TOWNSHIP OF UNION PUBLIC SCHOOLS

5th Grade Science Curriculum Guide

June 2017

Mission Statement

The mission of the Township of Union Public Schools is to build on the foundations of honesty, excellence, integrity, strong family, and community partnerships. We promote a supportive learning environment where every student is challenged, inspired, empowered, and respected as diverse learners. Through cultivation of students' intellectual curiosity, skills and knowledge, our students can achieve academically and socially, and contribute as responsible and productive citizens of our global community.

Philosophy Statement

The Township of Union Public School District, as a societal agency, reflects democratic ideals and concepts through its educational practices. It is the belief of the Board of Education that a primary function of the Township of Union Public School System is the formulation of a learning climate conducive to the needs of all students in general, providing therein for individual differences. The school operates as a partner with the home and community.

Statement of District Goals

- Develop reading, writing, speaking, listening, and mathematical skills.
- Develop a pride in work and a feeling of self-worth, self-reliance, and self-discipline.
- Acquire and use the skills and habits involved in critical and constructive thinking.
- Develop a code of behavior based on moral and ethical principles.
- Work with others cooperatively.
- Acquire a knowledge and appreciation of the historical record of human achievement and failures and current societal issues.
- Acquire a knowledge and understanding of the physical and biological sciences.
- Participate effectively and efficiently in economic life and the development of skills to enter a specific field of work.
- Appreciate and understand literature, art, music, and other cultural activities.
- Develop an understanding of the historical and cultural heritage.
- Develop a concern for the proper use and/or preservation of natural resources.
- Develop basic skills in sports and other forms of recreation.

Science: Grade 5

Introduction: The purpose of this curriculum is to provide students with fundamental understandings in life, earth and space, and physical sciences, while also developing critical thinking skills. Students will be encouraged to develop the qualities inherent in the practice of science, such as curiosity, skepticism, open-mindedness, and honesty. Particular attention will be paid to collecting of data and interpreting findings.

In fifth grade, students will demonstrate an understanding that matter is made of particles too small to be seen by developing a model, the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved; using models, students can describe the movement of matter among plants, animals, decomposers, and the environment, and they can explain that energy in animals' food was once energy from the sun; describe and graph data to provide evidence about the distribution of water on Earth, describe ways in which the geosphere, biosphere, hydrosphere, and atmosphere interact; and develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

This curriculum is aligned with the Next Generation Science Standards, the Common Core State Standards for English Language Arts & Literacy in Science, the Common Core State Standards for Math, and the New Jersey Core Curriculum Standards for Technology.

This document is a tool that will provide an overview as to what to teach, when to teach it, and how to assess student progress. With considerations made for altered pacing, modifications, and accommodations; this document is to be utilized for all students enrolled in this course, regardless of ability level, native language, or classification. It is meant to be a dynamic tool that we, as educators, will revise and modify as it is used during the course of the school year.

Pacing Guide - Fifth Grade Science

Unit 1: Properties of Matter **Instructional Days: 15**

In this unit of study, students describe that matter is made of particles too small to be seen by developing a model. The crosscutting concept of scale, proportion, and quantity is called out as an organizing concept for these disciplinary core ideas. Students demonstrate grade-appropriate proficiency in developing and using models, planning and carrying out investigations, and use these practices to demonstrate understanding of the core ideas. This unit is based on 5-PS1-3 and 5-PS1-1.

Unit 2: Changes to Matter **Instructional Days: 15**

In this unit of study, students develop an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved. Students determine whether the mixing of two or more substances results in new substances. The crosscutting concepts of cause and effect and scale, proportion, and quantity are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations and using mathematics and computational thinking. Students are expected to use these practices to demonstrate understanding of the core ideas. This unit is based on 5-PS1-4 and 5-PS1-2.

Unit 3: Energy and Matter in Ecosystems **Instructional Days: 15**

In this unit of study, students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment, and they can explain that energy in animals' food was once energy from the sun. The crosscutting concepts of energy and matter and systems and system models are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in 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 5-LS1-1, 5-LS2-1, and 5-PS3-1.

Unit 4: Water on the Earth **Instructional Days: 15**

In this unit of study, students describe and graph data to provide evidence about the distribution of water on Earth. The crosscutting concepts of scale, proportion, quantity and systems, and systems models are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in using mathematics and computational thinking and in obtaining, evaluating, and communicating information. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on 5-ESS2-2 and 5-ESS3-1.

Unit 5: Earth Systems **Instructional Days: 20**

In this unit of study, students are able to describe ways in which the geosphere, biosphere, hydrosphere, and atmosphere interact. The crosscutting concept of systems and system models is called out as an organizing concept for this disciplinary core idea. Students are expected to demonstrate grade-appropriate proficiency in developing and using models, obtaining, evaluating, and communicating information. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on 5-ESS2-1 and 5-ESS3-1.

Unit 6: Interactions Within the Earth, Sun, and Moon System **Instructional Days: 20**

In this unit of study, students develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. The crosscutting concepts of patterns, cause and effect, and scale, proportion, and quantity are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in analyzing and interpreting data and engaging in argument from evidence. Students are also expected to use these practices to demonstrate an understanding of the core ideas. This unit is based on 5-PS2-1, 5-ESS1-1, and5-ESS1-2.

Note: The number of instructional days is an estimate based on the information available at this time. 1 day equals approximately 42 minutes of seat time.

Unit 1: Properties of Matter

Unit Summary
When matter changes, does its weight change? In this unit of study, students describe that matter is made of particles too small to be seen by developing a model. The crosscutting concept of *scale, proportion, and quantity* is called out as an organizing concept for these disciplinary core ideas. Students demonstrate grade-appropriate proficiency in *developing and using models, planning and carrying out investigations*, and use these practices to demonstrate understanding of the core ideas.
Student Learning Objectives
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.]* **(5-PS1-3)**
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-PS1-1)**

Unit Sequence	
Part A: *How can properties be used to identify materials?*	
Concepts	**Formative Assessments**
• 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.)*	*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

Unit Sequence

Part B: *What kind of model would best represent/describe matter as made of particles that are too small to be seen?*

Concepts	Formative Assessments
• 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.	*Students who understand the concepts can:* • 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.

Connecting with English Language Arts/Literacy and Mathematics

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.

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.

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

Elementary 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 (NSDL, 2015).

Prior Learning

Grade 2 Unit 2: Properties of Matter

- 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.
- Different properties are suited to different purposes.
- A great variety of objects can be built up from a small set of pieces.

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.

Connections to Other Units

In **Unit 2, Changes to Matter**, students will use mathematical and computational thinking to understand the cause-and-effect relationship between physical changes in matter and conservation of weight.

Sample of Open Education Resources

Material Properties: The dangerous Androvax has crash-landed on Earth! Sabotage his escape plans by tricking him into building a space ship out of the wrong materials.

Teacher Professional Learning Resources

NSTA Web Seminar: Teaching NGSS in Elementary School—Fifth Grade

Carla Zembal-Saul, Professor of Science Education at Penn State University, Mary Starr, Executive Director of Michigan Mathematics and Science Centers Network, and Kathy Renfrew, K-5 Science Coordinator for VT Agency of Education, shared an overview of the NGSS for Fifth Grade level students. Strategies, such as Claims, Evidence and, Reasoning (CER) and Know, Learning, Evidence, Wondering and Science (KLEWS) were discussed. The bundling of performance expectations with a focus on scientific practices, disciplinary core ideas, and cross-cutting concepts was also presented as a strategy for pulling it all together.

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.

View the resource collection.

Continue discussing this topic in the community forums.

NSTA Web Seminar: NGSS Core Ideas: Matter and Its Interactions

Dr. Krajcik began the presentation by defining disciplinary core ideas and discussing the value of using core ideas to build understanding across time. He also talked about the way disciplinary core ideas work together with the other components of *NGSS*: scientific and engineering practices and crosscutting concepts. The program featured strategies for teaching about physical science concepts that answer questions such as "How do particles combine to form the variety of matter one observes?" and "How do substances combine or change (react) to make new substances?" Dr. Krajcik talked about the disciplinary core ideas for Properties of Matter and shared examples of student work. Participants had the opportunity to ask questions and discuss ideas for classroom application with other participating teachers.

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Teacher Professional Learning Resources

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Appendix A: NGSS and Foundations for the Unit

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.]* **(5-PS1-3)**

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-PS1-1)**

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 • 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)

English Language Arts	Mathematics
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** 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**	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** 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-PS1-1) **5.NBT.A.1** 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** Recognize volume as an attribute of solid figures and understand concepts of volume measurement. (5-PS1-1) **5.MD.C.3** Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft., and improvised units. (5-PS1-1) **5.MD.C.4**

Unit 2: Changes to Matter

Unit Summary

If I have a frozen water bottle that weighs 500 mg, how much will it weigh if the water melts?

In this unit of study, students develop an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved. Students determine whether the mixing of two or more substances results in new substances. The crosscutting concepts of *cause and effect* and *scale, proportion, and quantity* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *planning and carrying out investigations* and *using mathematics and computational thinking*. Students are expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 5-PS1-4 and 5-PS1-2.

Student Learning Objectives

Conduct an investigation to determine whether the mixing of two or more substances results in new substances. **(5-PS1-4)**

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. *[Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.]* [Assessment Boundary: Assessment does not include distinguishing mass and weight.]. **(5-PS1-2)**

Quick Links

Unit Sequence

Part A: *How can we make slime?*

Concepts	Formative Assessment
• Cause-and-effect relationships are routinely identified,	*Students who understand the concepts are able to:*

tested, and used to explain change. • When two or more different substances are mixed, a new substance with different properties may be formed.	• 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.

Unit Sequence	
Part B: *How can baking soda and vinegar burst a zip-lock bag?*	
Concepts	**Formative Assessment**
• 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.	*Students who understand the concepts are able to:* • 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.

Connecting with English Language Arts/Literacy and Mathematics

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.

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.

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

Student thinking about chemical change tends to be dominated by the obvious features of the change. For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame (NSDL, 2015).

Prior Learning

Grade 2 Unit 2: Properties of Matter

- 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.
- Different properties are suited to different purposes.

Grade 2 Unit 3: Changes to Matter

- A great variety of objects can be built up from a small set of pieces.
- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.

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.

Connections to Other Units

In **Unit 1: Properties of Matter**, students describe that matter is made of particles too small to be seen.

Sample of Open Education Resources

Time for Slime: Students combine water and borax to create slime. Be sure to read and follow all of the cautions on the borax box label.

Bubble Burst! How can baking soda and vinegar burst a zip-lock bag?

Flame Out: A candle flame is actually a chemical reaction in action! Candle wax is one of the chemicals in the reaction.

Teacher Professional Learning Resources

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.

***NGSS* Core Ideas: Matter and Its Interactions**

The presenter was Joe Krajcik from Michigan State University. The program featured strategies for teaching about physical science concepts that answer questions such as "How do particles combine to form the variety of matter one observes?" and "How do substances combine or change (react) to make new substances?"

Dr. Krajcik began the presentation by defining disciplinary core ideas and discussing the value of using core ideas to build understanding across time. He also talked about the way disciplinary core ideas work together with the other components of NGSS: scientific and engineering practices and crosscutting concepts. Dr. Krajcik talked about the disciplinary core ideas for PS1 and shared examples of student work. Participants had the opportunity to ask questions and discuss ideas for classroom application with other participating teachers.

Visit the resource collection.

Continue discussing this topic in the community forums.

Appendix A: NGSS and Foundations for the Unit

Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (5-PS1-4)

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. *[Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.]* [Assessment Boundary: Assessment does not include distinguishing mass and weight.]. **(5-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
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)	**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)	**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)

English Language Arts	Mathematics
Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (5-PS1-2),(5-PS1-4) **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-PS1-2)(5-PS1-4) **W.5.8** Draw evidence from literary or informational texts to support analysis, reflection, and research. (5-PS1-2),(5-PS1-4) **W.5.9**	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**

Unit 3: Energy and Matter in Ecosystems

Unit Summary
What happens to the matter and energy that are part of each organism?
In this unit of study, students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment, and they can explain that energy in animals' food was once energy from the sun. The crosscutting concepts of *energy and matter* and *systems and system models* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *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 5-LS1-1, 5-LS2-1, and 5-PS3-1.
Student Learning Objectives
Support an argument that plants get the materials they need for growth chiefly from air and water. *[Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]* (**5-LS1-1**)
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-LS2-1**)
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. *[Clarification Statement: Examples of models could include diagrams, and flow charts.]* (**5-PS3-1**)

Quick Links		

Unit Sequence	
Part A: *Where do plants get the materials they need for growth?*	
Concepts	**Formative Assessment**
• Matter is transported into, out of, and within systems. • Plants acquire their material for growth chiefly from air and water.	*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.)*

Unit Sequence	
Part B: *How does matter move among plants, animals, decomposers, and the environment?*	
Concepts	**Formative Assessment**
• 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.	*Students who understand the concepts are able to:* • 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

Unit Sequence	
Part C: *How can energy in animals' food be traced to the sun?*	
Concepts	**Formative Assessment**
• 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.	*Students who understand the concepts are able to:* • 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.

Connecting with English Language Arts/Literacy and Mathematics

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.

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.

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 can understand simple food links involving two organisms. Yet they often think of organisms as independent of each other but dependent on people to supply them with food and shelter. Upper elementary-school 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.

Some students of all ages have difficulty in identifying the sources of energy for plants and also for animals. [8] 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 Setting and The Living Environment benchmarks 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. [6] 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.

Students' meaning for "energy," both before and after traditional instruction, is considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable. Although students typically hold these meanings for energy at all ages, upper elementary-school students tend to associate energy only with living things, in particular with growing, fitness, exercise, and food (NSDL, 2015).

Prior Learning

Kindergarten Unit 4: Basic Needs of Living Things

- 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.

Grade 2: Relationships in Habitats

- Plants depend on water and light to grow.
- Plants depend on animals for pollination or to move their seeds around.

Grade 4: Weathering and Erosion

- Living things affect the physical characteristics of their regions.

Future Learning

Grade 4 Unit 5: Transfer of Energy

- 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 also transfers energy from place to place.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

Grade 4 Unit 6: Forces and Motion

- The faster a given object is moving, the more energy it possesses.
- 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.)

Grade 4 Unit 7: Using Engineering Design with Force and Motion Systems

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.

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)*

Connections to Other Units

This unit applies the ideas learned in **Grade 5 Unit 2: Changes to Matter.** In this unit, students developed an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved.

Sample of Open Education Resources

Bottle Biology Terrarium: 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.

Bio domes Engineering Design Project: 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 bio dome. 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 bio dome 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.)

Teacher Professional Learning Resources

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.

Engineering Design as a Core Idea

The presenter was Cary Sneider, Associate Research Professor at Portland State University in Portland, Oregon. The seminar focused on the Core Idea of Engineering, led by Cary Sneider, Associate Research Professor at Portland State University. Cary explained the overall *NGSS* engineering components for K-2, MS and HS, and went through a number of practical examples of how teachers could develop modules and investigations for their students to learn them. Cary also spoke about the ways in which teachers could include cross-cutting engineering concepts to a number of classroom subjects. The seminar concluded Q & A session with Cary.

Visit the resource collection.

Continue discussing this topic in the community forums.

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. Participants had the opportunity to ask questions and discuss ideas for classroom application with other participating teachers.

Visit the resource collection.

Continue discussing this topic in the community forums.

NGSS Core Ideas: Ecosystems: Interactions, Energy, and Dynamics

The presenters were Andy Anderson and Jennifer Doherty of Michigan State University. This was the ninth 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 life science concepts that answer questions such as "How do organisms interact with the living and nonliving environments to obtain matter and energy?" and "How do matter and energy move through an ecosystem?"

Dr. Anderson and Dr. Doherty began the presentation by discussing the two main strands of the ecosystems disciplinary core idea: community ecology and ecosystem science. They talked about common student preconceptions and strategies for addressing them. Next, Dr. Anderson and Dr. Doherty shared learning progressions for this core idea, showing how student understanding builds from elementary through high school. Last, the presenters described approaches for teaching about ecosystems and shared resources to use with students. Participants had the opportunity to submit their questions and comments in the chat.

Visit the resource collection.

Continue discussing this topic in the community forums.

Appendix A: NGSS and Foundations for the Unit

Support an argument that plants get the materials they need for growth chiefly from air and water. *[Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]* **(5-LS1-1)**

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-LS2-1)**

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. *[Clarification Statement: Examples of models could include diagrams, and flow charts.]* **(5-PS3-1)**

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
Engaging in Argument from Evidence • Support an argument with evidence, data, or a	LS1.C: Organization for Matter and Energy Flow in Organisms • Plants acquire their material for growth chiefly from air and water. (5-LS1-1) LS2.A: Interdependent Relationships in Ecosystems • 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	Energy and Matter • Matter is transported into, out of, and within systems. (5-LS1-1) • Energy can be

model. (5-LS1-1) **Developing and Using Models** • Develop a model to describe phenomena. (5-S2-1) • Use models to describe phenomena. (5-PS3-1)	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) **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • 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. (5-LS2-1) **PS3.D: Energy in Chemical Processes and Everyday Life** • 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). (5-PS3-1) **LS1.C: Organization for Matter and Energy Flow in Organisms** • 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. (secondary to 5-PS3-1)	transferred in various ways and between objects. (5-PS3-1) **Systems and System Models** • 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)

English Language Arts	Mathematics
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** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-LS1-1) **W.5.1** 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**	Reason abstractly and quantitatively. (5-LS1-1), (5-LS2-1) **MP.2** Model with mathematics. (5-LS1-1), (5-LS2-1) **MP.4** Use appropriate tools strategically. (5-LS1-1) **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-LS1-1) **5.MD.A.1**

Unit 4: Water on the Earth

Unit Summary

How do individual communities use science ideas to protect Earth's resources and environment?

In this unit of study, students describe and graph data to provide evidence about the distribution of water on Earth. The crosscutting concepts of *scale, proportion, quantity* and *systems, and systems models* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *using mathematics and computational thinking* and in *obtaining, evaluating, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 5-ESS2-2 and 5-ESS3-1.

Student Learning Objectives

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. *[Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.]* **(5-ESS2-2)**

Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (5-ESS3-1)

Quick Links

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Appendix A: NGSS and Foundations p. 8

Unit Sequence

Part A: *Where is water found on the Earth? What percentage of the Earth's water is fresh water?*

Concepts	Formative Assessment
• Standard units are used to measure and describe physical quantities such as weight and volume. • Nearly all of Earth's available water is in the ocean.	*Students who understand the concepts are able to:* • Describe physical quantities, such as weight and volume, in standard units. • Describe and graph quantities such as area and volume to address scientific questions.

• Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.	• 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. *(Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.).*

Unit Sequence	
Part B: *How do individual communities use science ideas to protect Earth's resources and environment?*	
Concepts	**Formative Assessment**
• A system can be described in terms of its components and their interactions. • Science findings are limited to questions that can be answered with empirical evidence. • Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. • Individuals and communities are doing things to help protect Earth's resources and environments.	*Students who understand the concepts are able to:* • 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

During this unit of study, students need to understand that Earth is a system made up of subsystems, all of which have multiple components that interact. Throughout this unit, students will consider scale and proportion when examining the amount of water on the Earth, and they will consider the impact that humans have on one of Earth's most valuable resources.

To begin the progression of learning in this unit, students conduct research, using informational texts and online resources, to determine the distribution of fresh water and salt water among Earth's oceans, rivers, lakes, glaciers, groundwater, and polar ice caps. Students organize their data into graphs or charts, showing the allocation of fresh water and salt water on Earth. (Amounts should be described in terms of volume, as well as in percentages.) After comparing and analyzing data, students should be able to conclude the following:

- Nearly all of Earth's available water is in the ocean.
- Fresh water makes up less than 3% of the total amount of water on the Earth.
- Most fresh water is found in glaciers or underground.
- Only a tiny fraction of the fresh water on Earth is in streams, lakes, wetlands, and the atmosphere.

Next, students conduct research in order to determine ways in which individuals and communities help to protect the Earth's resources and environments. Using books and other reliable media resources, as well as first-hand observations in the local community, students gather information about the ways in which humans affect the environment. They should look for examples of human activities in agriculture, industry, and in their everyday lives, and should describe, both orally and in writing, the ways in which these activities affect the land, oceans, streams, groundwater, air, and other organisms (both plants and animals). Students will need the opportunity to share their findings with the class, and then should conduct further research to find ways in which individual communities use science ideas to protect the Earth's resources and environments.

Working in pairs or small groups, students should gather relevant information from both observations and reliable resources to prepare a presentation that explains one way in which a community is minimizing the effects of human activities on Earth's resources and environment. The presentation should include both writing and speaking components, as well as a list of sources that were used to provide information. As a result of conducting research and creating a presentation, students should come to understand that the ecosystem is a system that includes both living and nonliving components that interact with one another. These interactions cause changes to the system and its components. Humans are just one of many components in an ecosystem, yet our activities affect all parts of the ecosystem, many times in adverse ways.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

Students use print and digital sources to gather information and data that describe the amount of fresh water and salt water on the Earth and where it is found. As students gather information, they should organize the information into graphs, analyze and interpret the information to answer questions, and summarize the information in order to describe the amounts and percentages of fresh water and salt water on the Earth and to provide evidence about the distribution of water in oceans, lakes, streams, and reservoirs. Students also use several print and digital resources to find examples of:

- The effects of human activities in agriculture, industry, and everyday life on Earth's resources and environments
- Ways in which communities are using science ideas to protect Earth's resources and environments.

Students summarize and paraphrase the information and use it when creating presentations that describe ways in which communities are using science ideas to protect Earth's resources and environments. The presentation should include both oral and written components, and a list of sources should be included with the presentation.

Mathematics

Students model with mathematics by using tables, charts, and/or graphs to organize data and information they collect. This includes the amount of fresh and salt water on Earth, the locations of both fresh and salt water on Earth, how human activities affect Earth's resources, and ways in which communities protect the Earth's resources and environments. Students also reason abstractly and quantitatively when analyzing these data to use as evidence to support their thinking.

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

Prior Learning

Grade 2 Unit 4: The Earth's Land and Water

- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

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.

Grade 7 Unit 8: Earth Systems

- 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.
- 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.

Connections to Other Units

In **Unit 5,** students are able to describe ways in which the geosphere, biosphere, hydrosphere, and atmosphere interact.

Sample of Open Education Resources

Global Water Distribution: In this lesson sequence, students predict and model the availability of water on Earth and discuss methods that can be used to purify and conserve this critical resource. They also assess how much water they and their families typically use, and think about ways to reduce their water usage. Finally, students explore different techniques being employed for water management around the world, including the use of dams to create reservoirs.

Simulating an Oil Spill to Understand Environmental Impact: This 8 minute instructional video provides a model for teachers to follow of a week long investigation of oil spills and the environmental impact they have on shorelines and creatures. Students take on the task of cleaning up a simulated oil spill. Educator uses the 5E curriculum model to engage students with fiction and non-fiction texts before exploring methods that simulate an oil spill and its cleanup. Video demonstrates the key portions of the activity and models appropriate teacher questioning and interactions with the students.

Teacher Professional Learning Resources

Teaching *NGSS* in K-5: Making Meaning through Discourse

The 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 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.

After a brief overview of the *NGSS,* 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. Dr. Lopez began the presentation by discussing the importance of systems and system models as a crosscutting concept. He talked about the key features of a system: boundaries, components, and flows and interactions. Dr. Lopez also described different types of system models, including conceptual, mathematical, physical, and computational models. Participants discussed their current classroom applications of systems and system models and brainstormed ways to address challenges associated with teaching this crosscutting concept.

***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.

***NGSS* Core Ideas: Earth and Human Activity**

The presenters were Susan Buhr Sullivan, Director of the CIRES Education and Outreach Group at University of Colorado; and Aida Awad, Science Department Chair at Maine East High School in Park Ridge, IL and president of the National Association of Geoscience Teachers (NAGT). The program featured strategies for teaching about Earth science concepts that answer questions such as "How do humans depend on Earth's resources?" and "How do humans change the planet?"

Dr. Buhr Sullivan began the presentation by describing the interconnections between this disciplinary core idea and other components of *NGSS*. She then talked about building a foundation for key concepts related to Earth and Human Activity at the elementary level. Ms. Awad continued the discussion by sharing the progression of this core idea through the middle school level and on to high school. The presenters provided a list of resources and activities that teachers can use to begin implementing *NGSS* in the classroom.

Visit the resource collection.

Continue discussing this topic in the community forums.

Appendix A: NGSS and Foundations for the Unit

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. *[*Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.*]* **(5-ESS2-2)**

Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (5-ESS3-1)

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 • Describe and graph quantities such as area and volume to address scientific questions. (5-ESS2-2) **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.C: The Roles of Water in Earth's Surface Processes** • Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2) **ESS3.C: Human Impacts on Earth Systems** • 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)	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2) **Systems and System Models** • A system can be described in terms of its components and their interactions. (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)

English Language Arts	Mathematics
Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-ESS3-1) **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-ESS2-2), (5-ESS3-1) **RI.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-ESS2-2), (5-ESS3-1) **W.5.8** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-ESS3-1) **RI.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. (5-ESS3-1) **W.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-ESS2-2) **SL.5.5**	Reason abstractly and quantitatively. (5-ESS2-2), (5-ESS3-1) **MP.2** Model with mathematics. (5-ESS2-2), (5-ESS3-1) **MP.4**

Unit 5: Earth Systems

Unit Summary
How do individual communities use science ideas to protect Earth's resources and environment?   In this unit of study, students are able to describe ways in which the geosphere, biosphere, hydrosphere, and atmosphere interact. The crosscutting concept of *systems and system models* is called out as an organizing concept for this disciplinary core idea. Students are expected to demonstrate grade-appropriate proficiency in *developing and using models, obtaining, evaluating, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on 5-ESS2-1 and 5-ESS3-1.
Student Learning Objectives
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-ESS2-1)**
Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (5-ESS3-1)

Quick Links		
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What it Looks Like in the Classroom p. 3	Prior Learning p. 5	Teacher Professional Learning Resources p. 7
Connecting with ELA/Literacy and Math p. 4	Future Learning p. 6	Appendix A: NGSS and Foundations p. 9
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Unit Sequence	
Part A: *In what ways do the geosphere, biosphere, hydrosphere, and/or atmosphere interact?*	
Concepts	**Formative Assessment**
• A system can be described in terms of its components and their	*Students who understand the concepts are able to:*

interactions. • 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). • The Earth's major 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 atmosphere interact with landforms to determine patterns of weather.	• 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.

Unit Sequence	
Part B: *How do individual communities use science ideas to protect Earth's resources and environment?*	
Concepts	**Formative Assessment**
• A system can be described in terms of its components and their interactions. • Science findings are limited to questions that can be answered with empirical evidence. • Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. • Individuals and communities are doing things to help protect Earth's resources and environments.	*Students who understand the concepts are able to:* • 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.

Connecting with English Language Arts/Literacy and Mathematics

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.

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.

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

Prior Learning

Grade 2 Unit 4: The Earth's Land and Water

- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.
- Wind and water can change the shape of the land.

Grade 3 Unit 1: 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.
- Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.

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.

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.

Connections to Other Units

In **unit 4**, students are able to describe and graph data to provide evidence about the distribution of water on Earth.

Sample of Open Education Resources

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.

Teacher Professional Learning Resources

Assessment for the Next Generation Science Standards

The presenters were Joan Herman, Co-Director Emeritus of the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) at UCLA; and Nancy Butler Songer, Professor of Science Education and Learning Technologies, University of Michigan.

Dr. Herman began the presentation by summarizing a report by the National Research Council on assessment for the Next Generation Science Standards (NGSS). She talked about the development of the report and shared key findings. Next, Dr. Songer discussed challenges for classroom implementation and provided examples of tasks that can be used with students to assess their proficiency on the NGSS performance expectations. Participants had the opportunity to submit questions and share their feedback in the chat.

View the resource collection.

Continue discussing this topic in the community forums.

NGSS Crosscutting Concepts: Patterns

The presenter was Kristin Gunckel from the University of Arizona. Dr. Gunckel began the presentation by discussing how patterns fit in with experiences and explanations to make up scientific inquiry. Then she talked about the role of patterns in NGSS and showed how the crosscutting concept of patterns progresses across grade bands. After participants shared their ideas about using patterns in their own classrooms, Dr. Gunckel shared instructional examples from the elementary, middle school, and high school levels.

NGSS Crosscutting Concepts: Structure and Function

The presenters were Cindy Hmelo-Silver and Rebecca Jordan from Rutgers University. Dr. Hmelo-Silver and Dr. Jordan began the presentation by discussing the role of the crosscutting concept of structure and function within NGSS. They then asked participants to think about the example of a sponge and discuss in the chat how a sponge's structure relates to its function. The presenters introduced the Structure-Behavior-Function (SBF) theory and talked about the importance of examining the relationships between mechanisms and structures. They also discussed the use of models to explore these concepts. Participants drew their own models for one example and shared their thoughts about using this strategy in the classroom.

NGSS Core Ideas: Earth and Human Activity

The presenters were Susan Buhr Sullivan, Director of the CIRES Education and Outreach Group at University of Colorado; and Aida Awad, Science Department Chair at Maine East High School in Park Ridge, IL and president of the National Association of Geoscience Teachers (NAGT). The program featured strategies for teaching about Earth science concepts that answer questions such as "How do humans depend on Earth's resources?" and "How do humans change the planet?"

Dr. Buhr Sullivan began the presentation by describing the interconnections between this disciplinary core idea and other components of *NGSS*. She then talked about building a foundation for key concepts related to Earth and Human Activity at the elementary level. Ms. Awad continued the discussion by sharing the progression of this core idea through the middle school level and on to high school. The presenters provided a list of resources and activities that teachers can use to begin implementing *NGSS* in the classroom.

Visit the resource collection.

Continue discussing this topic in the community forums.

Appendix A: NGSS and Foundations for the Unit

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-ESS2-1)**

Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (5-ESS3-1)

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	**ESS2.A: Earth Materials and Systems**	**Systems and System Models**
• Develop a model using an	• Earth's major systems are the geosphere (solid and molten rock, soil, and	• A system can be

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)	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 atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1) **ESS3.C: Human Impacts on Earth Systems** • 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)	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)

English Language Arts	Mathematics
Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-ESS3-1) **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-ESS2-1),(5-ESS3-1) **RI.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** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-ESS3-1) **RI.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. (5-ESS3-1) **W.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-ESS2-2),(5-ESS2-1) **SL.5.5**	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**

Unit 6: Interactions Within the Earth, Sun, and Moon System

Unit Summary

What patterns do we notice when observing the sky?

In this unit of study, students develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. The crosscutting concepts of *patterns, cause and effect*, and *scale, proportion, and quantity* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *analyzing and interpreting data* and *engaging in argument from evidence*. Students are also expected to use these practices to demonstrate an understanding of the core ideas.

This unit is based on 5-PS2-1, 5-ESS1-1, and5-ESS1-2.

Student Learning Objectives

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-PS2-1)**

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-ESS1-1)**

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.*]* **(5-ESS1-2)**

Quick Links

Unit Sequence	
***Part A:** What effect does Earth's gravitational force have on objects?*	
Concepts	**Formative Assessment**

• 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.	*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.).*

Unit Sequence	
Part B: *What effect does the relative distance from Earth have on the apparent brightness of the sun and other stars?*	
Concepts	**Formative Assessment**
• 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.	*Students who understand the concepts are able to:* • 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.)*

Unit Sequence	
Part C: *What patterns do we notice when observing the sky?*	
Concepts	**Formative Assessment**

• 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.
	Students who understand the concepts are able to:
	• 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.

Connecting with English Language Arts/Literacy and Mathematics

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.

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.

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

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" is challenging for students.

Explanations of the day-night cycle 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

Grade 1 Unit 1: Patterns of Change in the Sky

- Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.
- Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

Grade 3 Unit 2: 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 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.)
- 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.)

Grade 3 Unit 3: Electrical and Magnetic Forces

- 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.

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.

Connections to Other Units

N/A

Sample of Open Education Resources

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.

Teacher Professional Learning Resources

Framework for K-12 Science Education, **Developing and Using Models**: This section of the Framework provides a deeper explanation of what it means for students to develop and use models. Modeling is especially important when concepts are too large or too small for students to have direct experience.

APPENDIX F: Science and Engineering Practices in the NGSS, The Framework uses the term "practices," rather than "science processes" or "inquiry" skills for a specific reason: We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. (NRC Framework, 2012, p. 30). Appendix F provides further clarification of each science and engineering practice as well as specific details about what each looks like in each grade band.

NGSS Crosscutting Concepts: Stability and Change

The presenter was Brett Moulding, director of the Partnership for Effective Science Teaching and Learning. Mr. Moulding began the web seminar by defining stability and change and discussing the inclusion of this concept in previous standards documents such as the National Science Education Standards (NSES). Participants brainstormed examples of science phenomena that can be explained by using the concept of stability and change. Some of their ideas included Earth's orbit around the

Sun, carrying capacity of ecosystems, and replication of DNA. Mr. Moulding then discussed the role of stability and change within NGSS. Participants again shared their ideas in the chat, providing their thoughts about classroom implementation of this crosscutting concept.

NGSS Core Ideas: Earth's Place in the Universe

The presenter was Julia Plummer from Penn State University. The program featured strategies for teaching about Earth science concepts that answer questions such as "What goes on in stars?" and "What patterns are caused by Earth's movements in the solar system?"

Dr. Plummer began the presentation by discussing what students should know about the disciplinary core idea of Earth's Place in the Universe. She talked about using the scientific and engineering practices to help engage students. Participants shared their ideas about applying this core idea to the classroom, and then Dr. Plummer shared strategies for effective instruction. She also discussed the importance of spatial thinking for students to begin thinking scientifically about these concepts.

Continue the discussion in the community forums.

Appendix A: NGSS and Foundations for the Unit

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-PS2-1)**

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-ESS1-1)**

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.] **(5-ESS1-2)**

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 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**	**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,	**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

• Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	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)	patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

English Language Arts	Mathematics
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** 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** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-ESS1-2) **SL.5.5**	Reason abstractly and quantitatively. (5-ESS1-1),(5-ESS1-2) **MP.2** Model with mathematics. (5-ESS1-1,(5-ESS1-2)) **MP.4** 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**

Unit 1: Properties of Matter			
NGSS	**Student Learning Objective**	**STEM**	**Links/Resources**
5-PS1-1	Develop a model to describe that matter is made of particles too small to be seen.	Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water	Science Fusion Unit 13 Lesson 1: What Are Solids, Liquids, and Gases? Unit 13 Lesson 6: What Is Atomic Theory? Unit 13 Lesson 6: Inquiry: Model Atoms and Compounds Unit 14 Lesson 3: What Is Light? Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2161/ngss-5-ps1-1-develop-a-model-to-describe-that-matter-is-made-of-particles-too-small-to-be-seen?from=domain_core
5-PS1-3	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, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal	Science Fusion Unit 13 Lesson 1: What Are Solids, Liquids, and Gases? Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2163/ngss-5-ps1-3-make-observations-and-measurements-to-identify-materials-based-on-their-properties?from=domain_core

		conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.	

Unit 2: Changes to Matter

NGSS	Student Learning Objective	STEM	Links/Resources
5-PS1-4	Conduct an investigation to determine whether the mixing of two or more substances results in new substances.		Science Fusion Unit 13 Lesson 4: What Are Mixtures and Solutions? Unit 13 Lesson 3: How Does Matter Change? Unit 3 Lesson 6: How Does the Body Stay Cool? **(Inquiry Flipchart page 18)** Unit 1 Lesson 5: What Are Some Science Tools? Digital Lessons Virtual Labs Lesson Quizzes **https://betterlesson.com/next_gen_science/browse/2164/ngss-5-ps1-4-conduct-an-investigation-to-determine-whether-the-mixing-of-two-or-more-substances-results-in-new-substances?from=breadcrumb_core_dropdown**
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	Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.	Science Fusion Unit 13 Lesson 2: How Does Water Change? Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2162/ngss-5-ps1-2-measure-and-graph-quantities-to-provide-evidence-that-regardless-of-the-type-of-change-that-occurs-when-heating-coo?from=breadcrumb_core_dropdown

	conserved. .		

Unit 3: Energy and Matter in Ecosystems			
NGSS	**Student Learning Objective**	**STEM**	**Links/Resources**
5-LS1-1	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.	Science Fusion Unit 4 Lesson 3: How Do Plants Grow and Reproduce? Unit 5 Lesson 4: How Does Drought Affect Plants? Unit 3 Lesson 3: How Do Cells Work Together? Unit 3 Lesson 4: How Do Our Bodies Move, Breathe, and Circulate Blood? Unit 3 Lesson 4: How Do Our Bodies Move, Breathe, and Circulate Blood? Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2171/ngss-5-ls1-1-support-an-argument-that-plants-get-the-materials-they-need-for-growth-chiefly-from-air-and-water?from=domain_core

5-LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.	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.	Science Fusion Unit 5 Lesson 1: What is an Ecosystem? Unit 5 Lesson 3: How Do Environmental Changes Affect Organisms? Unit 6 Lesson 1: What Are Roles of Organisms in Ecosystems? Unit 6 Lesson 2: How Does Energy Move Through Ecosystems? Unit 6 Lesson 3: What Role Do Decomposers Play? Unit 4 Lesson 2: What is a Dichotomous Key? Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2172/ngss-5-ls2-ecosystems-interactions-energy-and-dynamics?from=breadcrumb_core_dropdown
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.	Examples of models could include diagrams, and flow charts.	Unit 6 Lesson 2: Inquiry: Model a Food Web **(Inquiry Flipchart page 32)** https://betterlesson.com/next_gen_science/browse/2168/ngss-5-ps3-1-use-models-to-describe-that-energy-in-animals-food-used-for-body-repair-growth-motion-and-to-maintain-body-warmth-w?from=core_child

Unit 4: Water on Earth

NGSS	Student Learning Objective	STEM	Links/Resources
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.		Science Fusion Unit 9 Lesson 3: How Can Rocks Be Classified? Do the Math Unit 8 Lesson 1: How Do Weathering and Erosion Shape Earth's Surface? Unit 11 Lesson 2: How Does Ocean Water Move? Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2180/ngss-5-ess2-2-describe-and-graph-the-amounts-and-percentages-of-water-and-fresh-water-in-various-reservoirs-to-provide-evidence?from=core_child
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.		Science Fusion Unit 6 : People In Science: Environmental Detectives pg.305-306 Unit 7 Lesson 1: How Do People Use Resources? Unit 7 Lesson 2: How Do People Conserve Resources? Unit 7: Careers in Science: Alternative Energy Engineers pg.355-356 Unit 9 STEM: Tools That Rock pg.443-444 Unit 10 STEM: Make a Process: Design a Fossil Exhibit Hall **(Inquiry Flip Chart pg.50)** Digital Lessons Virtual Labs Lesson Quizzes

			https://betterlesson.com/next_gen_science/browse/2182/ngss-5-ess3-1-obtain-and-combine-information-about-ways-individual-communities-use-science-ideas-to-protect-the-earth-s-resource?from=core_child

Unit 5: Earth Systems			
NGSS	**Student Learning Objective**	**STEM**	**Links/Resources**
5-ESS2-1	Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	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.	Science Fusion Unit 5: STEM/Digital Curriculum How It Works: Life in a Box? Pg.281-282 Unit 11 Lesson 4: What Are Some Ocean Ecosystems? Unit 10 Lesson 2: What Was Ancient Earth Like? Digital Lessons Virtual Labs Lesson Quizzes **https://betterlesson.com/next_gen_science/browse/2179/ngss-5-ess2-1-develop-a-model-using-an-example-to-describe-ways-the-geosphere-biosphere-hydrosphere-and-or-atmosphere-interact?from=core_child**
5-ESS3-1	Covered in Unit 4		

Unit 6: Interactions within the Earth, Sun, and Moon System			
NGSS	**Student Learning Objective**	**STEM**	**Links/Resources**
5-PS2-1	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.	Science Fusion Unit 15 Lesson 1: What Are Forces? Unit 2 Lesson 2: How Can You Design a Solution to a Problem? Pg.79-80 (Inquiry Flipchart pg.9) Unit 15 Lesson 4: What Are Newton's Laws? Digital Lessons Virtual Labs Lesson Quizzes **https://betterlesson.com/next_gen_science/browse/2166/ngss-5-ps2-1-support-an-argument-that-the-gravitational-force-exerted-by-earth-on-objects-is-directed-down?from=domain_core**
5-ESS1-1	Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.		Science Fusion Unit 12 Lesson 3: What Are Stars and Galaxies? Unit 12 Lesson 1: Inquiry: Make a Scale Model Unit 12 Lesson 2: How Do We Observe Objects in the Solar System? Pg.559-560 (Inquiry Flipchart pg.59) Digital Lessons Virtual Labs Lesson Quizzes https://betterlesson.com/next_gen_science/browse/2176/ngss-5-ess1-1-support-an-argument-that-the-apparent-brightness-of-the-sun-and-stars-is-due-to-their-relative-distances-from-eart?from=core_child
5-ESS1-2	Represent data in		

	graphical displays to reveal patterns in daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.		https://betterlesson.com/next_gen_science/browse/2177/ngss-5-ess1-2-represent-data-in-graphical-displays-to-reveal-patterns-of-daily-changes-in-length-and-direction-of-shadows-day-an?from=breadcrumb_core_dropdown