gases; and have problems in conceptualizing forces between particles. Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle-school students develop correct ideas about particles (NSDL, 2015).

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Unit 1: Structures and Properties of Matter

Instructional Days: 20

Prior Learning
By the end of Grade 5, students understand that: • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. • A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. • Measurements of a variety of observable properties can be used to identify materials. *[Note: In the fifth grade, no attempt was made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.]* • When two or more different substances are mixed, a new substance with different properties may be formed. • No matter what reaction or change in properties occurs, the total mass of the substances does not change. *[Note: Mass and weight were distinguished in 5th grade.]*

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Future Learning
Chemistry • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons surrounded by electrons. • The periodic table orders elements horizontally according to the number of protons in the atom's nucleus; it organizes elements with similar chemical properties vertically, in columns. The repeating patterns of this table reflect patterns of outer electron states. • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • A stable molecule has less energy than the same set of atoms separated; at least this much energy must be provided in order to take the molecule apart. *Earth and space science* • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The Big Bang theory is supported by observations of distant galaxies receding from our own, by the measured composition of stars and nonstellar gases, and by the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • Chemical processes, their rates, and whether or not they store or release energy can be understood in terms of collisions of molecules and rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines

the numbers of all types of molecules present.

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Connections to Other Units
Unit 2: Interactions of Matter • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. **Unit 3: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy.

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Sample of Open Education Resources
Middle school Chemistry, Chapter 1: Solids, Liquids, and Gases Students are introduced to the idea that matter is composed of atoms and molecules that are attracted to each other and in constant motion. Students explore the attractions and motion of atoms and molecules as they experiment with and observe the heating and cooling of a solid, liquid, and gas. Middle school Chemistry, Chapter 2: Changes of State Students help design experiments to test whether the temperature of water affects the rate of evaporation and whether the temperature of water vapor affects the rate of condensation. Students also look in more detail at the water molecule to help explain the state changes of water. (all activities/lessons) States of Matter: Use interactive computer models to trace an atom's trajectory at a certain physical stage, and investigate how molecular behavior is responsible for the substance's state. Molecular View of a Solid: Explore the structure of a solid at the molecular level. Molecules are always in motion, though molecules in a solid move slowly. All molecules are attracted to each other. Molecules can be weakly or strongly attracted to each other. The way that large molecules interact in physical, chemical and biological applications is a direct consequence of the many tiny attractions of the smaller parts. Molecular View of a Liquid: Explore the structure of a liquid at the molecular level. Molecules are always in motion. Molecules in a liquid move moderately. All molecules are attracted to each other. Molecules can be weakly or strongly attracted to each other. The way that large molecules interact in physical, chemical and biological applications is a direct consequence of the many tiny attractions of the smaller parts. Molecular View of a Gas: Explore the structure of a gas at the molecular level. Molecules are always in motion. Molecules in a gas move quickly. All molecules are attracted to each other. Molecules can be weakly or strongly attracted to each other. The way that large molecules interact in physical, chemical and biological applications is a direct consequence of the many tiny attractions of the smaller parts.

Curriculum: Grade 7

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Appendix A: NGSS and Foundations for the Unit		
Develop models to describe the atomic composition of simple molecules and extended structures. *[Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. The substructure of atoms and the periodic table are learned in high school chemistry.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]* **(MS-PS1-1)**		
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. *[Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]* **(MS-PS1-2)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Develop a model to predict and/or describe phenomena. (MS-PS1-1) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)	**PS1.A: Structure and Properties of Matter** • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) • Solids may be formed from molecules, or they may be extended structures with repeating subunits	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1) **Patterns** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

	(e.g., crystals). (MS-PS1-1) • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) **PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)	- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

Unit 1: Structures and Properties of Matter

Instructional Days: 20

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.(MS-PS1-2) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-1),(MS-PS1-2) **RST.6-8.7**	Reason abstractly and quantitatively. (MS-PS1-1),(MS-PS1-2) **MP.2** Model with mathematics. (MS-PS1-1) **MP.4** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1),(MS-PS1-2) **6.RP.A.3** Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. (MS-PS1-1) **8.EE.A.3** Display numerical data in plots on a number line, including dot plots, histograms, and box plots. (MS-PS1-2) **6.SP.B.4** Summarize numerical data sets in relation to their context. (MS-PS1-2) **6.SP.B.5**

Unit 1: Structures and Properties of Matter

Instructional Days: 20

Common Vocabulary	
Particle	Internal energy
Pressure	Kinetic energy
Transfer	Particle motion
Variation	Potential energy
Atom	Proportional
Average	Thermal energy
Building block	Carbon dioxide
Substance	Inert atom
Helium	Molecular arrangement
Internal	Molecular motion
	molecule

Curriculum: Grade 7

Unit 2: Interactions with Matter

Instructional Days: 20

Unit Summary
How can we trace synthetic materials back to natural ingredients?   Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide a molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of *cause and effect*, *scale, proportion and quantity*, *structure and function*, *interdependence of science, engineering, and technology*, and *the influence of science, engineering and technology on society and the natural world* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in *developing and using models*, and *obtaining, evaluating, and communicating information*. Students are also expected to use the scientific and engineering practices to demonstrate understanding of the core ideas.
Student Learning Objectives
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. *[Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]* **(MS-PS1-3)**
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. *[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]* **(MS-PS1-4)**

Unit 2: Interactions with Matter

Instructional Days: 20

MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society
MS-PS1-4	Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed
PS1.A	Substances are made from different types of atoms, which combine with one another in various ways
PS1.B	Substances react chemically in characteristic ways
PS3.A	The term “heat” as used in everyday language refers both to thermal energy and the transfer of that thermal energy from one object to another

Unit 2: Interactions with Matter

Instructional Days: 20

Enduring Understandings
• People use all of their senses to detect matter. • Even when matter seems to vanish, it is still conserved. The amount (weight) of matter is conserved when it changes form even when it seems to vanish (such as dissolving, mixing, melting and freezing.) • Matter can change state when external forces are applied.
Essential Questions
• How is matter structured? • How does matter react? • How are energy and matter connected?

Curriculum: Grade 7

Unit 2: Interactions with Matter

Instructional Days: 20

Unit Sequence	
Part A: *How can you tell what the molecules are doing in a substance?*	
Concepts	**Formative Assessment**
• Changes in particle motion, temperature, and state of a pure substance occur when thermal energy is added or removed. • Qualitative molecular-level models of solids, liquids, and gases can be used to show that adding or removing thermal energy increases or decreases the kinetic energy of the particles until a change of state occurs. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others. • In a gas, the molecules are widely spaced except when they happen to collide. • In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter. • The term heat as used in everyday language refers both to thermal energy and the transfer of that thermal energy from one object to another. • Thermal energy is the motion of atoms or molecules within a substance.	*Students who understand the concepts are able to:* • Develop a model that predicts and describes changes in particle motion that could include molecules or inert atoms or pure substances. • Use cause-and-effect relationships to predict changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural or designed systems.

• In science, heat is used to refer to the energy transferred due to the temperature difference between two objects. • The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). • The details of the relationship between the average internal kinetic energy and the potential energy per atom or molecule depend on the type of atom or molecule and the interactions among the atoms in the material. • Temperature is not a direct measure of a system's total thermal energy. • The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. • Cause-and-effect relationships may be used to predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural systems.	

Unit 2: Interactions with Matter

Instructional Days: 20

Unit Sequence	
Part B: *How can we trace synthetic materials back to natural ingredients?*	
Concepts	**Formative Assessment**
• Each pure substance has characteristic physical and chemical properties that can be used to identify it. • Substances react chemically in characteristic ways. • In a chemical process, the atoms that make up the original substances are regrouped into different molecules. • New substances that result from chemical processes have different properties from those of the reactants. • Natural resources can undergo a chemical process to form synthetic material. • Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used. • Engineering advances have led to discoveries of important synthetic materials, and scientific discoveries have led to the development of entire industries and engineered systems using these materials. • Technology use varies from region to region and over time. • The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by individual or societal needs, desires, and values. • The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions.	*Students who understand the concepts are able to:* • Obtain, evaluate, and communicate information to show that synthetic materials come from natural resources and affect society. • Gather, read, and synthesize information about how synthetic materials formed from natural resources affect society. • Assess the credibility, accuracy, and possible bias of each publication and methods used within the publication. • Describe how information about how synthetic materials formed from natural resources affect society is supported or not supported by evidence.

Unit 2: Interactions with Matter

Instructional Days: 20

What It Looks Like in the Classroom
Students will locate information that describes changes in particle motion, changes in temperature, or changes in state as thermal energy is added to or removed from a pure substance. Students will then use models to predict and describe the changes in particle motion, temperature, and state of a pure substance. An example could include the change of state of water from its solid (ice) to liquid and vapor with the addition of thermal energy. Students will come to understand that this process is reversible through the removal of thermal energy, where the pure substance can return from a vapor to a liquid and back to a solid state. Students who accurately demonstrate understanding will be able to develop qualitative molecular-level models of solids, liquids, and gases to show the cause-and-effect relationships of adding or removing thermal energy, which increases or decreases the kinetic energy of the particles until a change of state occurs. Models could include drawings and diagrams. Students will also need to use mathematics to demonstrate their understanding of the particle motion that is taking place during these changes in state. They will use positive and negative numbers to represent the changes in particle motion and temperature as thermal energy is added or removed. They will then integrate an expression of that same quantitative information in a visual format. It is important to note that students will need to be responsible for developing the models that they use. It is possible that the teacher could model the process with one type of model and provide opportunities for students to use different types of model to illustrate the same process. After students have a firm understanding of the motion of particles during a phase change, they will be able to move to the next section of this unit. In this portion of the unit of study, students will apply their understanding of particle and chemical change from Unit 1 to make sense of how natural resources react chemically to produce new substances. Students will explain that as a result of the rearrangement of atoms during a chemical process, the synthetic substance has different characteristic properties than the original pure substance. For example, pure substances like methane, carbon monoxide, and carbon dioxide can be combined chemically to form synthetic fuel. The synthetic fuel would have different characteristic properties than the original pure substances. Within this unit, students will gather, read, and synthesize qualitative information from multiple sources about the use of natural resources to form synthetic materials and how these new materials affect society. Examples of new materials could include new medicine, foods, and alternative fuels. Some sources could include journals, articles, brochures, or digital media from government publications and/or private industries. Students will cite some of these sources to support the analysis of evidence

that these synthetic materials were formed from natural resources and have an impact on society. They will pay special attention to the precise details of explanations or descriptions of how these new substances affect society. Students will also include relevant information from multiple print and digital sources about these impacts. While gathering this information, they will use search terms effectively, assess the credibility and accuracy of each source, and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific text to support the analysis of evidence that synthetic materials formed from natural resources affect society. Attend to the precise details of explanations or descriptions.
- Gather relevant information from multiple print and digital sources about the impact on society of synthetic materials that are formed from natural resources. Use search terms effectively, assess the credibility and accuracy of each source, and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics

- Integrate quantitative information about changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed that is expressed in words with a version of that information that is expressed visually.
- Understand that positive and negative numbers are used together to describe quantities having opposite directions or values. Use positive and negative numbers to represent changes in particle motion and temperature when thermal energy s added or removed, explaining the meaning of zero in each situation.

Unit 2: Interactions with Matter

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 2: Interactions with Matter

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Research on Student Learning
Students may think everything that exists is matter, including heat, light, and electricity. Alternatively, they may believe that matter does not include liquids and gases or they are weightless materials. With specially designed instruction, some middle school students can learn the scientific notion of matter. Students are deeply committed to a theory of continuous matter. Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. Students at beginning of middle school may be at different points in their conceptualization of a "theory" of matter. Although some 5th graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight" -- something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gases; and have problems in conceptualizing forces between particles. Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle-school students develop correct ideas about particles (NSDL, 2015).

Unit 2: Interactions with Matter

Instructional Days: 20

Prior Learning
By the end of Grade 5, students understand that: • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. • Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) • When two or more different substances are mixed, a new substance with different properties may be formed. • No matter what reaction or change in properties occurs, the total weight of the substances does not change. *[Note: Mass and weight are not distinguished by the end of 5th grade.]*

Unit 2: Interactions with Matter

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Future Learning
Chemistry • Each atom has a charged substructure consisting of a nucleus made of protons and neutrons surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in nucleus of the element's atoms and arranges elements with similar chemical properties vertically in columns. The repeating patterns of this table reflect patterns of outer electron states. • Electrical forces within and between atoms determine the structure and interactions of matter at the bulk scale. • A stable molecule has less energy than the same set of atoms separated; at least this energy must be provided in order to take the molecule apart. • Chemical processes, their rates, and whether or not they store ore release energy can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. *Physics* • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position) of the particles. • In some cases the relative position of energy can be thought of as stored in fields (which mediate interactions between

particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Life science

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).
- Humans depend on the living world for resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.
- Resource availability has guided the development of human society.
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Unit 2: Interactions with Matter

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Connections to Other Units
Grade 7 Unit 1: Properties of Matter • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. **Grade 7 Unit 3: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy.

Unit 2: Interactions with Matter

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Sample of Open Education Resources
Middle school Chemistry, Chapter 1: Solids, Liquids, and Gases Students are introduced to the idea that matter is composed of atoms and molecules that are attracted to each other and in constant motion. Students explore the attractions and motion of atoms and molecules as they experiment with and observe the heating and cooling of a solid, liquid, and gas. Middle school Chemistry, Chapter 2: Changes of State Students help design experiments to test whether the temperature of water affects the rate of evaporation and whether the temperature of water vapor affects the rate of condensation. Students also look in more detail at the water molecule to help explain the state changes of water. States of Matter: Use interactive computer models to trace an atom's trajectory at a certain physical stage, and investigate how molecular behavior is responsible for the substance's state. Molecular View of a Gas: Explore the structure of a gas at the molecular level. Molecules are always in motion. Molecules in a gas move quickly. All molecules are attracted to each other. Molecules can be weakly or strongly attracted to each other. The way that large molecules interact in physical, chemical and biological applications is a direct consequence of the many tiny attractions of the smaller parts. Molecular View of a Liquid: Explore the structure of a liquid at the molecular level. Molecules are always in motion. Molecules in a liquid move moderately. All molecules are attracted to each other. Molecules can be weakly or strongly attracted to each other. The way that large molecules interact in physical, chemical and biological applications is a direct consequence of the many tiny attractions of the smaller parts. Molecular View of a Solid: Explore the structure of a solid at the molecular level. Molecules are always in motion, though molecules in a solid move slowly. All molecules are attracted to each other. Molecules can be weakly or strongly attracted to each other. The way that large molecules interact in physical, chemical and biological applications is a direct consequence of the many tiny attractions of the smaller parts.

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Appendix A: NGSS and Foundations for the Unit		
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. *[Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]* **(MS-PS1-3)**		
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. *[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]* **(MS-PS1-4)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3) **Developing and Using Models** • Develop a model to predict and/or	**PS1.A: Structure and Properties of Matter** • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3) • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) • In a liquid, the molecules are constantly in contact with others; in a	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3) **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4) -

describe phenomena. (MS-PS1-4)	gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) **PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3) **PS3.A: Definitions of Energy** • The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. *(secondary to MS-PS1-4)*	- - - - - - - - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3) **Influence of Science, Engineering and Technology on Society and the Natural World** • The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)

	• The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. *(secondary to MS-PS1-4)*	

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS1-3) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-PS1-4)* **RST.6-8.7** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3) **WHST.6-8.8**	Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4) **6.NS.C.5**

Common Vocabulary	
Chemical	Substance
Conversion	Transition
Atom	Element
Conserve	Forms of matter
Dissolve	Proportional
Mass	Reactant
React	Reaction

Unit 2: Interactions with Matter

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Unit 3: Chemical Reactions

Instructional Days: 25

Unit Summary
How do substances combine or change (react) to make new substances?
Students provide molecular-level accounts of states of matters and changes between states, of how chemical reactions involve regrouping of atoms to form new substances, and of how atoms rearrange during chemical reactions. Students also apply their understanding of optimization design and process in engineering to chemical reaction systems. The crosscutting concept of *energy and matter* provides a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models, analyzing and interpreting data, designing solutions*, and *obtaining, evaluating, and communicating information*. Students are also expected to use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.
Student Learning Objectives
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. *[Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]* **(MS-PS1-5)**
Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* *[Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]* **(MS-PS1-6)**
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

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Unit 3: Chemical Reactions

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MS-PS1-5	Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved
MS-PS1-6	Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success
PS1.A	Substances are made from different types of atoms, which combine with one another in various ways
PS1.B	Substances react chemically in characteristic ways
PS3.A	The term “heat” as used in everyday language refers both to thermal energy and the transfer of that thermal energy from one object to another
ETS1.B	A solution needs to be tested, and then modified on the basis of the test results, in order to improve it
ETS1.C	Identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process

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Unit 3: Chemical Reactions

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Quick Links		

Enduring Understandings
• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
Essential Questions
• How do organisms interact within an ecosystem? • How does energy and matter cycle through ecosystems? • How can ecosystems be sustained? • How do humans adapt to changes in resources?

Unit 3: Chemical Reactions

Instructional Days: 25

Unit Sequence	
Part A: *What happens to the atoms when I bake a cake?*	
Concepts	**Formative Assessment**
• Substances react chemically in characteristic ways. • In a chemical process, the atoms that make up the original substances are regrouped into different molecules. • New substances created in a chemical process have different properties from those of the reactants. • The total number of each type of atom in a chemical process is conserved, and thus the mass does not change (the law of conservation of matter). • Matter is conserved because atoms are conserved in physical and chemical processes. • The law of conservation of mass is a mathematical description of natural phenomena.	*Students who understand the concepts are able to:* • Use physical models or drawings, including digital forms, to represent atoms in a chemical process. • Use mathematical descriptions to show that the number of atoms before and after a chemical process is the same.

Unit 3: Chemical Reactions

Instructional Days: 25

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>
• Some chemical reactions release energy, while others store energy.
• The transfer of thermal energy can be tracked as energy flows through a designed or natural system.
• Models of all kinds are important for testing solutions.
• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.
• A solution needs to be tested and then modified on the basis of the test results in order to for it to be improved.
• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process.
• Some of the characteristics identified as having the best performance may be incorporated into the new design.
</td><td>
Students who understand the concepts are able to:
• Undertake a design project, engaging in the design cycle, to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
• Specific criteria are limited to amount, time, and temperature of a substance.
• Analyze and interpret data for the amount, time, and temperature of a substance in testing a device that either releases or absorbs thermal energy by chemical processes to determine similarities and differences in findings.
• Develop a model to generate data for testing a device that either releases or absorbs thermal energy by chemical processes, including those representing inputs and outputs of thermal energy.
• Track the transfer of thermal energy as energy flows through a designed system that either releases or absorbs thermal energy by chemical processes.
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Unit 3: Chemical Reactions

Instructional Days: 25

What It Looks Like in the Classroom
Students begin by gaining understanding that substances react chemically in very characteristic ways. To develop this understanding, students will follow precisely a multistep procedure when carrying out experiments that involve chemical reactions that release energy and chemical reactions that absorb energy. As part of their data analysis, students will integrate quantitative information about atoms before and after the chemical reaction. The analysis will include translating written information into information that is expressed in a physical model or drawing or in digital forms. Reasoning both quantitatively and abstractly to communicate their understanding of these reactions, students will model the law of conservation of matter. They will use ratio and rate to demonstrate that the total number of atoms involved in the chemical reactions does not change and therefore mass is conserved. Within this unit, students will develop a model of the reactions they observe to describe how the total number of atoms does not change in a chemical reaction. Examples of models could include physical models, drawings, or digital forms that represent atoms. Student models ideally should have the ability to be manipulated to represent the rearrangement of reactants to products as a way to demonstrate that matter is conserved during chemical processes. Students will show how their model provides evidence that the law of conservation of matter is a mathematical description of what happens in nature. In prior units of study, students have learned about the behavior of particles of matter during a change of state and about characteristic chemical and physical properties of matter. This unit will leverage that prior learning by having students undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. For example, students could design a device that releases heat in a way similar to how heat is released when powdered laundry detergent is mixed with water to form a paste. Students will need to be able to track energy transfer as heat energy is either released to the environment or absorbed from the environment. Students could also design a device that absorbs and stores heat from the environment. The design problem has already been identified; therefore, the emphasis is on designing the device, controlling the transfer of energy to the environment, and modifying the device according to factors such as type and concentration of substance. The criteria for a successful design have not been determined; therefore, teachers will need to work with students to determine criteria for a successful design. Before attempting to determine criteria, students will conduct a short research project to familiarize themselves with scientific information they can use when designing the device. Students must draw on several sources and generate additional focused questions that allow for further avenues of exploration. After completing their research, students will compare and contrast the information gained from experiments, simulations,

videos, or multimedia sources with that gained from their reading about the design of the device. Students, with the support of the teacher, will then write design criteria.

Students are now at a point where they can begin the design process. Prior to construction, students should develop a probability model and use it as part of the process for testing their device. They will use the probability model to determine which designs have the greatest probability of success.

It is important that students use mathematics appropriately when analyzing their test results. They must apply properties of operations to calculate numerical data with numbers in any form, convert between forms as appropriate, and assess the reasonableness of answers using mental computations and estimation strategies.

Students will collect and analyze these numerical data to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks *related to chemical reactions that release energy and some that store energy.*
- Cite specific textual evidence to support analysis of science and technical texts on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance.
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text *on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance.*
- *Conduct* research on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- Draw evidence from informational texts to support analysis, reflection, and research on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance.

- Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points *on the design and modification of a device that controls the transfer of energy to the environment.*

Mathematics

- Integrate quantitative information expressed in words about atoms before and after a chemical process with a version of that information expressed in a physical model or drawing, including digital forms.
- Reason quantitatively and abstractly during communication about melting or boiling points.
- Use mathematics to model the law of conservation of matter.
- Use ratio and rate reasoning to describe how the total number of atoms does not change in a chemical reaction, and thus mass is conserved.
- Reason quantitatively and abstractly: Reason quantitatively using numbers to represent the criteria (amount, time, and temperature of substance) when testing a device that either releases or absorbs thermal energy by chemical processes; reason abstractly by assigning labels or symbols.
- Collect and analyze numerical data from tests of a device that either releases or absorbs thermal energy by chemical processes. Determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. Pose problems with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate the numerical data with numbers in any form, convert between forms as appropriate, and assess the reasonableness of answers using mental computations and estimation strategies.
- Develop a probability model and use it as part of an iterative process for testing to find the probability that a promising design solution will lead to an optimal solution. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy in order to ultimately develop an optimal design.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: [All Standards, All Students](#)/[Case Studies](#) for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Curriculum: Grade 7

Unit 3: Chemical Reactions

Instructional Days: 25

Research on Student Learning
Students may think everything that exists is matter, including heat, light, and electricity. Alternatively, they may believe that matter does not include liquids and gases or they are weightless materials. With specially designed instruction, some middle school students can learn the scientific notion of matter. Students are deeply committed to a theory of continuous matter. Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. Students at beginning of middle school may be at different points in their conceptualization of a "theory" of matter. Although some 5th graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight" -- something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gases; and have problems in conceptualizing forces between particles. Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle-school students develop correct ideas about particles (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • When two or more different substances are mixed, a new substance with different properties may be formed. • No matter what reaction or change in properties occurs, the total weight of the substances does not change. *(Note: Mass and weight are not distinguished by the end of fifth grade.)*

Unit 3: Chemical Reactions

Instructional Days: 25

Future Learning
Physical science • Each atom has a charged substructure consisting of a nucleus made of protons and neutrons and surrounded by electrons. • The periodic table orders elements horizontally according to the number of protons in nucleus of an element's atoms and places elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. • Electrical forces within and between atoms determine the structure and interactions of matter at the bulk scale. • A stable molecule has less energy than the same set of atoms separated; at least this much energy must be provided in order to take the molecule apart. • Chemical processes, their rates, and whether or not they store or release energy can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position) of the particles. • In some cases, the relative position of energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Unit 3: Chemical Reactions

Instructional Days: 25

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Unit 3: Chemical Reactions

Instructional Days: 25

Connections to Other Units
Grade 7 Unit 1: Properties of Matter • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. **Grade 7 Unit 2: Interactions of Matter** • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

Unit 3: Chemical Reactions

Instructional Days: 25

Sample of Open Education Resources
Middle School Chemistry, Chapter 4: Periodic Table and Bonding: (Lesson 1 and 2 only) Students look deeply into the structure of the atom and play a game to better understand the relationship between protons, neutrons, electrons, and energy levels in atoms and their location in the periodic table. Predict how elements will react to each other based on their location in the periodic table. Lesson 1: Students are constructing an explanation of why charges attract or repel.
Middle School Chemistry, Chapter 5: The Water Molecule and Dissolving*:* Students investigate the polarity of the water molecule and design tests to compare water to less polar liquids for evaporation rate, surface tension, and ability to dissolve certain substances. Students also discover that dissolving applies to solids, liquids, and gases.
Middle School Chemistry, Chapter 6: Chemical Change: Students explore the concept that chemical reactions involve the breaking of certain bonds between atoms in the reactants, and the rearrangement and rebonding of these atoms to make the products. Students also design tests to investigate how the amount of products and the rate of the reaction can be changed. Students will also explore endothermic and exothermic reactions. Students are using models to match what happens during a chemical change and mass is conserved.
Gumdrop Models: Students will design a model to explain the structure of an atom. This activity will allow for fast pacing for the gifted and talented students. Students will be given Data Cards to develop and modify models of molecules. Content will be differentiated Data Cards will begin with the construction of an atom. As students finish construction, they will draw the atom/molecule as a summative assessment.

Unit 3: Chemical Reactions

Instructional Days: 25

Appendix A: NGSS and Foundations for the Unit		
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. *[Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]* **(MS-PS1-5)**		
Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* *[Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]* **(MS-PS1-6)**		
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3).		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Develop a model to describe unobservable mechanisms. (MS-PS1-5) **Constructing Explanations and Designing Solutions** • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design	**PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-5) • The total number of each type of	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5) • The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6) -

criteria and constraints. (MS-PS1-6) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)	atom is conserved, and thus the mass does not change. (MS-PS1-5) • Some chemical reactions release energy, others store energy. (MS-PS1-6) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (*secondary to MS-PS1-6*) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful	**Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

	information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (*secondary to MS-PS1-6*) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary to MS-PS1-6) • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)	

Unit 3: Chemical Reactions

Instructional Days: 25

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-3) **RST.6-8.1** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6) **RST.6-8.3** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-5) **RST.6-8.7** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-3) **RST.6-8.9** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6) (MS-ETS1-3) **WHST.6-8.7** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-5) **6.RP.A.3**	Reason abstractly and quantitatively. (MS-PS1-5) (MS-ETS1-3) **MP.2** Model with mathematics. (MS-PS1-5) **MP.4** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-3) **7.EE.3**

Unit 3: Chemical Reactions

Instructional Days: 25

Common Vocabulary	

Curriculum: Grade 7

Unit 4: Structure and Function

Instructional Days: 15

Unit Summary
How do cells contribute to the functioning of an organism?   Students demonstrate age appropriate abilities to plan and carry out investigations to develop *evidence* that living organisms are made of cells. Students gather information to support explanations of the relationship between structure and function in cells. They are able to communicate an understanding of cell theory and understand that all organisms are made of cells. Students understand that special structures are responsible for particular functions in organisms. They then are able to use their understanding of cell theory to develop and use physical and conceptual models of cells. The crosscutting concepts of *scale, proportion, and quantity* and *structure and function* provide a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *planning and carrying out investigations*, *analyzing and interpreting data*, and *developing and using models*, Students are also expected to use these to use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.
Student Learning Objectives
Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. *[Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]* **(MS-LS1-1)**
Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. *[Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]* **(MS-LS1-2)**

Unit 4: Structure and Function

Instructional Days: 15

MS-LS1-1	Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells
MS-LS1-2	Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function
LS1.A	All living things are made up of cells, which is the smallest unit that can be said to be alive
LS1.B	Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction
LS1.C	Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth, or to release energy
LS1.D	Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain

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Quick Links		
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What it Looks Like in the Classroom p. 3	Prior Learning p. 5	Sample Open Education Resources p. 6
Connecting with ELA/Literacy and Math p. 4	Future Learning p. 5	Appendix A: NGSS and Foundations p. 7
Modifications p. 4		

Enduring Understandings
• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
Essential Questions
• What are the basic structures and functions of all living organisms? • How do organisms reproduce and grow? • How does energy flow through all living organisms? • How do living organisms process environmental stimuli?

Unit 4: Structure and Function

Instructional Days: 15

Unit Sequence	
Part A: How will astrobiologists know if they have found life elsewhere in the solar system?	
Concepts	**Formative Assessment**
• Distinguish between living and nonliving things. • Cells are the smallest unit of life that can be said to be alive. • All living things are made up of cells, either one cell or many different numbers and types of cells. • Organisms may consist of one single cell (unicellular). • Nonliving things can be composed of cells. • Organisms may consist of many different numbers and types of cells (multicellular). • Cells that can be observed at one scale may not be observable at another scale. • Engineering advances have led to important discoveries in the field of cell • biology, and scientific discoveries have led to the development of entire industries and engineered systems.	*Students who understand the concepts are able to:* • Conduct an investigation to produce data that provides evidence distinguishing between living and nonliving things. • Conduct an investigation to produce data supporting the concept that living things may be made of one cell or many and varied cells. • Distinguish between living and nonliving things. • Observe different types of cells that can be found in the makeup of living things.

Unit 4: Structure and Function

Instructional Days: 15

Unit Sequence	
Part B: How do the functions of cells support an entire organism?	
Concepts	**Formative Assessment**
• The cell functions as a whole system. • Identify parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall. • Within cells, special structures are responsible for particular functions. • Within cells, the cell membrane forms the boundary that controls what enters and leaves the cell. • Complex and microscopic structures and systems in cells can be visualized, modeled, and used to describe how the function of the cell depends on the relationships among its parts. • Complex natural structures/systems can be analyzed to determine how they function. • A model can be used to describe the function of a cell as a whole. • A model can be used to describe how parts of cells contribute to the cell's function. • The structures of the cell wall and cell membrane are related to their function.	*Students who understand the concepts are able to:* • Develop and use a model to describe the function of a cell as a whole. • Develop and use a model to describe how parts of cells contribute to the cell's function. • Develop and use models to describe the relationship between the structure and function of the cell wall and cell membrane.

Unit 4: Structure and Function

Instructional Days: 15

What It Looks Like in the Classroom
This unit of study begins with students distinguishing between living and nonliving things. Students will conduct investigations examining both living and nonliving things and using the data they collect as evidence for making this distinction. During this investigation, students will study living things that are made of cells, either one cell or many different numbers and types of cells. Students will also study nonliving things, some of which are made up of cells. Students will understand that life is a quality that distinguishes living things—composed of living cells—from once-living things that have died or things that never lived. Emphasis is on students beginning to understand the cell theory by developing evidence that living things are made of cells, distinguishing between living and nonliving things, and understanding that living things may be made of one cell or many and varied cells. Students will pose a question drawn from their investigations and draw on several sources to generate additional related, focused questions that allow for multiple avenues of exploration. They will conduct a short research project to collect evidence to develop and support their answers to the questions they generate. The report created from their research will integrate multimedia and visual displays of cells and specific cell parts into a presentation that will clarify the answers to their questions. Students will include in their reports variables representing two quantities, such as the number of cells that makes up an organism and units representing the size or type of the organism, and their conclusion about the relationship between these two variables. They will write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Students will analyze the relationship between the dependent and independent variables using graphs and tables and relate the graphs and tables to the equation. As a continuation of their study of the cell, students will study the structure of the cell. This study begins with thinking of the cell as a system that is made up of parts, each of which has a function that contributes to the overall function of the cell. Students will learn that within cells, special structures—such as the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall—are responsible for particular functions. It is important to remember that students are required only to study the functions of these organelles in terms of how they contribute to the overall function of the cell, not in terms of their biochemical functions. As part of their learning about the structure of the cell, students use models as a way of visualizing and representing structures that are microscopic. Students will develop and use a model to describe the function of the cell as a whole and the ways parts of the cell contribute to the cell's function. Models can be made of a variety of materials, including student-generated drawings,

digital representations, or 3-D structures.

Students will examine the structure and function relationship of the cell membrane and the cell wall. They will learn that the structure of the cell membrane makes it possible for it to form the boundary that controls what enters and leaves the cell. They will also learn that the structure of the cell wall makes it possible for it to serve its function. This study of the relationship between structure and function will be limited to the cell wall and cell membrane. Students will use variables to represent two quantities that describe some attribute of at least one structure of the cell—for example, how the surface area of a cell changes in relation to a change in the volume cell's volume. Students will write an equation to express the dependent variable in terms of the independent variable, and they will analyze the relationship between the dependent and independent variables using graphs and tables and relate these to the equation.

Throughout this unit, students will learn that some of the structures of the cell are visible when studied under certain magnification while others are and that engineering discoveries are making many new industries possible.

Unit 4: Structure and Function

Instructional Days: 15

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts • Conduct a short research project collecting evidence that living things are made of cells to answer a question (including a self-generated question). Draw on several sources and generate additional related, focused questions that allow for multiple avenues of exploration. • Integrate multimedia and visual displays of cells and specific cell parts into presentations to clarify information, strengthen claims and evidence, and add interest. *Mathematics* • Use variables to represent two quantities, such as the number of cells that makes up an organism and units representing the size or type of the organism, and determine the relationship between these two variables. • Write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. • Use variables to represent two quantities in a real-world problem that change in relationship to one another—for example, determining the ratio of a cell's surface area to its volume. Write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

Unit 4: Structure and Function

Instructional Days: 15

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: [All Standards, All Students](#)/[Case Studies](#) for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 4: Structure and Function

Instructional Days: 15

Research on Student Learning
Preliminary research indicates that it may be easier for students to understand that the cell is the basic unit of structure (which they can observe) than that the cell is the basic unit of function (which has to be inferred from experiments). Research also shows that high-school students may hold various misconceptions about cells after traditional instruction (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Future Learning
Life science • Systems of specialized cells within organisms help cells perform the essential functions of life. • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing the system to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system.

Unit 4: Structure and Function

Instructional Days: 15

Connections to Other Units
Grade 7 Unit 6: Inheritance and Variation of Traits • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. **Grade 7 Unit 8: Earth Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Unit 4: Structure and Function

Instructional Days: 15

Sample of Open Education Resources
Let's Talk Science: Seeding Argumentation About Cells and Growth: This is a sequence of lessons that have been developed to help middle school students learn and argue about the core concept of how a plant root grows at the cellular level. The first part of the sequence begins with a corn seed germination activity and the initial phase of teaching the students argumentation. The second part of the sequence consists of a microscope investigation to provide data upon which students will base their arguments explaining growth at the cellular level. In the third part of the sequence, students use their data to publicly make a claim, and provide evidence and reasoning to support their claims. This sequence unfolds over the course of three weeks.   Movement of Molecules Into or Out of Cells: Movement of Molecules Into and Out of Cells is one of a series of activities from "Scientific Argumentation in Biology: 30 Classroom Activities. Movement of Molecules engages students in planning and carrying out investigations, modeling, engaging in argument from evidence, and communication. After observing a figure of magnified red blood cells, and a figure of magnified red blood cells with sugar water added, students are presented with a question (Why do the red blood cells appear smaller) and three possible explanations. Based on their chosen explanation and a set of available materials, they design an experiment to test their claim. After engaging in an "Argumentation Session", they write an essay to support their explanation. Teachers are encouraged to refer to the preface, introduction, assessment samples, and appendix provided in the full book for important background on the practice of argumentation and resources for classroom implementation. The standards addressed in the lesson are also included in the teacher's notes.

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Unit 4: Structure and Function

Instructional Days: 15

Appendix A: NGSS and Foundations for the Unit		
Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. *[Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]* **(MS-LS1-1)**		
Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. *[Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]* **(MS-LS1-2)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations • Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1) **Developing and Using Models** • Develop a model to describe phenomena. (MS-LS1-2)	**LS1.A: Structure and Function** • All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1) • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2)	**Scale, Proportion, and Quantity** • Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1) **Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-

		LS1-2) - ***Connections to Engineering, Technology and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS1-1)

Unit 4: Structure and Function

Instructional Days: 15

English Language Arts	Mathematics
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1) **WHST.6-8.7** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS1-2) **SL.8.5**	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS1-1),(MS-LS1-2) **6.EE.C.9**

Common Vocabulary	
Organ	Internal cue
Cell	Invertebrate
Response	Muscular system
Circulatory system	Reproductive system
Elastic	Skeletal system
External	Subsystem
Function	Tolerance
Heart rate	Nutrient
Intellectual	Precision
	Tissue

Curriculum: Grade 7

Unit 5: Body Systems

Instructional Days: 15

Unit Summary
What are humans made of?   Students develop a basic understanding of the role of cells in body systems and how those systems work to support the life functions of the organism. Students will construct explanations for the interactions of systems in cells and organisms. Students understand that special structures are responsible for particular functions in organisms, and that for many organisms, the body is a system of multiple-interaction subsystems that form a hierarchy, from cells to the body. Students construct explanations for the interactions of systems in cells and organisms and for how organisms gather and use information from the environment. The crosscuttings concepts of *systems and system models* and *cause and effect* provide a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *engaging in argument from evidence* and *obtaining, evaluating, and communicating information*. Students use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.
Student Learning Objectives
Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. *[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]* [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]* **(MS-LS1-3)**
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. *[*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]* **(MS-LS1-8)**

Curriculum: Grade 7

Unit 5: Body Systems

Instructional Days: 15

MS-LS1-3	Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-LS1-8	Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories
LS1.A	All living things are made up of cells, which is the smallest unit that can be said to be alive
LS1.B	Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction
LS1.C	Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth, or to release energy
LS1.D	Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain

Curriculum: Grade 7

Unit 5: Body Systems

Instructional Days: 15

Quick Links		

Enduring Understandings
• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
Essential Questions
• What are the basic structures and functions of all living organisms? • How do organisms reproduce and grow? • How does energy flow through all living organisms? • How do living organisms process environmental stimuli?

Curriculum: Grade 7

Unit 5: Body Systems

Instructional Days: 15

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: What is the evidence that a body is actually a system of interacting subsystems composed of groups of interacting cells?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>In multicellular organisms, the body is a system of multiple, interacting subsystems.
Subsystems are groups of cells that work together to form tissues.
Organs are groups of tissues that work together to perform a particular body function.
Tissues and organs are specialized for particular body functions.
Systems may interact with other systems.
Systems may have subsystems and be part of larger complex systems.
Interactions are limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.
Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.</td><td>Students who understand the concepts are able to:
Use an oral and written argument supported by evidence to support or refute an explanation or a model of how the body is a system of interacting subsystems composed of groups of cells.</td></tr>
</table>

Unit 5: Body Systems

Instructional Days: 15

Unit Sequence	
Part B: *How do organisms receive and respond to information from their environment?*	
Concepts	**Formative Assessment**
• Sense receptors respond to different inputs (electromagnetic, mechanical, chemical). • Sense receptors transmit responses as signals that travel along nerve cells to the brain. • Signals are then processed in the brain. • Brain processing results in immediate behaviors or memories. • Cause-and-effect relationships may be used to predict response to stimuli in natural systems.	*Students who understand the concepts are able to:* • Gather, read, and synthesize information from multiple appropriate sources about sensory receptors' response to stimuli. • Assess the credibility, accuracy, and possible bias of each publication and methods used. • Describe how publications and methods used are supported or not supported by evidence.

Unit 5: Body Systems

Instructional Days: 15

What It Looks Like in the Classroom
Within this unit, students will use informational text and models to support their understanding that the body is a system of interacting subsystems. Instruction should begin with students understanding that the cell is a specialized structure that is a functioning system. Students will need to understand that different types of cells have different functions; therefore, each cell system is specialized to perform its particular function. Building on this understanding, students learn that different types of cells serve as subsystems for larger systems called tissues. Groups of specialized tissues serve as subsystems for organs that then serve as subsystems for body systems such as the circulatory, excretory, digestive, respiratory, muscular, and nervous systems. Students need to understand how each body system interacts with other body systems. Emphasis is on the conceptual understanding that each system and subsystem is specialized for particular body functions; it does not include the mechanisms of one body system independent of others. As part of their investigation of how body systems are interrelated, students should use variables to represent two quantities that describe how the inputs or outputs of one system change in relationship to another. They should write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable; analyze the relationship using graphs and tables; and relate these to the equation. For example, students can find the relationship between increased activity of the muscular system and the related increase in the activity of the circulatory or respiratory system and express this relationship as an equation. Students will demonstrate their understanding of this concept by writing an argument, supported by evidence, to support an explanation of how the body is a system of interacting subsystems. As part of their preparation for this written argument, students will read science resources and analyze the evidence used to support arguments in these resources. While gathering evidence, it is important that students connect to the nature of science by demonstrating scientific habits. They should be sure to display intellectual honesty by ensuring that whenever they cite specific textual information and quote or paraphrase the data and conclusions of others, they avoid plagiarism and provide basic bibliographic information for sources. Students will deepen their understanding of subsystems by gathering and synthesizing information about sensory receptors. Students will understand that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. Each sensory receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. Each response can be examined as a cause-and-effect relationship that can be used to predict response to stimuli in natural systems. Each step in the stimulus/response pathway can be connected to students' previous study of systems and subsystems. For example, the nervous system includes receptors that

are subsystems that respond to stimuli by sending messages to the brain.

Using multiple appropriate sources, students will read and synthesize information and will assess the credibility, accuracy, and possible bias of publications and methods used, and describe how the information they read is or is not supported by evidence. For example, students could participate in class discussions in which they can investigate whether information they have read in publications agree with scientific findings or seem to be biased in order to advertise a product or support a position.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

- Cite specific textual evidence to support analysis of science and technical texts that provide evidence for how the body is a system of interacting subsystems composed of cells.
- Trace and evaluate a text's argument that the body is a system of interacting subsystems composed of cells, distinguishing claims that are supported by reasons and evidence from claims that are not.
- Write arguments, supported by evidence, for how the body is a system of interacting subsystems composed of groups of cells.
- Gather relevant information concerning how sensory receptors function by responding to stimuli, then sending messages to the brain, which responds immediately through some form or behavior or by storing the messages as memory. Quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.

Mathematics

- N/A

Unit 5: Body Systems

Instructional Days: 15

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 5: Body Systems

Instructional Days: 15

Research on Student Learning
Preliminary research indicates that it may be easier for students to understand that the cell is the basic unit of structure (which they can observe) than that the cell is the basic unit of function (which has to be inferred from experiments). Research also shows that high-school students may hold various misconceptions about cells after traditional instruction (NSDL, 2015).

Prior Learning

By the end of Grade 5, students understand that:

- Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Future Learning

Life science

- Systems of specialized cells within organisms help the organisms perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing the living systems to remain alive and functional even as external conditions change, within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system.

Unit 5: Body Systems

Instructional Days: 15

Connections to Other Units
Grade 7 Unit 4: Structure and Function • All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. **Grade 7 Unit 6: Inheritance and Variation of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

Unit 5: Body Systems

Instructional Days: 15

Sample of Open Education Resources
NOVA body + brain: This link will take you to NOVA's homepage for journal articles, videos, and interactives that can be used to teach the body. Animal Communications: All animal species have some capacity for communication but communication abilities range from very simple to extremely complex, depending upon the species. Communication is influenced by a species' genetic makeup, its environment, and the numerous ways by which animals and humans respond to and adapt to their surroundings.

Unit 5: Body Systems

Instructional Days: 15

Appendix A: NGSS and Foundations for the Unit		
Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. *[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]* [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]* **(MS-LS1-3)**		
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. *[*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]* **(MS-LS1-8)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS1-8) **Engaging in Argument from Evidence** • Use an oral and written argument supported by evidence to support or	**LS1.A: Structure and Function** • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3) **LS1.D: Information Processing** • Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along	**Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3) **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8) - ***Connections to Nature of***

refute an explanation or a model for a phenomenon. (MS-LS1-3)	nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8)	***Science*** **Science is a Human Endeavor** • Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (MS-LS1-3)

Unit 5: Body Systems

Instructional Days: 15

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-3) **RST.6-8.1** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.(MS-LS1-3) **RI.6.8** Write arguments focused on discipline content. (MS-LS1-3) **WHST.6-8.1** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.(MS-LS1-8) **WHST.6-8.8**	**N/A**

Unit 5: Body Systems

Instructional Days: 15

Common Vocabulary	
Organ	Internal cue
Cell	Invertebrate
Response	Muscular system
Circulatory system	Reproductive system
Elastic	Skeletal system
External	Subsystem
Function	Tolerance
Heart rate	Nutrient
Intellectual	Precision
	Tissue

Curriculum: Grade 7

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Unit Summary
Why do kids look similar to their parents?
Students develop and use models to describe how gene mutations and sexual reproduction contribute to genetic variation. Students understand how genetic factors determine the growth of an individual organism. They also demonstrate understanding of the genetic implications of sexual and asexual reproduction. The crosscutting concepts of *cause and effect* and *structure and function* provide a framework for understanding how gene structure determines differences in the functioning of organisms. Students are expected to demonstrate proficiency in *developing and using models*. Students use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.
Student Learning Objectives
Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. *[Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]* **(MS-LS3-1)**
Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. *[Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]* **(MS-LS3-2)**

Curriculum: Grade 7

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

MS-LS3-1	Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism
MS-LS3-2	Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation
LS1.B	Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring
LS3.A	Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes.
LS3.B	Each parent contributes half of the genes acquired by the offpsring

Curriculum: Grade 7

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Quick Links		

Enduring Understandings
• Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.
Essential Questions
• How do organisms grow and develop? • How are traits inherited? • Why is there variation between organisms?

Curriculum: Grade 7

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Unit Sequence	
Part A: *How do structural changes to genes (mutations) located on chromosomes affect proteins or affect the structure and function of an organism?*	
Concepts	**Formative Assessment**
• Complex and microscopic structures and systems, such as genes located on chromosomes, can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among the parts of the system; therefore, complex natural structures/systems can be analyzed to determine how they function. • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. • Each distinct gene chiefly controls the production of specific proteins, which in turn affect the traits of the individual. • In addition to variations that arise from sexual reproduction, genetic information can be altered due to mutations. • Some changes to genetic material are beneficial, others harmful, and some neutral to the organism. • Changes in genetic material may result in the production of different proteins. • Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of	*Students who understand the concepts are able to:* • Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

the organism and thereby change traits. • Structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism • Though rare, mutations may result in changes to the structure and function of proteins.	

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Unit Sequence	
Part B: *How do asexual reproduction and sexual reproduction affect the genetic variation of offspring?*	
Concepts	**Formative Assessment**
• Organisms reproduce either sexually or asexually and transfer their genetic information to their offspring. • Asexual reproduction results in offspring with identical genetic information. • Sexual reproduction results in offspring with genetic variation. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. • Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. • Punnett squares, diagrams, and simulations can be used to describe the cause-and-effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.	*Students who understand the concepts are able to:* • Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information. • Develop and use a model to describe why sexual reproduction results in offspring with genetic variation. • Use models such as Punnett squares, diagrams, and simulations to describe the cause-and effect-relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

What It Looks Like in the Classroom
Using models, such as electronic simulations, physical models, or drawings, students will learn that genes are located in the chromosomes of cells and each chromosome pair contains two variants of each gene. Students will need to make distinctions between chromosomes and genes and understand the connections between them. DNA will be introduced in high school. Students will learn that chromosomes are the genetic material that is found in the nucleus of the cell and that chromosomes are made up of genes. They will also learn that each gene chiefly controls the production of specific proteins, which in turn affect the traits of the individual. Students should be given opportunities to use student-developed conceptual models to visualize how a mutation of genetic material could have positive, negative, or neutral impact on the expression of traits in organisms. Emphasis in this unit is on conceptual understanding that mutations of the genetic material may result in making different proteins; therefore, models and activities that focus on the expression of genetic traits, rather than on the molecular-level mechanisms for protein synthesis or specific types of mutations, are important for this unit of study. For example, models that assign genetic information to specific segments of model chromosomes could be used. Students could add, remove, or exchange genes located on the chromosomes and see that changing or altering a gene can result in a change in gene expression (proteins and therefore traits). Students will continue this unit of study by describing two of the most common sources of genetic variation, sexual and asexual reproduction. Students will be able to show that in sexual reproduction, each parent contributes half of the genes acquired by offspring, whereas in asexual reproduction, a single parent contributes the genetic makeup of offspring. Using models such as Punnett squares, diagrams, and simulations, students will describe the cause-and-effect relationship between gene transmission from parents(s) to offspring and the resulting genetic variation. Using symbols to represent the two alleles of a gene, one acquired from each parent, students can use Punnett squares to model how sexual reproduction results in offspring that may or may not have a genetic makeup that is different from either parent. Students can observe the same mixing of genetic information using colored counters or electronic simulations. Using other models, students can show that asexual reproduction results in offspring with the same combination of genetic information as the parents. Students can summarize the numerical data they collect during these activities as part of their description of why asexual reproduction results in offspring with identical genetic combinations and sexual reproduction results in offspring with genetic variations. As a culmination of this unit of study, students could make multimedia presentations to demonstrate their understanding of the key concepts. Students could participate in a short research project and cite the specific textual evidence used to support the analysis of any scientific information they gather. They could integrate quantitative or technical information

as part of their presentation. For example, students can take data collected during investigations of genetic mutations and provide a narrative description of their results. They could use data collected during their investigation of sexual and asexual reproduction. They could also include diagrams, graphs, or tables to clarify their data.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

- Cite specific textual evidence to support analysis of science and technical texts about structural changes to genes (mutations) located on chromosomes that may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
- Determine the meaning of symbols, key terms, and other domain-specific phrases as they are used to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
- Integrate quantitative or technical information about why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism that is expressed in words with a version of that information expressed visually in a flowchart, diagram, model, graph, or table.
- Include multimedia components and visual displays in presentations about structural changes to genes (mutations) located on chromosomes that may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism to clarify claims and findings and emphasize salient points.
- Cite specific textual evidence for why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation to support analysis of science and technical texts.
- Determine the meaning of symbols, key terms, and other domain-specific phrases as they are used to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- Integrate quantitative or technical information that describes why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation that is expressed in words with a version of that information that is expressed visually in a flowchart, diagram, model, graph, or table.

- Include multimedia components and visual displays in presentations that describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation to clarify claims and findings and emphasize salient points.

Mathematics

- Use mathematics to model why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- Summarize numerical data sets that describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation in relation to their context.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: [All Standards, All Students]/[Case Studies] for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.

- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning
When asked to explain how physical traits are passed from parents to offspring, elementary-school, middle-school, and some high-school students express the following misconceptions: Some students believe that traits are inherited from only one of the parents (for example, the traits are inherited from the mother, because she gives birth or has most contact as children grow up; or the same-sex parent will be the determiner). Other students believe that certain characteristics are always inherited from the mother and others come from the father. Some students believe in a "blending of characteristics." It may not be until the end of 5th grade that some students can use arguments based on chance to predict the outcome of inherited characteristics of offspring from observing those characteristics in the parents. Early middle-school students explain inheritance only in observable features, but upper middle-school and high-school students have some understanding that characteristics are determined by a particular genetic entity which carries information translatable by the cell. Students of all ages believe that some environmentally produced characteristics can be inherited, especially over several generations. By the end of 5th grade, students know that babies result from the fusion of sperm and eggs. However, they often don't understand how the fusion brings new life. Before students have an early understanding of genetics, they may believe that the baby exists in the sperm but requires the egg for food and protection, or that the baby exists in the egg and requires the sperm as trigger to growth (NSDL, 2015).

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Prior Learning
By the end of Grade 5, students understand that: • Many characteristics of organisms are inherited from parents. • Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. • Different organisms vary in how they look and function because they have different inherited information. • The environment also affects the traits that an organism develops.

Future Learning
Life science • Systems of specialized cells within organisms help the organisms perform the essential functions of life. • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. • Feedback mechanisms maintain a living system's internal conditions, within certain limits, and mediate behaviors, allowing the system to remain alive and functional even as external conditions change, within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system. • In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. • Each chromosome consists of a single, very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have

the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have, as yet, no known function.

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Connections to Other Units
Grade 6 Unit 1: Growth, Development and Reproduction of Organisms • Animals engage in characteristic behaviors that increase the odds of reproduction. • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. • Genetic factors as well as local conditions affect the growth of the adult plant. **Grade 7 Unit 4: Structure and Function** • All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. **Grade 8 Unit 2: Selection and Adaptation** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others. • In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Sample of Open Education Resources
Meiosis: How Does the Process of Meiosis Reduce the Number of Chromosomes in Reproductive Cells? This lab activity introduces students to the process of meiosis at the chromosomal level. The guiding question for the investigation is: How does the process of meiosis reduce the number of chromosomes in reproductive cells? Students develop an explanatory model based on their knowledge of mitosis and how cells divide. Students are provided with pictures showing various stages of meiosis. Students sequence the pictures and provide a description of what they think may be going on during each stage. The book provides a link (www.nsta.org/publications/press/extras/argument.aspx) to download images of meiosis (sequencing activity). Students use pop bead chromosomes (provided by the teacher) to create a valid model that explains : what happens to the chromosomes inside a cell as it goes through meiosis, why reproductive cells have half the number of chromosomes of the individuals who produce them, and why there are no pairs of chromosomes in reproductive cells. When students have finished the model, and after they have collected and analyzed the data, they develop an initial argument. They prepare a whiteboard presentation that includes the guiding question, claim, evidence, and justification of evidence and present it to the whole-class using a round-robin format. After collecting feedback, students return to their original small groups for editing and revising before writing a final report. Each lab ends with a list of checkout questions. The book includes an option to extend the lesson by asking students to complete a double-blind peer review of the argument using a rubric provided in the appendix. To provide additional support, four appendixes are included: standards alignment matrixes, options for implementing argument-driven inquiry lab investigations, investigation proposal options, and peer-review guide and instructor scoring rubric. A detailed step-by-step guide that explains the argument-driven inquiry is included for teachers not familiar with the model. Pedigrees and the Inheritance of Lactose Intolerance: In this activity students analyze a family's pedigrees to make a claim based on evidence about mode of inheritance of a lactose intolerance trait, determine the most likely inheritance pattern of a trait, and analyze variations in DNA to make a claim about which variants are associated with specific traits. This activity serves as a supplement to the film Got Lactose? The Co-evolution of Genes and Culture (http://www.hhmi.org/biointeractive/making-fittest-got-lactase-co-evolution-genes-and-culture). The film shows a scientist as he tracks down the genetic changes associated with the ability to digest lactose as adults. A detailed teacher's guide that includes curriculum connections, teaching tips, time requirements, answer key and a student guide can be downloaded at http://www.hhmi.org/biointeractive/pedigrees-and-inheritance-lactose-intolerance. Six supporting resource and two "click and learn" activities are also found on the link. How do Siamese Cats Get Their Color? This resource is an article from the January 2016 issue of The Science Teacher. The unit focuses on an essential question: How do Siamese cats develop their coloration? Students develop explanations by

making connections among genes, proteins, and traits. The unit is designed to be implemented over six or seven instructional days. However, each activity can be used as a stand-alone instructional strategy. During the instructional cycle, students develop an initial model to explain how Siamese cats get their coat coloration, learn about enzyme structure and function, use a computer model to see how proteins interact, experiment with Jell-O to see enzymes in action, learn about molecular motor proteins to see how structure relates to function, revise their model of coat coloration, and experiment with precursors of melanin to see how proteins can lead to observable traits. The unit is designed to help teachers extend the central dogma concept beyond the idea that proteins are the final products in the process. The unit provides opportunities for students to develop a conceptual understanding that proteins are important in cellular functions as well as trait-producing mechanisms. The article includes a teacher guide which describes how each activity is aligned to the Next Generation Science Standards. Unit handouts for students and the teacher guide are found on the NSTA website at www.nsta.org/highschool/connections.aspx.

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Appendix A: NGSS and Foundations for the Unit		
Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. *[Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]* **(MS-LS3-1)**		
Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. *[Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]* **(MS-LS3-2)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2)	**LS1.B: Growth and Development of Organisms** • Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)* **LS3.A: Inheritance of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1) **Cause and Effect** • Cause and effect relationships may

	proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2) **LS3.B: Variation of Traits** • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2) • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins.	be used to predict phenomena in natural systems. (MS-LS3-2)

	Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)	

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-LS3-1),(MS-LS3-2) **RST.6-8.1** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. (MS-LS3-1),(MS-LS3-2) **RST.6-8.4** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1),(MS-LS3-2) **RST.6-8.7** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS3-1),(MS-LS3-2) **SL.8.5**	Model with mathematics. (MS-LS3-2) **MP.4** Summarize numerical data sets in relation to their context. (MS-LS3-2) **6.SP.B.5**

Unit 6: Inheritance and Variation of Traits

Instructional Days: 20

Common Vocabulary	
Cell	Chromosome
Development	Formation
Instruction	Gene
Recognizable	Genetic
Version	Variation
Allele	Molecule
Contribute	Protein
Hereditary information	Sexual reproduction
Identical	Structural
Punnett square	Subset
Random	Chromosome pair
Transmission	DNA
Asexual reproduction	

Curriculum: Grade 7

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

Unit Summary
How do some organisms turn electromagnetic radiation into matter and energy?   Students provide a mechanistic account for how cells provide a structure for the plant process of photosynthesis in the movement of matter and energy needed for the cell. Students use conceptual and physical models to explain the transfer of energy and cycling of matter as they construct explanations for the role of photosynthesis in cycling matter in ecosystems. They construct scientific explanations for the cycling of matter in organisms and the interactions of organisms to obtain matter and energy from an ecosystem to survive and grow. They understand that sustaining life requires substantial energy and matter inputs, and that the structure and functions of organisms contribute to the capture, transformation, transport, release, and elimination of matter and energy. The crosscutting concepts of *matter and energy* and *structure and function* provide a framework for understanding of the cycling of matter and energy flow into and out of organisms. Students are also expected to demonstrate proficiency in *developing and using models*. Students use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.
Student Learning Objectives
Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. *[Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]* **(MS-LS1-6)**
Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism*.* *[Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]* **(MS-LS1-7)**

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

MS-LS1-6	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms
MS-LS1-7	Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism
LS1.A	All living things are made up of cells, which is the smallest unit that can be said to be alive
LS1.B	Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction
LS1.C	Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth, or to release energy
LS1.D	Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain

Curriculum: Grade 7

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

Quick Links		

Enduring Understandings
• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
Essential Questions
• What are the basic structures and functions of all living organisms? • How do organisms reproduce and grow? • How does energy flow through all living organisms? • How do living organisms process environmental stimuli?

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Unit 7: Organizations for Matter and Energy Flow in Organisms

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: What is the role of photosynthesis in the cycling of matter and flow of energy into and out of an organism?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>Photosynthesis has a role in the cycling of matter and flow of energy into and out of organisms.
The flow of energy and cycling of matter can be traced.
The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon based organic molecules and release oxygen.
Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen.
Sugars produced by plants can be used immediately or stored for growth or later use.
Within a natural system, the transfer of energy drives the motion and/or cycling of matter.</td><td>Students who understand the concepts are able to:
Construct a scientific explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms based on valid and reliable evidence obtained from sources (including the students' own experiments).
Construct a scientific explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms based on the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td></tr>
</table>

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: How is food rearranged through chemical reactions to form new molecules that support growth and/or release energy as this matter moves through an organism?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>
Food is rearranged through chemical reactions, forming new molecules that support growth.
Food is rearranged through chemical reactions, forming new molecules that release energy as this matter moves through an organism.
Molecules are broken apart and put back together to form new substances, and in this process, energy is released.
Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy.
In cellular respiration, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth or to release energy.
Matter is conserved during cellular respiration because atoms are conserved in physical and chemical processes.
</td><td>Students who understand the concepts are able to:
Develop and use a model to describe how food is rearranged through chemical reactions.
</td></tr>
</table>

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

What It Looks Like in the Classroom
Students will construct explanations about the role of photosynthesis using evidence obtained from sources, including the students' own experiments or outside sources. Student-constructed informative/explanatory responses will cite specific textual evidence, determine the central ideas to support their analysis, and provide an accurate summary distinct from their own prior knowledge or opinions. Some experiments could include observing elodea releasing oxygen, depriving a plant of sunlight or water, or using glucose test strips. In this unit of study, emphasis is on the transfer of energy that drives the motion and/or cycling of matter. Students can represent the matter and energy involved in the process of photosynthesis using the equation for this reaction. Using this equation, students can build ball-and-stick models to show how carbon dioxide and water are rearranged to form glucose. Students can also draw conclusions about the cycling of matter and the flow of energy by observing plants such as elodea. By contrasting elodea plants in a variety of controlled environments, students can draw conclusions about how carbon dioxide and oxygen enter and leave organisms. Students could also perform investigations where the input of light energy is manipulated. In these investigations, students can observe that even if the matter required for photosynthesis is present, the process will not proceed if light energy is not available. If light is available, students will be able to test the leaves of certain plants for the presence of stored sugar in the form of starch. If light is not available, students will observe that the sugars are not stored as starch in the leaves. This will emphasize that the transfer of light energy drives the cycling of matter into chemical energy. Students can also trace the flow of energy using models such as energy pyramids. Using the data collected during their investigations and observations of simulations, students construct an explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. They could participate in s short research project in which they will use textual evidence to support their analysis. As part of their research, students will provide an accurate summary of the text they use and determine the central ideas or conclusions of the text. They can they write informative or explanatory texts to explain the process. As a result of their research, students should be able to observe that the information they gather through research supports their scientific observations. They could then make predictions about the impact of different environmental changes on the cycling of matter and flow of energy. For example, students could make predictions about the impact that volcanic eruptions that produce massive clouds of sunlight-blocking ash that linger long periods of time could have on life in the affected area. Student learning will progress to developing and using models to describe how food is rearranged through chemical reactions.

Unit 7: Organizations for Matter and Energy Flow in Organisms

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These reactions form new molecules that support growth and/or release energy as the matter moves through an organism. Students can integrate multimedia and visual displays into models to clarify information, strengthen claims and evidence, and add interest. Emphasis is on describing that molecules are broken apart and reassembled and that in this process, energy is released. Student models will demonstrate that matter is conserved in cell respiration. Models can be created using materials similar to those used in students' photosynthesis models, thereby emphasizing the complementary nature of photosynthesis and cellular respiration. Students can also act out the roles of variables within the chemical-reaction rearrangement to deepen their understanding.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

- Cite specific textual evidence to support analysis of science and technical texts about the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- Determine the central ideas about the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinion.
- Write informative/explanatory texts to examine the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms, and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Draw evidence from informational texts to support analysis, reflection, and research about the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- Integrate multimedia and visual displays into presentations about how food is rearranged through chemical reactions to form new molecules that support growth and/or release energy as the matter moves through an organism to clarify information, strengthen claims and evidence, and add interest.

Mathematics

- Use variables to represent two quantities involved in the process whereby photosynthesis plays a part in the cycling of matter and energy into and out of organisms. Write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

Unit 7: Organizations for Matter and Energy Flow in Organisms

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

Research on Student Learning
Students of all ages see food as substances (water, air, minerals, etc.) that organisms take directly in from their environment. In addition, some students of all ages think food is a requirement for growth, rather than a source of matter for growth. They have little knowledge about food being transformed and made part of a growing organism's body. Some students of all ages hold misconceptions about plant nutrition. They think plants get their food from the environment rather than manufacturing it internally, and that food for plants is taken in from the outside. These misconceptions are particularly resistant to change. Even after traditional instruction, students have difficulty accepting that plants make food from water and air, and that this is their only source of food. Understanding that the food made by plants is very different from other nutrients such as water or minerals is a prerequisite for understanding the distinction between plants as producers and animals as consumers (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). • Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. • The food of almost any kind of animal can be traced back to plants. • Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. • Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. • Organisms can survive only in environments in which their particular needs are met. • A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life.

- Newly introduced species can damage the balance of an ecosystem.
- Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die.
- Organisms obtain gases and water from the environment and release waste matter (gas, liquid, or solid) back into the environment.

Future Learning
Physical science • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. *Life science* • The process of photosynthesis converts light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. • The sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. • Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds that can transport energy to muscles are formed.

Unit 7: Organizations for Matter and Energy Flow in Organisms

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- Cellular respiration releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web.
- At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web.
- Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded.
- The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways.
- At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

Earth and space science

- The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space.
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

Curriculum: Grade 7

Unit 7: Organizations for Matter and Energy Flow in Organisms

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Connections to Other Units
Grade 7 Unit 3: Chemical Reactions • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. **Grade 7 Unit 4: Structure and Function** • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. **Grade 7 Unit 8: Earth Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Sample of Open Education Resources
Plant Growth and Gas Exchange Unit: This model unit from Michigan State University includes 11 lessons that guide students through the process of collecting evidence and developing explanations of where the dry matter of plants comes from and of the roles of photosynthesis and respiration in the carbon cycle. Along with the focus on building explanations of these core ideas, the unit explicitly integrates the crosscutting concepts of matter and energy and scale, proportion, and quantity. This unit is built around the question of how small seeds grow into large plants, and the core activities of the unit guide students in tracing the mass changes that occur as seeds germinate and grow. These core activities are supported through a carefully planned sequence of learning and assessment activities that follow a research-based learning progression to support the development of student understanding.

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

Appendix A: NGSS and Foundations for the Unit		
Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. *[Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]* (**MS-LS1-6**)		
Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. *[Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]* (**MS-LS1-7**)		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-6) **Developing and Using Models** • Use a model based on evidence to illustrate the relationships between systems or between components of a	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) • Within individual organisms, food moves through a series of chemical reactions in which it is broken down	**Energy and Matter** • Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6) • Matter is conserved because atoms are conserved in physical and chemical processes. (MS-LS1-7) - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based upon

system. (HS-LS1-7)	and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7) **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6) • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)	logical connections between evidence and explanations. (MS-LS1-6)

Curriculum: Grade 7

Unit 7: Organizations for Matter and Energy Flow in Organisms

Instructional Days: 15

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-6) **RST.6-8.1** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-LS1-6) **RST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-6) **WHST.6-8.2** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-6) **WHST.6-8.9**	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS1-6) **6.EE.C.9**

Common Vocabulary	
Breed	Plumage
Diverse	Reproductive system
Transfer	Soil fertility
Development	Vocalization
Attract	Fertilizer
Characteristics of life	Genetic
Germination	Specialized
Plant structure	

Curriculum: Grade 7

Unit 8: Earth Systems

Instructional Days: 30

Unit Summary
If no one was there, how do we know the Earth's history? ***What provides the forces that drive Earth's systems?*** Students examine geoscience data in order to understand processes and events in Earth's history. Important crosscutting concepts in this unit are *scale, proportion, and quantity*, *stability and change*, and *patterns* in relation to the different ways geologic processes operate over geologic time. An important aspect of the history of Earth is that geologic events and conditions have affected the evolution of life, but different life forms have also played important roles in altering Earth's systems. Students understand how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. Students investigate the controlling properties of important materials and construct explanations based on the analysis of real geoscience data. Students are expected to demonstrate proficiency in *analyzing and interpreting* data and *constructing explanations*. They are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives
Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. *[Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.]* [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.*]* **(MS-ESS1-4)**
Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. *[Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.]* [Assessment Boundary: Assessment does not include the identification and naming of minerals.*]* **(MS-ESS2-1)**
Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. *[Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides*

or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] **(MS-ESS2-2)**
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. *[Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [*Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.*]* **(MS-ESS2-3)**

MS-ESS1-4	Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history
MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS2-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales
MS-ESS2-3	Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
ESS2.A	All Earth processes are the result of energy flowing and matter cycling within and among the planets systems
ESS2.C	Water continually cycles among land, ocean and the atmosphere
ESS2.D	Because these patterns are so complex, weather can only be predicted probabilistically

Curriculum: Grade 7

Unit 8: Earth Systems

Instructional Days: 30

Quick Links		

Enduring Understandings
• Some natural disasters are predictable while others are not • Natural disasters are driven by interior processes, surface processes, and/or severe weather events • Human activity impacts ecosystems • The relationship between human population and the impact on natural resources
Essential Questions
• What are resources? • Why do natural disasters occur? • How do humans impact the environment? • What affects climate change?

Unit 8: Earth Systems

Instructional Days: 30

Unit Sequence	
Part A: *How do we know that the Earth is approximately 4.6-billion-year-old history?*	
Concepts	**Formative Assessment**
• The geologic time scale is used to organize Earth's 4.6-billion-year-old history. • Rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. • Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.	*Students who understand the concepts are able to:* • Construct a scientific explanation based on valid and reliable evidence from rock strata obtained from sources (including the students' own experiments). • Construct a scientific explanation based on rock strata and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Unit 8: Earth Systems

Instructional Days: 30

Unit Sequence	
Part B: *What drives the cycling of Earth's materials?*	
Concepts	**Formative Assessment**
• Energy drives the process that results in the cycling of Earth's materials. • The processes of melting, crystallization, weathering, deformation, and sedimentation act together to form minerals and rocks through the cycling of Earth's materials. • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. • Energy flowing and matter cycling within and among the planet's systems derive from the sun and Earth's hot interior. • Energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • Explanations of stability and change in Earth's natural systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.	*Students who understand the concepts are able to:* • Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

Unit 8: Earth Systems

Instructional Days: 30

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: Do all of the changes to Earth systems occur in similar time scales?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>

Geoscience processes have changed Earth’s surface at varying time and spatial scales.
Processes change Earth’s surface at time and spatial scales that can be large or small; many geoscience processes usually behave gradually but are punctuated by catastrophic events.
Geoscience processes shape local geographic features.
The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years.
Interactions among Earth’s systems have shaped Earth’s history and will determine its future.
Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations.
Time, space, and energy phenomena within Earth’s systems can be observed at various scales using models to study systems that are too large or too small.

</td><td>
Students who understand the concepts are able to:

Construct a scientific explanation for how geoscience processes have changed Earth’s surface at varying time and spatial scales based on valid and reliable evidence obtained from sources (including the students’ own experiments).
Construct a scientific explanation for how geoscience processes have changed Earth’s surface at varying time and spatial scales based on the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
Collect evidence about processes that change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges).
Collect evidence about processes that change Earth’s surface at time and spatial scales that can be small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events.

</td></tr>
</table>

Unit 8: Earth Systems

Instructional Days: 30

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part D: How is it possible for the same kind of fossils to be found in New Jersey and in Africa?</td></tr>
<tr><th>Concepts</th><th>Formative Assessment</th></tr>
<tr><td>• Tectonic processes continually generate new sea floor at ridges and destroy old sea floor at trenches.
• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.
• Patterns in rates of change and other numerical relationships can provide information about past plate motions.
• The distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of past plate motions.
• Similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches) provide evidence of past plate motions.</td><td>Students who understand the concepts are able to:
• • Analyze and interpret data such as distributions of fossils and rocks, continental shapes, and sea floor structures to provide evidence of past plate motions.
• Analyze how science findings have been revised and/or reinterpreted based on new evidence about past plate motions.</td></tr>
</table>

Unit 8: Earth Systems

Instructional Days: 30

What It Looks Like in the Classroom
Within this unit, students will use the geologic time scale to organize Earth's 4.6-billion-year-old history. They will cite specific textual evidence from science and technical texts to support analysis of rock strata to show how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. They will use analysis of rock formations and the fossils they contain to establish relative ages of major events in Earth's history. Examples of Earth's major events could include the Ice Age or the earliest fossils of Homo sapiens, or the formation of Earth and the earliest evidence of life. Emphasis should be on analyses of rock strata providing only relative dates, not an absolute scale. Students can use variables to represent numbers or quantities and write expressions when solving problems while constructing their explanations. Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions. *[Note: Assessment does not include recalling the names of specific periods or epochs and events within them.]* Students will develop and use models to describe the cycling of Earth materials and the flow of energy that drives this process. This energy comes from the heat of the core of the Earth, which is transferred to the mantle. Convection currents within the mantle then drive the movement of tectonic plates. Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials. Students can generate models to demonstrate the rock cycle, with specific focus on the processes causing change. Students can analyze pictures and rock samples that demonstrate various processes of melting, crystallization, weathering, deformation, and sedimentation. *[Note: Students are not identifying and naming minerals within this unit].* Students will construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions). Further emphasis is on how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Students can gather data and plot volcanoes and earthquakes in order to collect evidence to support the idea that these interactions among Earth's systems have shaped Earth's history and will determine its future. Additional examples can include changes on Earth's surface from weathering and deposition by the movements of water, ice, and wind. Emphasis is also on geoscience processes that shape local geographic features, such as New Jersey's Ridge and Valley Province, Highlands, Piedmont, and Coastal Plain. Students convey ideas, concepts, and information through the selection, organization, and analysis of relevant content, and they may use multimedia components and visual displays. Students can also compare and contrast the information gained from experiments, simulations, video, or multimedia sources showing evidence of past plate motion with that gained by reading

a text on the same topic. They use informative/explanatory texts to examine evidence for how geoscience processes have changed and reason abstractly and quantitatively when analyzing this evidence. They may integrate quantitative or technical information expressed in a flowchart, diagram, model, graph, or table. They can also use variables to represent numbers or quantities and write expressions when solving problems while constructing their explanations. Students will analyze and interpret data on the distribution of fossils and rocks, and they will look at the continental shapes and sea floor structures to provide evidence of past plate motions. Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. Examples of the data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches). Students may use numerical relationships, symbols, and words while analyzing patterns in rates of change on Earth's crust. Students can use variables to represent numerical data and write expressions or construct simple equations and inequalities when solving a problems involved in the analysis of data about past plate motions. Applying interpreted data on the distribution of fossils and rocks, continental shapes, and sea floor structures, students can provide evidence of past plate motions. *[Note: Students are not analyzing paleomagnetic anomalies in oceanic and continental crust in this unit]*.

Unit 8: Earth Systems

Instructional Days: 30

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts • Cite specific textual evidence based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history to support analysis of science and technical texts. • Write informative/explanatory texts to examine evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6 billion-year-old history and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. • Cite specific textual evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales to support analysis of science and technical texts. • Use informative/explanatory texts to examine evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. • Include multimedia components and visual displays in presentations about evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales to clarify claims and findings and emphasize salient points. • Cite specific textual evidence of past plate motion to support analysis of science texts. • Integrate quantitative or technical information about evidence of past plate motions expressed in words in a text with a version of that information expressed in a flowchart, diagram, model, graph, or table. • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources showing evidence of past plate motion with that gained from reading a text on the same topic. *Mathematics* • Use variables to represent numbers and write expressions when solving problems while constructing explanations from evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history; understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specific set. • Use variables to represent quantities in a real-world or mathematical problem when solving problems while constructing

explanations from evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

- Reason abstractly and quantitatively when analyzing evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- Use variables to represent numbers and write expressions when solving a real-world or mathematical problem involving evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.
- Use variables to represent quantities in a real-world or mathematical problem involving evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
- Use numbers, symbols, and words while analyzing and interpreting data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of past plate motions.
- Use variables to represent numerical data and write expressions when solving a problems involved in the analysis of data about past plate motions. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.
- Use variables to represent quantities when analyzing data about past plate motions and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Unit 8: Earth Systems

Instructional Days: 30

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Unit 8: Earth Systems

Instructional Days: 30

Research on Student Learning
Students of all ages may hold the view that the world was always as it is now, or that any changes that have occurred must have been sudden and comprehensive. The students in these studies did not, however, have any formal instruction on the topics investigated. Moreover, students taught by traditional means are not able to construct coherent explanations about the causes of volcanoes and earthquakes. Few students understand the molecular basis of heat conduction even after instruction. For example, students attribute to particles properties such as "hotness" and "coldness" or believe that heat is produced by particles rubbing against each other. During instruction, students use ideas that give heat an active drive or intent to explain observations of convection currents. They also draw parallels between evaporation and the water cycle and convection, sometimes explicitly explaining the upwards motion of convection currents as evaporation. Students rarely think energy is measurable and quantifiable. Students' alternative conceptualizations of energy influence their interpretations of textbook representations of energy. Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen. The idea of energy conservation seems counterintuitive to middle- and high-school students who hold on to the everyday use of the term energy, but teaching heat dissipation ideas at the same time as energy conservation ideas may help alleviate this difficulty. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle- and high-school students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted). Although teaching approaches which accommodate students' difficulties about energy appear to be more successful than traditional science instruction, the main deficiencies outlined above remain despite these approaches (NSDL, 2015).

Unit 8: Earth Systems

Instructional Days: 30

Prior Learning
By the end of Grade 5, students understand that: • Some kinds of plants and animals that once lived on Earth are no longer found anywhere. • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. • For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. • A variety of natural hazards result from natural processes. • Humans cannot eliminate natural hazards but can take steps to reduce their impacts. • Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. • The presence and location of certain fossil types indicate the order in which rock layers were formed. • Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. • The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. • Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. • Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth. • Living things affect the physical characteristics of their regions. • A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). • Humans cannot eliminate the hazards but can take steps to reduce their impacts.

Unit 8: Earth Systems

Instructional Days: 30

Future Learning
Physical science • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. • The total number of neutrons plus protons does not change in any nuclear process. • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. *Life science* • Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. • Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. • The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. • At each link in an ecosystem, matter and energy are conserved. • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. • Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. • Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the

genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.

- Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait lead to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species.

Earth and space science

- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years.
- Studying these objects can provide information about Earth's formation and early history.
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in

the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities.

- These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection.
- Plate tectonics can be viewed as the surface expression of mantle convection.
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.
- Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.
- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

Unit 8: Earth Systems

Instructional Days: 30

Connections to Other Units
Grade 7 Unit 1: Structure and Properties of Matter • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). **Grade 7 Unit 2: Interactions of Matter** • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. **Grade 7 Unit 3: Chemical Reactions** • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. **Grade 8 Unit 4: Human Impacts on Earth Systems and Global Climate Change** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Unit 8: Earth Systems

Instructional Days: 30

Grade 8 Unit 5: Relationships among Forms of Energy

- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Grade 7 Unit 8: Earth Systems

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Unit 8: Earth Systems

Instructional Days: 30

Sample of Open Education Resources
Rock Cycle Journey: This is an activity out of one of the DLESE Teaching boxes. The Teaching Box is titled Mountain Building. This activity is from Lesson 4 Activity #2 called Rock Cycle Journey. Stations are set up to represent different parts of the rock cycle. There is a die at each station. Students begin at one point and roll the die. The students record on their data sheet what happens to them (the rock). The student may end up staying where they are at or going to another station. Students continue individually through a set number of rolls of the dice. Students then look at their data and answer some questions. At the very end they share their information with others. Interactives-Dynamic Earth: Dynamic Earth is an interactive website where students can learn about the structure of the Earth, the movements of its tectonic plates, as well as the forces that create mountains, valleys, volcanoes and earthquakes. This site consists of four sections with both embedded assessments to check progress and a final summative assessment. Each section explores one aspect of the earth's structure and the movement of its tectonic plates. The instructions are simple and are located on each screen. Students will view animations, read explanations, and use their mouse to drag and drop the earth's continents into the correct places, highlight features on a map and cause earth's tectonic plates to move. At various points, students will check their knowledge by taking a quick quiz or playing a game to see how much they have learned about the Dynamic Earth. This website does have teacher information tabs located as related resources.

Curriculum: Grade 7

Unit 8: Earth Systems

Instructional Days: 30

Appendix A: NGSS and Foundations for the Unit
Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. *[Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.]* [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.] **(MS-ESS1-4)**
Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. *[Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.]* [Assessment Boundary: Assessment does not include the identification and naming of minerals.] **(MS-ESS2-1)**
Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. *[Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]* **(MS-ESS2-2)**
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. *[Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).]* [Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.] **(MS-ESS2-3)**

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The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Develop and use a model to describe phenomena. (MS-ESS2-1) **Constructing Explanations and Designing Solutions** • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (MS-ESS1-4),(MS-ESS2-2) **Analyzing and Interpreting Data** • Analyze and interpret data to provide evidence for phenomena. (MS-ESS2-3)	**ESS1.C: The History of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **ESS2.A: Earth's Materials and Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1) • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1) **Scale Proportion and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4),(MS-ESS2-2) **Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) - ***Connections to Nature of Science*** **Scientific Knowledge is Open to**

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	ESS2.B: Plate Tectonics and Large-Scale System Interactions • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS-ESS2-3)	**Revision in Light of New Evidence** • Science findings are frequently revised and/or reinterpreted based on new evidence. (MS-ESS2-3)

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-4),(MS-ESS2-2) **RST.6-8.1** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS1-4),(MS-ESS2-2) **WHST.6-8.2** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS2-3) **RST.6-8.7** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-3) **RST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS2-1),(MS-ESS2-2) **SL.8.5**	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS2-2),(MS-ESS2-3) **7.EE.B.4** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS1-4),(MS-ESS2-2),(MS-ESS2-3) **6.EE.B.6** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS1-4) **7.EE.B.6** Reason abstractly and quantitatively. (MS-ESS2-2),(MS-ESS2-3) **MP.2**

Unit 8: Earth Systems

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Common Vocabulary	
Earth force	Geologic evidence
Plate tectonics	Homo sapiens
Rock formation	Meteorite
Ancient	Ocean basin
Development	Decay
Mineral	Formation
Relative	Rack strata
Account	Time scale
Asteroid	Extent
Crater	Lunar rock
Earth’s age	Moon rock
Fossil record	Nuclear
Geologic	Planetary

Curriculum: Grade 8

Unit 1: Evidence of a Common Ancestry

Instructional Days: 15

Unit Summary
How do we know when an organism (fossil) was alive?   ***How do we know that birds and dinosaurs are related?***   In this unit of study, students analyze graphical displays and gather evidence from multiple sources in order to develop an understanding of how fossil records and anatomical similarities of the relationships among organisms and species describe biological evolution. Students search for patterns in the evidence to support their understanding of the fossil record and how those patterns show relationships between modern organisms and their common ancestors. The crosscutting concepts of *cause and effect, patterns*, and *structure and function* are called out as organizing concepts for these disciplinary core ideas. Students use the practices of *analyzing graphical displays* and *gathering, reading, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-LS4-1, MS-LS4-2, and MS-LS4-3.
Student Learning Objectives
Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. *[Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]* **(MS-LS4-1)**
Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. *[Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]* **(MS-LS4-2)**
Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. *[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]* **(MS-LS4-3)**

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Unit 1: Evidence of a Common Ancestry

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MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy
LS4.A	The collection of fossils and their placement in chronological order is known as the fossil record
LS4.B	Natural selection leads to the predominance of certain traits in a population, and the suppression of others
LS4.C	Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions

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Unit 1: Evidence of a Common Ancestry

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Quick Links		

Enduring Understandings
• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MSLS41) • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.
Essential Questions
• How do we know that evolution occurs? • How do populations change over time?

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: How do we know when an organism (fossil) was alive?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>

The fossil record documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
The collection of fossils and their placement in chronological order as identified through the location of sedimentary layers in which they are found or through radioactive dating is known as the fossil record.
Relative fossil dating is achieved by examining the fossil’s relative position in sedimentary rock layers.
Objects and events in the fossil record occur in consistent patterns that are understandable through measurement and observation.
Patterns exist in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in rock layers.
Patterns can occur within one species of organism or across many species.

</td><td>
Students who understand the concepts can:

Use graphs, charts, and images to identify patterns within the fossil record.
Analyze and interpret data within the fossil record to determine similarities and differences in findings.
Make logical and conceptual connections between evidence in the fossil record and explanations about the existence, diversity, extinction, and change in many life forms throughout the history of life on Earth.

</td></tr>
</table>

Unit 1: Evidence of a Common Ancestry

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: How do we know that birds and dinosaurs are related?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>

Similarities and differences exist in the gross anatomical structures of modern organisms.
There are anatomical similarities and differences among modern organisms and between modern organisms and fossil organisms.
Similarities and differences exist in the gross anatomical structures of modern organisms and their fossil relatives.
Similarities and differences in the gross anatomical structures of modern organisms enable the reconstruction of evolutionary history and the inference of lines of evolutionary decent.
Patterns and anatomical similarities in the fossil record can be used to identify cause-and-effect relationships.
Science assumes that objects and events in evolutionary history occur in consistent patterns that are understandable through measurement and observation.

</td><td>
Students who understand the concepts can:

Apply scientific ideas to construct explanations for evolutionary relationships.
Apply the patterns in gross anatomical structures among modern organisms and between modern organisms and fossil organisms to construct explanations of evolutionary relationships.
Apply scientific ideas about evolutionary history to construct an explanation for evolutionary relationships evidenced by similarities or differences in the gross appearance of anatomical structures.

</td></tr>
</table>

Unit 1: Evidence of a Common Ancestry

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: Other than bones and structures being similar, what other evidence is there that birds and dinosaurs are related?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>Relationships between embryos of different species show similarities in their development.
General patterns of relatedness among embryos of different organisms can be inferred by comparing the macroscopic appearance of diagrams or pictures.
Pictorial data can be used to identify patterns of similarities in embryological development across multiple species.
Similarities in embryological development across multiple species show relationships that are not evident in the fully formed organisms.</td><td>Students who understand the concepts can:
Use diagrams or pictures to identify patterns in embryological development across multiple species.
Analyze displays of pictorial data to identify where the embryological development is related linearly and where that linear nature ends.
Infer general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.</td></tr>
</table>

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What It Looks Like in the Classroom
Prior to middle school, students know that some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago. In this unit of study, students will build on this knowledge by examining how the fossil record documents the existence, diversity, extinction, and change of many life forms through Earth's history. The fossil record and comparisons of anatomical similarities between organisms and their embryos enable the inference of lines of evolutionary descent. Students analyze images or data to identify patterns in the locations of fossils in layers of sedimentary rock. They can use their understanding of these patterns to place fossils in chronological order. Students may make connections between their studies of plate movement in grade 7 and the possible shifting of layers of sedimentary rock to explain inconsistencies in the relative chronological order of the fossil record as it is seen today. Students can analyze data on the chronology of the fossil record based on radioactive dating. An explanation of radioactive dating can be provided to students along with data, but students are not expected to complete any calculations. Information can be provided in the form of data tables correlating fossil age with half-life. This information could also be presented in the form of a graph. Students may analyze images from the fossil record to identify patterns of change in the complexity of the anatomical structures in organisms. For example, students can observe pictures of fossilized organisms with similar evolutionary histories in order to compare and contrast changes in their anatomical structures over time. Students may be placed in groups, with each group examining changes in anatomical structures over time within one evolutionary lineage (e.g., the whale, the horse, cycads). Once students have identified patterns of change within one evolutionary lineage, they can meet with students from other groups to discuss patterns of change across multiple evolutionary lineages. Students could then present their findings using a variety of media choices (PowerPoint, poster, short skit or play, comic strip, etc.). This activity would provide application of the real-world phenomenon that life on Earth changes over time. Students could be provided with multimedia experiences in order to analyze visual displays of the embryological development of different species. They can analyze the linear and nonlinear relationships among the embryological developments of different species. For example, students can analyze data about embryological development to determine whether development across species shares a similar rate, similar size of embryos, or similar characteristics over a period of time. If these characteristics are consistent across species, a linear relationship can be inferred. At the point where the rate, size, or general characteristics of development diverge, the relationship can then be classified as nonlinear.

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Students can integrate the patterns they identified in the fossil record by studying sedimentary rock images and radioactive dating data provided by the teacher and the relationships they discovered through their study of embryological development with evidence from informational texts to develop an explanation of changes in life forms throughout the history of life on Earth. This explanation could be presented in the form of a claim, with students required to cite evidence from their studies of diagrams, images, and texts to explain that life on Earth has changed over time.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific textual evidence to support the analysis of patterns found in the fossil record to document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth.
- Use scientific, precise details in the explanations.
- Integrate quantitative or technical information about the fossil record that is expressed in words into a version of that information expressed visually in the form of a flowchart, diagram, model, graph, or table.
- Attending to the precise details of explanations or descriptions, cite specific textual evidence to support analysis of science texts' information on the relationships between the anatomical similarities and differences among modern organisms and between modern and fossil organisms and their fossil relationships.
- Write informative/explanatory text examining anatomical similarities and differences among modern organisms and between modern and fossil organisms and their fossil relationships. The text should convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Draw evidence from informational texts to support an analysis of, reflection on, and research about anatomical similarities and differences among modern organisms and between modern and fossil organisms used to infer evolutionary relationships.
- Engage in a range of collaborative discussions about the anatomical similarities and differences among modern organisms and between modern and fossil organisms used to infer evolutionary relationships. Discussions must provide opportunities for students to clearly express their own ideas and exchange ideas with others. The discussions may be one on one, in groups, or led by the teacher.

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- Present claims and findings to explain the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. Emphasize the important points in a focused, coherent manner with relevant evidence, valid reasoning, and well-chosen details. During the presentation, students must use appropriate eye contact, adequate volume, and clear pronunciation.
- Cite specific textual evidence to support the analysis of pictorial data comparing patterns of similarities in embryological development across multiple species to identify relationships not evident in the fully formed anatomy. Attention must be paid to the precise details of explanation or descriptions.
- Integrate quantitative or technical information about general patterns of relatedness among embryos of different organisms expressed in words in a text with a version expressed in a flowchart, diagram, model, graph, or table.
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with the information gained from reading a text about embryological development across multiple species in order to identify relationships not evident in the fully formed anatomy.

Mathematics

- Use variables to represent numbers and write expressions to represent patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearances in the rock record to document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth, under the assumption that natural laws operate today as in the past. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.
- Use variables to represent numbers and write expressions showing patterns that can be used to identify cause-and-effect relationships among the anatomical similarities and differences among modern organisms and between modern and fossil organisms. This representation will be used to infer evolutionary relationships. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 1: Evidence of a Common Ancestry

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Research on Student Learning
Some research suggests that students' understanding of evolution is related to their understanding of the nature of science and their general reasoning abilities. Findings indicate that students who cannot argue with evidence tend to retain nonscientific beliefs such as "evolutionary change occurs as a result of need" because they fail to examine alternative hypotheses and their predicted consequences, and they fail to comprehend conflicting evidence. Thus, they are left with no alternative but to believe their initial intuitions or the misstatements they hear (NSDL, 2015).

Prior Learning
By the end of Grade 5, students understand that: • Some kinds of plants and animals that once lived on Earth are no longer found anywhere. • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.

Future Learning
Life science • Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. *Earth and space science* • Continental rocks, which can be more than 4 billion years old, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

Unit 1: Evidence of a Common Ancestry

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Connections to Other Units
Grade 7, Unit 6: Inheritance and Variation of Traits • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **Grade 6, Unit 8: Earth Systems** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

Sample of Open Education Resources
NOVA: Judgement Day: Intelligent Design on Trial: Human Chromosome 2: This video segment from NOVA: "Judgment Day: Intelligent Design on Trial" reveals how genetic evidence helped to confirm an important component of Darwin's theory of evolution by natural selection: the common ancestry of humans and apes. In particular, it explains that humans have one fewer chromosome pair in their cells than apes, due to a mutation found in chromosome number 2 that caused two chromosomes to fuse into one. The Day the Mesozoic Died This three-act film tells the story of the detective work that solved the mystery of what caused the disappearance of the dinosaurs at the end of the Cretaceous period. Shot on location in Italy, Spain, Texas, Colorado, and North Dakota, the film traces the uncovering of key clues that led to the discovery that an asteroid struck the Earth 66 million years ago, triggering a mass extinction of animals, plants, and microorganisms.

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Unit 1: Evidence of a Common Ancestry

Instructional Days: 15

Appendix A: NGSS and Foundations for the Unit
Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. *[Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]* **(MS-LS4-1)**
Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. *[Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]* **(MS-LS4-2)**
Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. *[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]* **(MS-LS4-3)**
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze displays of data to identify linear and nonlinear relationships. (MS-LS4-3) • Analyze and interpret data to determine similarities and differences in findings. (MS-LS4-1)	**LS4.A: Evidence of Common Ancestry and Diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It	**Patterns** • Patterns can be used to identify cause and effect relationships. (MS-LS4-2) • Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-1),(MS-LS4-3)

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Constructing Explanations and Designing Solutions • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. (MS-LS4-2) - **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-LS4-1)	documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1) • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2) • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3)	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-5),(MS-LS4-6) - **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS4-1),(MS-LS4-2)

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Unit 1: Evidence of a Common Ancestry

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-LS4-1),(MS-LS4-2),(MS-LS4-3) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-1),(MS-LS4-3) **RST.6-8.7** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-LS4-3) **RST.6-8.9** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2) **WHST.6-8.2** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-2) **WHST.6-8.9** Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS4-2) **SL.8.1** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS4-2) **SL.8.4**	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-LS4-1),(MS-LS4-2) **6.EE.B.6**

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Unit 1: Evidence of a Common Ancestry

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Common Vocabulary	
Diversity Life form Sedimentary Chronological order Fossil record History of life	Natural law Anatomical Ancestry Radioactive dating

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Unit 2: Selection and Adaptation

Instructional Days: 20

Unit Summary
Are Genetically Modified Organisms (GMO) safe to eat?
Students construct explanations based on evidence to support fundamental understandings of natural selection and evolution. They will use ideas of genetic variation in a population to make sense of how organisms survive and reproduce, thus passing on the traits of the species. The crosscutting concepts of *patterns* and *structure and function* are called out as organizing concepts that students use to describe biological evolution. Students use the practices of *constructing explanations*, *obtaining, evaluating, and communicating information*, and *using mathematical and computational thinking*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-LS4-4, MS-LS4-5, and MS-LS4-6.
Student Learning Objectives
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. *[Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations]* **(MS-LS4-4)**
Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. *[Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]* **(MS-LS4-5)**
Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. *[Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.]* **(MS-LS4-6)**

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MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-5	Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.
MS-LS4-6	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time
LS4.A	The collection of fossils and their placement in chronological order is known as the fossil record
LS4.B	Natural selection leads to the predominance of certain traits in a population, and the suppression of others
LS4.C	Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions

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Enduring Understandings
• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MSLS41) • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.
Essential Questions
• How do we know that evolution occurs? • How do populations change over time?

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Unit Sequence	
Part A: *How can changes to the genetic code increase or decrease an individual's chances of survival?*	
Concepts	**Formative Assessments**
• Genetic variations of traits in a population increase or decrease some individuals' probability of surviving and reproducing in a specific environment. • Natural selection leads to the predominance of certain traits in a population and the suppression of others. • Natural selection may have more than one cause, and some cause-and-effect relationships within natural selection can only be described using probability.	*Students who understand the concepts can:* • Construct an explanation that includes probability statements regarding variables and proportional reasoning of how genetic variations of traits in a population increase some individuals' probability surviving and reproducing in a specific environment. • Use probability to describe some cause-and-effect relationships that can be used to explain why some individuals survive and reproduce in a specific environment.

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: How can the environment effect natural selection?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>Natural selection, which over generations leads to adaptations, is one important process through which species change over time in response to changes in environmental conditions.
The distribution of traits in a population changes.
Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common.
Natural selection may have more than one cause, and some cause-and-effect relationships in natural selection can only be described using probability.
Mathematical representations can be used to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.</td><td>Students who understand the concepts can:
Explain some causes of natural selection and the effect it has on the increase or decrease of specific traits in populations over time.
Use mathematical representations to support conclusions about how natural selection may lead to increases and decreases of genetic traits in populations over time.</td></tr>
</table>

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: Are Genetically Modified Organisms (GMO) safe to eat?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>

In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding.
In artificial selection, humans choose desirable, genetically determined traits in to pass on to offspring.
Phenomena, such as genetic outcomes in artificial selection, may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.
Technologies have changed the way humans influence the inheritance of desired traits in organisms.
Engineering advances have led to important discoveries in the field of selective breeding.
Engineering advances in the field of selective breeding have led to the development of entire industries and engineered systems.
Scientific discoveries have led to the development of entire industries and engineered systems.

</td><td>
Students who understand the concepts can:

Gather, read, and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection) from multiple appropriate sources.
Describe how information from publications about technologies and methods that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection) used are supported or not supported by evidence.
• Assess the credibility, accuracy, and possible bias of publications and they methods they used when gathering information about technologies that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection).

</td></tr>
</table>

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What It Looks Like in the Classroom
In this unit of study, students will build on their prior knowledge by constructing explanations that describe how genetic variations increase some individuals' probability of surviving and reproducing. Mathematical representations will be used to support explanations of how natural selection leads to increases and decreases of specific traits in populations over time. Students will analyze numerical data sets that represent a proportional relationship between some change in the environment and corresponding changes in genetic variation over time. Students will summarize these numerical data sets and construct explanations for how the proportional relationship could impact the probability of some individuals surviving and reproducing in a specific environment. Students will construct explanations based on evidence that describes how genetic variations can provide a survival and reproductive advantage over other traits. This evidence could be provided through activities that model these phenomena or by examining and analyzing data from informative texts. Based on their findings, students can write claims about how natural selection leads to a predominance of some traits in a population and the suppression of other traits. Students will pay attention to precise details in explanations from specific textual evidence and will cite this evidence to support their analysis and reflection on research that explains how genetic variation of traits in a population increases some individuals' probability of surviving and reproducing in a specific environment. Students will compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading these texts and write informative/explanatory texts on how natural selection leads to the predominance of some traits and the suppression of others in a population. Students will engage effectively in a range of collaborative discussions where they will present their claims and findings. These discussions may be one-on-one between students, in small groups, or teacher-led large group discussions. In these discussions, students will build on others' ideas while expressing their own clearly. Claims must emphasize salient points in a focused, coherent manner, supported with relevant evidence, sound valid reasoning, and well-chosen details. Students must use appropriate eye contact, adequate volume, and clear pronunciation. There are multiple activities available that show students how one trait can provide a survival advantage over another in a specific environment. As part of these activities, students can analyze data and determine ratio relationships to provide evidence of cause-and-effect relationships. These ratios can be used to explain why some inherited traits result in individuals that have a survival advantage in a specific environment over time or why other traits in a population are suppressed. When an environment changes as a result of human influence and/or natural processes on Earth, traits that were present in populations of organisms and that led to a survival advantage in that environment before the change may no longer offer an advantage. Changes in environmental conditions can

be the driving cause of the suppression of traits in populations.

Students will examine a variety of environmental factors that may influence the natural selection that is taking place in populations. Students will need to use simple probability statements and proportional reasoning to explain why each factor may or may not be responsible for the changes being observed. Students will compare and contrast the information gained from experiments, simulations, video, or multimedia sources with information gained from reading science and technical texts to support their explanations. After students have constructed their explanations, they will participate in collaborative discussions in small groups; in larger, teacher-led groups, or in pair.

After students have developed a strong understanding of natural selection, they will need to begin gathering evidence from multiple sources, including print and digital, to support analysis of information about technologies that have changed how humans can influence the inheritance of desired traits in organisms (artificial selection). Students need to examine current technologies as well as the technologies that have led to these scientific discoveries. Students will cite the information they gathered and quote or paraphrase relevant data and conclusions from their resources to describe the impact that current technologies have on society. Some of the influences of humans on genetic outcomes in artificial selection that students can examine include genetic modifications, animal husbandry, and gene therapy.

Students can be provided with multiple sources to determine the credibility, accuracy, and possible bias of the resources. In order to determine the best sources, students can investigate and describe how information in these resources is supported or not supported by evidence. Once students have determined appropriate sources, they can begin to synthesize information about the technologies that have changed how humans can influence the inheritance of desired traits in organisms (artificial selection). Students can quote or paraphrase the data and conclusions and provide basic bibliographic information. They can do this in a variety of ways (e.g., in writing, verbal discussion, debate, Socratic seminar, etc.).

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Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy Cite specific textual evidence to support analysis of scientific and technical texts about how genetic variations in a population increase some individuals' probability of surviving and reproducing in a specific environment. Attention must be paid to precise details of explanations or descriptions. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with information gained from reading a text on how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. Write informative/explanatory texts examining how natural selection leads to the predominance of some traits in a population and the suppression of others. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. Draw evidence from informational texts to support the analysis, reflection, and research used to construct an explanation of how genetic variation of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. Engage effectively in a range of collaborative discussions with diverse partners to discuss how natural selection leads to the predominance of certain traits in a population and the suppression of others. Discussions may be one-on-one, in groups, or teacher-led; in these discussions, students should build on others' ideas while expressing their own clearly. Present claims and findings about how natural selection leads to the predominance of certain traits in a population and the suppression of others. Claims must emphasize salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details. Students must use appropriate eye contact, adequate volume, and clear pronunciation. Cite specific textual evidence to support analysis of information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection). Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others about technologies that have changed the way humans influence the inheritance of desired traits. Avoid plagiarism and provide basic bibliographic information for sources. *Mathematics*

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Understand the concept of a ratio and use ratio language to describe a ratio relationship between specific genetic variations in a population and the probability of some individuals in that populations surviving and reproducing in a specific environment. Summarize numerical data sets about a ratio relationship between genetic variations in a population and the probability of some individuals in that population surviving and reproducing in a specific environment. Recognize and represent proportional relationships in trends in changes to populations over time. Use mathematical models to support explanations of trends in changes to populations over time. Understand the concept of a ratio and use ratio language to describe a ratio relationship between natural selection and decreases of specific traits in populations over time. Summarize numerical data sets to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

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Research on Student Learning
Students, even after some years of biology instruction, have difficulties understanding the notion of natural selection. A major hindrance to understanding natural selection appears to be students' inability to integrate two distinct processes in evolution, the occurrence of new traits in a population and their effect on long-term survival. Many students believe that environmental conditions are responsible for changes in traits, or that organisms develop new traits because they need them to survive, or that they over-use or under-use certain bodily organs or abilities. By contrast, students have little understanding that chance alone produces new heritable characteristics by forming new combinations of existing genes or by mutations of genes. Some students believe that a mutation modifies an individual's own form during its life rather than only its germ cells and offspring (see almost any science fiction movie). Students also have difficulties understanding that changing a population results from the survival of a few individuals that preferentially reproduce, not from the gradual change of all individuals in the population. Explanations about "insects or germs becoming more resistant" rather than "more insects or germs becoming resistant" may reinforce these misunderstandings. Specially designed instruction can improve students' understanding of natural selection. Students may have difficulties with the various uses of the word "adaptation". In everyday usage, individuals adapt deliberately. But in the theory of natural selection, populations change or "adapt" over generations, inadvertently Students of all ages often believe that adaptations result from some overall purpose or design, or they describe adaptation as a conscious process to fulfill some need or want. Elementary- and middle-school students also tend to confuse non-inherited adaptations acquired during an individual's lifetime with adaptive features that are inherited in a population (NSDL, 2015)

Prior Learning
By the end of Grade 5, students understand that: • Different organisms vary in how they look and function because they have different inherited information. • The environment also affects the traits that an organism develops. • Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. • For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

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Future Learning
Life Science and Environmental Science • Ecosystems have carrying capacities, which are limits on the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources, predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, the ecosystem may return to its original status, more or less (i.e., the ecosystem is resilient) as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Moreover, anthropogenic changes (i.e, changes induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. • In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. • Environmental factors also affect the expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed in a population depends on both genetic and environmental factors. • Natural selection occurs only if there is both (1) variation in the genetic information among organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. • The traits that positively affect survival are more likely to be reproduced and thus are more common in the population. • Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number; (2) the genetic variation of individuals in a species due to mutation and sexual reproduction; (3) competition for an environment's

limited supply of the resources that individuals need in order to survive and reproduce; and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.

- Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. The differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new, distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

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Connections to Other Units
Grade 6: Unit 3: Interdependent Relationships in Ecosystems • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **Grade 7, Unit 6: Inheritance and Variation of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. **Grade 7, Unit 8: Earth Systems** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

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Sample of Open Education Resources
99.99% Antibacterial Products and Natural Selection: This activity is a hands-on simulation using Skittles and mini-marshmallows to show how natural selection can act as a mechanism to increase the presence of antibacterial resistance in a population. An Origin of Species: Pollenpeepers: This web simulation allows students to explore adaptive radiation of a fictitious group of birds called Pollenpeepers over a period of 5 million years. Making Sense of Natural Selection: This article from The Science Teacher magazine describes a unit of study on natural selection. Students begin by trying to explain the phenomenon of the exponential increase in a population of fish. Bug Hunt "Bug Hunt" uses NetLogo software and simulates an insect population that is preyed on by birds. There are six speeds of bugs from slow to fast and the bird tries to catch as many insects as possible in a certain amount of time. Students are able to see the results graphed as the average insect speed over time, the current bug population and the number of insects caught. Color Variation over Time in Rock Pocket Mouse Populations: This activity provides an introduction to natural selection and the role of genetic variation by asking students to analyze illustrations of rock pocket mouse populations (dark/light fur) on different color substrates in the Sonoran Desert (light/dark) over time. Based on this evidence, and what they learn about variation and natural selection in the accompanying short film, students use this evidence to explain the change in the rock pocket mouse populations on the lava flow (dark substrate) over time. Catch Up on Tomato Technology: This lesson is a tool to demonstrate how various technological advances have changed the tomato and the tomato industry over the years. The technology includes both selective breeding and genetic engineering.

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Appendix A: NGSS and Foundations for the Unit		
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. *[Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations]* **(MS-LS4-4)**		
Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. *[Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]* **(MS-LS4-5)**		
Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. *[Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.]* **(MS-LS4-6)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (MS-LS4-4) **Obtaining, Evaluating, and Communicating Information** • Gather, read, and synthesize information from multiple appropriate	**LS4.B: Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4) • In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-5),(MS-LS4-6) - ***Connections to Engineering, Technology, and***

sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS4-5) **Using Mathematics and Computational Thinking** • Use mathematical representations to support scientific conclusions and design solutions. (MS-LS4-6)	offspring. (MS-LS4-5) **LS4.C: Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)	***Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS4-5) - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS4-5)

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-LS4-4),(MS-LS4-5) **RST.6-8.1** Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-LS4-4) **RST.6-8.9** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-4) **WHST.6-8.2** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-LS4-5) **WHST.6-8.8** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-4) **WHST.6-8.9** Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS4-4) **SL.8.1** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS4-4) **SL.8.4**	Model with mathematics. (MS-LS4-6) **MP.4** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-LS4-4),(MS-LS4-6) **6.RP.A.1** Summarize numerical data sets in relation to their context. (MS-LS4-4),(MS-LS4-6) **6.SP.B.5** Recognize and represent proportional relationships between quantities. (MS-LS4-4),(MS-LS4-6) **7.RP.A.2**

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Common Vocabulary	
Diversity Life form Sedimentary Chronological order Fossil record History of life	Natural law Anatomical Ancestry Radioactive dating

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Unit 3: Stability and Change on Earth

Instructional Days: 30

Unit Summary
Why aren't minerals and groundwater distributed evenly across the world?   Students construct an understanding of the ways that human activities affect Earth's systems. Students use practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts on the development of these resources. Students also understand that the distribution of these resources is uneven due to past and current geosciences processes or removal by humans. The crosscutting concepts of *patterns, cause and effect*, and *stability and change* are called out as organizing concepts for these disciplinary core ideas. In this unit of study students are expected to demonstrate proficiency in *asking questions, analyzing and interpreting data, constructing explanations, and designing solutions.* Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-ESS3-1, MS-ESS3-2, MS-ESS3-4, and MS-ESS3-5.

Student Learning Objectives
Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. *[Clarification Statement: Emphasis is on how these resources are limited and typically nonrenewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]* **(MS-ESS3-1)**
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. *[Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]* **(MS-ESS3-2)**

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Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. *[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]* **(MS-ESS3-4)**
Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. *[Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]* **(MS-ESS3-5)**

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(MS-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes
MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects
MS-ESS3-4	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century
ESS3.A	Humans depend on Earth's land, ocean, atmosphere and biosphere for many different resources
ESS3.B	Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events
ESS3.C	Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species
ESS3.D	Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature

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Quick Links		

Enduring Understandings
• Some natural disasters are predictable while others are not • Natural disasters are driven by interior processes, surface processes, and/or severe weather events • Human activity impacts ecosystems • The relationship between human population and the impact on natural resources
Essential Questions
• What are resources? • Why do natural disasters occur? • How do humans impact the environment? • What affects climate change?

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Unit Sequence	
Part A: *Why aren't minerals and groundwater distributed evenly across the world?*	
Concepts	**Formative Assessments**
• Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. • All human activities draw on Earth's land, ocean, atmosphere, and biosphere resources and have both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. • Minerals, fresh water, and biosphere resources are distributed unevenly around the planet as a result of past geologic processes. • Cause-and-effect relationships may be used to explain how uneven distributions of Earth's mineral, energy, and groundwater resources have resulted from past and current geosciences processes. • Resources that are unevenly distributed as a result of past processes include but are not limited to petroleum, metal ores, and soil. • Mineral, fresh water, ocean, biosphere, and atmosphere resources are limited, and many are not renewable or replaceable over human lifetimes. • The distribution of some of Earth's land, ocean, atmosphere, and biosphere resources are changing significantly due to removal by humans.	*Students who understand the concepts can:* • Construct a scientific explanation based on valid and reliable evidence of how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes. • Obtain evidence from sources, which must include the student's own experiments. • Construct a scientific explanation based on the assumption that theories and laws that describe the current geosciences process operates today as they did in the past and will continue to do so in the future.

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Unit Sequence	
Part B: *How can we predict and prepare for natural disasters?*	
Concepts	**Formative Assessments**
• Natural hazards can be the result of interior processes, surface processes, or severe weather events. • Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events. • Data on natural hazards can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. • Data on natural hazards can include the locations, magnitudes, and frequencies of the natural hazards. • Graphs, charts, and images can be used to identify patterns of natural hazards in a region. • Graphs, charts, and images can be used to understand patterns of geologic forces that can help forecast the locations and likelihoods of future events. • Technologies that can be used to mitigate the effects of natural hazards can be global or local. • Technologies used to mitigate the effects of natural hazards vary from region to region and over time.	*Students who understand the concepts can:* • Analyze and interpret data on natural hazards to determine similarities and differences and to distinguish between correlation and causation.

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: How might we treat resources if we thought about the Earth as a spaceship on an extended survey of the solar system? (How would astronauts manage their resources?)</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>• All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
• Increases in human population and per-capita consumption of natural resources impact Earth's systems.
• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
• Cause and effect relationships may be used to predict how increases in human population and per-capita consumption of natural resources impact Earth's systems.
• The consequences of increases in human populations and consumption of natural resources are described by science.
• Science does not make the decisions for the actions society takes.
• Scientific knowledge can describe the consequences of human population and per-capita consumption of natural resources impact Earth's systems but does not necessarily prescribe the decisions that society takes.</td><td>Students who understand the concepts can:
• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td></tr>
</table>

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part D: How can basic chemistry be used to explain the mechanisms that control the global temperature the atmosphere?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>
• Stability in Earth’s surface temperature might be disturbed either by sudden events or gradual changes that accumulate over time.
• Human activities and natural processes are examples of factors that have caused the rise in global temperatures over the past century.
• Human activities play a major role in causing the rise in global temperatures.
• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming).
• Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior, and on applying that knowledge wisely in decisions and activities.
• Evidence that some factors have caused the rise in global temperature over the last century can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.
</td><td>
Students who understand the concepts can:
• Ask questions to identify and clarify a variety of evidence for an argument about the factors that have caused the rise in global temperatures over the past century.
• Ask questions to clarify human activities and natural processes that are major factors in the current rise in Earth’s mean surface temperature.
</td></tr>
</table>

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What It Looks Like in the Classroom
Students will begin by building on their prior knowledge that human activities affect the Earth. Students will describe how human activities have positive as well as negative impacts on land, ocean, atmosphere, and biosphere resources. In this unit of study, students will build upon this knowledge by examining the causes of the uneven distribution of resources on Earth. Students can then write an informative text to explain the causes of uneven distributions of Earth's minerals, energy, and groundwater resources. These causes can include past and current geosciences processes as well as human removal of resources. The written text needs to include specific evidence to support the student's explanation. Students will use variables to represent numbers and write expressions. They will convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. Students will perform investigations to gather data showing how natural processes can lead to the uneven distributions of Earth's mineral, energy, and groundwater resources. The resources considered should include but not be limited to petroleum, metal ores, and soil. An example of an investigation could include using models of different layers of sediment that will show the uneven distribution of groundwater as it permeates through different types of soil and rock. A saturated mineral solution (i.e. salt) can be poured over the sedimentary layers and then evaporated to leave behind a deposit. Students could then take core samples using straws to gather data from the model. Emphasis is on how these resources, including land, ocean, atmosphere, biosphere, mineral, and fresh water, are limited and typically are nonrenewable, and how their distributions are significantly changing as a result of removal by humans. Students will use variables to represent quantities and construct simple equations and inequalities to solve problems by reasoning about the quantities. Students may use maps showing the current global distribution of different resources along with maps showing past global distribution of the same resources to gather data. Students could use these data to create mathematical expressions that could show the impact of current human consumption on possible future resource distribution (renewable and nonrenewable energy resources). In addition, students could use maps of different geosciences processes alongside other data to explain the uneven distributions of Earth's resources. Students will continue to learn about Earth's systems as they consider how natural hazards can be the result of interior processes, surface processes, or severe weather events. They will learn that some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur

suddenly and with no notice, and thus are not yet predictable. Students will also look at how technology can be used to predict natural hazards to reduce their impacts. Last, students will examine evidence of natural processes and human activities that have caused global climate change.

Students can analyze maps, charts, and images of natural hazards to look for patterns in past occurrences of catastrophic events. Data on natural hazards can include the locations, magnitudes, and frequencies of the natural hazards. Students can use these data to make reliable predictions of future catastrophic events.

Students can also look at past occurrences of catastrophic events to determine how those events have influenced the development of technologies scientists use to predict future events. It might be useful to include local catastrophic events, since the technology used to predict and diminish effects of future events varies from region to region over time. Some of the data students might analyze could include locations, magnitudes, and frequencies of the natural hazards.

Students will continue their study of Earth's systems and processes by investigating the impact of sudden events or gradual changes that accumulate over time and affect the stability of Earth's surface temperature.

Students will cite specific textual evidence to support an argument about the role of human activity and natural processes in the gradual increase in global temperatures over the past century.

Students can ask questions to clarify how human activities, such as the release of greenhouse gases from the burning of fossil fuels, play major roles in the rise in global temperatures. Students can also ask questions about how natural events, such as volcanic activity, also contribute to the rise in global temperature. Students can look at a variety of sources for evidence, such as tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases, such as carbon dioxide and methane; and rates of human activities, to support an argument that global temperatures have risen over the past century. Students can use these data to write mathematical expressions that show relationships between these variables.

Students will examine a variety of changes that humans have made to Earth's natural systems and determine whether these changes have positive impacts, negative impacts, or some combination of positive and negative impacts. As part of this study, students will collect evidence to support arguments they develop about the impact of the modifications to Earth's systems. Students will consider how a variety of human actions can impact an ecosystem. Among the human actions considered will be human population growth and the consumption of resources from the ecosystem. Students will prepare a report on the system and describe how the system is impacted. Evidence must be recorded to support their arguments and must be presented in both an oral and a written format.

Students can cite specific textual evidence to develop an argument about the need to reduce the level of climate change due to human activity. The argument can include the need for reduction in human vulnerability to whatever climate change occurs as a result of natural events.

This unit of study will be will be leveraged in the Unit 4 engineering and design process.

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy
Cite specific textual evidence to support analysis of how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes.
Write informative/explanatory texts examining how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
Draw evidence from informational texts to support analysis, reflection, and research on how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes.
Cite specific textual evidence in data used to support the analysis of natural hazards and to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
Integrate quantitative or technical information about natural hazards and forecasting future catastrophic events that is expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Use the integrated text and visual displays to analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
Cite specific textual evidence to support an argument about the role of human activity and natural processes in the gradual increase in global temperatures over the past century.
Mathematics
Use variables to represent numbers and write expressions for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

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Use variables to represent quantities for how the distribution of Earth's mineral, energy, and groundwater resources are significantly changing as a result of removal by humans. Construct simple equations and inequalities to solve problems by reasoning about the quantities.

Analyze and interpret data on natural hazards by reasoning abstractly (manipulating symbols abstractly) and quantitatively (while attending to the meaning of those symbols) to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Use variables to represent numbers and write expressions for the locations, magnitudes, and frequencies of natural hazards and how these data can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. The variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

Use variables to represent quantities for the location, magnitudes, and frequencies of natural hazards and how these data can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. Construct simple equations and inequalities to solve problems by reasoning about the quantities.

Students will clarify evidence of the factors that have caused the rise in global temperatures over the past century, reasoning abstractly (manipulating symbols abstractly) and quantitatively (while attending to the meaning of those symbols).

Use variables to represent numbers and write expressions for data found in tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane' and the rates of human activities. The variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

Use variables to represent quantities found in tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Construct simple equations and inequalities to solve problems by reasoning about the quantities.

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning
N/A

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Prior Learning
By the end of Grade 5, students understand that: • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. • A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). • Humans cannot eliminate the hazards but can take steps to reduce their impacts. • Populations live in a variety of habitats, and change in those habitats affects the organisms living there. • Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

Future Learning
This unit of study will be will be leveraged in the Unit 4 engineering and design process. • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g.,

water flows downhill, objects hotter than their surrounding environment cool down).

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins used to form new cells).
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
- Evidence from deep probes, seismic waves, reconstructions of historical changes in Earth's surface and magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

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- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.
- Resource availability has guided the development of human society.
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, along with its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's re-radiation into space. Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.
- Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations.
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal

energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

- Photoelectric materials emit electrons when they absorb light of a high enough frequency.
- The sustainability of human societies and the biodiversity that supports them require responsible management of natural resources.
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Connections to Other Units

Grade 7 Unit 1: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Grade 7 Unit 2: Interactions of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Grade 7 Unit 3: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.

Grade 8 Unit 5: Forms of Energy

- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

Grade 6 Unit 7: Weather and Climate

- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.

Sample of Open Education Resources
USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development. NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

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Appendix A: NGSS and Foundations for the Unit
Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. *[Clarification Statement: Emphasis is on how these resources are limited and typically nonrenewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]* **(MS-ESS3-1)**
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. *[Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]* **(MS-ESS3-2)**
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. *[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]* **(MS-ESS3-4)**
Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. *[Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases*

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such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.] **(MS-ESS3-5)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1) **Engaging in Argument from Evidence** • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)	**ESS3.A: Natural Resources** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) **ESS3.B: Natural Hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2) **ESS3.C: Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2) **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1),(MS-ESS3-4) **Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the**

	resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4) **ESS3.D: Global Climate Change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	**Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1),(MS-ESS3-4) • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2) - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-1),(MS-ESS3-2) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2) **RST.6-8.7** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS3-1) **WHST.6-8.2** Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-1) **WHST.6-8.9**	Reason abstractly and quantitatively. (MS-ESS3-2) **MP.2** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-1),(MS-ESS3-2) **6.EE.B.6** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-1),(MS-ESS3-2) **7.EE.B.4**

Common Vocabulary	
Conservation	Mineral
Nonrenewable energy	Physical replica
Renewable energy	Economic
Agricultural	Energy source
Biosphere	Geologic trap
Development	Impact
Groundwater	Issue
Material world	Organic

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Unit 4: Human Impact

Instructional Days: 25

Unit Summary
How do we monitor the health of the environment (our life support system)?   ***Is it possible to predict and protect ourselves from natural hazards?***   In this unit of study, students analyze and interpret data and design solutions to build on their understanding of the ways that human activities affect Earth's systems. The emphasis of this unit is the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts of these uses. The crosscutting concepts of *cause and effect* and *the influence of science, engineering, and technology on society and the natural world* are called out as organizing concepts for these disciplinary core ideas.   Building on Unit 3, students define a problem by precisely specifying criteria and constraints for solutions as well as potential impacts on society and the natural environment; systematically evaluate alternative solutions; analyze data from tests of different solutions; combining the best ideas into an improved solution; and develop and iteratively test and improve their model to reach an optimal solution. In this unit of study students are expected to demonstrate proficiency in *analyzing and interpreting data* and *designing solutions.* Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-ESS3-3, MS-ETS1-1, MS-ETS1-2, and MS-ETS1-3.

Student Learning Objectives
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. *[Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating) solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]* **(MS-ESS3-3)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)

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Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success
ETS1.B	There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem

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Connecting ELA/Literacy and Math p. 3	Future Learning p. 6	Appendix A: NGSS and Foundations p. 8
Modifications p. 4		

Enduring Understandings
• Some natural disasters are predictable while others are not • Natural disasters are driven by interior processes, surface processes, and/or severe weather events • Human activity impacts ecosystems • The relationship between human population and the impact on natural resources
Essential Questions
• What are resources? • Why do natural disasters occur? • How do humans impact the environment? • What affects climate change?

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: How do we monitor the health of the environment (our life support system)?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species.
Changes to Earth’s environments can have different impacts (negative and positive) for different living things.
Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.
Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.</td><td>Students who understand the concepts can:
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.</td></tr>
</table>

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What It Looks Like in the Classroom
Throughout this unit of study, students will be engaged in the engineering design process. Students can start by identifying a human impact on the environment that has resulted from human consumption of natural resources. Using what they have identified, students will begin to define the criteria and constraints of the design problem whose solution will help to monitor and minimize the human impact on the environment. Using informational texts to support this process is important. Students will draw evidence from these texts in order to support their analysis, reflection, and research. When students consider criteria, they should conduct short research projects to examine factors such as societal and individual needs, cost effectiveness, available materials and natural resources, current scientific knowledge, and current advancements in science and technology. They should also consider limitations due to natural factors such as regional climate and geology. While conducting their research, students will need to gather their information from multiple print and digital sources and assess the credibility of each source. When students quote or paraphrase the data and conclusions found in these resources, they will need to avoid plagiarism and provide basic bibliographic information for each source. After comparing the information gained from their research, experiments, simulations, video, or other multimedia sources, they will be able to determine precise design criteria and constraints that lead to a successful solution. Students will need to jointly develop and agree upon the design criteria that will be used to evaluate competing existing design solutions (i.e., varying dam designs, irrigation systems, varying methods of reducing pollution, varying methods of urban development). Students can use a rubric, checklist, or decision tree to assist them in evaluating the design solution selected. Students can be provided with data from tests performed on these existing design solutions. They will analyze and interpret these data to determine similarities and differences in findings. This is where they are deciding where different parts of the pre-existing solutions can be combined. For example, the building materials of a particular dam may be superior while the shape of another design may be more suitable. Students should consider the ratio relationship between the impacts that humans have on the environment and the impact that the design solution has on minimizing these impacts. Students will need to consider both qualitative and quantitative data when drawing conclusions about the various design solutions. It is important that students handle mathematical data appropriately. They should use variables to represent quantities and construct simple equations and inequalities to solve problems. While analyzing numerical data, students will need to solve mathematical problems that show both positive and negative values and apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental

computations and estimation strategies. Support from mathematics teachers will help students with the mathematics required for this type of analysis.

Once students have evaluated competing solutions and analyzed and interpreted data showing the similarities and differences of these solutions, they may then begin designing their own solutions. It is important that students consider the benefits and risks of each existing design solution. The impact on the environment and human society must be considered in the design. The final goal for students is to identify the parts of each design solution that best fit their criteria and constraints and combine these parts into a design solution that is better than any of its predecessors.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Conduct short research projects to determine a method for monitoring and minimizing a human impact on the environment, drawing on several sources and generating additional, related, focused questions that allow multiple avenues of exploration.
- Gather relevant information from multiple print and digital sources about a method for monitoring and minimizing a human impact on the environment, assess the credibility of each source, and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.
- Draw evidence from informational texts about minimizing a human impact on the environment to support analysis, reflection, and research.
- Cite specific textual evidence about a method for monitoring and minimizing a human impact on the environment to support analysis of science and technical texts.
- Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on a method for monitoring and minimizing a human impact on the environment.
- Integrate quantitative or technical information about a method for monitoring and minimizing a human impact on the environment expressed in words with a version of that information expressed visually.

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Mathematics

- Use abstract and quantitative reasoning to analyze and interpret data in order to determine similarities and differences in findings of how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment.
- Understand the concept of a ratio and use ratio language to describe a ratio relationship between *human impacts on environments and the impact of methods to minimize these impacts.*
- Use variables to represent quantities when analyzing and interpreting data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment and construct simple equations and inequalities to solve problems by reasoning about the quantities.
- While analyzing data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment, solve multistep mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; covert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

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- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning
N/A

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Prior Learning
By the end of Grade 5, students understand that: When the environment changes in ways that affect a place's physical characteristics, temperature, or resource availability, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. Students also know that populations live in a variety of habitats, and change in those habitats affects the organisms living there. Human activities in agriculture, industry, and everyday life have major effects on land, vegetation, streams, oceans, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. A simple design problem can be solved through the development of an object, tool, process, or system, and the solution can include several criteria for success and constraints on materials, time, or cost. Students know that they can test two different models of the same proposed object, tool, or process to determine which better meets criteria for success. Students also analyzed data to refine a problem statement or the design of a proposed object, tool, or process and used data to evaluate and refine design solutions. They applied scientific ideas to solve design problems and generate and compare multiple solutions to a problem based on how well they met the criteria and constraints of the design solution. Students have made claims about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Future Learning
• A complex set of interactions within an ecosystem can keep numbers and types of organisms in the ecosystem relatively constant over long periods of time under stable conditions. • If a modest biological or physical disturbance to an ecosystem occurs, the ecosystem may return, more or less, to its original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. • Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability. • Anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

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- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.
- Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well-suited to survive and reproduce in a specific environment. The differential survival and reproduction of organisms within a population that have an advantageous heritable trait lead to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species.
- Species become extinct because they can no longer survive and reproduce in an altered environment.
- If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.
- Humans depend on the living world for resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.
- Sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.
- The foundation of Earth's global climate system is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into

space.

- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affectclimate.
- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.
- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- Humanity faces major global challenges today—such as the need for supplies of clean water and food and forenergy sources that minimize pollution—which can be addressed through engineering.
- These global challenges also may have manifestations in local communities.

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Connections to Other Units
Grade 6, Unit 2: Matter and Energy in Organisms and Ecosystems • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources. • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. **Grade 6, Unit 5: Types of Interactions** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. • Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health. • Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

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Sample of Open Education Resources
USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development. NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

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Appendix A: NGSS and Foundations for the Unit		
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. *[Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating) solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]* **(MS-ESS3-3)**		
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)		
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)		
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world	**ESS3.C: Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and	**Cause and Effect** • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3) -

operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1) • Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3) **Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) **Engaging in Argument from Evidence** • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)	positive) for different living things. (MS-ESS3-3) • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4) **ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can	***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-3) **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural

	be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4)	environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-3)**,**(MS-ETS1-3) **RST.6-8.7** Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3) **RST.6-8.9** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-3) **6.EE.B.6** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-3) **7.EE.B.4** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS3-3) **6.RP.A.1** Recognize and represent proportional relationships between quantities. (MS-ESS3-3) **7.RP.A.2** Reason abstractly and quantitatively. (MS-ETS1-1),(MS-

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WHST.6-8.7 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS3-3),(MS-ETS1-1) **WHST.6-8.8** Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) **WHST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4) **SL.8.5**	ETS1-2),(MS-ETS1-3) **MP.2** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) **7.EE.3**

Common Vocabulary	
Natural process	Geologic
Resistant	Impact
Natural resource	Magnitude
Development	Satellite
Reservoir	Frequency
Catastrophic	Interdependence
Debris	Mass wasting
Economic	

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Unit 5: Relationships Among Forms of Energy

Instructional Days: 20

Unit Summary
How can physics explain sports?
In this unit, students use the practices of *analyzing and interpreting data*, *developing and using models*, and *engaging in argument from evidence* to make sense of relationship between energy and forces. Students develop their understanding of important qualitative ideas about the conservation of energy. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions. Students also understand the difference between energy and temperature, and the relationship between forces and energy. The crosscutting concepts of *scale, proportion, and quantity*, *systems and system models*, and *energy and matter* are called out as organizing concepts for these disciplinary core ideas. Students use the practices of *analyzing and interpreting data*, *developing and using models*, and *engaging in argument from evidence*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-PS3-1, MS-PS3-2, and MS-PS3-5.
Student Learning Objectives
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. *[Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]* **(MS-PS3-1)**
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. *[Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]* **(MS-PS3-2)**
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. *[Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.]* **(MS-PS3-5)**

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MS-PS3-1	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object
MS-PS3-2	Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system
MS-PS3-5	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object
PS3.A	A system of objects may also contain stored energy, depending on their relative positions
PS3.B	Energy is spontaneously transferred out of hotter regions or objects and into colder ones
PS3.C	When two objects interact, each on exerts a force on the other that can cause energy to be transferred to or from the object

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Unit 5: Relationships Among Forms of Energy

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Quick Links		

Enduring Understandings
• When the motion energy of an object changes, there is inevitably some other change in energy at the same time. • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. • Energy is spontaneously transferred out of hotter regions or objects and into colder
Essential Questions
• What is energy? • How is energy conserved and transferred? • What is the relationship between energy and forces?

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Unit 5: Relationships Among Forms of Energy

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: Is it better to have an aluminum (baseball/softball) bat or a wooden bat?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>Kinetic energy is related to the mass of an object and to the speed of an object.
Kinetic energy has a relationship to mass separate from its relationship to speed.
Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of the object’s speed.
Proportional relationships among different types of quantities provide information about the magnitude of properties and processes.</td><td>Students who understand the concepts can:
Construct and interpret graphical displays of data to identify linear and nonlinear relationships of kinetic energy to the mass of an object and to the speed of an object.</td></tr>
</table>

Unit 5: Relationships Among Forms of Energy

Instructional Days: 20

Unit Sequence	
Part B: *What would give you a better chance of winning a bowling match, using a basketball that you can roll really fast, or a bowling ball that you can only roll slowly?*	
Concepts	**Formative Assessments**
• When the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. • A system of objects may contain stored (potential) energy, depending on the objects' relative positions. • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the objects. • Models that could include representations, diagrams, pictures, and written descriptions of systems can be used to represent systems and their interactions, such as inputs, processes, and outputs, and energy and matter flows within systems.	*Students who understand the concepts can:* • Develop a model to describe what happens to the amount of potential energy stored in the system when the arrangement of objects interacting at a distance changes • Use models to represent systems and their interactions, such as inputs, processes, and outputs, and energy and matter flows within systems. Models could include representations, diagrams, pictures, and written descriptions.

Unit 5: Relationships Among Forms of Energy

Instructional Days: 20

<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: Who can design the best roller coaster?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>When the kinetic energy of an object changes, energy is transferred to or from the object.
When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
Kinetic energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).</td><td>Students who understand the concepts can:
Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
Conduct an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object. Do not include calculations of energy.</td></tr>
</table>

Unit 5: Relationships Among Forms of Energy

Instructional Days: 20

What It Looks Like in the Classroom
Prior to middle school, students know that energy is present whenever there are moving objects, sound, light, or heat and that when objects collide, energy can be transferred from one object to another, thereby changing the objects' motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. Students also know that when objects collide, the contact forces transfer energy so as to change the objects' motions. Students will need to construct graphical displays of data that describe the relationships between kinetic energy and mass of an object and speed of an object. These displays can be based on information from examples such as riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball. Through using one of these examples, students can record either mass or speed data to identify linear and nonlinear relationships. When constructing and interpreting graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object, students will use square root and cube root symbols to represent solutions to equations of the form $x^2=p$ and $x^3=p$, where p is a positive rational number. A simple demonstration of how increased speed or mass contributes to increased kinetic energy could include two objects of different masses (e.g., balls) rolling into a targets (e.g., plastic bowling pins, wooden blocks, etc.). From these examples, students will also be able to describe differences between kinetic energy and mass separately from kinetic energy and speed. Students will understand that an increase in speed will have a different effect on kinetic energy than an increase in mass. They will recognize and represent proportional relationships between kinetic energy and mass separately from kinetic energy and speed. Students will include a narrative that explains the information found in their graphical displays. Students investigate the potential energy stored in a variety of systems. It will be necessary for students to have opportunities to rearrange objects in the systems in order to determine the impact on the amount of potential energy stored in the system. Systems to be investigated could be balloons with static electrical charge being brought closer to a classmate's hair, carts at varying positions on a hill, cars at different positions on hot wheels tracks, objects at varying heights on shelves (drop a book of the same mass from different heights onto a cup) to demonstrate changes to potential energy in a system. Students will develop models to describe how changing distance changes the amount of potential energy stored in the system. The models students use to describe any of these examples will be multimedia presentations that could include diagrams, pictures, and/or written descriptions of the system examined. These models will help students represent interactions within systems, such as inputs, processes, and outputs, and energy flows within the system.

Unit 5: Relationships Among Forms of Energy

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Students will now have an opportunity to use an understanding of kinetic and potential energy within a system to construct a claim about the relationship between the transfer of energy to or from an object and changes in kinetic energy. Using data from the graphical displays of data and models that students developed earlier in this unit of study, as well as textual evidence, students will construct, use, and present oral and written arguments to support claims that when kinetic energy changes, energy is transferred to or from the object.

Students can provide evidence of this energy transfer by looking at the distance an object travels when energy is transferred, how temperature changes when energy is transferred, or how a compass responds to a magnetic field at different distances. Students will conduct an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object, but they are not required to include calculations of energy. However, students should interpret the equation $y = mx + b$ as defining a linear function whose graph is a straight line and be able to give examples of functions that are not linear when describing the change in the kinetic energy of an object and the energy transferred to or from the object.

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy Cite specific textual evidence to support analysis of science and technical texts that describe the relationships of kinetic energy to the mass of an object and to the speed of an object, attending to the precise details of explanations or descriptions. Integrate quantitative or technical information that describes the relationship of kinetic energy to the mass of an object and to the speed of object that is expressed in words with a version of that information expressed visually in a flowchart, diagram, model, graph, or table. Integrate multimedia and visual displays into presentations that describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system to clarify information, strengthen claims and evidence, and add interest. Cite specific textual evidence to support analysis of science and technical texts to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object, attending to the precise details of explanations or descriptions. Write arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the

object.

Mathematics

Reason abstractly and quantitatively by interpreting numerical, graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Describe a ratio relationship between kinetic energy and mass separately from kinetic energy and speed.

Understand the concept of a unit rate a/b associated with a ratio a:b with b≠, and use rate language in the context of a ratio relationship between kinetic energy and mass separately from kinetic energy and speed.

Recognize and represent proportional relationships between kinetic energy and mass separately from kinetic energy and speed.

Know and apply the properties of integer exponents to generate equivalent numerical expressions when describing the relationships between kinetic energy and mass separately from kinetic energy and speed.

When constructing and interpreting graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object, use square root and cube root symbols to represent solutions to equations of the form $x^2=p$ and $x^3=p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational.

When constructing and interpreting graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object, interpret the equation y = mx + b as defining a linear function whose graph is a straight line; give examples of functions that are not linear.

Reason abstractly and quantitatively when analyzing data to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Understand the concept of ratio and use ratio language to describe the ratio relationships between the change in the kinetic energy of an object and the energy transferred to or from the object.

Recognize and represent proportional relationships between the change in the kinetic energy of an object and the energy transferred to or from the object.

Interpret the equation y = mx + b as defining a linear function whose graph is a straight line; give examples of functions that

are not linear when describing the change in the kinetic energy of an object and the energy transferred to or from the object.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
Research on Student Learning
Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical

energy, can be used to make things happen.

The idea of energy conservation seems counterintuitive to middle- school students who hold on to the everyday use of the term energy. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted) (NSDL, 2015)

Prior Learning

By the end of Grade 5, students understand that:

- Energy is present whenever there are moving objects, sound, light, or heat.
- When objects collide, energy can be transferred from one object to another, thereby changing the objects' motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- Light also transfers energy from place to place.
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light.
- Transforming the energy of motion into electrical energy may have produced currents.
- When objects collide, the contact forces the transfer of energy so as to change the objects' motions.

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Future Learning
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). • In some cases, the relative position of energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

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Connections to Other Units
Grade 7, Unit 1: Structure and Properties of Matter • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **Grade 7, Unit 2: Interaction of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **Grade 6, Unit 4: Forces and Motion** • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. **Grade 6, Unit 7: Weather and Climate** • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. • Because these patterns are so complex, weather can only be predicted probabilistically. • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Sample of Open Education Resources
Soccer - Kick It**:** In this video, watch how two young soccer players investigate the relationship between the size of a player's leg and how far the ball can be kicked. It's All Downhill: Forces and Sports Lesson Plan**:** This lesson plan allows the learner to do free research to find information on a sport and the physics in that particular sport. This lesson references a streaming video from Discovery School. It is not entirely necessary to complete the lesson. Energy Skate Park: Basics: With this lesson, students learn about conservation of energy with a skateboarding simulation. Students build tracks, ramps, and jumps for the skater and view the kinetic energy, potential energy and friction as he moves. There are teacher-suggested lessons using the simulation. Energy: Different Kinds of Energy: Students use simulations to learn about potential and kinetic energy, how it is classified and how to calculate it.

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Appendix A: NGSS and Foundations for the Unit
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. *[Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]* **(MS-PS3-1)**
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. *[Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]* **(MS-PS3-2)**
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. *[Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.]* **(MS-PS3-5)**

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<table>
<tr><td colspan="3">The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr>
<td>Developing and Using Models
• Develop a model to describe unobservable mechanisms. (MS-PS3-2)
Analyzing and Interpreting Data
• Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)
Engaging in Argument from Evidence
• Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)
- -
Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon</td>
<td>PS3.A: Definitions of Energy
• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)
• A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)
PS3.B: Conservation of Energy and Energy Transfer
• When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)
PS3.C: Relationship Between Energy and Forces
• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)</td>
<td>Scale, Proportion, and Quantity
• Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1)
Systems and System Models
• Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)
Energy and Matter
• Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)</td>
</tr>
</table>

logical and conceptual connections between evidence and explanations (MS-PS3-5)		

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS3-1),(MS-PS3-5)* **RST.6-8.1** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1) **RST.6-8.7** Write arguments focused on discipline content. *(MS-PS3-5)* **WHST.6-8.1** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3) **WHST.6-8.7** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS3-2)* **SL.8.5**	Reason abstractly and quantitatively. (MS-PS3-1),(MS-PS3-5) **MP.2** Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS3-1),(MS-PS3-5) **6.RP.A.1** Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship. (MS-PS3-1) **6.RP.A.2** Recognize and represent proportional relationships between quantities. (MS-PS3-1),(MS-PS3-5) **7.RP.A.2** Know and apply the properties of integer exponents to generate equivalent numerical expressions. (MS-PS3-1) **8.EE.A.1** Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational. (MS-PS3-1) **8.EE.A.2** Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS3-1),(MS-PS3-5) **8.F.A.3**

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Common Vocabulary	
Orientation	Mass to energy conversion
Albert Einstein	Special theory of relativity
Bernoulli's principle	Speed of light
Buoyancy	Torque
Elasticity	Conversion
Electric field	Particle
Inertial frame of reference	Store
Magnetic field	Transfer

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Unit 6: Structures and Properties of Matter

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Unit Summary
How can a standard thermometer be used to tell you how particles are behaving?   In this unit, students *ask questions*, *plan and carry out investigations*, *engage in argument from evidence*, *analyze and interpret data, construct explanations*, *define problems and design solutions* as they make sense of the difference between energy and temperature. They use the practices to make sense of how the total change of energy in any system is always equal to the total energy transferred into or out of the system. The crosscutting concepts of *energy and matter, scale, proportion, and quantity*, and *influence of science, engineering, and technology on society and the natural world* are the organizing concepts for these disciplinary core ideas. Students ask *questions*, *plan and carry out investigations*, *engage in argument from evidence*, *analyze and interpret data*, *construct explanations*, *define problems and design solutions.* Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-PS3-3, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4.
Student Learning Objectives
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. *[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]* **(MS-PS3-3)**
Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. *[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]* **(MS-PS3-4)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and

constraints of the problem. (MS-ETS1-2)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)

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MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer
MS-PS3-4	Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved
ETS1.A	The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful
ETS1.B	There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem

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Unit 6: Structures and Properties of Matter

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Quick Links		

Enduring Understandings
• When the motion energy of an object changes, there is inevitably some other change in energy at the same time. • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. • Energy is spontaneously transferred out of hotter regions or objects and into colder
Essential Questions
• What is energy? • How is energy conserved and transferred? • What is the relationship between energy and forces?

Unit 6: Structures and Properties of Matter

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part A: How can a standard thermometer be used to tell you how particles are behaving?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>
There are relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.
Temperature is a measure of the average kinetic energy of particles of matter.
The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
Proportional relationships among the amount of energy transferred, the mass, and the change in the average kinetic energy of particles as measured by temperature of the sample provide information about the magnitude of properties and processes.
</td><td>Students who understand the concepts can:
Individually and collaboratively plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.
As part of a planned investigation, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
Make logical and conceptual connections between evidence and explanations.
</td></tr>
</table>

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Unit 6: Structures and Properties of Matter

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part B: You are an engineer working for NASA. In preparation for a manned space mission to the Moon, you are tasked with designing, constructing, and testing a device that will keep a hot beverage hot for the longest period of time. It costs approximately $10,000 per pound to take payload into orbit so the devise must be lightweight and compact. The lack of atmosphere on the Moon produces temperature extremes that range from -157 degrees C in the dark to +121 degrees C in the light. Your devise must operate on either side of the Moon (https://spaceflightsystems.grc.nasa.gov/education/rocket/moon.html).</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>
Temperature is a measure of the average kinetic energy of particles of matter.
The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
The transfer of energy can be tracked as energy flows through a designed or natural system.
The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful.
Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.
A solution needs to be tested and then modified on the basis of the test results in order to improve it.
There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.
</td><td>Students who understand the concepts can:

Apply scientific ideas or principles to design, construct, and test a design of a device that either minimizes or maximizes thermal energy transfer.
Determine design criteria and constraints for a device that either minimizes or maximizes thermal energy transfer.
Test design solutions and modify them on the basis of the test results in order to improve them.
Use a systematic process for evaluating solutions with respect to how well they meet criteria and constraints.
</td></tr>
</table>

Unit 6: Structures and Properties of Matter

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What It Looks Like in the Classroom
In Unit 5, students learned about the interactions between kinetic and potential energy. In this unit, they will be introduced to the idea of thermal energy and will explore how it relates to the interactions from Unit 5. Prior to planning an investigation, students will need to understand that temperature is actually a measure of the average kinetic energy of the particles in a sample of matter. Students will begin this unit by individually and collaboratively planning an investigation to determine energy transfer relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample. Students could start with an individual, small-group, or whole-class brainstorm to determine what might happen if they changed the temperature in a sample of matter. This brainstorm could take the form of a sketch, graphic organizer, or written response, and it could include everyday activities like taking a can of soda out of the refrigerator and setting it on a table or putting an ice cube into a warm beverage. After brainstorming, students may need some guidance to determine what variables they would like to test in their experiment. Students could examine how the mass of ice cubes added to the beverage affects the temperature change. They could also investigate how the mass of the can of soda affects the temperature change as it sits on the table after being removed from the refrigerator. Examples of experiments could include a comparison of final temperatures after different masses of ice have melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials as they cool or heat in the environment, or the same material with different masses when a specific amount of thermal energy is added. Another example could include placing heated steel washers into water to investigate temperature changes. Each of these examples helps to show the proportional relationship between different masses of the same substance and the change in average kinetic energy when thermal energy is added to or removed from the system. In planning, students will identify independent and dependent variables and controls, decide what tools and materials are needed, how measurements will be recorded, and how many data are needed to support their claim. Once experiments have been planned and performed, students will move into the engineering process to solve a problem using this content. In Unit 4, students used the design and engineering process to maximize a solution to a problem. In this unit of study, students will combine the concepts of thermal energy and engineering processes to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. Examples of devices could include an insulated box, a solar cooker, or a Styrofoam cup. Calculation of the total amount of thermal energy is not to be assessed at this time.

Based on their brainstorm and investigations, students will identify a device to control the transfer of thermal energy into or out of the system they studied. Once students have identified the type of device they will construct, they can begin to define the criteria and constraints of the design problem that will help to minimize or maximize the transfer of thermal energy. Using informational texts to support this process is important. Students will draw evidence from these texts in order to support their analysis, reflection, and research.

When students consider constraints, they should conduct short research projects to examine factors such as societal and individual needs, cost effectiveness, available materials and natural resources, current scientific knowledge, and current advancements in science and technology. They should also consider limitations (design constraints) due to the properties of the materials of their design (i.e., Styrofoam vs. glass). While conducting their research, students will need to gather their information from multiple print and digital sources and assess the credibility of each source. When they quote or paraphrase the data and conclusions found in their resources, they will need to avoid plagiarism and provide basic bibliographic information for each source. After comparing the information gained from their research, experiments, simulations, video, or other multimedia sources, they will be able to determine precise design criteria and constraints that lead to a successful solution.

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Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Follow precisely a multistep procedure for an investigation that has been planned individually and collaboratively to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. • Conduct short research projects to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. • Follow precisely a multistep process for the design, construction, and testing of a device that either minimizes or maximizes thermal energy transfer. • Conduct short research projects to apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer, drawing on several sources and generating additional related, focused questions that allow for multiple avenue of exploration. • Gather relevant information to inform the design, construction, and testing of a device that either minimizes or maximizes thermal energy transfer using multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. • Draw evidence from informational texts to support analysis, reflection, and research that informs the design, construction, and testing of a device that either minimizes or maximizes thermal energy transfer. • Cite specific textual evidence to support analysis of science and technical texts that provide information about the application of scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. • Compare and contrast the information gained from experiments, simulations, or multimedia sources with that gained from reading text about devices that either minimize or maximize energy transfer. *Mathematics* • Reason abstractly and quantitatively while collecting and analyzing numerical and symbolic data as part of an investigation

that has been planned individually and collaboratively.

- Summarize numerical data sets in relation to the amount of energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles in the sample as measured by the temperature of the sample.
- Reason abstractly and quantitatively while collecting and analyzing numerical and symbolic data as part of a systematic process for evaluating solutions with respect to how well they meet criteria and constraints of a problem involving the design of a device that either minimizes or maximizes thermal energy transfer.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Unit 6: Structures and Properties of Matter

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Research on Student Learning
Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen. The idea of energy conservation seems counterintuitive to middle- school students who hold on to the everyday use of the term energy. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted) (NSDL, 2015)

Prior Learning
By the end of Grade 5, students understand that: • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • Light transfers energy from place to place. • Energy can be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. • Transforming the energy of motion into electrical energy may have produced the currents to begin with. • When objects collide, the contact forces transfer energy so as to change the objects' motions.

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Future Learning
Physical science • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

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- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical and in making a persuasive presentation to a client about how a given design will meet his or her needs.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

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Connections to Other Units
Grade 6, Unit 4: Forces and Motion • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. **Grade 6, Unit 7: Weather and Climate** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity. • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. • Because these patterns are so complex, weather can only be predicted probabilistically. • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

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Unit 6: Structures and Properties of Matter

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Grade 7, Unit 1: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

Grade 7, Unit 2: Interactions of Matter

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

Grade 7, Unit 3: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Grade 7, Unit 8: Earth Systems

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Unit 6: Structures and Properties of Matter

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Grade 8, Unit 3: Stability and Change on Earth
• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Sample of Open Education Resources
Energy Forms and Changes: Explore how heating and cooling iron, brick, and water adds or removes energy. See how energy is transferred between objects. Build your own system, with energy sources, changers, and users. Track and visualize how energy flows and changes through your system. States of Matter: Watch different types of molecules form a solid, liquid, or gas. Add or remove heat and watch the phase change. Change the temperature or volume of a container and see a pressure-temperature diagram respond in real time. Relate the interaction potential to the forces between molecules.

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Appendix A: NGSS and Foundations for the Unit
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. *[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]* **(MS-PS3-3)**
Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. *[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]* **(MS-PS3-4)**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)

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The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4) **Constructing Explanations and Designing Solutions** • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3) **Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4) **PS3.B: Conservation of Energy and Energy Transfer** • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) **ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the	**Scale, Proportion, and Quantity** • Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-4) **Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3) **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of

solutions. (MS-ETS1-1) **Developing and Using Models** • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3) **Engaging in Argument from Evidence** • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)	designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that	scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

	performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-PS3-5),MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) **RST.6-8.1** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS3-3),(MS-PS3-4) **RST.6-8.3** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-3),(MS-PS3-4),(MS-ETS1-3) **RST.6-8.7** Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3) **RST.6-8.9** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2) **WHST.6-8.7** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) **WHST.6-8.8** Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) **WHST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4) **SL.8.5**	Reason abstractly and quantitatively. (MS-PS3-4)**,**(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4) **MP.2** Summarize numerical data sets in relation to their context. (MS-PS3-4) **6.SP.B.5** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) **7.EE.3** Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. (MS-ETS1-4) **7.SP**

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Common Vocabulary	
Orientation	Mass to energy conversion
Albert Einstein	Special theory of relativity
Bernoulli’s principle	Speed of light
Buoyancy	Torque
Elasticity	Conversion
Electric field	Particle
Inertial frame of reference	Store
Magnetic field	Transfer

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Unit 7: The Electromagnetic Spectrum

Instructional Days: 20

Unit Summary
How do cell phones work?
In this unit of study, students *develop and use models, use mathematical thinking,* and *obtain, evaluate, and communicate information* in order to describe and predict characteristic properties and behaviors of waves. Students also apply their understanding of waves as a means of sending digital information. The crosscutting concepts of *patterns* and *structure and function* are used as organizing concepts for these disciplinary core ideas. Students *develop and use models, use mathematical thinking,* and *obtain, evaluate, and communicate information.* Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-PS4-1, MS-PS4-2, and MS-PS4-3.
Student Learning Objectives
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. *[Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]* **(MS-PS4-1)**
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. *[Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]* **(MS-PS4-2)**
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. *[Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]* **(MS-PS4-3)**

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MS-PS4-1	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-PS4-3	Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals
PS4.A	A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude
PS4.B	A wave model of light is useful for explaining brightness, color, and the frequency dependent bending of light at a surface between media
PS4.C	Digitized signals are a more reliable way to encode and transmit information

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Quick Links		

Enduring Understandings
• When the motion energy of an object changes, there is inevitably some other change in energy at the same time. • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. • Energy is spontaneously transferred out of hotter regions or objects and into colder
Essential Questions
• What is energy? • How is energy conserved and transferred? • What is the relationship between energy and forces?

Unit 7: The Electromagnetic Spectrum

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Unit Sequence	
Part A: *Why do surfers love physicists?*	
Concepts	**Formative Assessments**
• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. • Describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. • Graphs and charts can be used to identify patterns in data. • Waves can be described with both qualitative and quantitative thinking.	*Students who understand the concepts can:* • Use mathematical representations to describe and/or support scientific conclusions about how the amplitude of a wave is related to the energy in a wave. • Use mathematical representations to describe a simple model.

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Unit 7: The Electromagnetic Spectrum

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Unit Sequence	
Part B: *How do the light and sound system in the auditorium work?*	
Concepts	**Formative Assessments**
• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • Waves are reflected, absorbed, or transmitted through various materials. • A sound wave needs a medium through which it is transmitted. • Because light can travel through space, it cannot be a matter wave, like sound or water waves. • The structure of a wave can be modified to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.	*Students who understand the concepts can:* • Develop and use models to describe the movement of waves in various materials.

Unit 7: The Electromagnetic Spectrum

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<table>
<tr><th colspan="2">Unit Sequence</th></tr>
<tr><td colspan="2">Part C: If rotary phones worked for my grandparents, why did they invent cell phones?</td></tr>
<tr><th>Concepts</th><th>Formative Assessments</th></tr>
<tr><td>• Structures can be designed to use properties of waves to serve particular functions.
• Waves can be used for communication purposes.
• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information than are analog signals.
• Wave-related technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.</td><td>Students who understand the concepts can:
• Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims that digitized signals are a more reliable way to encode and transmit information than analog signals are.</td></tr>
</table>

Unit 7: The Electromagnetic Spectrum

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What It Looks Like in the Classroom
In this unit of study, students learn that simple waves have repeating patterns with specific wavelengths, frequencies, and amplitudes. They will use both qualitative and quantitative thinking as they describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. For example, students could use a slinky to make a small wave, then increase the energy input and observe that an increase in energy results in an increase in the amplitude of the wave. Or they could push on the surface of a container of water with different amounts of energy and observe the amplitude of the waves created inside the container. Any modeling or demonstrations used to help students visualize this should be followed up with mathematical representations that students could use as evidence to support scientific conclusions about how the amplitude of a wave is related to the energy in a wave. Students can use graphs and charts (teacher provided) to identify patterns in their data. Students will then develop and use models to describe the movement of waves in various materials. Through the use of models and other multimedia and visual displays, students will describe that when light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. Students could then broaden their understanding of wave behavior by using models to demonstrate that waves are reflected, absorbed, or transmitted through various materials. Students can observe the behavior of ways by using a penlight and tracing the path that light travels between different transparent materials (e.g., air and water, air and glass. Students could also shine a light through a prism onto a screen or piece of paper, observe a pencil in a glass of water. A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. For example, students could observe some of the wave behaviors or light by observing that when light passes through a small opening the waves spread out. They could observe that if the wavelength is short, the waves spread out very little, whereas longer wavelengths spread out more. Students could them produce sketches of their observations. They may need some guidance in the elaboration of their sketches as it relates to the wave properties of light. Students can use a model of the electromagnetic spectrum to make connections between the brightness and color of light and the frequency of the light. Students will continue their study of waves by observing the behavior of sound waves. Before students begin to study the behavior of sound waves, the teacher could demonstrate the importance of the presence of a medium for sound to travel. For example, if an alarm clock is placed inside a bell jar and the air is removed, the alarm will not be heard outside of the jar. Students could be asked to explain why the can hear the sound before the air is pumped out and not after. This type of demonstration could be followed by discussion of the types of media that sound passes through and how these different media

impacts the sound.

Students could then participate in scientific discussions where they compare the behavior of mechanical waves (sound) and light waves. Based on their observations, students should be able to explain that the amplitude of all waves are related to the energy of the wave and that waves are reflected, absorbed, or transmitted through various materials. They should be able to explain that while mechanical waves need a medium in order to be transmitted, light waves do not. Therefore, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Once students have a clear understanding of how different types of waves behave, they can start to explore how society utilizes those waves. The structure of a wave can be modified to serve particular functions by taking into account properties of different materials and how materials can be shaped and used. Devices have been designed to utilize properties of waves to serve particular functions. For example, cell phones use wave properties for mobile communication purposes. These devices use digitized signals (sent as wave pulses) because they are a more reliable way than analog signals to encode and transmit information (compare capacity of an LP record to a CD or MP3 player). Another example of this is how digital signals can send information over much longer distances with less loss of information because background noise can be easily converted out by the receiving devices. Wave related technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. Students will integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims that digitized signals are a more reliable way to encode and transmit information than analog signals. Examples include basic understanding that waves can be used for communication purposes including using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversation of stored binary patterns to make sound or text on a computer screen.

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Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Integrate multimedia and visual displays into presentations that describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave, to clarify information. • Integrate multimedia and visual displays into presentations of a model that describes that waves are reflected, absorbed, or transmitted through various materials to clarify information. • Cite specific textual evidence to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. • Determine the central ideas or conclusions of a text; provide an accurate summary of the text to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals, distinct from prior knowledge or opinions. • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. • Draw evidence from informational texts to support the analysis of digitized signals as a more reliable way to encode and transmit information than analog signals. • Integrate multimedia and visual displays into presentations to strengthen claims and evidence showing that digitized signals as a more reliable way to encode and transmit information than analog signals.
Mathematics • Include mathematical representations to describe a simple model for waves. • Use mathematical representations to describe and/or support scientific conclusions about how the amplitude of a wave is related to the energy in a wave. • Understand the concept of a ratio and use ratio language to describe the relationship between the amplitude of a wave and

the energy in the wave.

- Use ratio and rate reasoning to solve problems showing the relationship between the amplitude of a wave and the energy of the wave.
- Recognize and represent proportional relationships when using mathematical representations to describe a simple model.
- When using mathematical representations to describe a simple model, interpret the equation $y = mx + b$ as defining a linear function whose graph is a straight line and give examples of functions that are not linear.

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning
N/A

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Prior Learning
By the end of Grade 5, students understand that: • The faster a given object is moving, the more energy it possesses. • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. • Energy is present whenever there are moving objects, sound, light, or heat. • When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • Light transfers energy from place to place. • Energy can be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by the transformation of energy of motion into electrical energy. • Waves, which are regular patterns of motion, can be made in water by disturbing the surface. • When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. • An object can be seen when light reflected from its surface enters the eyes. • Digitized information can be transmitted over long distances without significant degradation. • High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.

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Future Learning

Physical science

- The wavelength and frequency of a wave are related to one another by the speed *P* of the wave, which depends on the type of wave and the medium through which it is passing.
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
- Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons.
- The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat).
- Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
- Photoelectric materials emit electrons when they absorb light of a high enough frequency.

Earth and space science

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- The Big Bang theory is supported by observations of distant galaxies receding from our own, by the measured composition of stars and nonstellar gases, and by maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic

nuclei lighter than and including iron, and the process releases electromagnetic energy.

- Heavier elements are produced when certain massive stars achieve a supernova stage and explode.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

Connections to Other Units

Grade 7, Unit 5: Body Systems

- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Sample of Open Education Resources

Waves on a String: With this simulation (from PHeT), students explore the properties of waves and the behavior of waves through varying mediums and at reflective endpoints. There is a teacher's guide and suggested lessons on related topics that incorporate the simulation.

Sound Waves: Students will learn about frequency, amplitude, how to calculate the speed of sound, and sound waves.

Electromagnetic Math is designed to supplement teaching about electromagnetism. Students explore the simple mathematics behind light and other forms of electromagnetic energy including the properties of waves, wavelength, frequency, the Doppler shift, and the various ways that astronomers image the universe across the electromagnetic spectrum to learn more about the properties of matter and its movement. This collection of 84 problems provides a variety of practical application in mathematics and science concepts including proportions, analyzing graphs, evaluating functions, the inverse-square law, parts of a wave, types of radiation, and energy. Each one-page assignment includes background information. One-page answer keys accompany the assignments.

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Appendix A: NGSS and Foundations for the Unit		
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. *[Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]* **(MS-PS4-1)**		
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. *[Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]* **(MS-PS4-2)**		
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. *[Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]* **(MS-PS4-3)**		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking • Use mathematical representations to describe and/or support scientific conclusions and design solutions. (MS-PS4-1) **Developing and Using Models** • Develop and use a model to describe	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) • A sound wave needs a medium through which it is transmitted. (MS-PS4-2)	**Patterns** • Graphs and charts can be used to identify patterns in data. (MS-PS4-1) **Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be

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phenomena. (MS-PS4-2) **Obtaining, Evaluating, and Communicating Information** • Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (MS-PS4-3) - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS4-1)	**PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2) • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2) • However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2) **PS4.C: Information Technologies and Instrumentation** • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)	shaped and used. (MS-PS4-2) • Structures can be designed to serve particular functions. (MS-PS4-3) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3) - ***Connections to Nature of Science*** **Science is a Human Endeavor** • Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)

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English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-PS4-3) **RST.6-8.1** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-PS4-3) **RST.6-8.2** Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-PS4-3) **RST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-PS4-3) **WHST.6-8.9** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-PS4-1),(MS-PS4-2) **SL.8.5**	Reason abstractly and quantitatively. (MS-PS4-1) **MP.2** Model with mathematics. (MS-PS4-1) **MP.4** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1) **6.RP.A.1** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1) **6.RP.A.3** Recognize and represent proportional relationships between quantities. (MS-PS4-1) **7.RP.A.2** Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS4-1) **8.F.A.3**

Common Vocabulary	
Conservation	Mass
Convert	Design task
Current	Field
Electric circuit	Insulate
Electric current	Evolve
Transfer	Systematic