Guilford Public Schools

Focused on Learning

Science Curriculum
K-12

Approved by the Guilford Board of Education
June 11, 2018
Updated August 1, 2018

Table of Contents

Introduction

In the summer of 2017, a committee of K-12 science teachers convened to review and revise the science curriculum. The committee used the *Next Generation Science Standards* as its guide. This document, organized by grade level, provides expectations for student learning in physical, life and earth and space sciences. The document is designed to help students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields. The learning experiences provided for students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions. Throughout the K-12 grades, students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas. The document supports teachers in understanding the content and pedagogy of science instruction and reflects the guiding principles for Science established by the committee to align with the mission and vision of Guilford Public Schools.

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

Guiding Principles

The following guiding principles should be considered to engage all students in a rigorous, authentic, student centered learning environment that incorporates disciplinary core ideas, cross cutting concepts and science and engineering practices:

- Build on student's prior understanding and learning experiences; practices grow in complexity and sophistication across the grades.
- Provide students time and opportunity to process disciplinary core standards.
- Promote learning that is connected to a real-life phenomenon and is experiential.
- Ask open-ended questions that require evidence-based reasoning.
- Encourage mistakes as an opportunity to learn and to refine thinking.
- Engage students in discourse to understand different perspectives and remember new ideas, terms or concepts.
- Provide opportunities for students to think like scientists and engineers.
- Promote understanding of social and ethical implications of science decisions.
- Apply understanding to new contexts.

Overview

For each disciplinary core idea, sample instructional approaches are provided to assist teachers in understanding the intent of the dimension and focusing student learning as it relates to the standard. The grade level curricular components of this document are organized into four columns. The first three columns contain the engineering practices, crosscutting concepts and the disciplinary core ideas that are used to form the performance expectations. The science and engineering practices are activities that scientist and engineers engage in to either understand the world or solve a problem. Crosscutting concepts are ideas that are not specific to any one discipline but cut across all of them. Disciplinary core ideas are concepts in science and engineering that have broad importance within and across disciplines as well as relevance in people's lives. The fourth column provides instructional approaches, examples, or tasks developed by the committee as suggestions to support teachers in creating lessons that invite effort and support academic rigor. The guide reflects a specific, conscious decision not to produce fully developed and comprehensive lessons or units. However, teachers should find guidance within each grade level document around the key components of instruction.

The Guilford Public Schools teachers who were members of the curriculum review committee are:

Tara White, Kindergarten, Calvin Leete Elementary School
Cristina Fontana, Grade 2, A.W. Cox Elementary School
Matt Guarnieri, Grade 3, Melissa Jones Elementary School
Lori Luyckx, Grade 4, Guilford Lakes Elementary School
Jennifer Lisi, Grade 5, Baldwin Middle School
Kristin Skelly, Grade 6, Baldwin Middle School
Cory Slifstein, Grades 7-8, Adams Middle School
Kristie Whitcomb, Grades 9-12, Guilford High School
Scott Macdowall, 9-12 Science Chair, Guilford High School
Jim Murtagh, Technology Specialist, Guilford Public Schools
Heather Gaieski, K-4 Special Education, Guilford Public Schools
Jennifer DeWallace, Mathematics Specialist, Guilford Public Schools
Stacy Ewings, Ed.D., Literacy Coach, Guilford Public Schools
Anne Keene, Ed.D., Associate Superintendent, Guilford Public Schools

Next Generation Science Standards

Disciplinary Core Ideas

- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Engineering Design

Science and Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

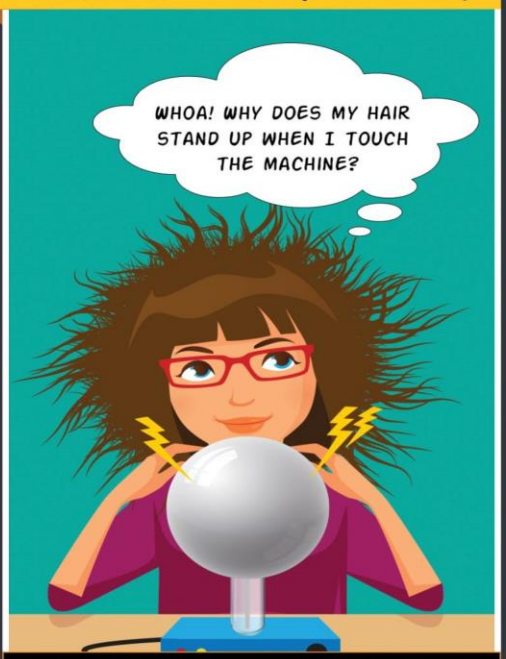
Crosscutting Concepts

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change

measured progress STEM Gauge® Gathering Evidence of Three-Dimensional Learning | www.measuredprogress.org/stem-gauge

How today's students learn SCIENCE

OBSERVING, POSING QUESTIONS, MAKING SENSE OF REAL-WORLD OBJECTS AND EVENTS (PHENOMENA)

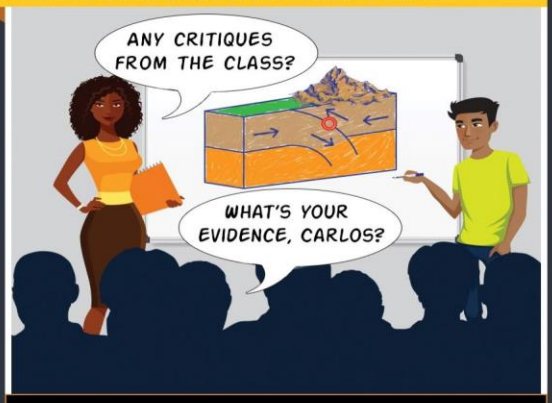


IN PHYSICS CLASS, JENNY CAN'T WAIT TO INVESTIGATE WHAT MAKES HER HAIR STAND ON END.

DESIGNING SOLUTIONS USING ENGINEERING AND TECHNOLOGY

AFTER MANY DESIGN CHANGES, DEJA BUILT THE STRONGEST BRIDGE IN THE CLASS.

DEVELOPING MODELS TO EXPLAIN REAL-WORLD OBJECTS OR EVENTS



MEANWHILE, IN MS. STURGEON'S EARTH SCIENCE CLASS, CARLOS EXPLAINS HOW SOME MOUNTAINS FORM.

PLANNING AND CARRYING OUT INVESTIGATIONS AND ANALYZING DATA

STUDENTS INVESTIGATE THE QUALITY OF WATER IN A NEARBY POND.

DISCUSSING, EXPLAINING, AND USING EVIDENCE FOR IDEAS

IN THE GYM, BOBBY DEMONSTRATES AND EXPLAINS HIS IDEAS ABOUT ENERGY TRANSFER.

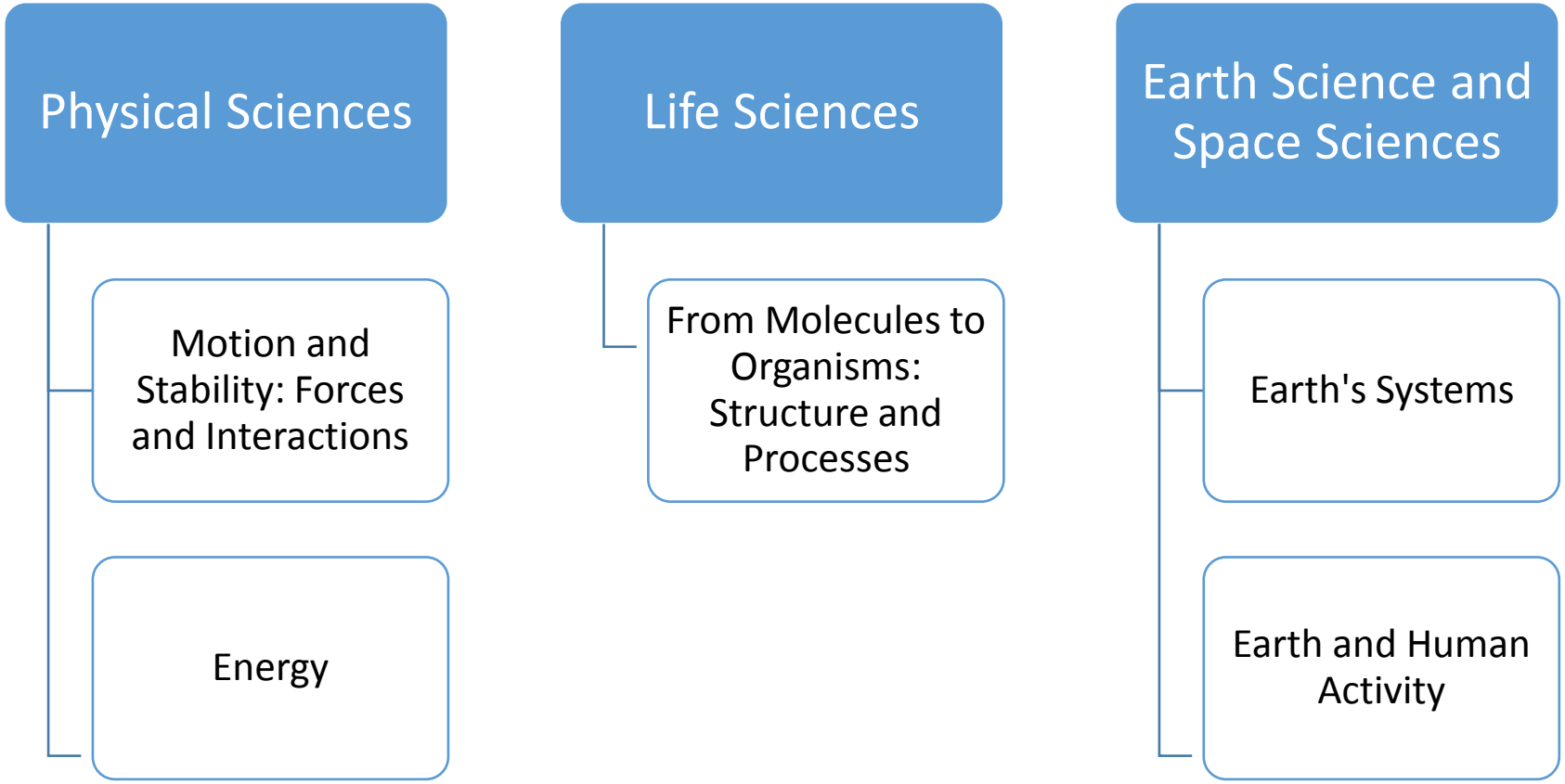
NEXT GENERATION SCIENCE STANDARDS

Pathway to Success

NGSS@NSTA

STEM STARTS HERE

Kindergarten



The Physical Sciences

Topic: Motion and Stability: Forces and Interactions	**Kindergarten**

Overview:

Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other. Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.

Guiding Questions:

- What happens when you push or pull on an object?
- How can you make an object move faster or in a different direction?

Performance Expectations:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes, and pulls on the motion of an object.

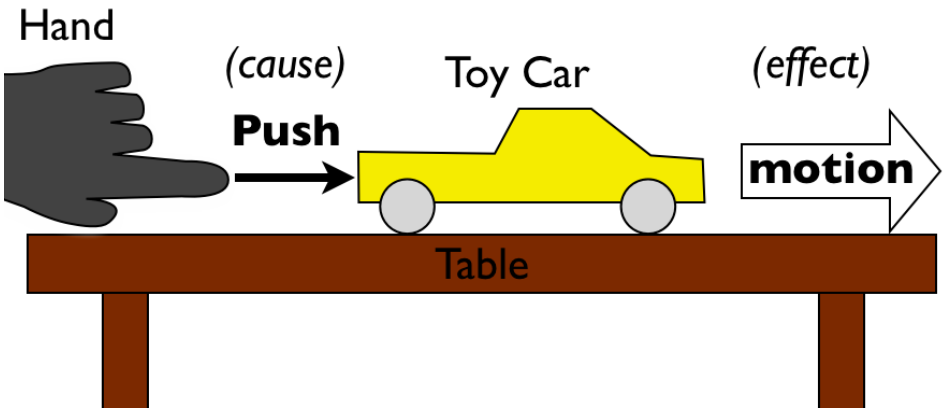
K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=Tpkq_GYIxRk
  Which path is faster? Why?
- https://www.youtube.com/watch?v=gnrrbKFWL3Q&list=PLA95indu8zalyCKi7w-3IK1wyvmik6_aq
  Pin ball machine
- https://www.youtube.com/watch?v=h4eGtoua4y4
  A bowling ball in motion (play from 50-54 sec)

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-2] Cause and Effect	**PS2.A: Forces and Motion** Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. **PS2.B: Types of Interactions** When objects touch or collide, they push on one another and can change motion. **PS3.C: Relationship Between Energy and Forces** A bigger push or pull makes things speed up or slow down more quickly. **ETS1.A: Defining Engineering Problems** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.	• Invent a back scratcher from everyday objects and compare designs and effectiveness with classmates' designs. • Explore pushing and pulling different objects through different hands-on **i**nvestigations (Push, pull, kick, throw, etc.) • Draw a diagram showing how they can move an object around a corner using a push and then a second diagram showing how they can use a pull. • Label objects around the school according to how they apply pushes and pulls to them. • Looking at an illustration, students describe the direction the object is moving, what push or pull caused it to start moving, and which direction that the push or pull was acting. (Example texts include: *Move It!: Motion, Forces, and You* by Adrienne Mason; *Motion: Push and Pull, Fast and Slow* by Darlene Stille) • Build ramps for cars, blocks, marbles, etc. with a specific goal in mind (ex: distance, knock over a stack of blocks) • Design an experiment to see how a push changes the speed on a slide, of a kickball, etc., and explore changing directions. • Change the ramp to increase speed of object and record results. Students can keep track of the results of their motion experiments in a table format. They can compare results using "greater than/less than" vocabulary; for example, "The ball went farther after it hit the cardboard tube than after it hit the bubble wrap."

Pushes Cause Changes in Motion



The Physical Sciences

Topic: Energy	**Kindergarten**
Overview: Examples of Earth's surface could include sand, soil, rocks, and water. Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.	
Guiding Questions: • What happens when the sun shines on different objects? • How can I protect myself from the sunlight? • How do we prepare for severe weather?	
Performance Expectations: K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.	

Example Phenomena/Engineering Problem:

- Different materials block sunlight better than others.
- https://www.youtube.com/watch?v=1RTOYbcDS2k
  Time-lapsed video showing ice melting faster in the sun than in the shade.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions	[CCC-2] Cause and Effect	**PS3.B: Conservation of Energy and Energy Transfer** Sunlight warms Earth's surface.	• Design and build a shelter for a small animal to protect them from the sun. Students brainstorm possible shelter designs. They debate the pros and cons of each roof material and explain their reasoning. They then draw their individual design idea and label the parts. • Build a shelter for an ice cube. What materials are most effective?

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			• Design and conduct an experiment to measure how long it takes for an ice cube to melt in the shade verses in the sun. Is there a difference from one surface to another? Does it melt faster in the grass, on sand, on soil, or on pavement?

The Life Sciences

Topic: From Molecules to Organisms: Structures and Processes	**Kindergarten**
Overview: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.	
Guiding Questions: • How do we know that something is alive? • What do animals and plants need to survive? • Does what they need affect where they live?	
Performance Expectations: K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.	

Example Phenomena/Engineering Problem:

- Rivers have a wide variety of plants and animals that live near them (observed on a virtual field trip from videos and photographs).
- https://www.thespruce.com/best-ways-to-save-dead-herbs-1763018
  Dead house plant

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-4] Analyzing and Interpreting Data	[CCC-1] Patterns	**LS1.C: Organization for Matter and Energy Flow in Organisms** All animals need food in order to live and	• Students should begin to group plants and animals together based upon their similar environmental needs (water, sunlight) and the availability of their preferred food sources. For example, students might read a story about the grasslands of Africa where a gazelle eats grass and then a lion

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.	eats the gazelle. Students should be able to explain why each animal lives in that area. • https://cptv.pbslearningmedia.org/resource/tdc02.sci.life.colt.lp_stayalive/the-needs-of-living-things/#.WnoEVq6nGpo In this lesson, students watch video clips of animals and plants in their natural environment, to gather evidence that all living things have basic needs that must be met in order to survive. Then, to illustrate their understanding of this concept, students draw pictures of real or imaginary pets eating, drinking, breathing, and taking shelter (from the elements or from other animals). This can be completed on paper or using the app My Story. • Interview a parent or guardian about to get a new pet. What does it need? Where will it live? Identify the pet. • https://www.teachengineering.org/lessons/view/duk_sunflower_mary_less In an introductory discussion, students identify the physical needs of animals and then speculate on the needs of plants. With teacher guidance, students then design an experiment that can take place in the classroom to test whether or not plants need light and water in order to grow. This prepares them to conduct the associated activity in which sunflower seeds are planted in plastic cups, and once germinated, are exposed to different conditions. In a classroom setting it is easy to test for the effects of light versus darkness, and watered versus non-watered conditions. During exposure of the plants to these different conditions, students measure growth of the seedlings every few days using non-standard measurements. After a few weeks, they compare the growth of plants exposed to the different conditions, and make pictorial bar graphs that demonstrate these comparisons.

The Earth Science and Space Sciences

Topic: Earth's Systems	**Kindergarten**

Overview:

Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months. Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.

Guiding Questions:

- What is the weather like today and how it is different from yesterday?

Performance Expectations:

K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.

K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

Example Phenomena/Engineering Problem:

- Display a graph of local temperatures or precipitation from the past month (any weather site generates it for you).
- https://www.youtube.com/watch?v=WIlDyvS6pY4
  Video of a bald eagle building a nest

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-4] Analyzing and Interpreting Data [SEP-7] Engaging in Argument from Evidence	[CCC-1] Patterns [CCC-4] Systems and System Models	**ESS2.D: Weather and Climate** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. **ESS2.E: Bio geology** Plants and animals can change their environment. **ESS3.C: Human Impacts on Earth Systems** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.	• Using a thermometer, students can record the temperature at the same time of day, several times a day for a week to determine the weather pattern. Students should be able to describe this pattern and ask questions about what causes it. Students can make a claim based on past experiences that the Sun causes this daily warming. Collect observations that support the argument. They also undergo a design challenge to reduce the effect of sunlight. • Work as a team to research and discuss seasonal weather patterns in CT. Create a display to communicate information regarding weather throughout the seasons. • Take a walk around the school grounds and look for evidence of animals and humans changing their surroundings to meet their needs. Similarly, view images of homes being built by humans and animals. Discuss the impacts of these events. Sample images: beaver dams, deer paths, logging roads, bridges, homes, tree houses, dens, beehives. • https://cptv.pbslearningmedia.org/resource/tdc02.sci.life.colt.lp_stayalive/the-needs-of-living-things/#.Wp63H2rwapo Students learn what animals and plants need to survive, how their habitats support these needs, and how organisms can change their environment.

The Earth Science and Space Sciences

Topic: Earth and Human Activity	**Kindergarten**

Overview:

Examples of relationships could include that deer eat buds and leaves, so, they usually live in forested areas, and, grasses need sunlight so they often grow in meadows. Examples of weather forecasting should emphasize local forms of severe weather. Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Plants, animals, and their surroundings make up a system. Other examples of solutions could include reusing paper and recycling cans and bottles.

Guiding Questions:

- How do animals and plants change their environment to survive?
- What do we (humans) do that changes our environment?
- What can we do to modify our impact on the environment?

Performance Expectations:

K-ESS3-1. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.

K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.

K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

Example Phenomena/Engineering Problem:

- http://poopy.org/water-pollution/duck-in-polluted-lake/

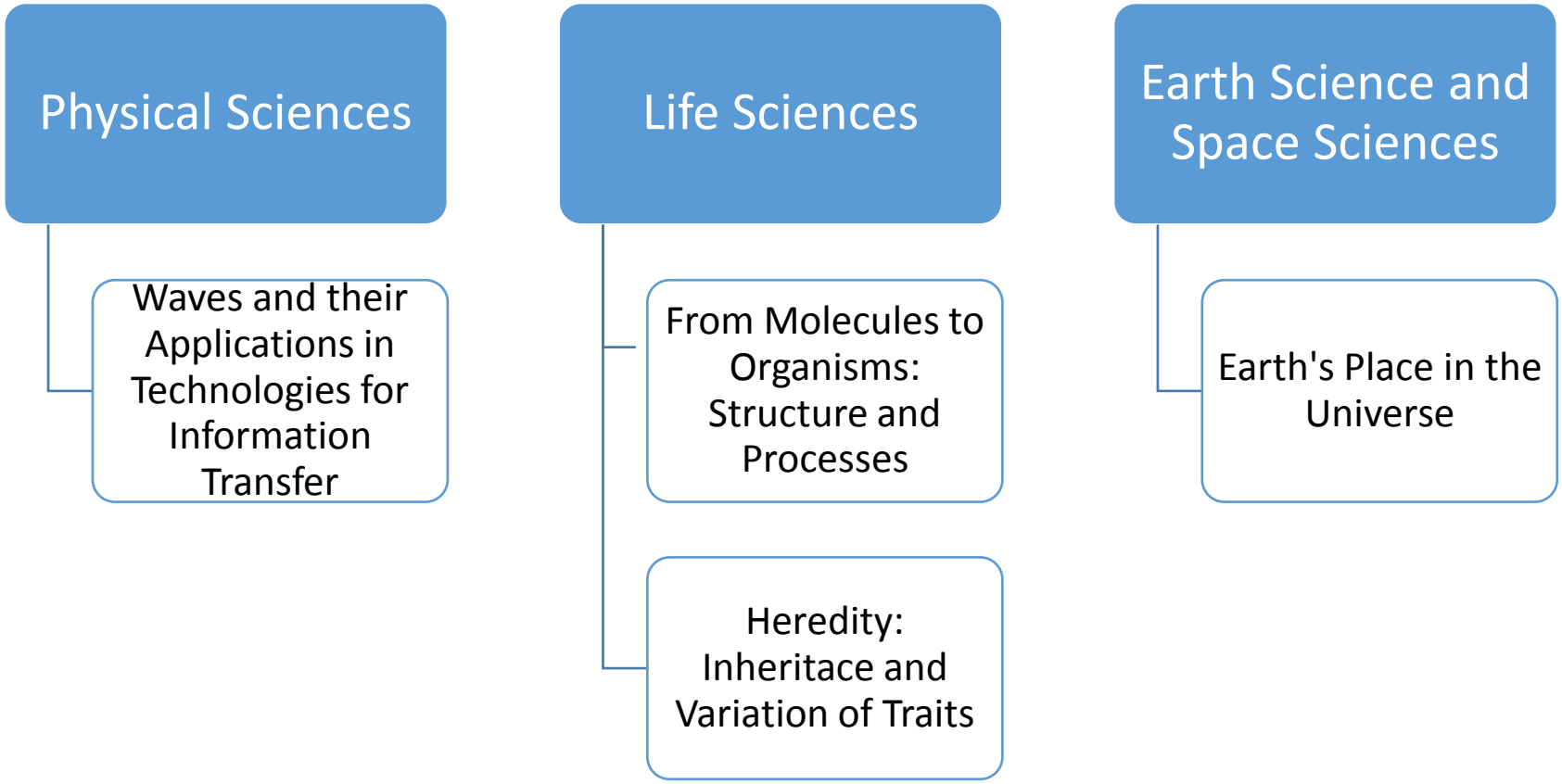
Image of a duck navigating polluted water

- http://lrr.cli.det.nsw.edu.au/web/wir_recyceln/Stage5_German/Activities/ger_act_int_03_seq.htm

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-1] Asking Questions and Defining Problem [SEP-2] Developing and Using Models [SEP-8] Obtaining, Evaluating, and Communicating Information	[CCC-2] Cause and Effect [CCC-4] Systems and System Models	**ESS3.A: Natural Resources** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. **ESS3.B: Natural Hazards** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. **ESS3.C: Human Impacts on Earth Systems** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.	• Text Suggestion: *Because You Recycle* by Harriet Rosenbloom • https://www.youtube.com/watch?v=dRXNo7Ieky8 Video about composting and the positive effects • Explore decomposition and compost at school with a "worm farm." • Research a specific animal to learn about its needs, then create a model depicting the animal in a suitable habitat. Be sure to include food and shelter needs for this animal.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		ETS1.A: Defining and Delimiting an Engineering Problem Asking questions, making observations, and gathering information are helpful in thinking about problems. **ETS1.B: Developing Possible Solutions** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	

Grade 1


Physical Sciences
Waves and their Applications in Technologies for Information Transfer
Life Sciences
From Molecules to Organisms: Structure and Processes
Heredity: Inheritace and Variation of Traits
Earth Science and Space Sciences
Earth's Place in the Universe

The Physical Sciences

Topic: Waves and their Applications in Technologies for Information Transfer	**Grade 1**

Overview:

Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork. Examples of observations could include those made through a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light. Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror). Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drumbeats.

Guiding Questions:

- What causes shadows?
- What happens when there is no light?
- How is sound produced?
- How can we use sound to communicate information?

Performance Expectations:

1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated.

1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=QdoTdG_VNV4
  This video shows a man playing water glasses. How do the glasses produce noise?
- https://www.youtube.com/watch?v=TL6mjhuS64c
  Explorers entering a cave. How does the light change as they enter? Play until 2:30- mute the video.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions	[CCC-2] Cause and Effect	**PS4.A: Wave Properties** Sound can make matter vibrate, and vibrating matter can make sound. **PS4.B: Electromagnetic Radiation** Objects can be seen if light is available to illuminate them or if they give off their own light. Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) **PS4.C: Information Technologies and Instrumentation** People also use a variety of devices to communicate (send and receive information) over long distances.	• In a darkened classroom, students look around and observe things are dim and harder to see. They are able to see things clearly when they shine a narrow light on them, but not as clearly without that light. This would be an example of cause and effect relationship. • Students plan an investigation to compare the effect of placing different types of objects in the path of the light. The collection of objects should include opaque, transparent, translucent and reflective materials. (The teacher should not introduce these distinctions prior to the investigation. It will be the job of students to identify these differences.) • Students can group the materials into categories based on patterns about the amount of light that travels through them. • Students can generate sounds using a rubber band stretched around the opening of a paper cup. Teachers can ask students to describe the motion of the rubber band (“back and forth”) and then introduce the term “vibrate” to describe what they see.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			• They can feel the vibrations in their own throats as they talk or sing. They can further visualize the motion of an object that makes sound by gently dipping a vibrating tuning fork in a cup of water or by placing it adjacent to a lightweight ping pong ball and watching the ball move. • Students will design and build their own sound device, understanding that sound is caused by vibrations. Communicate different messages with the device. (different sounds or number of sounds for calls of help, joy, sadness)

The Life Sciences

Topic: From Molecules to Organisms: Structures and Processes	**Grade 1**

Overview:

Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and, detecting intruders by mimicking eyes and ears. Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).

Guiding Questions:

- How do plants and animals use different attributes to survive various situations?

Performance Expectations:

1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=5MlytL6JSik
  Tool Use- Jane Goodall Institute

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-6] Structure and Function	**LS1.A: Structure and Function** All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air.	• Ask students to brainstorm a problem they have that they usually ask an adult for help. They should then think about plants, or parts of a plant that may help them solve their problem.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-8] Obtaining, Evaluating, and Communicating Information		Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. **LS1.B: Growth and Development of Organisms** Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. **LS1.D: Information Processing** Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs.	• Using nature as a model, have students design a solution to a problem illustrating it with a simple sketch or diagram. For example, students design a coat rack that has enough hooks to hold their jackets. How wide should the base be? What features does it need in order to be stable? Students can look at trees to help decide. *The Discovering Scientists unit touches upon this concept because scientist observe plants and animals meeting their needs for survival. This unit can serve as a bridge for students to act as scientist to design solutions based on problems that plants and animals have. *The Watcher- Jane Goodall's Life with the Chimps* by Jeanette Winter- can be used as a text discussion.

The Life Sciences

Topic: Heredity: Inheritance and Variation of Traits	**Grade 1**
Overview: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.	
Guiding Questions: • How are parents and their children similar and different? • How do animal parents and children interact to meet their needs?	
Performance Expectations: 1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.	

Example Phenomena/Engineering Problem:

- https://stemeducation.nd.edu/resources/scientific-phenomena/november-2016
  Two black labs have yellow lab puppies. Use the pictures to explore this idea.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns	**LS3.A: Inheritance of Traits** Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents.	• Find local opportunities for observing animals and their offspring such as a classroom aquarium or terrarium, a field trip to a farm, duck pond, or zoo, or a webcam or video clips. https://nationalzoo.si.edu/webcams https://www.houstonzoo.org/meet-the-animals/animal-webcams/ https://www.zoo.org/webcams

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		LS3.B: Variation of Traits Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.	• Students communicate their observations about animal appearance and behavior through science notebook entries or oral presentations.

The Earth Science and Space Sciences

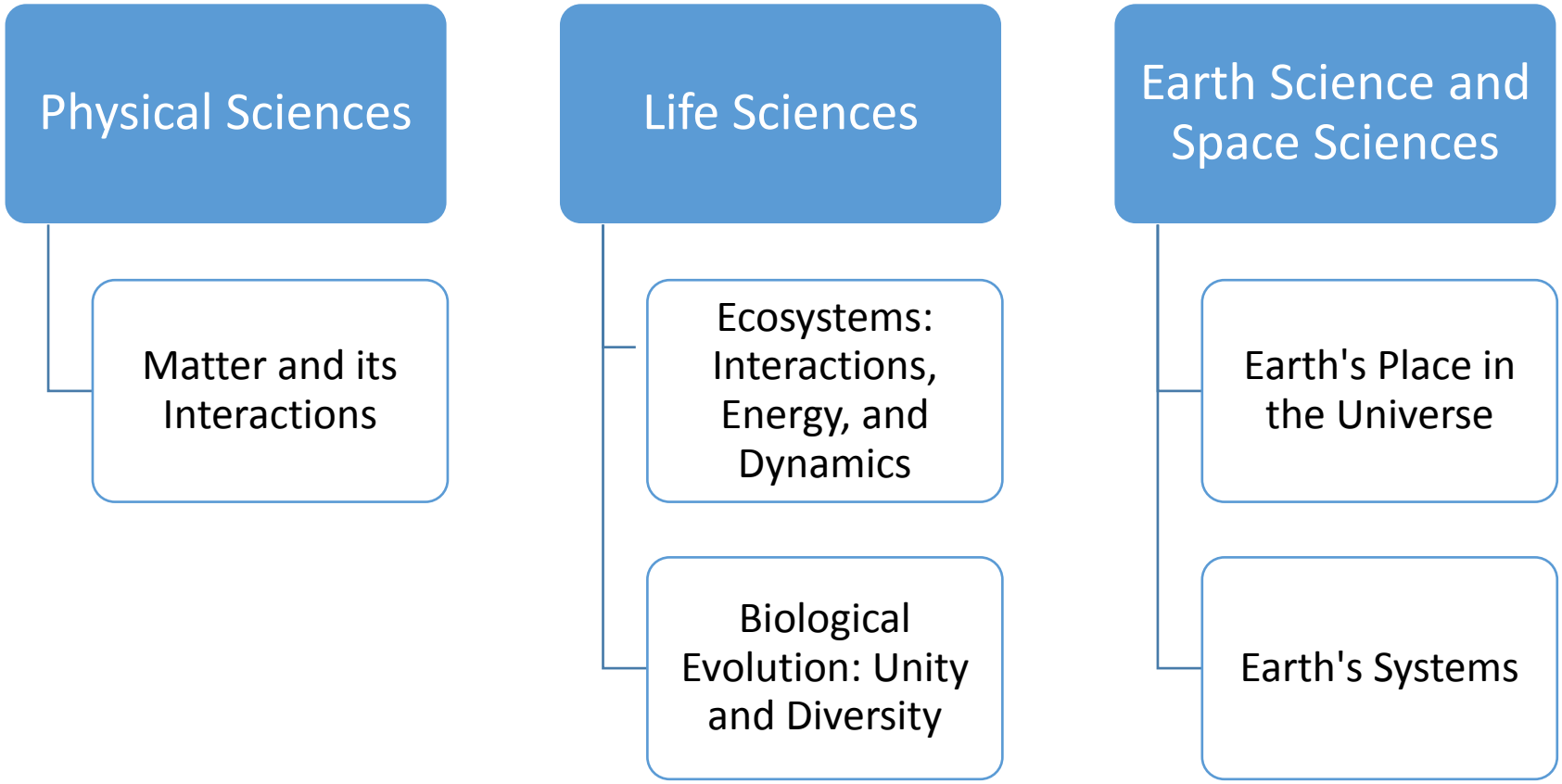
Topic: Earth's Place in the Universe	**Grade 1**
Overview: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day. Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.	
Guiding Questions: • What objects are in the sky and how do they seem to move? • How does the moon's appearance change over each month?	
Performance Expectations: 1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted. 1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year.	

Example Phenomena/Engineering Problem:
• https://www.youtube.com/watch?v=yhXlUUfxoZk Video shows the sun, moon and stars moving across the sky

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data	[CCC-1] Patterns	**ESS1.A: The Universe and its Stars** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.	• Have students look up how much daylight there is on their birthday. This will give students a picture of the amount of day light across each season. Have each student make a strip of paper that coincides with the hours of day light on their birthday. (1 inch for each hour, round to the half hour and add a half an inch, if needed.) Arrange the strips on a graph in order of the months. Draw conclusions about

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		ESS1.B: Earth and the Solar System Seasonal patterns of sunrise and sunset can be observed, described, and predicted.	patterns and how the amount of daylight changes through the seasons. • Students can draw or photograph the shape of the Moon over several weeks. • Student can become familiar with the different phases of the Moon through a series of read-aloud books, such as *The Moon Book* by Gail Gibbons; *Faces of the Moon* by Bob Crelin; *Phases of the Moon* by Gillian M. Olson; and *The Moon Seems to Change* by Franklyn M. Bradley. • Ask students to find as many shadows as they can. How many can they find? What is "making" each shadow? What makes the biggest and smallest shadows? What discoveries do they make as they explore? What questions do they have about shadows? Do this activity again at a different time of day. • Selecting a particularly sunny day students play tag, but with the twist that they never actually touch—one shadow needs to "tag" another person's shadow. No matter which direction the children run or turn, students notice that their shadow always points in the same direction. Discuss why. Play the game at different times of the day to notice direction shadows are pointing. Students understand that their shadows are markers that allow them to track the moving position of the Sun throughout the day or year.

Grade 2


Physical Sciences
Matter and its Interactions
Life Sciences
Ecosystems: Interactions, Energy, and Dynamics
Biological Evolution: Unity and Diversity
Earth Science and Space Sciences
Earth's Place in the Universe
Earth's Systems

The Physical Sciences

Topic: Matter and its Interactions	**Grade 2**

Overview:

Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share. Examples of properties could include, strength, flexibility, hardness, texture, and absorbency. Examples of pieces could include blocks, building bricks, or other assorted small objects. Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.

Guiding Questions:

- How are materials similar and different from one another?
- What sort of changes can happen to materials?

Performance Expectations:

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=dN2VDcmuTl4
  This animated video (3:36) engages students in the real-life connection to the physical properties of matter using lunch bags. It reviews the properties of temperature and transparency.
- https://www.youtube.com/watch?v=HxW6t-Htbzs
  This video (3:25) explores the Watts Towers created by Simon Rodia who gathered fragments of "junk" he found in the neighborhood. He put all of these small pieces together to build a spectacular tower.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	[CCC-1] Patterns [CCC-2] Cause and Effect [CCC-5] Energy and Matter	**PS1.A: Structure and 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. **PS1.B: Chemical Reactions** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.	• Students explore their schoolyard with a specific focus on the materials that make it up. They make observations and record them in a table, noting what materials they find, words to describe the material, and what the material is used for. In a class discussion: Does the adjective always apply to this material? For example, the metal of the chairs in the classroom is always pretty shiny, but the concrete of the playground is not always "hot". Students describe properties of materials such as texture, hardness, absorbency, flexibility, etc. They can use these properties to describe everyday materials during class explorations. • To explore material strength, students make synthetic rocks using different materials and drop them from different heights to see which are strongest. • To explore absorption, students can time how long it takes for a cup of water to soak into different surfaces in the schoolyard. • Students conduct investigations to determine if objects mixed or fastened together can be separated back into their original components. • Students can explore making sculptures out of beeswax, which begins as a rigid material but becomes more flexible as students warm it up in their hands. • Students explore changing forms of matter such as melting and freezing of ice cubes.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			• Present students a series of design challenges where they begin by defining the problem (figuring out what criteria are most important) and then selecting the appropriate materials to solve the problems. They would need to perform tests to determine the material's properties and analyze the results.

The Life Sciences

Topic: Ecosystems: Interactions, Energy, and Dynamics	**Grade 2**
Overview: Emphasis on students' developing an understanding of what plants need to grow and how plants depend on animals for seed dispersal and pollination.	
Guiding Questions: • How can we determine what plants need to grow? • How do plants depend on animals?	
Performance Expectations: 2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow. 2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants	

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=gJDDhFAjJSc
  This video (23 seconds) explores the natural phenomena of an impatient seed pod exploding that may be used as a lead into a discussion about another way that seeds disperse.
- https://www.kqed.org/science/781757/this-vibrating-bumblebee-unlocks-a-flowers-hidden-treasure
  This video (5:00) describes a particular kind of pollination, called buzz pollination, an adaption of plants to select their pollinator for maximum dispersal.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models	[CCC-2] Cause and Effect	**LS2.A: Interdependent Relationships in Ecosystems** Plants depend on water and light to grow.	• Students can begin by visiting their schoolyard and describing the physical conditions in different sections of the school. Which have the most sunlight and which receive the most water? These observations can motivate questions like, "How

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-3] Planning and Carrying Out Investigations	[CCC-6] Structure and Function	Plants depend on animals for pollination or to move their seeds around. **ETS1.B: Developing Possible Solutions** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	much sunlight or water do plants need to survive?" They can then plan an investigation to answer that question. • Use a map that shows Connecticut's habitats. Discuss their observations. Notice that areas with similar conditions have similar plant and animal life. Students describe the differences they see between two different habitats on the map. "What might make them have different plants and animals?" • Dissect flowers collected from the schoolyards or around the community. They inspect the specific structures of the flower that are involved in pollination or parts of the seed that allow it to stick to an animal's fur or a person's clothing. Using simple materials, students create physical models that mimic the behavior of pollinators or seeds. Students compare their solutions by testing their devices to see how well they pollinate or disperse seeds. Using the evidence from their tests, they can engage in argument to compare and contrast the characteristics of different devices.

The Life Sciences

Topic: Biological Evolution: Unity and Diversity	**Grade 2**
Overview: Emphasis is on the diversity of living things in each of a variety of different habitats.	
Guiding Questions: • How many types of living things live in a place? How can we tell?	
Performance Expectations: 2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.	

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=JIQelV2ZbpQ&feature=youtu.be
  This video (5:00) highlights animals that live in Costa Rica. It features the diverse animals in their natural rainforest environment.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-3] Planning and Carrying Out Investigations		**LS4.D: Biodiversity and Humans** There are many different kinds of living things in any area, and they exist in different places on land and in water.	• https://www.montereybayaquarium.org/-/m/pdf/education/curriculum/aquarium-prek-5-habitatinabucket.pdf What is a habitat? Explore a "habitat in a bucket" that includes outdoor habitat items (e.g., leaves, branches, snails, etc.) that have been collected and brought into the classroom. Make observations, generate questions of interest and design and conduct their own investigations. Typical investigations might focus on plant and animal interactions, food chains, physical and behavioral adaptations of living things and biodiversity.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			• Make a map of an outdoor exploration. Sketch and label plants and animals observed. Draw conclusions from the map. • Students obtain information from texts about the factors that affect diversity in a particular place. • Students identify patterns in the diversity of different sections of their field area. • Students compare areas that are more “natural” with those that are affected by human activities. Students identify specific cause-and-effect relationships in their observations.

The Earth Science and Space Sciences

Topic: Earth's Place in the Universe	**Grade 2**
Overview: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly.	
Guiding Questions: • What evidence do natural processes leave behind as they shape the Earth? • How do the properties of rocks affect what happens to them in landscapes?	
Performance Expectations: 2-ESS1-1. Use information from several sources to provide evidence that Earth events can occur quickly or slowly.	

Example Phenomena/Engineering Problem:
• https://www.smithsonianmag.com/videos/category/science/alaskas-glaciers-take-up-more-space-than-al/ Landscapes covered with glaciers

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-6] Constructing Explanations and Designing Solutions	[CCC-7] Stability and Change	**ESS1.C: The History of Planet Earth** Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.	• Make observations of landforms that display different and interesting shapes. • Students obtain information about specific landforms in Connecticut and beyond from textbooks or articles. They focus on the processes and timescales in which water and wind shape each landscape. • Students select two landforms to compare side-by-side: one that formed slowly and one that formed quickly. Which changes could they witness in a single day and which would take lifetimes?

The Earth Science and Space Sciences

Topic: Earth's Systems	**Grade 2**
Overview: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.	
Guiding Questions: • How can we describe the shape of land and water on Earth?	
Performance Expectations: 2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. 2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area. 2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.	

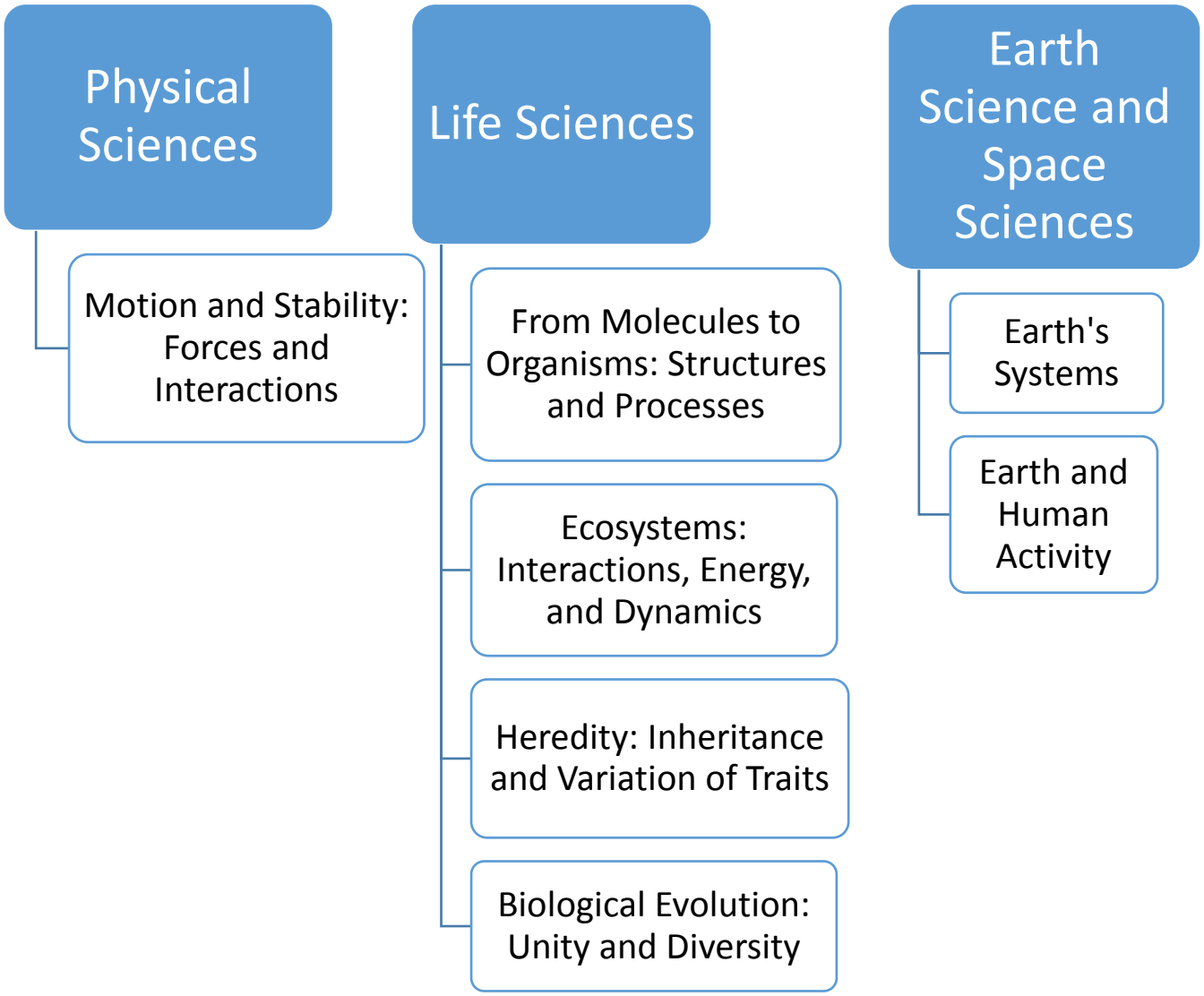
Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=N8C9OaBRW2g
  Time-elapse video (27 seconds) of water eroding away sand and rocks at a Prince Edward Island beach.
- https://betterlesson.com/lesson/resource/3232314/photos-to-show-wind-erosion?from=resource image
  Photos to show wind erosion.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-7] Stability and Change	**ESS2.A: Earth Materials and Systems** Wind and water can change the shape of the land.	• On Earth, wind and water are the most common natural forces that reshapes landforms. Students plan investigations of each. They pour water onto the top of a stream table (a container or tray filled with sand propped up on one end to represent a sloping mountain side), a physical model that simulates a river. They investigate the effects of different amounts of water, slope, or

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-8] Obtaining, Evaluating, and Communicating Information		**ESS2.B: Plate Tectonics and Large-Scale System Interactions** Maps show where things are located. One can map the shapes and kinds of land and water in any area. **ESS2.C: The Roles of Water in Earth's Surface** Processes Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. **ETS1.C: Optimizing the Design Solution** Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	materials in the riverbed. Which scenarios produce the most rapid changes overall? How would the results differ if the stream table were filled with a material that was stronger or less absorbent? • Students blow into straws as a physical model of the wind. The landforms that are created by the wind often have very different shapes than landforms created by moving water. Students use the shapes of the landforms as evidence to argue that either wind or water was responsible for sculpting a given landform in a sandbox.

Grade 3


Physical Sciences
Motion and Stability: Forces and Interactions
Life Sciences
From Molecules to Organisms: Structures and Processes
Ecosystems: Interactions, Energy, and Dynamics
Heredity: Inheritance and Variation of Traits
Biological Evolution: Unity and Diversity
Earth Science and Space Sciences
Earth's Systems
Earth and Human Activity

The Physical Sciences

Topic: Motion and Stability: Forces and Interactions	**Grade 3**

Overview:

Examples could include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all. Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw. Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force. Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.

Guiding Questions:

- What happens when several different forces push or pull an object at once?
- How can an object be pushed or pulled but not move?
- What do we need to know to predict the motion of objects?
- How can some objects push or pull one another without even touching?

Performance Expectations:

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.

Example Phenomena/Engineering Problem:

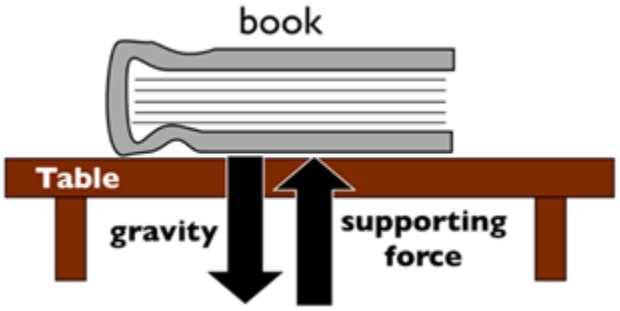
- https://ak6.picdn.net/shutterstock/videos/12305066/preview/stock-footage-soccer-players-pass-the-ball-down-the-field-at-night-and-make-a-goal-and-celebrate.mp4
  Students feel a force as they kick a ball.
- https://ak5.picdn.net/shutterstock/videos/13616015/preview/stock-footage-a-young-boy-scores-a-goal-during-a-penalty-shoot-out-shot-in-slow-motion.mp4
  A ball sometimes rises off the ground when kicked.
- https://ak0.picdn.net/shutterstock/videos/6019250/preview/stock-footage-animation-of-bowling-strike-bowling-ball-crashing-into-the-pins-on-wooden-lane-hq-video-clip.mp4
  A bowling ball hitting pins.
- https://phet.colorado.edu/en/simulation/balancing-act
  Simulation of balance by applying weights.
- https://media.giphy.com/media/26tn9Qrs7avBUskNi/giphy.gif
  Force between permanent magnets.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-1] Asking Questions and Defining Problems [SEP-3] Planning and Carrying Out Investigations	[CCC-1] Patterns [CCC-2] Cause and Effect	**PS2.A: Forces and Motion** Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause	• Students explore a variety of physical systems where they can physically feel forces. They kick balls, hang from bars, push one another on the swing, slide down the slide, and land on the ground after leaping from a step on the play structure. • Students can investigate specific situations that illustrate what happens when multiple forces act on an object at once. Students can push one

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-4] Analyzing and Interpreting Data		changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces is used at this level.) The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) **PS2.B: Types of Interactions** 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	another around in cardboard box "race cars." What happens when two people push on the box together instead of just one? What happens when one person pushes the box forward while another student pushes it in the opposite direction? How about if two people push it forward and only one pushes opposite? Or two people push forward and one person pushes sideways? ● Students can illustrate the effects of multiple forces acting on the same object at the same time. ● Two students can face one another, place their palms together, and then lean in towards one another. As they each push against one another, they can stay stationary as long as they balance one another with equal forces. If one person pulls away or pushes forward with more force, the system is no longer stable and they move. ● A student can place his or her hand between a heavy book and the table in order to feel both the downward force of the book and the force of the table from below. Students should be able to draw a model that shows the force of the table pushing upwards to balance out the force of gravity that pulls the book downward.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		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.	• Students can draw pictorial models showing different strength arrows representing friction for different surfaces. • Foss Grade 3 Motion and Matter

Student's Model of Balanced Forces Acting on a Book



The Life Sciences

Topic: From Molecules to Organisms: Structures and Processes	**Grade 3**
Overview: Changes organisms go through during their life form a pattern.	
Guiding Questions: ● What is the advantage of having a complicated lifecycle of growth and development?	
Performance Expectations: 3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.	

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=iZMjBO6A7AE
  Life cycle of a bean plant
- https://www.youtube.com/watch?v=ocWgSgMGxOc
  Monarch Butterfly metamorphosis time-lapse

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models	[CCC-1] Patterns	**LS1.B: Growth and Development of Organisms** Reproduction is essential to the continued existence of every kind of organism. Plants	• Students can grow seeds (including vegetables in a garden or fast growing plants such as Brassica rapa in the classroom), hatch insect eggs (such as milkweed bug, butterfly, or ladybug) or raise frogs from tadpole eggs. As they observe and carefully notice the changes in the organism, students develop a model for the growth and

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		and animals have unique and diverse life cycles.	development of the organism's lifecycle. This model will likely take the form of a pictorial model (a diagram) that illustrates each stage of the lifecycle. Record findings in a science notebook. ● Students can use images from informational texts or videos. Ideally, these images are presented as a sequence of regular snapshots of the animal (daily, weekly, etc.) so that the exercise is a virtual investigation where students analyze the image data to develop a model about the organism's lifecycle. ● Students can combine information in written text about the life cycle of different plants and animals with that contained in corresponding tables, diagrams, and/or charts to support claims about the diversity of life cycles. ● Foss Grade 3 Structures of Life

The Life Sciences

Topic: Ecosystems: Interactions, Energy, and Dynamics	**Grade 3**
Overview: Certain animals have adaptations that allow them to survive alone in their environment, while other animals live in large groups to survive.	
Guiding Questions: ● Why do some animals live alone while others live in large groups?	
Performance Expectations: 3-LS2-1. Construct an argument that some animals form groups that help members survive.	
Example Phenomena/Engineering Problem: ● https://www.youtube.com/watch?v=8wl8ZxAaB2E Order in a pack of wolves	

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
EP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect	**LS2.D: Social Interactions and Group Behavior** Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.	● Students can indirectly observe group behavior through computer simulations like NetLogo. Students track individual organisms to see how they interact with others to meet their needs. In a simulation of an ant colony, students can explore how the size of the ant colony affects the amount of food collected (including the success of a single ant) or what would happen if the colony were unable to communicate using pheromones.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Students use this evidence to support an argument that the colony helps the ants survive.

The Life Sciences

Topic: Heredity: Inheritance and Variation of Traits.	**Grade 3**
Overview: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans. Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted, and a pet dog that is given too much food and little exercise may become overweight.	
Guiding Questions: ● How similar are animals and plants to their siblings and their parents? ● How does being similar to parents help an animal survive?	
Performance Expectations: 3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. 3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.	

Example Phenomena/Engineering Problem:

● http://www.gardenswithwings.com/identify-caterpillars.html
Caterpillars of the same type share many features in common, but other features differ.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-4] Analyzing and Interpreting Data	[CCC-1] Patterns [CCC-2] Cause and Effect	**LS3.A: Inheritance of Traits** Many characteristics of organisms are inherited from their parents.	● Students compare and contrast data on individuals' interactions with the environment collected by different groups in order to discuss similarities and differences in their findings. Students can construct an explanation of how different organisms look and function.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-6] Constructing Explanations and Designing Solutions		Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. **LS3.B: Variation of Traits** Different organisms vary in how they look and function because they have different inherited information. The environment also affects the traits that an organism develops.	● Students can provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. ● Foss Grade 3 Structures of Life

Topic: Biological Evolution: Unity and Diversity	**Grade 3**

Overview:

Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms. Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring. Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other. Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.

Guiding Questions:

- How does the environment affect living organisms?
- How do organisms' traits help them survive in different environments?
- What happens to organisms when the environment changes?

Performance Expectations:

3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

Example Phenomena/Engineering Problem:

- http://science.unctv.org/content/lessonplan/dinosaur-fossils

  A dinosaur bone or a fossil imprint

- https://www.youtube.com/watch?v=Nbuu1Fa-c1k
  Characteristics of a stingray that help it survive and produce offspring.
- https://www.chesapeakebay.net/issues/wetlands
  Threats to wetlands

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect [CCC-3] Scale, Proportion, and Quantity [CCC-4] Systems and System Models	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. **LS4.A: Evidence of Common Ancestry and Diversity** Some kinds of plants and animals that once lived on Earth are no longer found anywhere. Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.	• Students can explore what happens when the same type of plant grows in places that have different environmental conditions on their schoolyard. First, they must find two plants in different locations that are the same type and make specific observations of the individual plants and their environments, measuring specific quantities when possible (number of leaves or flowers, height, largest leaf size for plants, temperature of environment.) How do environmental conditions affect the plant's ability to survive? • Students identify specific living and non-living factors of the environment as well as human-caused changes. • Students can use computer simulations of ecosystems to directly manipulate the amount of resources such as water or space and see how populations react.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		LS4.B: Natural Selection Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. **LS4.C: Adaptation** For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. **LS4.D: Biodiversity and Humans** Populations live in a variety of habitats, and change in those habitats affects the organisms living there.	● Students can define a simple design problem caused by the fact that some kinds of organisms cannot survive at all in a particular environment. ● Students can draw a map of a location showing the variation, populations, and distribution of organisms in that area.

The Earth Science and Space Sciences

Topic: Earth's Systems	**Grade 3**
Overview: Examples of data could include average temperature, precipitation, and wind direction.	
Guiding Questions: ● What is typical weather in my local region? ● How does it compare to other areas of Connecticut and the world?	
Performance Expectations: 3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.	

Example Phenomena/Engineering Problem:

- https://www.wunderground.com/history/
  Weather conditions change each day over the course of the year.
- Features such as the flow of water, the growth of plants and animals, and wind patterns all vary by location on the schoolyard.
- https://earthobservatory.nasa.gov/Experiments/Biome/graphs.php
  Characteristics of climates in a variety of biomes

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-4] Analyzing and Interpreting Data	[CCC-1] Patterns	**ESS2.D: Weather and Climate** Scientists record patterns of the weather across different times and areas so that they can make predictions about	● Create a yearlong "Schoolyard Survey Map." Map the natural and building features of the area, identify different ways that various areas are used, note environmental features like sunny and shady areas, the direction of prevailing winds, and any visible signs of

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-8] Obtaining, Evaluating, and Communicating Information		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.	water runoff. Students record where living things like plants and animals are located and indicate the ways that children use each area of the schoolyard. Each student makes his or her own individual map. ● Generate questions about the weather and the impact it has on them. Students wonder: “Why is it so hot today?” “Why am I so sweaty?” “What’s the hottest it’s ever been on this day?” “Where is the hottest place in the world?” Using a class set of laptops, students work individually to quickly try to find answers to these questions. ● Students analyze the data they have collected throughout the school year and produce reports summarizing the weather in each month of the school year. ● Students use their observations to describe the major characteristics of the four seasons. Using their data, they then make a claim about when each season “begins” and “ends.”

The Earth Science and Space Sciences

Topic: Earth and Human Activity	**Grade 3**
Overview: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.	
Guiding Questions: ● What weather patterns are common for different seasons? ● What weather-related hazards are in my region? ● How can we reduce weather-related hazards?	
Performance Expectations: 3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.	

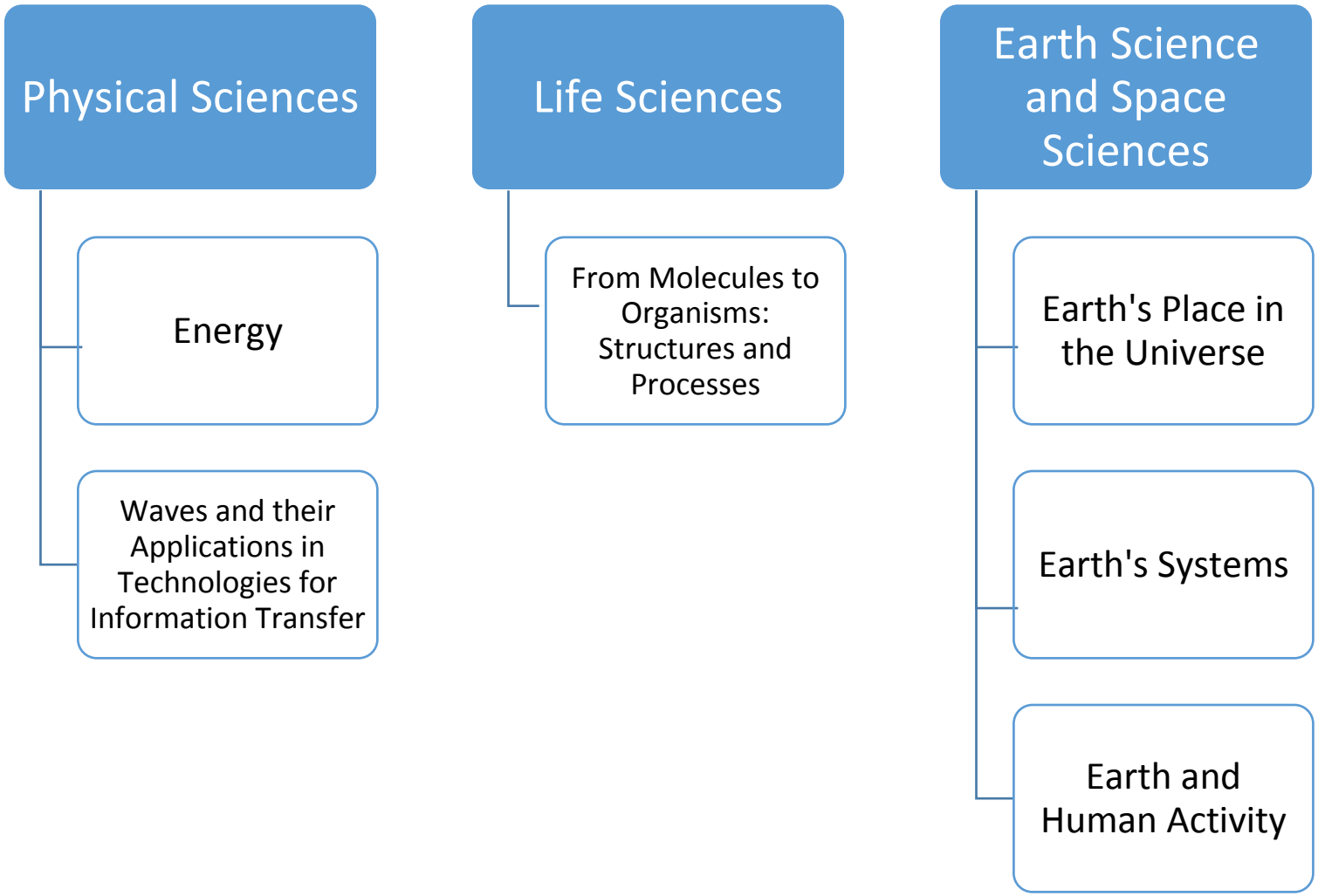
Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=XPdcFbbpaD4
  The school faces certain hazards caused by weather conditions.
- https://www.youtube.com/watch?v=uGTrGHND6bs
  House survives Hurricane Sandy
- Design a model to withstand weather hazards.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect	**ESS3.B: Natural Hazards**	● Students identify hazards that affect their school and then engage in an argument about which hazards are most dangerous and significant at their school.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	● Student's research places around the world that experience similar weather problems and find how those communities solve similar problems. Then students return to the problem they face at their own school and decide what their overall goal will be. They figure what they will be allowed to change and what is off limits. ● Students brainstorm criteria by which they will compare possible solutions to weather hazards; develop a variety of possible solutions; draw diagrams of one solution; share their diagrams with other students; use their criteria to choose among the solutions; and complete a final design. ● Students communicate their design ideas to others.

Grade 4


Physical Sciences
Energy
Waves and their Applications in Technologies for Information Transfer
Life Sciences
From Molecules to Organisms: Structures and Processes
Earth Science and Space Sciences
Earth's Place in the Universe
Earth's Systems
Earth and Human Activity

The Physical Sciences

Topic: Energy	**Grade 4**

Overview:

Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.

Guiding Questions:

- Why do car crashes cause so much damage?
- What happens to energy when objects collide?

Performance Expectations:

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=0LnbyjOyEQ8
  Newton's Cradle illustrating the law of conservation of energy and momentum

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-1] Asking Questions and Defining Problems	[CCC-5] Energy and Matter	**PS3.A: Definitions of Energy** The faster a given object is moving, the more energy it possesses.	● Explore movements and collisions with a set of materials such as toy cars, marbles, ramps, and other objects. Challenge students to get their vehicle to move faster or explore what happens

<table>
<tr><th>Highlighted Science and Engineering Practices</th><th>Highlighted Cross Cutting Concepts</th><th>Disciplinary Core Ideas</th><th>Sample Instructional Strategies</th></tr>
<tr>
<td>[SEP-3] Planning and Carrying Out Investigations

[SEP-6] Constructing Explanations and Designing Solutions

[SEP-7] Engaging in Argument from Evidence</td>
<td></td>
<td>Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

PS3.B: Conservation of Energy and Energy Transfer
Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

Light also transfers energy from place to place.

Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.</td>
<td>when it collides with various objects. Students begin to ask their own questions, predict outcomes of different combinations of motion and collision, and then try them out.
● Identify common injuries and different forms of energy. Some samples include the following:

<table>
<tr><th>Verb Phrase Describing an Injury</th><th>Related Form of Energy</th></tr>
<tr><td>Fell down</td><td>Gravity (gravitational potential energy)</td></tr>
<tr><td>Crashed into a wall on a bicycle</td><td>Energy of motion (kinetic energy)</td></tr>
<tr><td>Hit by a baseball</td><td>Energy of motion (kinetic energy)</td></tr>
<tr><td>Burned by touching a hot stove</td><td>Heat (thermal energy)</td></tr>
<tr><td>Shocked by touching an electrical outlet</td><td>Electricity (electrical energy)</td></tr>
<tr><td>Sunburnt</td><td>Light energy</td></tr>
<tr><td>Ruptured eardrums at a loud concert</td><td>Sound energy</td></tr>
<tr><td>Poisoned by accidentally drinking household cleaning products</td><td>Chemical energy (chemical potential energy)</td></tr>
</table>
</td>
</tr>
</table>

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		PS3.C: Relationship Between Energy and Forces When objects collide, the contact forces transfer energy so as to change the objects' motions. **PS3.D: Energy in Chemical Processes and Everyday Life** The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. **ETS1.A: Defining Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	● Students explore the effect a rolling marble or toy car has when it hits a paper cup or another car. They can devise ways to increase or decrease the speed of their vehicle (e.g., roll it down ramps at different speeds) and then describe the effect on the paper cup (e.g., the distance the cup moved).

The Physical Sciences

Topic: Waves and their Applications in Technologies for Information Transfer	**Grade 4**
Overview: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves. Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.	
Guiding Questions: • How do waves help us receive and send messages?	
Performance Expectations: 4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. 4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. 4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.*	

Example Phenomena/Engineering Problem:

- lines of code
  Photograph of computer coding

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
	[CCC-1] Patterns	**PS4.A: Wave Properties**	• Wave demonstration – Slinky and Sound Waves https://www.youtube.com/watch?v=kxQj-wPePBU

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-6] Constructing Explanations and Designing Solutions	[CCC-2] Cause and Effect	Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). **PS4.B: Electromagnetic Radiation** An object can be seen when light reflected from its surface enters the eyes. **PS4.C: Information Technologies and Instrumentation** Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as	In small groups, explore slinky movement. Encourage students to make various waves. • How Energy Moves through Water Lesson Plan: http://static.nsta.org/files/sc0701_50.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	

The Life Sciences

Topic: From Molecules to Organisms: Structures and Processes	**Grade 4**

Overview:

Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin. Emphasis is on systems of information transfer.

Guiding Questions:

- How do the structures of animals help them live in their environment?
- How do senses help animals survive, grow, and reproduce?
- What role does light play in how we see?
- How do humans encode information and transmit it across the world?

Performance Expectations:

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Example Phenomena/Engineering Problem:

- Different plants and animals have different external structures and also different behaviors.
- **cat & can opener**
  Cats react to buzzing electric can opener as a signal for feeding.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models	[CCC-4] Systems and System Models	LS1.A: Structure and Function Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	● animal mouth structure lesson plan Each student chooses a plant or animal to carefully observe and sketch. The goal of drawing the organism is to identify different structures and ask questions about how they help the

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-7] Engaging in Argument from Evidence		**LS1.D: Information Processing** Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.	organism survive. These questions set the stage for gathering evidence. Based on further observations, research, and classroom and outdoor experiences, students construct an argument about the importance of specific structures of an insect to its survival, growth, behavior, and reproduction. ● Lesson on Animal eyes with additional links Discuss "The World Through Animal Eyes" text. Students work in small groups to compare and contrast the various structures of animals' eyes. ● Students explore how their two eyes provide depth perception through games and challenges where they operate with only one eye open (such as trying to catch a falling object or drop a penny into a bucket). To demonstrate the difference of using one vs. two eyes to judge depth, hold the ends of a pencil, one in each hand. Hold them either vertically or horizontally facing each other at arms-length. With one eye closed, try to touch the end of the pencils together. Compare the process using two eyes and explain the difference. ● Students sort through the pictures of animal eyes along with information about what they eat and how they live. Students identify the animals they think might have the best depth perception. What do they have in common?

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Why would some animals benefit from better field of view versus better depth perception?

The Earth Science and Space Sciences

Topic: Earth's Place in the Universe	**Grade 4**
Overview: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.	
Guiding Questions: ● How do water, ice, wind, and vegetation sculpt landscapes? ● What factors affect how quickly landscapes change?	
Performance Expectations: 4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.	

Example Phenomena/Engineering Problem:

- https://www.fossilera.com/p/409/Carbonization-Fossil-Leaf.jpg
  Photo of a fossil of a leaf
- https://www.youtube.com/watch?v=loI584OFVpE&t=23s
  Animated video how glaciers shape the landscape.
- https://www.smithsonianchannel.com/videos/how-was-the-grand-canyon-formed/49029
  Aerial America video of how the Grand Canyon was formed

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-6] Constructing Explanations and	[CCC-1] Patterns	**ESS1.C: The History of Planet Earth** Local, regional, and global patterns of rock formations	• Students examine several fossil samples as they analyze different ways these fossils formed using both real and virtual samples. Fun with Fossils Lesson

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Designing Solutions		reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.	• Students explore one area of their yard, documenting the effects of rain, wind, ice, vegetation over time. Students should be able to present findings to others.

The Earth Science and Space Sciences

Topic: Earth's Systems	**Grade 4**
Overview: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow. Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.	
Guiding Questions: ● How are landscape changes recorded by layers of rocks and fossils? ● How can people minimize the effects of changing landscape on property while still protecting the environment?	
Performance Expectations: 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. 4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.	

Example Phenomena/Engineering Problem:

- https://www.history.com/shows/how-the-earth-was-made/videos/erosion
  History Chanel video on erosion
- https://www.youtube.com/watch?v=ALBUX31tW4M
  Animation of continents separating (Pangea)

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-3] Planning and	[CCC-1] Patterns	**ESS2.A: Earth Materials and Systems** Rainfall helps to shape the land and affects the types of living things found in a region.	● Students can analyze maps of their community and predict places where erosion has or could occur. These maps could show topography as different

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data	[CCC-2] Cause and Effect	Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. **ESS2.E: Bio geology** Living things affect the physical characteristics of their regions.	colors where students recognize that the steepest slopes have the most erosion, or simplified geologic maps that indicate the strength of different rocks and therefore their resistance to erosion. ● Students explore earthquakes from different perspectives: They use maps to identify patterns about where earthquakes occur on Earth, they develop models that describe waves and apply them to understanding earthquake shaking.

The Earth Science and Space Sciences

Topic: Earth and Human Activity	**Grade 4**
Overview: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; nonrenewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels. Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.	
Guiding Questions: ● How does human use of natural resources affect the environment?	
Performance Expectations: 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.	

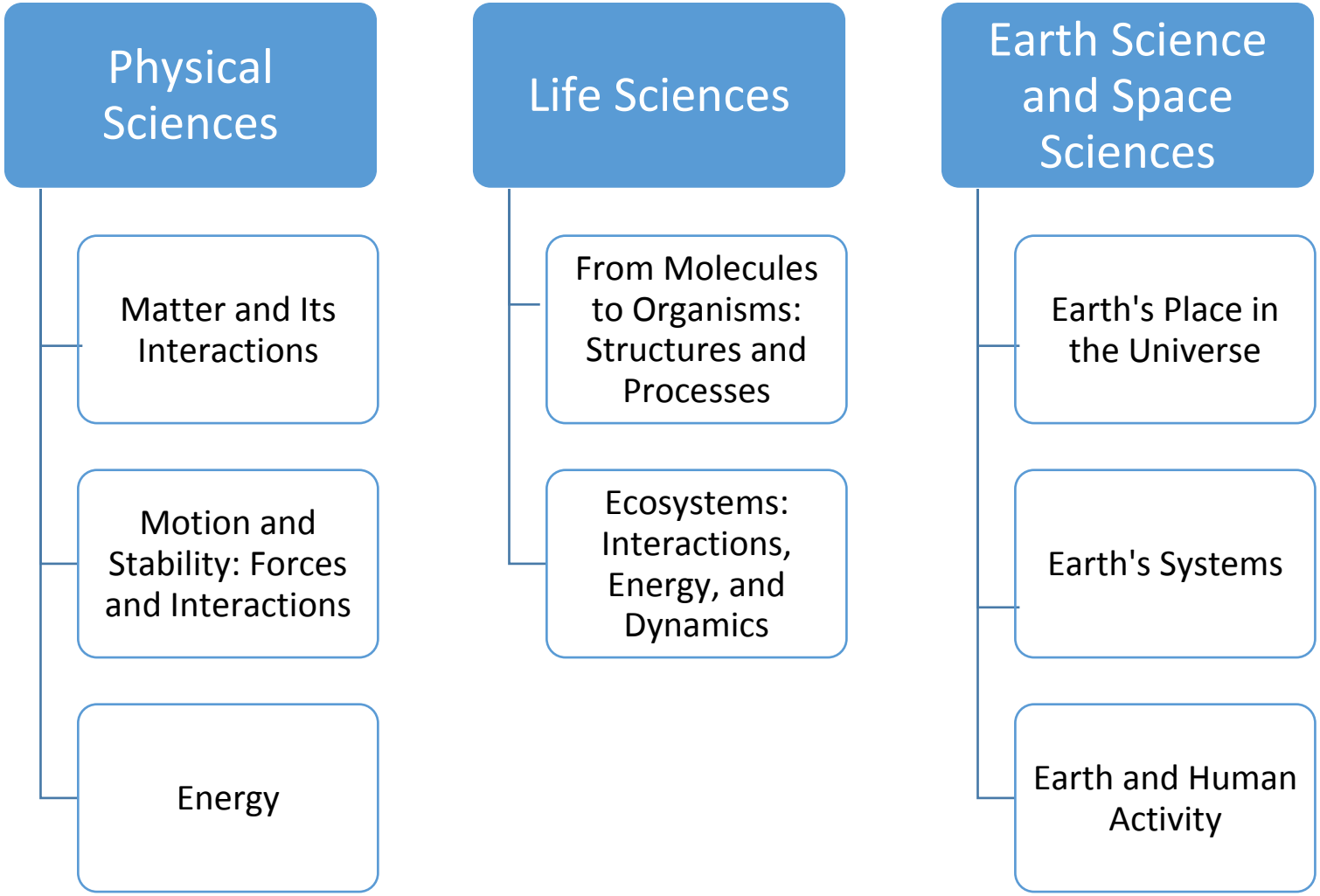
Example Phenomena/Engineering Problem:

- **windfarm**
- **Tacoma Bridge swaying**

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-6] Constructing Explanations and Designing Solutions [SEP-8] Obtaining, Evaluating, and Communicating	[CCC-2] Cause and Effect	**ESS3.A: Natural Resources** Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.	● Students obtain information about a specific renewable resource (e.g., wind, solar, water stored behind dams used to drive hydroelectric generation, biofuels) and non-renewable resource (e.g., fossil fuels such as gasoline, natural gas, or coal). Students review information they find in print and digital media to discover which objects

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Information		**ESS3.B: Natural Hazards** A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. **ETS1.B: Designing Solutions to Engineering Problems** Testing a solution involves investigating how well it performs under a range of likely conditions.	and forms of energy play a role in each energy resource; how the energy resource is used (running cars, generating heat, producing electricity); and how the use of the energy source affects the environment. ● Students design and test earthquake-resistant structures to withstand that shaking. (Connect to wave motion lessons.)  ● **Straw Bridge Challenge** – (Students should use what they learned in math, unit 8, from grade 3, to create a bridge that withstands natural hazards.)

Grade 5


Physical Sciences
Matter and Its Interactions
Motion and Stability: Forces and Interactions
Energy
Life Sciences
From Molecules to Organisms: Structures and Processes
Ecosystems: Interactions, Energy, and Dynamics
Earth Science and Space Sciences
Earth's Place in the Universe
Earth's Systems
Earth and Human Activity

The Physical Sciences

Topic: Matter and Its Interactions	**Grade 5**
Overview: Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water. Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances. 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.	
Guiding Questions: ● What causes different materials to have different properties? ● How do materials change when they dissolve, evaporate, melt, or mix together? ● What are the differences between solids, liquids, and gases?	
Performance Expectations: 5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen. 5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. 5-PS1-3. Make observations and measurements to identify materials based on their properties. 5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.	

Example Phenomena/Engineering Problem:
● Legos - small blocks can be joined together to create larger blocks or structures to show molecular structure ● Baking soda and vinegar demo to illustrate conservation of mass

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-5] Using Mathematics and Computational Thinking	[CCC-2] Cause and Effect [CCC-3] Scale, Proportion, and Quantity	**PS1.A: Structure and Properties of Matter** Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the	• Students should understand that all matter on Earth is made up of tiny particles and that even though they are invisible, they are still there. Observation/evidence: blow air into a balloon - can push on it and it will "push" back proving that they exist. Watch leaves moving on trees to demonstrate that those tiny particles of air actually exist. • To introduce students to the concept of atoms use a form of matter that students are very familiar with, such as wood. Explain that wood can be cut it into parts, but even as it gets smaller, it will still be wood. We can keep cutting it smaller and it will still be wood, until it is so small, it is no longer visible, but, it remains wood. • Use a scale to measure the mass of some water and then the mass of some sugar cubes (separately) students make observations and record then dissolve sugar cubes in water to find mass of the sugar water is equal to the mass of the individual items separately. Even though sugar is dissolved and can't be seen, it still exists matter is conserved. • PHET simulation link - shows how molecules in a solid, liquid, and gas are structured and how they change when they are heated or cooled • PHET simulation on Reactions and Rates – shows molecular collision • Conduct a demo/experiment using baking soda and vinegar. Measure mass of each separately and put baking soda in a balloon and attach to top of beaker, balloon

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) **PS1.B: Chemical Reactions** When two or more different substances are mixed, a new substance with different properties may be formed. No matter what reaction or change in properties occurs, the total weight of the substances does not change.	inflates, holding in the liquid. Take measurement of mass of liquid again and the sum should equal the same amount as individual components. Chemical bonds are broken and reformed but mass stays the same.

The Physical Sciences

Topic: Motion and Stability: Forces and Interactions	**Grade 5**
Overview: "Down" is a local description of the direction that points toward the center of the spherical Earth.	
Guiding Questions: ● **How would life on Earth be different without gravity?** ● **How can we explain and predict the motion of objects on Earth?** ● **How does an object's mass affect its gravitational force in relation to other objects?**	
Performance Expectations: 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.	

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=FHtvDA0W34I&t=8s
  YouTube clip of Felix Baumgartner's record-breaking 24- mile free fall to Earth. (Watch from 3:30-12:38)
  Why does Felix Baumgartner fall to Earth and not float off into space?

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect	**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.	● Magnets can be used to show how forces at a distance work by sometimes attracting (as in gravity) and sometimes repelling. Demonstrate the idea of magnetic fields using magnets on top of iron filings. North and South poles will attract the filings. Two Norths or two Souths will repel the filings. ● Hold a ball in your hand and ask students what will happen to the ball if you let it go. They should realize that it will fall to the ground. Let it go, and watch it fall to

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			the ground. Hold the ball as high as you can and ask what will happen if you let it go. Drop it and watch it fall to the ground. Now, stand on a chair and ask students what will happen if you drop the ball from there. Drop it and watch it fall to the ground. Have student discuss where they think the ball will go if it is dropped from a tower that is 6 miles high. Have students explain their thinking. ● Using the video of Felix Baumgartner's world record skydive from 128,000 feet, ask students what forces were acting on Baumgartner as he fell to Earth. They will likely mention that gravity was pulling him down and the air was slowing him down. They might recognize that the parachute released at the end slowed him down and caused him to move back and forth above Earth's surface. Point out that before the parachute opened, Baumgartner fell straight down toward Earth's surface. Ask students why Baumgartner did not float away from Earth at 24 miles above it. ● Read *Gravity* by Jason Chin considering the following questions: o Is gravity a pushing or pulling force? o Which way does gravity pull? Students will likely say gravity pulls down. For example, if you dropped something at the equator or the South Pole, which way would it fall? (Students should realize

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			that “down” means toward the Earth’s surface. Explain that gravity pulls things toward the center of the Earth. So “down” really means toward Earth’s center.) Reread the information on pages 30–31. Create six index cards that contain the information in each of the six paragraphs in the “More About Gravity” section. The cards should have the following titles and the corresponding informational paragraph: 1. Gravity Is Attractive 2. More Mass, More Gravity 3. Weaker with Distance 4. Mass Matters 5. The Measure of Gravity 6. Gravity Keeps It All Together Divide students into six groups and give each group one of the index cards. Tell them that they need to read the card and come up with a visual that demonstrates the fact about gravity described on the card. When each group is finished, have them share with the rest of the class and compare their drawing to Jason Chin’s illustration accompanying the paragraph. After each group shares, ask them to relate their fact about gravity to Felix Baumgartner’s fall to Earth. Give them an opportunity to correct or refine their original answer

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			• Write a letter to a friend using words and diagrams to convince him that he will not fall off the Earth's surface and explain why.

Physical Sciences

Topic: Energy	**Grade 5**
Overview: Examples of models could include diagrams, and flowcharts.	
Guiding Questions: ● How do animals use their energy to sustain life? ● How is energy transferred and transformed as it flows through a food chain?	
Performance Expectations: 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.	

Example Phenomena/Engineering Problem:
https://www.teachengineering.org/activities/view/cub_energy2_lesson01_activity1
Three short, hands-on, in-class demos expand students' understanding of energy. First, using peanuts and heat, students see how the human body burns food to make energy. Then, students create paper snake mobiles to explore how heat energy can cause motion. Finally, students determine the effect that heat energy from the sun (or a lamp) has on temperature by placing pans of water in different locations.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-7] Engaging in Argument from Evidence	[CCC-5] Energy and Matter	**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	● Show three demos from above phenomena resource to prove the sun is a source of energy. ● Students create food chains and food webs to describe the movement of matter among organisms in an ecosystem. Students trace the flow of energy through food chains from the Sun to other organisms in an ecosystem.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		plant matter (from air and water). **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.	● Create an accurate model, in the form of a food web, to illustrate the transfer of energy through an ecosystem.

The Life Sciences

Topic: From Molecules to Organisms: Structures and Processes	**Grade 5**
Overview: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.	
Guiding Questions: ● What matter do plants need to grow?	
Performance Expectations: 5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.	

Example Phenomena/Engineering Problem:
Show a photo of a dying plant. Make observations and discuss what we see and why.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-7] Engaging in Argument from Evidence	[CCC-5] Energy and Matter	**LS1.C: Organization for Matter and Energy Flow in Organisms** Plants acquire their material for growth chiefly from air and water.	● Students use the scientific inquiry process to conduct an experiment in which they vary the amount of water, sunlight and air to which plants are exposed; collect and analyze data to determine optimal amounts and combinations for growth.

The Life Sciences

Topic: Ecosystems: Interactions, Energy, and Dynamics	**Grade 5**
Overview: 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.	
Guiding Questions: ● How does matter move within an ecosystem? ● How does energy move within an ecosystem?	
Performance Expectations: 5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.	

Example Phenomena/Engineering Problem:
● Link to Montreal Biodome video

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models	[CCC-4] Systems and System Models	**LS2.A: Interdependent Relationships in Ecosystems** The food of almost any kind of animal can be traced back to plants. **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** Matter cycles between the air and soil and among plants,	● Students create self-sustaining biomes in a bottle, jar, or bag. There are examples online such as http://pbskids.org/zoom/activities/sci/biomeinabaggie.html ● Students create a model of how energy and matter flow in an ecosystem. ● Students construct food webs by making direct observations about what animals consume. Observations can be in small classroom ecosystems such as a terrarium or fish tank.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		animals, and microbes as these organisms live and die.	● Students investigate some of the waste products produced by plants. When students place a plastic bag over the leaves of a plant, the inside of the bag gets wet revealing that the plant gives off water. When they submerge Anacharis, Elodea, or rosemary plants in water, they observe tiny bubbles of gas released from the leaves. Students can measure the quantity of gas by counting bubbles or trapping the gas in an inverted test tube placed over the plant, recognizing that the rate of gas release depends on the amount of light shining on the plant.

The Earth Science and Space Sciences

Topic: Earth's Place in the Universe	**Grade 5**
Overview: 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.	
Guiding Questions: ● How far away are the stars? How can we tell? ● What trends and patterns are there in the movement of the Sun and stars?	
Performance Expectations: 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 Earth. 5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.	

Example Phenomena/Engineering Problem:
Day and Night Seasons Moon phases

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP4] Analyzing and Interpreting Data	[CCC-1] Patterns	**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	● Students graph sunrise and sunset times for one month or more to show predictable patterns ● Students observe constellations to determine patterns and locations of stars during different seasons. ● Students graph hours of daylight for several months to show how the number of daylight increases gradually as

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-7] Engaging in Argument from Evidence	[CCC-3] Scale, Proportion, and Quantity	range greatly in their distance from Earth. **ESS1.B: Earth and the Solar System** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.	we move from winter to spring and spring to summer correlating to Earth's orbit around the Sun and its tilt toward the Sun. ● Students keep a Moon journal and then create a diagram/model of a moon phase.

The Earth Science and Space Sciences

Topic: Earth's Systems	**Grade 5**
Overview: 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.	
Guiding Questions: ● How can we represent systems as complicated as the entire planet? ● Where does my tap water come from and where does it go? ● How much water do we need to live, to irrigate plants? How much water do we have?	
Performance Expectations: 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere Interact. 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.	

Example Phenomena/Engineering Problem:

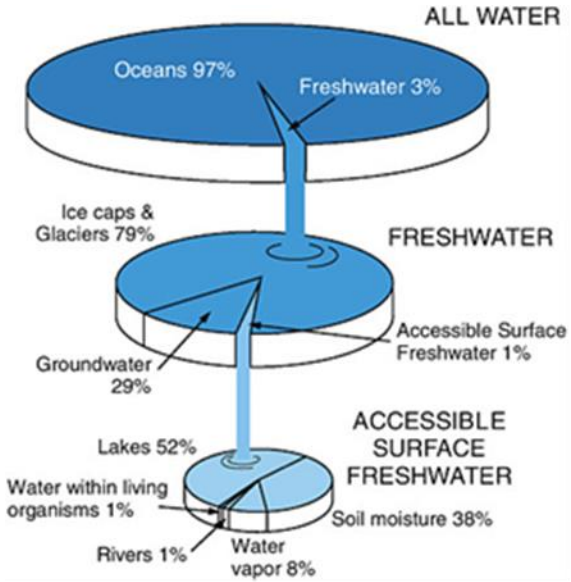
- https://www.youtube.com/watch?v=4RUGmBxe65U
  Ocean biome

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-5] Using Mathematics and	[CCC-3] Scale, Proportion, and Quantity	**ESS2.A: Earth Materials and Systems** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the	● Exploring Ecosystems: Coral Reef Symbiosis ● Students visit a small "ecosystem" on their schoolyard. Their goal is to observe and list as many objects in the ecosystem as possible. Returning to the classroom, they look at pictures of more ecosystems (ideally a wide

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Computational Thinking	[CCC-4] Systems and System Models	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. **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.	variety of local settings they have visited) and again make lists of all the components in each ecosystem. Students then work in teams to group all these different items into four or five categories. Students will have to formulate these categories themselves based on the similarities they think are most important between groups of objects on their lists. Groups then communicate their rationale for selecting their categories. ● Students return to the photographs of the ecosystems and their lists, sorting the objects into the four different Earth systems. Students identify some of these interactions in their ecosystem pictures. For example, a river flowing over rocks results in components of the hydrosphere causing erosion in the geosphere and helping support life in the biosphere. The water itself almost certainly comes from clouds in the atmosphere, and the cool water (along with shade from the trees of the biosphere) keeps the temperature low in the atmosphere immediately surrounding riverbanks. ● Students create a model of how one or more phenomena exemplify interactions between different Earth systems. ● Students use mathematical thinking to describe the relative proportions of water found in different forms. How much water is in the ocean, glaciers, rivers, underground? How much is salt water? Students

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			describe and provide evidence that nearly all of Earth's available water is in the ocean.

Distribution of Earth's Water



The Earth Science and Space Sciences

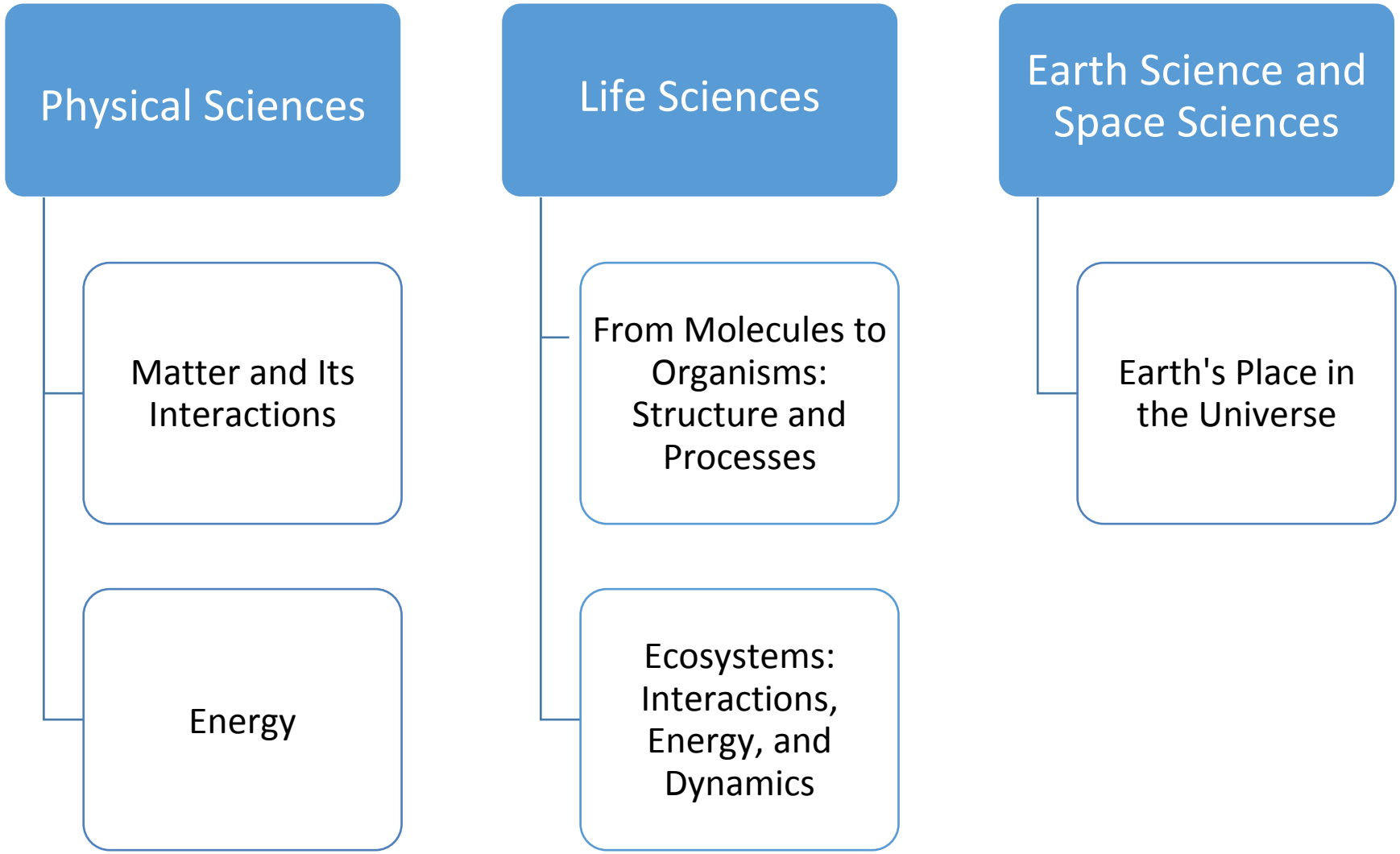
Topic: Earth and Human Activity	**Grade 5**
Overview: Examples of Earth and human activity may include problems such as population growth, shrinking resource supplies, greenhouse gases, acid rain, deforestation, and misuse of fertilizers and pesticides.	
Guiding Questions: ● What can we do to protect Earth's resources?	
Performance Expectations: 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	

Example Phenomena/Engineering Problem:
Post fracking tap water

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-8] Obtaining, Evaluating, and Communicating Information	[CCC-4] Systems and System Models	**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.	● Students can obtain information about the source of their local tap water and which human activities are the primary users of the local water sources. What measures are taken to protect these sources? Students think about problems and solutions that help us protect our resources. Student work focuses on obtaining, evaluating, and communicating information that shows how human activities in agriculture, industry, and everyday life have major effects on the land, vegetation, streams, underground water storage levels (aquifer), and ocean.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			● Group projects could investigate particular local resource issues and examine what individuals and communities are doing or could do to help protect Earth's resources and environments. Students present their findings and solutions to each other, emphasizing specific cause and effect relationships where a particular technology or action prevents the exchange of pollutants between different parts of Earth's systems or otherwise reduces human-induced changes to these systems.

Grade 6


Physical Sciences
Matter and Its Interactions
Energy
Life Sciences
From Molecules to Organisms: Structure and Processes
Ecosystems: Interactions, Energy, and Dynamics
Earth Science and Space Sciences
Earth's Place in the Universe

The Physical Sciences

Topic: Matter and Its Interactions	**Grade 6**

Overview:

Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels. Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

Guiding Questions:

- How do particles combine into new substances?
- How do synthetic materials positively and negatively affect society?
- How does the addition or removal of energy affect the particle motion, temperature and state of a substance?

Performance Expectations:

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Example Phenomena/Engineering Problem:

- http://tinyurl.com/la757go
  chemical reactions video and two photos of car - pre/post iron oxide/rust

- https://www.thesamba.com/vw/gallery/pix/332560.jpg
  No rust
- http://images.thesamba.com/vw/gallery/pix/1052479.jpg
  Rust -- chemical reaction of bioluminescence occurs when a microorganism in seawater is disturbed by oxygen
- http://i.dailymail.co.uk/i/pix/2016/02/18/15/3157BEBA00000578-3452868-Natural_phenomenon_Glowing_blue_water_washes_up_on_a_beach_in_Va-a-77_1455809847764.jpg
  NGSS chemical reactions phenomena
- https://www.ngssphenomena.com/exampleconnections/
- http://america.aljazeera.com/content/ajam/articles/2014/11/11/the-afterlife-ofplastic/jcr:content/mainpar/adaptiveimage/src.adapt.960.high.plastic_oil_beakers.1415721182099.jpg
  The afterlife of plastic
- https://www.youtube.com/watch?v=4M47FAkQjyo
  Great Pacific Garbage Patch video
- http://www2.padi.com/blog/wp-content/uploads/2016/09/Plastic-Ocean.jpg
- http://coastalcare.org/wp-content/uploads/2014/07/plastic-pollution-below.jpg
  Image from NOAA
- https://taldepot.com/media/catalog/product/cache/1/thumbnail/9df78eab33525d08d6e5fb8d27136e95/5/1/51_CLj_T2_Brc_L.jpg
  Individual creamers form ice cream when placed into a system of ice, salt, and water.
- https://addapinch.com/wp-content/uploads/2014/07/old-fashioned-vanilla-ice-cream-recipe-DSC_4239-1.jpg
- https://www.youtube.com/watch?v=HbXNQfHnI3w
- Dry Ice example- can also use sublimation video- on mute

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data [SEP-8] Obtaining, Evaluating and Communicating Information	[CCC-1] Patterns [CCC-2] Cause and Effect [CCC-3] Scale, Proportion, and Quantity [CCC-6] Structure and Function	**PS1.A: Structure and Properties of Matter** Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) (MS-PS1-3) Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and	**lessons for atom/molecule models:** https://betterlesson.com/lesson/634009/marshmallow-molecules https://www.teachengineering.org/activities/view/cub_mix_lesson1_activity1 **PHET Interactive Simulations:** https://phet.colorado.edu/en/simulation/build-a-molecule **matter, structure and properties anchor charts:** https://thewonderofscience.com/anchor-charts/?tag=ms-matter-structure-and-properties **Chemical properties and reactions:** https://betterlesson.com/lesson/634016/chemical-reactions-un-notes# **Demonstrations/stations for additional chemical changes** (dirty pennies placed in a container with salt and vinegar which will strip away dirt; Alka seltzer & water show chemical reaction- fizzing, bubbling, etc.; clear bottle with vinegar in it & baking soda in balloon- flip balloon over the top - CO2 inflates balloon; leave shiny pennies in a pie pan over paper towel and pour vinegar on it- will

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		may vibrate in position but do not change relative locations. (MS-PS1-4) Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1) The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4) **PS1.B: Chemical Reactions** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2) (MS-PS1-3)	create chemical change and greenish/blue compound (malachite) will form. **Energy Changes in Chemical Reactions** Focus is on endothermic and exothermic changes. http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson7 **Phase Changes, endothermic and exothermic reactions** https://betterlesson.com/lesson/634014/talk-about-burning-your-money-phase-changes-endothermic-and-exothermic-reactions Students identify physical and chemical properties independently and go through a series of lab stations in which they must identify properties and how they are affected by thermal energy. https://betterlesson.com/lesson/634012/peppery-properties-of-matter-labs **Chemical Interactions- Interactive Technology** https://authoring.concord.org/activities/1021/single_page/c5a65446-647d-424f-97bc-08d36004b723 **Heat, temperature and conduction lesson:**

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		PS3.A: Definitions of Energy The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (MS-PS1-4) Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS1-4)	http://www.middleschoolchemistry.com/lessonplans/chapter2/lesson1 **Phase Change Lab** https://betterlesson.com/lesson/633397/phase-change-lab **5 Changes of State** http://www.middleschoolchemistry.com/lessonplans/chapter2 **Natural Resources and Synthetic Materials** http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson12

Topic: Energy **Grade 6**

Overview:

Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added. Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.

Guiding Questions:

- How does energy transfer through various systems in the natural world?
- How do changes in energy, or energy transfers, affect motion? How does motion allow energy to be transferred?
- How does the types, states, and amount of matter present affect the relationship between temperature and the total energy of a system?

Performance Expectations:

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Example Phenomena/Engineering Problem:

- https://www.greenandgrowing.org/wp-content/uploads/2017/08/Solar-oven-2-e1503051014991.jpg
  Solar energy oven
- https://taldepot.com/media/catalog/product/cache/1/thumbnail/9df78eab33525d08d6e5fb8d27136e95/5/1/51_CLj_T2_Brc_L.jpg
  Individual creamers form ice cream when placed into a system of ice, salt, and water. How does this happen?
- https://addapinch.com/wp-content/uploads/2014/07/old-fashioned-vanilla-ice-cream-recipe-DSC_4239-1.jpg

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating and Communicating Information	[CCC-3] Scale, Proportion, and Quantity [CCC-5] Energy and Matter	**PS3.A: Definitions of Energy** Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3) (MS-PS3-4) **PS3.B: Conservation of Energy and Energy Transfer** When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) Energy is spontaneously transferred out of hotter regions	**Misconceptions about Heat** http://ngss.nsta.org/Resource.aspx?ResourceID=858 https://www.youtube.com/watch?v=hNGJ0WHXMyE **How Does Heat Move?** Students will be able to identify and explain the various ways that heat transfers through systems in the natural world. https://betterlesson.com/lesson/633999/how-does-heat-move-introduction-to-heat-transfer **Heat Transfer Lab Rotation** https://betterlesson.com/lesson/634878/heat-transfer-lab-rotation-conduction-convection-and-radiation **Heat lesson:** https://www.teachengineering.org/lessons/view/ucd_heat_lesson01 **Radiation** https://scied.ucar.edu/activity/learn/radiation-albedo **Energy Heat Transfer - Solar Oven** http://static.nsta.org/files/ss1806_55.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		or objects and into colder ones. (MS-PS3-3) **ETS1.A: Defining and Delimiting an Engineering Problem** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	or https://www.teachengineering.org/activities/view/duk_solaroven_tech_act **Culminating STEM project ideas: Design a thermal protection system (heat shield) for NASA** Students use their knowledge of radiation, conduction, and convection to design thermal protection systems for NASA that will protect a spacecraft from burning up in the atmosphere **Thermal Protection lesson Day 1** https://betterlesson.com/lesson/634000/thermal-protection-systems-day-1 **Thermal Protection lesson Days 2 & 3** https://betterlesson.com/lesson/635048/thermal-protection-systems-day-2-and-day-3 **NASA Engineering Design Challenges background** https://www.nasa.gov/pdf/221638main_EDC_TPS.pdf **Save the Penguins** http://www.auburn.edu/~cgs0013/ETK/SaveThePenguinsETK.pdf

Topic: From Molecules to Organisms: Structures and Processes	**Grade 6**

Overview:

Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury. Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.

Guiding Questions:

- How do structures and behaviors increase the likelihood of successful reproduction of organisms?
- How do the environment and genetic factors influence the growth of organisms?

Performance Expectations:

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=W7QZnwKqopo
  BBC Planet Earth - Birds of Paradise mating dance
- https://www.youtube.com/watch?v=xW_AsV7k42o
  Blooming Flowers, Amazing Nature You Tube video clip
- http://organics.org/wp-content/uploads/2015/05/california-drought-1.jpg
  California drought photos before and after

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect	**LS1.B: Growth and Development of Organisms** Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4) Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4) Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)	**Beetle Battle** http://datanuggets.org/2016/08/beetle-battles/ **Why are Butterfly Wings Colorful?** http://datanuggets.org/2017/06/butterfly-wings/ **The Beauty of a Flower- Structure and Function** The student will be able to explain how flower structure increases probability of successful reproduction of plants https://betterlesson.com/lesson/633272/the-beauty-of-a-flower-structure-and-function# **How Plants Reproduce** Students use observation skills while dissecting a flowering plant to describe the process of reproduction for both flowering and nonflowering plants. https://betterlesson.com/lesson/636388/how-plants-reproduce **STEM- Have Seeds Will Travel** A plant's systems, processes, and components enable it to grow and reproduce. Students are introduced to one aspect

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			of a plant's reproductive system by observing, collecting and classifying seeds. https://www.plt.org/stem-strategies/have-seeds-will-travel/ **Effect of Environment on Plant Growth** Students will plant, grow and maintain plants under different environmental conditions while observing the differences. http://www.apsnet.org/EDCENTER/K-12/TEACHERSGUIDE/PLANTBIOTECHNOLOGY/Pages/Activity7.aspx

Topic: Ecosystems: Interactions, Energy, and Dynamics **Grade 6**

Overview:

Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial. Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system. Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

Guiding Questions:

- How does competition for resources affect the growth and reproduction of organisms and populations?
- In what way can organisms become dependent on each other for survival?
- How do interactions of organisms with their environments (and each other) compare throughout the world's ecosystems?
- How is matter and energy transferred between producers, consumers, and decomposers within an ecosystem?
- How does the dynamic nature of an ecosystem affect its populations?
- How do changes in biodiversity affect humans?

Performance Expectations:

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Example Phenomena/Engineering Problem:

- https://upload.wikimedia.org/wikipedia/commons/thumb/7/7f/Fighting_Hartebeest.jpg/1200px-Fighting_Hartebeest.jpg

photos depicting types of interactions- competition/predation/mutualism

- https://thebiomesavanna.weebly.com/uploads/1/1/1/6/11167170/1423829.jpg
- https://s3.amazonaws.com/skinner-production/stories/featured_images/000/017/320/large/thats_oaky.jpg?1511009250
  trees
- https://trttemperaterainforest.weebly.com/uploads/1/7/3/7/17371767/973761773.jpg?291
  interspecific example
- https://trttemperaterainforest.weebly.com/uploads/1/7/3/7/17371767/201265912.jpg?409
- https://biologydictionary.net/wp-content/uploads/2016/10/Cheetah-Hunting.jpg
- https://upload.wikimedia.org/wikipedia/commons/thumb/1/1d/European_honey_bee_extracts_nectar.jpg/608px-European_honey_bee_extracts_nectar.jpg
- https://fthmb.tqn.com/PL1VdeH9mHiA0EMfpes58aQKW4c=/768x0/filters:no_upscale()/clownfish_sea_anemone-581b994d3df78cc2e879cc71.jpg
- http://i.dailymail.co.uk/i/pix/2013/01/24/article-2267504-17212EB3000005DC-781_634x663.jpg
  Garden in a bottle - sealed seedling in its own ecosystem and watered just once in 53 years
- http://assets.climatecentral.org/images/made/10_7_15_Brian_CatlinAmericanSamoaBeforeAfter_1050_700_s_c1_c_c.jpg
- coral bleaching- affecting populations
- https://ecowatchroar-img.rbl.ms/simage/https%3A%2F%2Fassets.rbl.ms%2F10098722%2F1200x600.jpg/2000%2C2000/SeIRkest0OzU%2FbcB/img.jpg
  Colorful reef
- https://images.csmonitor.com/csm/2017/03/1031431_1_0312-coral-bleaching_standard.jpg?alias=standard_900x600nc
  Bleached reef
- https://csfs.colostate.edu/media/sites/22/2016/05/DurangoBeforeandAfter.jpg
  wildfires affecting populations

- http://mda.maryland.gov/SiteAssets/Pages/Manure/irecyclenew.jpg
  nutrient recycling

• http://ww1.prweb.com/prfiles/2017/02/10/14060975/before%20and%20after%20test.jpg water purification

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	[CCC-1] Patterns [CCC-2] Cause and Effect [CCC-5] Energy and Matter [CCC-7] Stability and Change	**LS2.A: Interdependent Relationships in Ecosystems** Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)	**Endangered Species Project** https://betterlesson.com/lesson/639346/endangered-species-a-multiday-project# **Exploring Resource Availability and Population Size** https://betterlesson.com/lesson/639457/exploring-resource-availability-and-population-size# **Going, Going, Gone Project Based Lesson** https://betterlesson.com/lesson/631896/going-going-gone-5-day-project-based-lesson **Relationships Between Organisms** https://betterlesson.com/lesson/639336/relationships-between-organisms **Exploring Predator Prey Relationships** https://betterlesson.com/lesson/639356/exploring-predator-and-prey-relationships

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2) **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and	**Biotic and Abiotic Factors** https://betterlesson.com/lesson/639248/biotic-and-abiotic-factors **Energy Flow in Ecosystems** https://betterlesson.com/lesson/639253/energy-flow-in-ecosystems **Carbon and Nitrogen Cycles** https://betterlesson.com/lesson/639294/carbon-and-nitrogen-cycles-1-of-2 https://betterlesson.com/lesson/639306/carbon-and-nitrogen-cycles-2-of-2 **Carbon Time- Transformations of Matter and Energy lesson:** http://carbontime.bscs.org/ecosystems FOSS Populations and Ecosystems Module including: Mono Lake Food Web Activity www.fossweb.org **Chesapeake Bay Food Web Lesson:** https://www.amnh.org/explore/curriculum-collections/ecology-disrupted/chesapeake-bay

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		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. (MS-LS2-3) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Modeling Marine Food Webs and Human Impacts on Marine Ecosystems** https://www.pbslearningmedia.org/resource/marinesci-sci-foodwebs/food-webs/#.Wt6Zfy7wbX4 FOSS Populations and Ecosystems Module including: Eco-scenario Project (research and project based) Jane Goodall (National Geographic documentary) Population study video- *Among the Wild Chimpanzees* **Biodiversity Unit:** https://www.wyobio.org/education/middle-school-biodiversity-unit/ **Soil Erosion** http://sciencenetlinks.com/lessons/soil-erosion/ **Where's the Beach? – Investigating Ways to Protect Shorelines from Erosion (Research/Project based/STEM)** https://www.natureworkseverywhere.org/resources/ **Various lessons MS LS 2-1 through 2-5** https://www.ck12.org/ngss/middle-school-life-sciences/ecosystems:-interactions,-energy,-and-dynamics

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5) **LS4.D: Biodiversity and Humans** Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5) **ETS1.B: Developing Possible Solutions** There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5)	

Earth and Space Sciences

Topic: Earth's Systems	**Grade 6**

Overview:

Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical. Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation). Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.

Guiding Questions:

- How do the properties and movement of water shape Earth's surface?
- What regulates weather and climate?
- How do scientists gather and analyze information to prepare for a severe weather event?

Performance Expectations:

MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=oZjKgHErMj0
  Water cycle time lapse

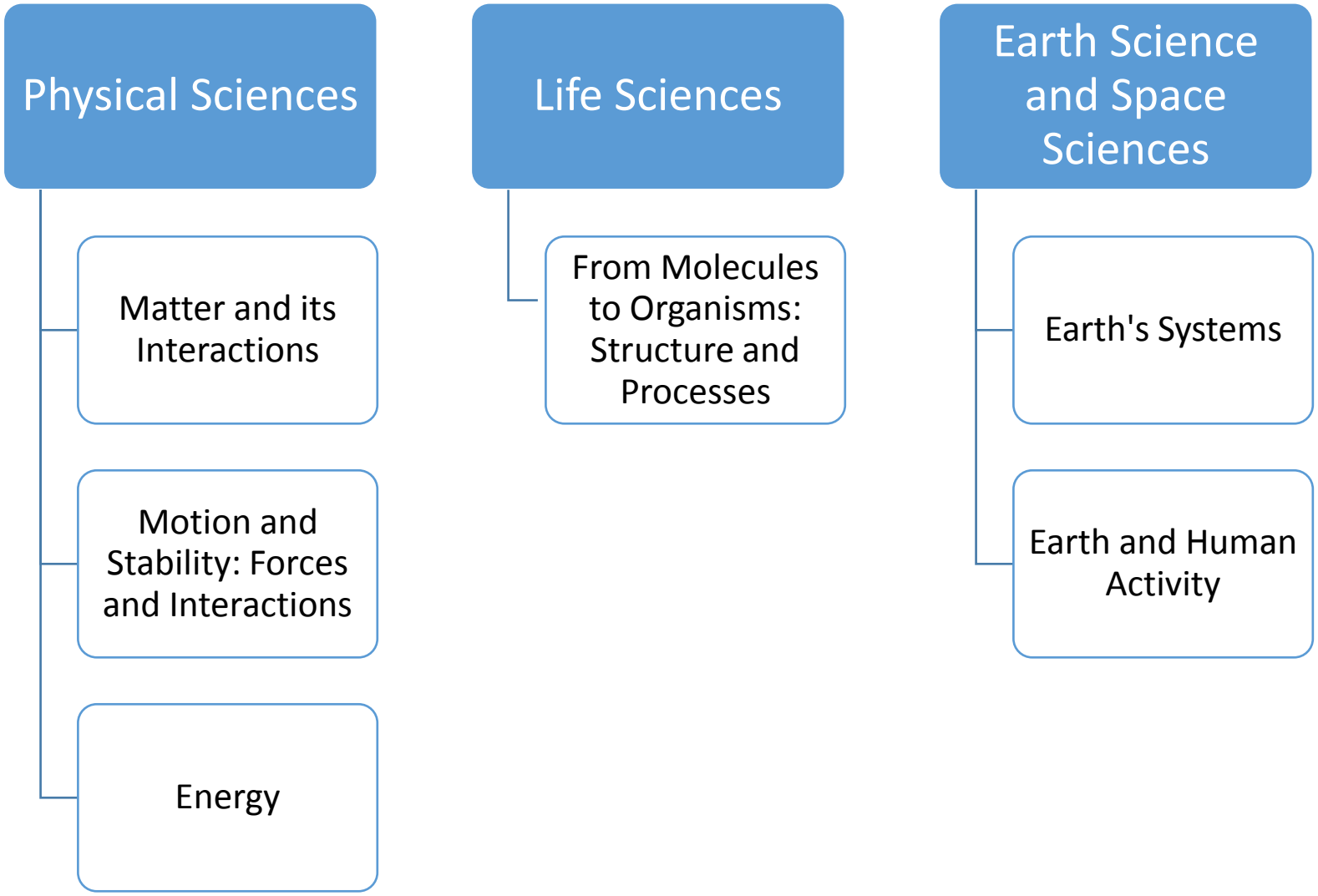
- https://img.buzzfeed.com/buzzfeed-static/static/enhanced/terminal01/2011/5/24/16/enhanced-buzz-31419-1306268261-16.jpg
  Tornado photo
- http://ngss.nsta.org/Resource.aspx?ResourceID=876
  Arctic Cold Front time lapse video
- https://www.youtube.com/watch?v=SJ3Gs0JpxMQ
- https://www.youtube.com/watch?v=C_HiBj0teRY
  NASA jet stream animation

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations	[CCC-2] Cause and Effect [CCC-4] Systems and System Models [CCC-5] Energy and Matter	**ESS2.C: The Roles of Water in Earth's Surface Processes** Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are	**Water Cycle lessons:** https://pmm.nasa.gov/education/lesson-plans/exploring-water-cycle https://pmm.nasa.gov/education/lesson-plans/earth-wheel-lesson-plan https://scied.ucar.edu/WaterCycleActivity https://www.calacademy.org/educators/lesson-plans/amazon-water-cycle-role-play FOSS Module- Weather and Water www.fossweb.org **Hydrologic Cycle** http://www.earthsciweek.org/classroom-activities/earths-hydrologic-cycle

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		major determinants of local weather patterns. (MS-ESS2-5) Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4) Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6) **ESS2.D: Weather and Climate** Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6) Because these patterns are so complex, weather can only be	**Ocean Currents** http://www.cpalms.org/Public/PreviewResourceLesson/Preview/75613 **Do Ocean Currents Affect Climate?** http://www.adp.noaa.gov/sites/adp/lessons/ADP_LessonPlan_Climographs_Cook.pdf **NASA Data Lesson: Ocean Currents and Sea Surface Temperature (2 links below)** http://nasawavelength.org/resource/nw-000-000-002-209/ https://mynasadata.larc.nasa.gov/lesson-plans/my-nasa-data-lesson/?passid=9 **Weather Fronts (animation)** http://www.classzone.com/books/earth_science/terc/content/visualizations/es2002/es2002page01.cfm?chapter_no=visualization **Air Masses and Fronts** https://betterlesson.com/lesson/631782/air-masses-and-fronts **Video on global circulation** https://www.youtube.com/watch?v=0j6oi1fdo5E

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		predicted probabilistically. (MS-ESS2-5) The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)	**Science Seminar lesson-** focus on scientific argumentation related to regional climate phenomena: http://scienceandliteracy.org/sites/scienceandliteracy.org/files/presentation/MS_SG-Engaging_in_Argumentation_with_a_Science_Seminar-Regional_Climate_in_the_Atacama_Desert.pdf **Multiple lessons for PE ESS 2-6 and 2-5** https://betterlesson.com/common_core/browse/2252/ngss-ms-ess2-6-develop-and-use-a-model-to-describe-how-unequal-heating-and-rotation-of-the-earth-cause-patterns-of-atmospheric-a **Background information:** https://oceanexplorer.noaa.gov/facts/climate.html

Grade 7


Physical Sciences
Matter and its Interactions
Motion and Stability: Forces and Interactions
Energy
Life Sciences
From Molecules to Organisms: Structure and Processes
Earth Science and Space Sciences
Earth's Systems
Earth and Human Activity

The Physical Sciences

Topic: Matter and its Interactions	**Grade 7**
Overview: Emphasis is on the law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms. Emphasis is on design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.	
Guiding Questions: • How can particles combine to produce a substance with different properties? • What happens when new materials are formed?	
Performance Expectations: MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.	

Example Phenomena/Engineering Problem:

- http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson1
  What is a Chemical Reaction?
- http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson11
  Save the Eggs: Engineering Design Challenge

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing	[CCC-5] Energy and Matter	**PS1.B: Chemical Reactions** Substances react chemically in characteristic ways. In a chemical	**What is a Chemical Reaction?** Students will be able to explain that for a chemical reaction to take place, the bonds between atoms in the

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
and Using Models [SEP-6] Constructing Explanations and Designing Solutions		process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2) (MS-PS1-3) (MS-PS1-5) The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5) Some chemical reactions release energy, others store energy. (MS-PS1-6) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary to MS-PS1-6) **ETS1.C: Optimizing the Design Solution** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the	reactants are broken, the atoms rearrange, and new bonds between the atoms are formed to make the products. Students will also be able to explain that in a chemical reaction, no atoms are created or destroyed. http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson1 **Understanding Air - Climate Change and Combustion** Students learn about the components of air, and the chemical reactions that release carbon dioxide into the atmosphere. https://mpbn.pbslearningmedia.org/resource/envh10.health.lp58a/understanding-air-climate-change-and-modeling-combustion-with-legosupsup-bricks/#.Wro5G9MbP6r **Decomposing Sucrose** Students work to identify the elements that makeup sucrose (common table sugar). https://betterlesson.com/lesson/637188/decomposing-sucrose **Chemical Reactions and Engineering Design** Students will design, test, modify, and optimize a device that uses a chemical reaction to reach a specific temperature range for a portable reptile egg incubator.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		characteristics may be incorporated into the new design. (secondary to MS-PS1-6) The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary to MS-PS1-6)	http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson11 **Lethargic Lizard** Students design a warm pack that can keep a bearded dragon warm during transport during the cold winters. Students choose a chemical, a concentration, and a cover for their warm pack that will maintain the optimal temperature of the lizard! https://betterlesson.com/lesson/634027/lethargic-lizard

Topic: Motion and Stability: Forces and Interactions **Grade 7**

Overview:

Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle. Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.

Guiding Question:

- How can one describe physical interactions between objects and within systems of objects?

Performance Expectations:

MS-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Example Phenomena/Engineering Problem:

- http://sciphile.org/lessons/stacked-ball-drop-lessons-conservation-energy-and-momentum
  Stacked Ball Drop
- https://www.youtube.com/watch?v=7JcJcZWke1c
  Falcon Heavy Rocket Launch
- https://www.youtube.com/watch?v=l5I8jaMsHYk
  Falcon Heavy Rocket Landing
- http://www.teacherstryscience.org/ngsslp/lift-chair-challenge-ngss
  Lift Chair Challenge

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions	[CCC-4] Systems and System Models [CCC-7] Stability and Change	**PS2.A: Forces and Motion** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with	**What Are Newton's Laws?** Through a series of three lessons and one activity, students are introduced to inertia, forces and Newton's three laws of motion. https://www.teachengineering.org/curricularunits/view/ucd_newton_unit **Crashes and Collisions** Students explore what happens when two objects collide. In particular, they examine what happens to each object after the collision. https://betterlesson.com/lesson/640499/crashes-and-collisions **Collisions and Momentum: Bouncing Balls** Students explore momentum, elastic and inelastic collisions by bouncing assorted balls on different surfaces and calculating the momentum for each ball. https://www.teachengineering.org/lessons/view/cub_energy_lesson03 **Force: Collision Safety** Students apply Newton's Third Law to design a solution to a problem involving the motion of colliding objects. http://twobitcircus.org/wp-content/uploads/2017/03/MS-FORCES-Scramble-Car-lesson-plans.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		other people, these choices must also be shared. (MS-PS2-2)	**Balloon Care Course** Through a series of activities, students explore forces and their effects on motion. Students apply concepts of forces and Newton's Laws of Motion to engineering design challenges. http://www.t4t.org/wp-content/uploads/2013/08/8th_Grade_Forces-Motion_Overview.pdf

Topic: Energy **Grade 7**

Overview:

Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball. Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

Guiding Question:

- How can energy be transferred from one object or system to another?

Performance Expectations:

MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=3opTwpiCZ6c
  Where is Chloe Kim Moving Fastest?
- https://www.teachengineering.org/activities/view/wpi_amusement_park_ride
  Amusement Park Ride Design Challenge

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data	[CCC-4] Systems and System Models [CCC-3] Scale, Proportion, and Quantity	**PS3.A: Definitions of Energy** Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2) **PS3.C: Relationship Between Energy and Forces** When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	**Energy of Motion** Through a series of learning activities, students explore energy of motion, the types of energy, and their relationships. https://www.teachengineering.org/curricularunits/view/cub_energy_curricularunit **Energy Forms and States Demonstrations** Students explore forms of energy, energy conversions, and the conservation of energy. https://www.teachengineering.org/activities/view/cla_activity1_forms_states **Amusement of the Future** Students will apply their understanding of energy transfer, including potential and kinetic energy to produce a prototype of an amusement park that includes a variety of rides and attractions. http://www.doe.in.gov/sites/default/files/elme/sixth-grade-lessons-amusement.pdf

The Life Sciences

Topic: From Molecules to Organisms: Structures and Processes	**Grade 7**

Overview:

Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells. Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall. Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems. Emphasis is on tracing movement of matter and flow of energy. Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.

Guiding Questions:

- How do the structures of organisms contribute to life's functions?
- How do organisms obtain and use matter and energy?

Performance Expectations:

MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Example Phenomena/Engineering Problem:

- http://lasp.colorado.edu/home/wp-content/uploads/2011/11/Life_What_is_it_Where_is_it.pdf
  Extremophiles: Are they alive? Challenge students to determine if something is alive.
- https://stardate.org/radio/program/2017-11-24
  Challenge: Propose design criteria for space probe instruments to detect life on another planet.
- https://www.forbes.com/sites/shaenamontanari/2016/09/12/can-anything-live-forever/#4ae2a8d93e7d
  Can Anything Live Forever?
- http://highered.mheducation.com/sites/0072943696/student_view0/chapter20/case_study__hyperthermia.html
  Heat Stroke/Hyperthermia Case Study
- http://www.af.mil/News/Article-Display/Article/1441846/military-working-dog-revived-by-vet-tech/
  Dog Heat Stroke News Story
- https://www.teachengineering.org/activities/view/cub_lifescience_lesson01_activity1
  Engineering Design Challenge: Corn for Fuel?! Students are challenged to design systems for plants to grow most efficiently.
- https://www.youtube.com/watch?v=3UO2A2p-19A
  Snickers commercial (You're not you when you're hungry);
- https://www.scienceworld.ca/resources/activities/reaction-time-ruler
  Reaction Time Challenge. Students test and compare reaction times to various stimuli.

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-3] Planning and	[CCC-2] Cause and Effect [CCC-3] Scale, Proportion,	**LS1.A: Structure and Function** All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1)	**Properties of Life** Students work towards building an understanding of how certain properties and processes define living organisms. https://manoa.hawaii.edu/exploringourfluidearth/biological/what-alive/properties-life

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating and Communicating Information	and Quantity [CCC-4] Systems and System Models [CCC-5] Energy and Matter [CCC-6] Structure and Function	Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2) In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3) **LS1.C: Organization for Matter and Energy Flow in Organisms** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)	**What van Leeuwenhoek Saw** Students explore the discovery of microscopic life and the scale of size. http://www.hhmi.org/biointeractive/what-van-leeuwenhoek-saw http://www.hhmi.org/biointeractive/seeing-the-invisible **From Molecules to Organisms: Structures and Processes** Students conduct online investigations to provide evidence that living things are made of cells and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. https://www.ck12.org/ngss/middle-school-life-sciences/from-molecules-to-organisms:-structures-and-processes **Cell City** Students identify cell organelles' structure and function, compare these to structures found in a town or city, and create and use models to describe the function of a cell as a whole and the way that parts of cells contribute to their functioning. http://thepartnershipineducation.com/pdfs/Powers_of_Minus_Ten_Bone/Cell_City_Lesson_Plan.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		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. (MS-LS1-7) **LS1.D: Information Processing** Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8) **PS3.D: Energy in Chemical Processes and Everyday Life** The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules	**Engineering and the Human Body Unit** Students explore the structures and functions of human body systems. https://www.teachengineering.org/curricularunits/view/cub_human_curricularunit **Yeast Cells Respire, Too (But Not Like Me and You)** Students set up a simple way to indirectly observe and quantify the amount of respiration occurring in yeast-molasses cultures. https://www.teachengineering.org/activities/view/duk_cellresp_mary_act **Population Growth in Yeasts** Students design experiments that determine how environmental factors affect yeast population growth. https://www.teachengineering.org/lessons/view/duk_yeast_mary_less **Why do we get hangry?** Students will evaluate evidence to determine how the digestive and circulatory system are connected through the phenomena of being “hangry”. http://ngss.nsta.org/CommunityResource.aspx?ID=ZMvZb6pFERY_E

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		and release oxygen. (secondary to MS-LS1-6) Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)	**Exploring Energy Transformation in Plants** Students investigate how plants harness and use different sources of energy during germination and growth. https://www.glbrc.org/outreach/educational-materials/exploring-energy-transformation-plants **Detecting Photosynthesis- Analyzing Other Scientists' Data** Students analyze the results of a scientist's experiment by examining leaves that have been exposed to different treatments, and draw conclusions about the process of photosynthesis. http://www.seplessons.org/node/377 **Investigating Photosynthesis: Discovering what plants need for photosynthesis** Students design and conduct simple experiments using elodea and Bromthymol blue to determine whether plants consume or release carbon dioxide in the process of photosynthesis. https://serc.carleton.edu/sp/mnstep/activities/35653.html **Human Body 2.0** Engineering design challenge that in which students explore and analyze the structures and functions of the

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			human body before attempting to redesign a body system. https://betterlesson.com/lesson/632422/human-body-2-0-introducing-the-project **Food for thought: What fuels us? Glucose, the Endocrine System, and Health** By investigating the question "What fuels us?", students integrate bodily and metabolic phenomena on a cellular and systemic level. https://neuron.illinois.edu/units/food-for-thought-what-fuels-us **What changes our minds? (Drugs) Foods, drugs, and the brain** Through a series of investigations, students develop understanding of the nervous system within the context of the effects of various foods and drugs. https://neuron.illinois.edu/units/what-changes-our-minds-drugs **Connect the Neurons!** Students develop and use models the chemical communication neurons. http://brainu.org/lesson/connect-neurons

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Virtual Neurons Students use the Virtual Neurons software to construct neural circuits and visualize how messages travel through the circuits. http://brainu.org/lesson/virtual-neurons **Reaction Time** Students experiment to see which of their senses (sight, sound, or touch) has the fastest response time. Students investigate the response time of each of these senses using interactive simulations. https://authoring.concord.org/activities/1058/single_page/79671f8d-74f9-47ea-b129-a97996613113

Earth and Space Sciences

Topic: Earth's Systems	**Grade 7**

Overview:

Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials. Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate. Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).

Guiding Question:

- How do the materials in and on the Earth's crust change over time?
- How does the movement of tectonic plates impact the surface of the Earth?

Performance Expectations:

MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=fZ_x-Yy7sUY
  Videos of Deep Ocean Hydrothermal Vents
- https://www.youtube.com/watch?v=y6iK19xaYJg
  Black Smokers
- http://volcano.si.axismaps.io/
  Eruptions, Earthquakes, and Emissions

- https://www.youtube.com/user/cscotese/videos
  Paleomap project

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-3] Scale, Proportion, and Quantity [CCC-7] Stability and Change	**ESS1.C: The History of Planet Earth** Tectonic processes continually generate new ocean seafloor at ridges and destroy old seafloor at trenches. (secondary to MS-ESS2-3) **ESS2.A: Earth's Materials and Systems** All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1) The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)	**Rock Cycle Journey** Students explore processes by which rocks are created and destroyed over time through the cycling of Earth's materials. http://ngss.nsta.org/Resource.aspx?ResourceID=51 https://web.archive.org/web/20170104034010/http://www.teachingboxes.org:80/mountainBuilding/lessons/lesson4.jsp **Rock Cycle Investigation** Students will be able to identify the three main rock types, and how they form. https://betterlesson.com/lesson/635343/rock-cycle **Rock Solid** Students explore the factors that affect the strength of rocks. https://www.teachengineering.org/lessons/view/cub_rock_lesson01 **Ride the Rock Cycle – Comic Strip Adventure** Station activity in which students use and develop models to show how rocks are created and destroyed over time through the cycling of Earth's materials.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		ESS2.B: Plate Tectonics and Large-Scale System Interactions Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS-ESS2-3) **ESS2.C: The Roles of Water in Earth's Surface Processes** Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	https://middleschoolscience.com/tag/ms-ess3-1/ **Plate Tectonics Puzzle** Students use logic, data, and evidence to reconstruct the position of large islands and continents as they appeared 220 million years ago. https://www.amnh.org/explore/curriculum-collections/dinosaurs-activities-and-lesson-plans/plate-tectonics-puzzle **Seafloor Features and Mapping the Seafloor** Students simulate sonar mapping of the ocean floor. https://manoa.hawaii.edu/exploringourfluidearth/physical/ocean-floor/seafloor-features **Continental Movement by Plate Tectonics** Students investigate the processes by which the Earth's surface, and continues to, change over time. https://manoa.hawaii.edu/exploringourfluidearth/node/1348 **Sediment Deposition Supports Seafloor Spreading** Students manipulate and graph data collected by the research vessel, JOIDES Resolution, to determine whether sediment thickness located near the Juan de Fuca Ridge supports the concept of seafloor spreading.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			http://joidesresolution.org/activities/seafloor-spreading/ **Relative Age of Rocks** Students work to infer relative ages of rocks and fossils from index fossils and the ordering of the rock layers. https://betterlesson.com/lesson/636295/relative-age-of-rocks

Topic: Earth and Human Activity **Grade 7**

Overview:

Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock). Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Guiding Question:

- How can natural hazards be predicted?

Performance Expectations:

MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes

MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects

Example Phenomena/Engineering Problem:

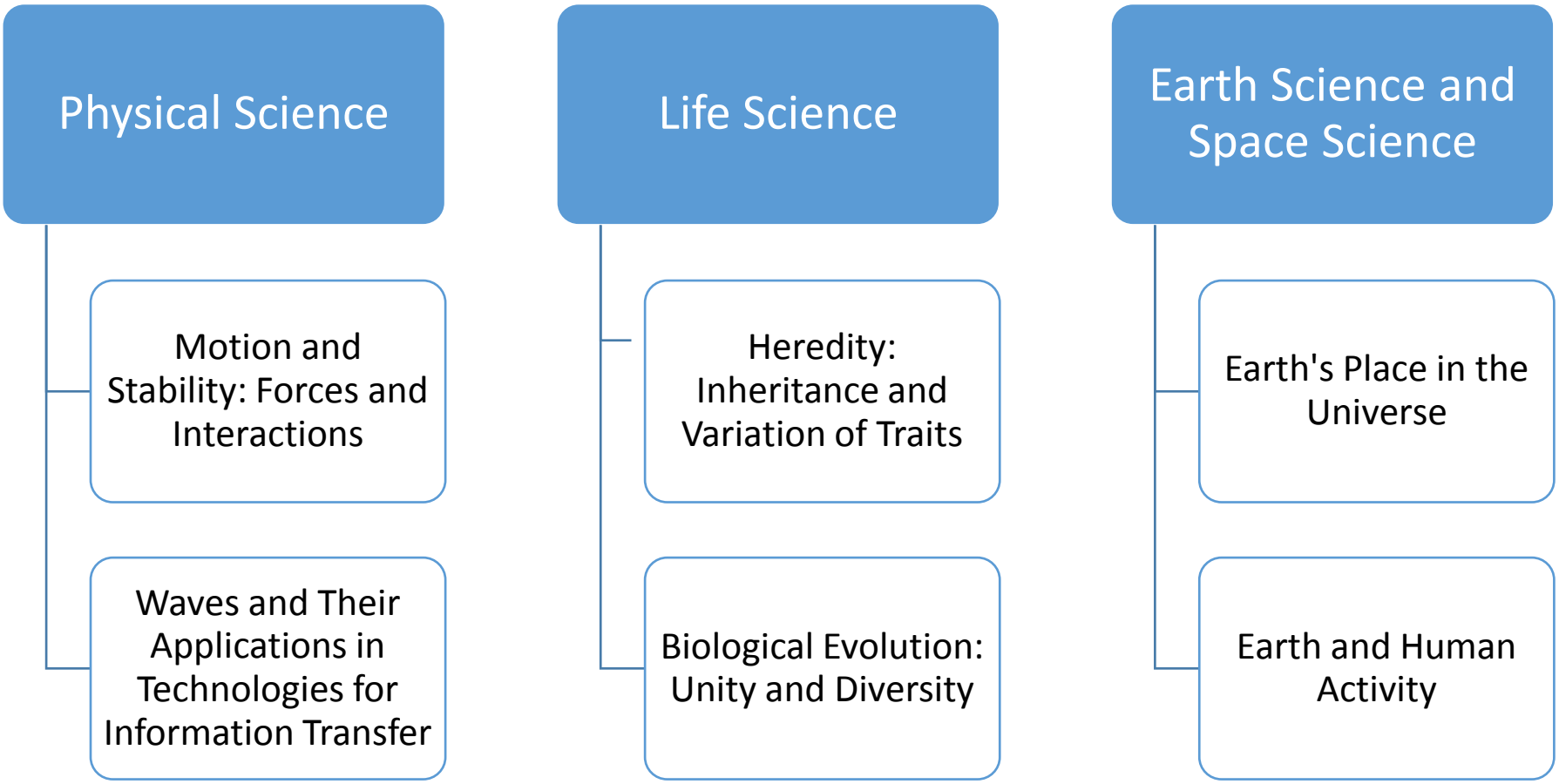
- https://www.eia.gov/analysis/studies/worldshalegas/images/EIA_ARI_World_Shale_Gas_Oil_Basins_Logos_Map_092215_HighRes.jpg
- https://www.eia.gov/maps/
  Where does it come from? Location of the World's Oil and Gas Deposits Found?
- Design Challenge: What's Next?
  Students use existing data to identify natural hazards and natural catastrophes that can impact Guilford. This data is used to design educational programming and information for residents.
- https://maps.ngdc.noaa.gov/viewers/hazards/?layers=0
- https://www.ngdc.noaa.gov/hazard/
  NOAA Natural Hazards Viewers

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-2] Cause and Effect	**ESS3.A: Natural Resources** Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) **ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	**Dig into Mining - The Story of Copper: Patterns of Natural Resources** Students compare a map of worldwide copper distribution sites to a tectonic map detailing active volcano and plate boundary locations. Once their analysis is complete, students will be able to construct an explanation describing the relationship between geologic processes, in this case volcanism, and locations of copper ore. http://www.digintomining.com/sites/digintomining.com/files/content-files/Classroom_Extension_1_FINAL.pdf **Saltwater Intrusion** Students will model how wells function and model and explain what causes saltwater intrusion. They will then design and present a solution for saltwater intrusion. http://watereducationtoday.com/pdf/WET_Lesson_Plan_15_Saltwater_Intrusion.pdf **Where Should We Land This Ship?** Students consider the availability of natural resources and natural hazards as they determine the best location to develop a new society. Students develop and support an explanation for their decision. https://betterlesson.com/lesson/639004/where-should-we-land-this-ship

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Earthquakes Living Lab: Designing for Disaster Students learn about factors that engineers take into consideration when designing buildings for earthquake-prone regions. https://www.teachengineering.org/activities/view/csm_designingfordisaster_activity1 **Real Time Earthquake Mapping Activity** Students explore where earthquakes occur, how they are recorded and measured, the relationship between earthquake location and magnitude, and how earthquakes impact humans and the environment. https://middleschoolscience.com/2016/06/04/real-time-earthquake-data-mapping-activity/ **Natural Disasters: Earthquakes, Volcanoes, Tornadoes & More** Students are introduced to our planet's structure and its dynamic system of natural forces through an examination of the natural hazards of earthquakes, volcanoes, landslides, tsunamis, floods and tornadoes, as well as avalanches, fires, hurricanes and thunderstorms. https://www.teachengineering.org/curricularunits/view/cub_natdis_curricularunit

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Who Moved the Beach? Students will identify coastal erosion as a natural process, analyze and interpret beach elevation data, and make inferences from these data about the relative vulnerability of different beaches to coastal erosion. Students will explain how human activity can increase the risks associated with coastal erosion, identify options for reducing risks caused by coastal erosion, and discuss the advantages and problems associated with these options. https://oceanservice.noaa.gov/education/lessons/who_moved_the_beach.html

Grade 8


Physical Science
Motion and Stability: Forces and Interactions
Waves and Their Applications in Technologies for Information Transfer
Life Science
Heredity: Inheritance and Variation of Traits
Biological Evolution: Unity and Diversity
Earth Science and Space Science
Earth's Place in the Universe
Earth and Human Activity

Physical Science

Topic: Motion and Stability: Forces and Interactions	**Grade 8**

Overview:

Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor. Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system. Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.

Guiding Question:

- How can one describe physical interactions between objects and within systems of objects?

Performance Expectations:

MS-PS2-3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Example Phenomena/Engineering Problem:

- http://www.tsin.org/wp-content/uploads/2014/04/Electromagnetism.pdf
  Electromagnetism Engage Activity
- https://www.youtube.com/watch?v=NqknphAAY5E
  Electromagnet Crane
- https://www.cnn.com/2015/04/21/asia/japan-maglev-train-world-record/index.html
  Maglev train sets world record
- https://www.scientificamerican.com/article/would-you-fall-all-the-wa/
  Would you fall all the way through a theoretical hole in the earth?
- https://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html

- PHET Gravity Simulation (students engage to figure out how gravity works)
- https://www.youtube.com/watch?v=fVsONlc3OUY
- https://www.youtube.com/watch?v=izYiDDt6d8s
  Videos of Aurora Borealis
- https://www.youtube.com/watch?v=PBJAR3-UvSQ
  Aurora Borealis from Space

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-1] Asking Questions and Defining Problems [SEP-3] Planning and Carrying Out Investigations [SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect [CCC-4] Systems and System Models	**PS2.B 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. (MS-PS2-3) 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. (MS-PS2-4)	**Electromagnet Design Challenge: Clean Up This Mess** Students are challenged to design a method for separating steel from aluminum based on magnetic properties as is frequently done in recycling operations. After completion of a series of activities, students design, test and present an effective electromagnet to solve the design challenge. https://www.teachengineering.org/curricularunits/view/van_cleanupmess_unit **Balloons and Static Electricity** Students investigate the actions of charged balloons. They then use the PhET simulation "Balloons and Static Electricity" to make sense of their observations in the light of electric charge, and the simulation "Electric Field Hockey" to apply their understanding of electric charge. https://phet.colorado.edu/en/simulation/balloons-and-static-electricity

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		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, a magnet, or a ball, respectively). (MS-PS2-5)	**Electromagnetism** Students will do an activity to explore the link between electricity and magnetism. They then test variables that they believe may affect the strength of electromagnets. http://www.tsin.org/wp-content/uploads/2014/04/Electromagnetism.pdf **Levitation Engineers** Students experiment with magnets to identify magnetic properties and the differences between contact and non-contact forces. Based on the results of their experiments, students design and build a levitating pencil. http://science4inquiry.com/LP_Levitation.php **Build a Charge Detector** Students investigate the transfer of electric charge and electric force by building and using electroscopes. They use the electroscopes they built to make qualitative observations about the static electric charge between pairs of objects. Students also graph sets of pre-given data, in order to determine the relationship between force and charge, and between force and distance, for pairs of charged objects. https://www.teachengineering.org/activities/view/cub_electricity_lesson02_activity2

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Exploring Gravity Students use an online simulation to explore the relationship between gravitational pull, masses, and distance. Students write one or two claim-evidence-reasoning paragraphs about whether gravity is a force and about what factors affect the strength of gravity. https://phet.colorado.edu/en/simulation/gravity-force-lab **Weight on Other Worlds** Students enter a weight on Earth, and view the equivalent weight on other planets, Pluto, Earth's moon, some of Jupiter's moons, and a few types of stars. The calculator/model is followed by a reading about the difference between mass and weight, and the relationship between gravity, mass, and distance. http://www.exploratorium.edu/ronh/weight/

Topic: Waves and Their Applications in Technologies for Information Transfer **Grade 8**

Overview: Emphasis is on describing waves with both qualitative and quantitative thinking. Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions. Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversion of stored binary patterns to make sound or text on a computer screen.

Guiding Question:

- What are the characteristic properties of waves and how can they be used?

Performance Expectations:

MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

Example Phenomena/Engineering Problem:

- https://www.youtube.com/watch?v=no7ZPPqtZEg
  Standing Waves Generated by String Vibration
- https://www.woodstown.org/cms/lib4/NJ01001783/Centricity/Domain/8/Texts/ACS/resources/ap/ch3/act1.pdf
  Slinky Wave Exploration
- https://www.youtube.com/watch?v=MgRh_Q_xwys
  Video of bat echo-locating and capturing moths
- http://www.bbc.com/news/disability-35550768
  The blind boy who learned to see with sound
- https://scontent-ort2-1.xx.fbcdn.net/v/t1.0-9/22449909_10214294943825842_1753132401852241524_n.jpg?oh=dfb53b566d0d620fa2cef084bb245341&oe=5AF68F6B
  Can a rainbow touch the ground?
- https://technofaq.org/wp-content/uploads/2015/04/fibre-optics.png
- https://www.ispreview.co.uk/index.php/2013/07/alcatel-lucent-breaks-record-with-31tbps-over-a-single-fibre-optic-cable.html
  Fiber Optic Cable Images

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-5] Using Mathematics and Computational Thinking [SEP-8] Obtaining, Evaluating, and Communicating Information	[CCC-1] Patterns [CCC-6] Structure and Function	**PS4.A: Wave Properties** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) A sound wave needs a medium through which it is transmitted. (MS-PS4-2) **PS4.B: Electromagnetic Radiation** When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)	**Waves and Wave Properties** Students understand the types of waves and how they change direction, as well as basic wave properties such as wavelength, frequency, amplitude and speed. https://www.teachengineering.org/lessons/view/clem_waves_lesson02 **Wave Behavior Lab Rotation** Students create mathematical representations of waves. https://betterlesson.com/lesson/633386/wave-behavior-lab-rotation-day-1 **What's the Frequency, Roy G. Biv?** Students explore the concepts of frequency and wavelength, how they relate to each other, and how they correlate with the colors of the visible spectrum. The students will examine these concepts through a hands-on lab that involves measuring and timing "wavelengths" by pulling adding machine tape through a simple, student-made apparatus. This lab is also followed up with critical thinking and performance assessment style questions. https://imagine.gsfc.nasa.gov/educators/lessons/roygbiv/ **Bending Light** Simulation in which students manipulate variables to see and describe that waves are reflected, absorbed, or transmitted as they pass through different materials. The accompanying activity

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2) However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2) **PS4.C: Information Technologies and Instrumentation** Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)	allows students to work through the simulation with structure. Students can create a table or spreadsheet to record data for further analysis. https://phet.colorado.edu/en/simulation/bending-light https://phet.colorado.edu/en/contributions/view/4316 **How are frequency, amplitude, and wavelength related?** In this interactive tutorial, students can explore how frequency, amplitude, and wavelength are related. Students can create 16 different scenarios, make observations, & take notes for each scenario. Students explore the characteristic properties of waves. https://middleschoolscience.com/2015/04/06/how-are-frequency-amplitude-and-wavelength-related/ http://www.classzone.com/books/ml_science_share/vis_sim/wslm05_pg18_graph/wslm05_pg18_graph.html **Riding the Radio Waves** Students learn how AM radios work, the difference between transverse and longitudinal waves, and about the amplitude and frequency of waveforms. Students learn about magnetic fields and how radio waves are created and transmitted. This prepares students to be able to comprehend the functioning of the AM radios they will build during the associated activity. https://www.teachengineering.org/lessons/view/duk_amradio_tech_less

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Seismic Waves: How Earthquakes Move the Earth Students learn about the types of seismic waves produced by earthquakes and how they move the Earth. Students learn how engineers build shake tables that simulate the ground motions of the Earth caused by seismic waves in order to test the seismic performance of buildings. https://www.teachengineering.org/lessons/view/cub_seismicw_lesson01 **Discovery of Sound in the Sea** Various learning activities and resources for students to explore the science of sound, how marine animals use sound, and the effects of human-generated sound in oceans. https://dosits.org/resources/ **Analog World, Digital World: Encoding and Transmitting Information** Over the course of this lesson set students will argue the merits and limitations of various devices that operate with digital and analog signals. The unit includes a performance task that allows students to demonstrate what they have learned. Students will analyze, reproduce, encode, and transmit analog information to learn that digital signals use a 0/1/off /on code format. They will also compare analog and digital devices performing various tasks and graph and interpolate digital sound wave data. https://capecodstemnetwork.org/uploads/resources/AnalogWorldDigitalWorld.pdf

Topic: Earth and Human Activity **Grade 8**

Overview:

Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land). Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes. Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.

Guiding Questions:

- How do human activities affect Earth systems?

Performance Expectations:

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Example Phenomena/Engineering Problem:

- https://www.teachengineering.org/activities/view/cub_enveng_lesson07_activity1
  I Breathe WHAT?
- https://vimeo.com/130468614
  World Population Video
- https://www.youtube.com/watch?v=8auMIfF50Ng
  Weekly Arctic Sea Ice Age Between 1984 and 2016

- https://climate.nasa.gov/interactives/global-ice-viewer/#/3/7
  Arctic Sea Ice Trend Since 1979

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-1] Asking Questions and Defining Problems [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect [CCC-7] Stability and Change	**ESS3.C: Human Impacts on Earth Systems** Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on	**I Breathe What?** Students place "pollution detectors" at various locations near their school. Capture and examine the air particles they collect to get an idea how much dust, pollen, and other particulate matter is present in the air around them. Students share their data, create a map with details of their findings, and hypothesize as to why some locations have more particles than others. They explore why engineers count particulate matter when observing air quality. https://www.teachengineering.org/activities/view/cub_enveng_lesson07_activity1 **Cleaning the Air** Students use the engineering process to create a model indoor air filter and then count and calculate the average number of particles collected. After they have tested their design, they make a sales pitch presentation to their classmates, highlighting the effectiveness of their design. https://www.teachengineering.org/activities/view/cub_enveng_lesson07_activity2 **Pollution Lab Stations** Students investigate the advantages, limitations, and consequences of new technologies as they utilize a water treatment and desalination process to purify water.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3), (MS-ESS3-4) (MS-ESS3-5) **ESS3.D: Global Climate Change** Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other	https://betterlesson.com/lesson/638336/pollution-lab-stations?from=cc_lesson_title **Water Conservation** Students study the availability of fresh water on Earth and the methods that can be used to purify and conserve it. They also assess how much water they and their families typically use and think about ways to reduce water usage. https://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.lp_waterconservation/water-conservation/#.WttUQS7wbIU **Citizen Science** Student explore a form of open collaboration in which members of the public participate in the scientific process to address real-world problems. Volunteers can work with scientists to identify research questions, collect and analyze data, interpret results, make new discoveries, develop technologies and applications, as well as solve complex problems. https://www.citizenscience.gov/ https://ccsinventory.wilsoncenter.org/ **Your Family's Carbon Footprint** Students investigate how much greenhouse gas (carbon dioxide and methane) their family releases into the atmosphere each year and relate it to climate change. They use the EPA Personal Emissions Calculator to estimate the greenhouse gases emitted by each student's family. Students

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	use the calculator to examine potential ways to reduce greenhouse emissions, calculate the average emissions, and explore ways to reduce emissions. Finally, they are asked to create a brochure to inform others about greenhouse emissions and answer reflection questions. https://www.purdue.edu/discoverypark/climate/climate-change/toolkit-fossil-fuels.php **Energy Enigma** This activity is a learning game in which student teams are each assigned a different energy source. Working cooperatively, students use their reading, brainstorming, and organizational skills to hide the identity of their team's energy source while trying to guess which energy sources the other teams represent. http://www.need.org/files/curriculum/guides/Energy%20Enigma.pdf **Water Conservation with the Water Footprint Calculator** A collection of resources and tools for students to explore water use in agriculture, energy production, the home, and all the products we use in our lives. Students can use the information to design solutions to reduce water use and can construct arguments about various solutions to minimize the impacts of water use. https://www.watercalculator.org/education/teaching-conservation-with-water-footprint-calculator/ **Conserve Water** Students explore different uses of water, discuss how clean water is supplied to our homes, record an inventory of home water use, compare

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			amounts of water used in different activities, discuss consequences of overusing or wasting water, compare the consequences of overusing water from wells and from utility services, and discuss a local issue relating to water supply. At the end of this lesson, students can design or propose solutions to conserve water at school and in the community. http://www.longwood.edu/cleanva/images/Sec4.conservewaterlesson.pdf **Water, Water, Anywhere** Students experience the effects of water abundance, water scarcity, and economic scarcity. https://thewaterproject.org/resources/lesson-plans/water-water-anywhere **Plastic, Plastic Everywhere!** This lesson expands the concept of marine debris, especially as it relates to plastic bags. Students are asked to do a research project measuring the number of plastic bags they use at home and school and create a communications piece that educates others on plastics contribution to marine debris. https://nmsflowergarden.blob.core.windows.net/flowergarden-prod/media/archive/document_library/eddocs/plasticbaglesson.pdf **How Much Space do we Need?** Students investigate their consumption of natural resources water, energy, food and oxygen and calculate the consumption per capita. Based on the calculations the students will answer questions such as, "As our population increases, does the amount of space each individual need change?" https://populationeducation.org/resource/how-much-space-do-we-need/

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Watch Your Step Students examine evidence of how per-capita consumption of natural resources in the United States compares to Argentina, China, Italy, and South Africa. Students calculate their own ecological footprint as a measure of the impact of their lifestyle on Earth's resources, developing awareness of the carrying capacity of the Earth. Students then measure the ecological footprint of students from other countries, answer questions about the impact of humans on Earth, and discuss the impact of the American lifestyle on the environment and economy and sustainability issues in their community. https://populationeducation.org/sites/default/files/watch_your_step.pdf **Gravity and Climate Experiment (GRACE)** Students explore real data to see for themselves how Earth's water is changing. https://www.amnh.org/explore/curriculum-collections/grace **Next Generation Climate** Students investigate causes of global temperature change, research the major repercussions of climate change, and find out how they can monitor and minimize those repercussions. https://www.climategen.org/take-action/teach-climate-change/curriculum/next-generation-climate-for-grades-6-8/ **Energy Choices Board Game**

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			This board game, designed for middle school students, introduces the concepts of energy use in our lives and the real impact that personal choices can have on our energy consumption, energy bills, and fuel supply. http://internal.clarkson.edu/highschool/k12/project/energychoicesgame.html **Great Energy Debate** This is a debate-style learning activity in which student teams learn about energy sources and are then assigned to represent the different energy sources. Working cooperatively, students develop arguments on the pros and cons of their source over the others. http://www.need.org//Files/curriculum/guides/GreatEnergyDebate.pdf **Are You an Energy Efficient Consumer?** Students examine how different countries and regions around the world use energy over time, as reflected in night light levels. They then track their own energy use, identify ways to reduce their individual energy consumption, and explore how community choices impact the carbon footprint. https://koshland-science-museum.org/explore/lights-night-webquest **Clearing the Air** In this activity, students learn about the scientific evidence supporting climate change, use this information to evaluate and improve conclusions some people might draw about climate change, and participate in a role-play to negotiate solutions to climate change.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			http://sfrc.ufl.edu/extension/ee/climate/section1/activity2/ **Climate Change and the 2017 Hurricane Season** Students examine the hyperactivity of the 2017 Atlantic hurricane season and explore how changes in the Earth's climate affect the severity of storms. After exploring the hurricane season and climate, students can construct a response to the question, "What might extreme storms during a hurricane season tell scientists about the role of climate change?". http://www.pbs.org/newshour/extra/lessons-plans/lesson-plan-climate-change-and-the-2017-hurricane-season/ **Degree of Impact cards** Students compare resource use in the United States and worldwide and construct explanations for differences in resource use and human impact in different countries. https://populationeducation.org/resource/degree-of-impact-cards/ **Eyewitness to Change** Students explore recent changes in the Arctic's climate that have been observed and documented by indigenous Arctic residents and examine historical weather data for an Arctic community. Students generate questions about the causes of changes in arctic climate. http://forces.si.edu/arctic/pdf/ACT%201_EYEWITNESS.pdf **Polar Climate Change Lesson Plans** Students explore and understand climate change with particular attention to the impact of climate change on the polar regions. Topics include the

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			role of the polar regions in the global climate system, the impact of changing temperatures on ecosystems, and the effect of increased CO_2 on food webs. https://www.amnh.org/explore/curriculum-collections/polar-climate-change-lesson-plans **The Dynamics of Climate** Students explore fossil fuels, the carbon cycle, carbon dioxide emissions, and the environmental impact of the use of fossil fuels. Students will analyze the data and evidence used to assess changes in climate, and construct evidence-based arguments about the causes and effects of change. https://www.purdue.edu/discoverypark/climate/climate-change/toolkit-fossil-fuels.php

Life Science

Topic: Heredity: Inheritance and Variation of Traits	**Grade 8**
Overview: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.	
Guiding Question: • How does genetic variation among organisms in a species affect survival and reproduction?	
Performance Expectations: MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.	

Example Phenomena/Engineering Problem:

- https://www.cnn.com/2015/03/03/living/feat-black-white-twins/index.html
  UK twins turn heads: One is white, the other black
- http://www.pbs.org/wgbh/nova/evolution/does-race-exist.html
  Human Skin Tone

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models	[CCC-2] Cause and Effect	**LS1.B: Growth and Development of Organisms** Organisms reproduce, either sexually or asexually, and transfer their genetic	**Tour of the Basics** Students construct an explanation about why genes influence proteins and affect the structure and function of an organism. http://learn.genetics.utah.edu/content/basics/

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
	[CCC-6] Structure and Function	information to their offspring. (MS-LS3-2) **LS3.A: Inheritance of Traits** Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes	**A Recipe for Traits** Students create and decode a "DNA recipe" for dogs to observe how variations in DNA lead to the inheritance of different traits. Strips of paper (representing DNA) are randomly selected and used to assemble a DNA molecule. Students read the DNA recipe to create a drawing of their pet, and compare it with others in the class to note similarities and differences. http://teach.genetics.utah.edu/content/heredity/#item8 **Genetic Mutation** Through a series of activities, students will explore how genes determine phenotype through a variety of proteins with different functions, that the pattern of base pairs in a gene determines the structure of the protein which the gene codes for, and the causes of genetic mutations. https://earthref.org/SCC/lessons/2013/geneticmutation/ **DNA – Paper Protein Chains Activity** Students will convert their name into a DNA sequence and create a protein chain. Students will be able to use a model of the paper chain as a representation of the process by which DNA sequences code for different proteins. https://middleschoolscience.com/2015/11/25/dna-paper-protein-chains-activity/ **Stalking the Genetic Basis of a Trait**

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		(and therefore genes) inherited. (MS-LS3-2) **LS3.B: Variation of Traits** In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2) In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful,	Students analyze data on the expression of the tb1 gene and use it to formulate an explanation as to how a specific difference in the corn version of the gene explains the phenotype of less branching. http://www.hhmi.org/biointeractive/stalking-genetic-basis-trait **Biology of Skin Color** Students explore the evidence that the different shades of skin color among human populations arose as adaptations to the intensity of ultraviolet radiation in different parts of the world, and how changes in genes over time in response to environmental conditions have impacted human skin color. http://www.hhmi.org/biointeractive/the-biology-of-skin-color **Molecular Genetics of Color Mutations in Rock Pocket Mice** Students transcribe and translate portions of the wild-type and mutant rock pocket mouse *Mc1r* genes and compare sequences to identify the locations and types of mutations responsible for the coat color variation described in the film. http://www.hhmi.org/biointeractive/molecular-genetics-color-mutations-rock-pocket-mice **Developing an Explanation for Mouse Fur Color** Students collect and analyze evidence for each of the major conditions for evolution by natural selection to develop an explanation for how populations change over time. http://www.hhmi.org/biointeractive/developing-explanation-mouse-fur-color

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		and some neutral to the organism. (MS-LS3-1)	**Simulate Natural Selection** Students model how variation in a phenotypic trait affects a prey population over time, and how a variation in the phenotypic traits of a predator affects predation efficiency. https://manoa.hawaii.edu/exploringourfluidearth/biological/what-alive/evolution-natural-selection/activity-simulate-natural-selection https://cptv.pbslearningmedia.org/resource/tdc02.sci.life.repro.lp_reproduce/reproduction/#.Wtt3Iy7wbIU **Investigating Reproductive Strategies** Students work in pairs to compare five aspects of an organism that reproduces sexually, asexually, or both sexually and asexually. Students share their comparisons and generate a list of general characteristics for each mode of reproduction and then discuss the advantages and disadvantages of both. http://learn.genetics.utah.edu/content/basics/reproduction/ http://teach.genetics.utah.edu/content/evolution/files/ReproductiveStrategies.pdf **Color Vision Genetics Evolution Simulation** Students simulate how genes on chromosomes are passed from generation to generation while exploring color vision and its genetic history in humans and other primates. Students will understand the sex-linked trait of color vision and how it affects males and females in different proportions. The lesson introduces selective pressures, in the form of attributes of the physical environment that will

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			selectively kill off certain members of the population that are then replaced by the surviving offspring, and gradually change the gene pool. https://www.calacademy.org/educators/lesson-plans/color-vision-genetics **Dragon Genetics – Understanding Inheritance** Students simulate the processes of meiosis and fertilization as they investigate the inheritance of multiple genes. The simulation also allows the student to see the cause and effect relationship of gene transmission from parents to offspring and resulting genetic variation. Students use their understanding of dominant and recessive alleles, incomplete dominance, and sex-linked inheritance to interpret the results of the simulation. http://serendip.brynmawr.edu/exchange/waldron/dragongenetics2 **Genetics of Sesame Street Characters** Students use Sesame Street Characters to create a gene map for a particular Sesame Street character, move the resulting chromosomes through the steps of meiosis to produce the possible gametes of that individual character, choose a spouse and diagram the genetic crosses that would produce two different children, by using Punnett Squares, and draw family portraits based on the genotypes of each individual, both offspring and parents. http://www.nclark.net/Genetics_of_Sesame_Street.pdf https://www.anderson5.net/cms/lib02/SC01001931/Centricity/Domain/1863/SesameStreetGenetics.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			https://www.lcps.org/cms/lib4/VA01000195/Centricity/Domain/3604/project_explanation%20sesame%20street%20GenEng%20Version.pdf **Pasta Genetics** In this hands-on activity, students investigate the phenomenon of human inheritance. They seek to explain why each person, except for identical twins, is unique in their appearance. This activity demonstrates that traits are passed down from parent to offspring, an equal number of traits are passed on from each parent, and children don't look exactly like their brothers and sisters because they each receive different combination of genes. https://gsoutreach.gs.washington.edu/files/pastagenetics_12-10-10.pdf **Asexual Reproduction** Students explore how asexual reproduction results in offspring with identical genetic information and construct an explanation to show the characteristics and results of asexual reproduction. https://betterlesson.com/lesson/633954/asexual-reproduction **Sexual Heredity vs Asexual Heredity** Students compare sexual reproduction and asexual reproduction, and how each type of reproduction leads to offspring that are either genetically identical or genetically similar to the parent organisms. https://geneed.nlm.nih.gov/topic_subtopic.php?tid=5&sid=10

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Xs and Os: The Tic-Tac-Toe of Sex Determination A jigsaw format activity to explore the sex determination mechanisms of seven organisms. http://www.hhmi.org/biointeractive/xs-and-os-tic-tac-toe-sex-determination **Stem Cells** Students understand the nature of stem cells, and why and how cells differentiate. http://learn.genetics.utah.edu/content/stemcells/

Topic: Biological Evolution: Unity and Diversity **Grade 8**

Overview: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers. Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures. Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures. Emphasis is on using simple probability statements and proportional reasoning to construct explanations. Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries. Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

Guiding Questions:

- How does the environment influence genetic traits in populations over multiple generations?

Performance Expectations:

MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Example Phenomena/Engineering Problem:

- http://humanorigins.si.edu/
  What does it mean to be human? (Smithsonian Exhibition)

- https://www.plt.org/educator-tips/camouflage-nature-examples
  Thirty-two examples of camouflage in nature
- https://www.youtube.com/watch?v=UftzbFan9hw
  Video challenge-finding camouflaged animals
- https://imgur.com/z1kteVL
  Normal and Genetically Modified Cow photos
- https://www.washingtonpost.com/news/wonk/wp/2016/05/18/fruits-and-vegetables-used-to-look-so-different-you-might-not-even-recognize-them/?utm_term=.ad934c88912b
  Fruits and Vegetables Look Different Than They Used To Video
- https://www.youtube.com/watch?v=gUtDyqcnRS0
  Octopus Changes Color and texture video

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-4] Analyzing and Interpreting Data [SEP-5] Using Mathematics and Computational Thinking [SEP-6]	[CCC-1] Patterns [CCC-2] Cause and Effect	**LS4.A: Evidence of Common Ancestry and Diversity** The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)	**Deep Thinking Over Geologic Time** Students investigate the role of fossils and rock layers in determining the Earth's age and geologic history and use the concept of index fossils in their analysis of a simple geologic timeline. http://static.nsta.org/files/ss1704_30.pdf **Patterns in Time: Staggered Origins of Vertebrate Fossils in Familiar Time** Students explore geologic time, sequence of events, and changes in the vertebrate fossil record to understand that fossil records show a pattern of increasing diversity and large-scale gradual changes through time. http://www.indiana.edu/~ensiweb/lessons/pat.in.time.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Constructing Explanations and Designing Solutions [SEP-8] Obtaining, Evaluating, and Communicating Information		Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2) Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3) **LS4.B: Natural Selection** Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4) In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are	**Sequencing of rocks: what was the order of events?** Students describe weathering and erosion that lead to the breakdown of rocks into smaller and smaller pieces and can, over many years and under suitable conditions, form sedimentary rocks. http://www.rsc.org/education/teachers/resources/jesei/sequenc/students.htm **A Guide to Developing Literacy Practices in Science: Supporting Claims with Evidence by Using an Argumentation Card Sort: Fossils** Students evaluate evidence for two different claims related to a fossil tooth. They are asked to answer the question, "From what kind of animal did this fossil tooth come?" Students can choose between the claim that the fossil tooth is from a prehistoric lion or that is it from a prehistoric shark. http://scienceandliteracy.org/sites/scienceandliteracy.org/files/presentation/MS_SG-Supporting_Claims_with_Evidence-Fossils.pdf **Stickleback Evolution Virtual Lab** Students virtually analyze the pelvic structures of the threespine stickleback fish, using photographs of living fish and fossil specimens. Students complete three experiments, each focusing on changes to the pelvic girdle and pelvic spines of freshwater stickleback populations. Students explore the

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		then passed on to offspring. (MS-LS4-5) **LS4.C: Adaptation** Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)	connections between the development of the pelvic asymmetry and genetics. The lab emphasizes quantitative measurement of phenotypic diversity in related stickleback populations and encourages inquiry into the role of natural selection and underlying genetic mechanisms. http://www.hhmi.org/biointeractive/stickleback-evolution-virtual-lab http://www.hhmi.org/biointeractive/making-fittest-evolving-switches-evolving-bodies **The Making of the Fittest: Natural Selection and Adaptation** A collection of resources, including activities, interactives, and videos to help students understand the mechanisms for natural selection and adaptation. http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation **Color Variation Over Time in Rock Pocket Mouse Populations** Students analyze illustrations of rock pocket mouse populations (dark/light fur) on different color substrates in the Sonoran Desert (light/dark) over time. Students use this evidence to explain the change in the rock pocket mouse populations on the lava flow over time. http://www.hhmi.org/biointeractive/color-variation-over-time-rock-pocket-mouse-populations%20

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Variation, Selection, and Time Students research how naturally occurring genetic differences in individuals can become an advantage or a fatal flaw in the struggle for survival. Those who live to reproduce pass their favorable genes to future generations. Certain characteristics become more or less prevalent over time as the group as a whole evolves. http://learn.genetics.utah.edu/content/selection/ **Pepper Moths** Students explore the case of natural selection in Pepper Moths as a result of changes in environmental conditions in England. http://peppermoths.weebly.com/ **The Biology of Skin Color** A collection of resources, including activities, interactives, and videos to help students understand the mechanisms for natural selection, adaptation, and changes in and diversity of human skin color. http://www.hhmi.org/biointeractive/the-biology-of-skin-color **HHMI Data Point: Effects of Natural Selection on Finch Beak Size** Effects of Natural Selection on Finch Beak Size is one of a series of Data Point resources from HHMI Biointeractive. Data Points engage students in analyzing and interpreting data from primary literature and authentic phenomena in the biological

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			sciences. Students analyze the effects of a drought on the distribution of beak sizes in a population of ground finches in the Galapagos Islands and are asked to explain why the population surviving the drought exhibited a larger mean beak size, and to predict how this would be reflected in offspring. http://www.hhmi.org/biointeractive/effects-of-natural-selection-on-finch-beak-size **Color Vision Genetics Evolution Simulation** Students participate in a natural selection simulation, flipping pennies to mimic the probability of passing on certain traits. The traits are the three genes for color-vision, found on the X chromosome. In the simulation, students will simulate six generations of primates, and track how the gene pool changes over time. The activity loosely mimics some of the mechanisms that led to the evolution of our own improved color vision. https://www.calacademy.org/educators/lesson-plans/color-vision-genetics **Natural Selection** This interactive simulation allows students to explore natural selection in bunnies by controlling factors in the environment (equator or arctic environment), selection factors (wolves, food), and characteristics of the bunnies (fur color, tail length and teeth length). https://phet.colorado.edu/en/simulation/legacy/natural-selection

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			*Note: This is a JAVA-based simulation **Look Who's Coming to Dinner: Selection by Predation** This activity is written in a case-study format, in which students are asked to formulate a hypothesis and analyze a set of sample research data from actual field experiments designed to test a hypothesis about the role of predation as an agent of natural selection. This HHMI Biointeractive activity supplements the film, *The Origin of Species: Lizards in an Evolutionary Tree*, which is based on real measurements from a year-long field study on lizard predation. http://www.hhmi.org/biointeractive/look-whos-coming-dinner-selection-predation **Genetic Engineering & Genetically Modified Organisms: Forming Informed Opinions** The students become familiar with the science behind selective breeding, biotechnology, genetic engineering, and GMOs. They will be able to identify the potential benefits and risks of genetic engineering and bias around this topic. https://www.uaf.edu/case/lessons-1/GMOs.pdf **Cloning** Using the Genetic Science Learning Center at the University of Utah, students explore informational sections and interactive simulations to learn the basics of the cloning process, the reason why humans clone, the history, and myths of cloning.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			http://learn.genetics.utah.edu/content/cloning/ **Catch Up on Tomato Technology** The purpose of this lesson is for students to see how technological advances have benefited a particular commodity. This lesson is a tool to demonstrate how various technological advances have changed the tomato and the tomato industry over the years. The technology includes both selective breeding and genetic engineering. http://archives.lessoncorner.com/e9f8ef1e4c901b193.pdf **Biomimicry: The "Natural" Intersection of Biology and Engineering** The article describes an engineering project that is a culminating event in a unit on biodiversity and adaptation. Students apply what they have learned about how adaptations give organisms a competitive advantage in survival to design products for humans that are inspired by nature's adaptations. Students are asked to design their own 2 or 3 dimensional "biomimetic" products http://static.nsta.org/files/ss1507_18.pdf

Earth and Space Science

Topic: Earth's Place in the Universe	**Grade 8**

Overview:

Examples of models can be physical, graphical, or conceptual. Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models. Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

Guiding Questions:

- What is the Earth's place in the Universe?
- What makes up our solar system and how can the motion of the Earth explain seasons and eclipses?
- How do people figure out that Earth and life on Earth have changed over time?

Performance Expectations:

MS-ESS1-1 Develop and use model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.

MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

Example Phenomena/Engineering Problem:

- https://www.ngssphenomena.com/new-gallery-1/22fiatbxrcwxps0p73sib25ji0fy93

Moon Phase Time Lapse Images

- https://www.youtube.com/watch?v=yQnpWyXMyL8
  Time Lapse of the Highest Ocean Tides
- https://www.youtube.com/watch?v=tp6UkqIwVfk&t=2s
  North Star (STAR TRAILS) Time-lapse
- https://www.jpl.nasa.gov/spaceimages/images/largesize/PIA14098_hires.jpg
- https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA14098
  Galaxy Image Collection
- https://www.youtube.com/watch?v=17jymDn0W6U&t=31s
  The Known Universe (by AMNH)
- http://scaleofuniverse.com/
  The Scale of the Universe
- https://www.youtube.com/watch?v=i93Z7zljQ7I
  Universe Size Comparison
- https://astrosociety.org/edu/family/materials/toiletpaper.pdf
  Toilet Paper Solar System
- https://www.amnh.org/explore/curriculum-collections/dinosaurs-activities-and-lesson-plans/solve-a-sedimentary-layers-puzzle/
  Solve a Sedimentary Layers Puzzle
- https://www.earthsciweek.org/classroom-activities/its-about-time
  It's About Time

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-3] Scale, Proportion, and Quantity [CCC-4] Systems and System Models	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1) Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2) **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2) (MS-ESS1-3) This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that	**The Reasons for the Seasons** Students use polystyrene foam balls and light bulbs to investigate the sun's intensity on the surface of the Earth. After completing this activity, students will be able to explain the relationship between the Sun and Earth, describe how the tilt and position of the Earth affects the seasons, and explain differences in direct and indirect sunlight. **https://www.nationalgeographic.org/activity/the-reason-for-the-seasons/** **Daylight Hours Explorer** In the Daylight Hours Explorer Interactive, students manipulate the latitude and date to find out the number of daylight hours. Students explore the relationships between latitude, date, and daylight hours. From this information, students can be asked to construct explanations. **http://astro.unl.edu/classaction/animations/coordsmotion/daylighthoursexplorer.html** **Lunar Phases** In this simulation, students use an interactive model to investigate the cyclic patterns of lunar phases. Lunar Phases is an interactive simulation consisting of three scaffolding activities. After completing these activities, students will be able to construct a working model and an explanation phases of the moon as it orbits the Earth.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1) The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2) **ESS1.C: The History of Planet Earth** The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4)	**http://aspire.cosmic-ray.org/Labs/LunarPhases/lunar_phases_main.html** **Phases** In this kinesthetic activity students will use objects to model the Earth, Sun, and Moon system to discover why moon phases occur. Students will explore these relationships and will be able to construct explanations of moon phases. **https://www.calacademy.org/educators/lesson-plans/kinesthetic-astronomy-moon-phases** **Exploring Lunar and Solar Eclipses via a 3-D Modeling Design Task** *Exploring Lunar and Solar Eclipses via a 3-D Modeling Design Task i*s a detailed lesson plan published in the October 2016 issue of NSTA's Science Scope journal. The article outlines a classroom activity in which students investigate solar and lunar eclipses by developing a model using simple, inexpensive materials to provide students with an opportunity to construct models of eclipses using prior knowledge of solar system scale and observable patterns of the Sun-Earth-Moon. **http://multiverse.ssl.berkeley.edu/Portals/0/Documents/Eclipse2017/Science%20Scope%20-%20Oct2016%20-%20Exploring%20Lunar%20and%20Solar%20Eclipses%20via%20a%203-D%20Modeling%20Design%20Task%20by%20Miranda,%20Kruse%20and%20Hermann.pdf?ver=2017-04-13-165029-633**

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			NASA Eclipse Web Site The NASA Eclipse Web Site contains multiple pages of data which students can explore, analyze and use to explain phenomena. The site contains data on solar and lunar eclipses and on the transits of Venus and Mars. On the solar eclipse page, students can access dates and details for 5,000 years of eclipses. **https://eclipse.gsfc.nasa.gov/eclipse.html** **The Great Gravity Escape** *The Great Gravity Escape* is an outdoor based, kinesthetic activity designed to illustrate the role of gravity and velocity in orbital interactions by calculating the escape velocity for a water balloon "spacecraft" orbiting a student. The activity utilizes a twine/clothespin apparatus to represent the force of gravity while spinning motions represent velocity. **https://www.teachengineering.org/activities/view/cub_mars_lesson04_activity1** **Gravity and Orbits** Gravity and Orbits allows students the opportunity to investigate the role of gravity on orbital paths within our solar system. Students are active participants in the simulation since they can manipulate two variables in each cartoon scenario: the size of the objects and the distance between them. Students are not developing their own model; rather, they are using pre-designed scenarios to investigate the Disciplinary Core Idea.

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			https://phet.colorado.edu/en/simulation/gravity-and-orbits **The Pull of the Planets** The Pull of the Planets is part of a thematic series of lessons highlighting the Juno mission to Jupiter. It is a traditional hands-on activity that provides qualitative information on the role of gravity in our Solar System and models how gravitational forces can keep planets and asteroids in orbit within the Solar System. Students explore and model how mass and size affect the strength of gravitational forces. **https://www.lpi.usra.edu/education/explore/solar_system/activities/bigKid/planetPull/** **My Solar System** *My Solar System* is an orbital simulator which students use to investigate how mass, position and velocity affect gravitational forces. students use, but do not develop, a model to explain the role of complex phenomena, in this case, the role of gravitational forces. Students can either select from ten preset scenarios or they can create their own scenarios by selecting and dragging symbols into position. Note: students can either run the simulation from the webpage or can download the file. Java is required. Additional Teacher Resources are available if users register for a free account. **https://phet.colorado.edu/en/simulation/legacy/my-solar-system**

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Solar System Scale and Size *Solar System Scale and Size* is a two-part activity that explores relative distances and sizes of objects in our Solar System using the 5E Instructional Model. **http://marsed.asu.edu/solar-system-scale-and-size** **Size and Scale of the Universe** In this hands-on activity, students learn about the different realms of the Universe and explore their sizes and relative scales. They will be guided through a process that uncovers the immense sizes of the Sun, Solar System, Solar Neighborhood, Milky Way, Local Group, Supercluster, and the observable Universe. **http://nasawavelength.org/resource/nw-000-000-003-549** **http://wise.ssl.berkeley.edu/documents/scalerealmsuniverse.pdf** **The Scale of the Universe** These interactive programs allow students to zoom to different size and distance scales within the universe. After manipulating the sizes, students can construct explanations about the relative and/or quantitative size and distance scale differences. **http://scaleofuniverse.com/** **https://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/**

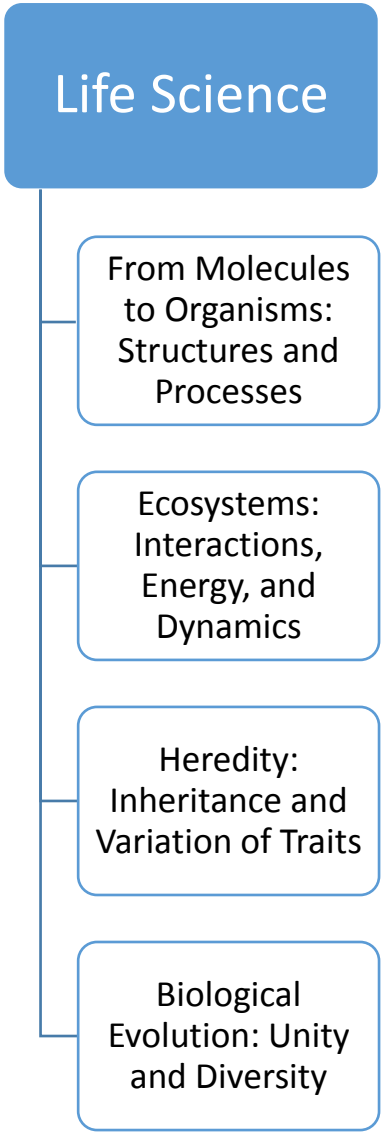
Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Scale Models of the Solar System This lesson allows students to visualize the comparative sizes and distances of solar system bodies by making solar system objects to scale using common objects, walking off the distances between planets and participating in a Web-based Sun/Earth scale model activity. In this lesson, students will demonstrate the size of the sun and the bodies of the solar system on the ten-billionth scale, construct and walk the distances between the bodies of the solar system on the ten-billionth scale, and compare the temperature, diameter and distance to the sun with familiar things on Earth. **https://www.nasa.gov/offices/education/programs/national/summer/education_resources/earthspacescience_grades7-9/ESS_ss-scale-models.html** **Toilet Paper Solar System** This activity provides students with the opportunity to investigate the relative sizes of planetary orbits within our Solar System. *Toilet Paper Solar System* is a kinesthetic group activity in which students create a scalar model of distances in the solar system using toilet paper. This activity can be conducted in either a long hallway or outdoors. To bring this activity more in line with NGSS practices, teachers could substitute actual distances and challenge students to design their own scale. **https://astrosociety.org/edu/family/materials/toiletpaper.pdf**

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Solve a Sedimentary Layers Puzzle Students identify how scientists use the structure of sedimentary rock layers to study fossils and use clues within layers to reconstruct layering sequence, and use fossil clues to explore the changing plant and animal groups throughout Earth's history. **https://www.amnh.org/explore/curriculum-collections/dinosaurs-activities-and-lesson-plans/solve-a-sedimentary-layers-puzzle/** **Who's on First? A Relative Dating Activity** This exercise introduces students to the concepts of sequencing and using fossils to establish relative dates for rock strata. In the first part of the activity, students are asked to sequence cards by identifying and ordering overlapping letters found on the cards. In the second part of the activity, students date rock layers by sequencing fossils found in different strata. Using the results of these activities, students can construct explanations of the Law of Superposition and the identification and value of index fossils. **http://www.ucmp.berkeley.edu/fosrec/BarBar.html** **Geologic Timeline** Students will build a timeline using both a physical and/or digital medium to understand that geologic time encompasses all the time that has passed since the formation of Earth. The timeline

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			will include and describe the continuous order of events and environmental interactions that have shaped the planet. https://www.k12northstar.org/cms/lib/AK01901510/Centricity/domain/1090/lesson%20plans/secondary/Geologic%20Timeline.pdf **Deep Thinking Over Geologic Time** A seven-part unit consisting of hands on activities and graphical analysis designed to investigate the role of fossils and rock layers in determining the Earth's age and geologic history. Students investigate relative dating, the Laws of Superposition and Original Horizontality, analyze a Stratigraphic Succession Map, develop a relative biological timeline of Earth's history, create a 4.6 billion-year biological timeline and investigating connections among the stratigraphic succession maps of several US national parks. Finally, students utilize the concept of index fossils in their analysis of a simple geologic timeline. http://static.nsta.org/files/ss1704_30.pdf **Patterns in Time: Staggered Origins of Vertebrate Fossils in Familiar Time** Students explore deep geologic time and sequence of events and changes in the vertebrate fossil record. Students develop understanding that fossil record shows a pattern of increasing diversity and large-scale gradual changes through time. http://www.indiana.edu/~ensiweb/lessons/pat.in.time.pdf

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
			Rocks, Fossils, and the Law of Superposition Sequencing Activity Students sequence information, relate sequencing to the Law of Superposition, and show how fossils can be used to give relative dates to rock layers. https://middleschoolscience.com/2016/08/13/rocks-fossils-and-the-law-of-superposition-sequencing-activity/ **Understanding Geologic Time** Working in small groups responsible for different eras, students create a timeline for their assigned era based upon scientific data from research. The activity concludes by having students review all the timelines to compare how long humans have been on the Earth to the length of time dinosaurs inhabited the planet. https://www.amnh.org/explore/curriculum-collections/dinosaurs-activities-and-lesson-plans/understanding-geologic-time

High School


Life Science
From Molecules to Organisms: Structures and Processes
Ecosystems: Interactions, Energy, and Dynamics
Heredity: Inheritance and Variation of Traits
Biological Evolution: Unity and Diversity

Life Science

Topic: From Molecules to Organisms: Structures and Processes	**High School**

Overview: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels. Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models. Emphasis is on using evidence from models and simulations to support explanations. Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.

Guiding Questions:

- How do organisms live, grow, respond to their environment and reproduce?
- How do the structures of organisms enable life's functions?
- How do organisms obtain and use the matter and energy they need to live and grow?
- How do organisms detect, process and use information about the environment?

Performance Expectations:

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Example Phenomena/Engineering Problem:

- What happens when you Breathe? The World's Fastest Runners: Slowed Down & Up Close (http://i.giphy.com/Avbc4NWc4THq0.gif)
- Cell Division (Time Lapse) (https://www.youtube.com/watch?v=Wz4igVjNGq4)
- Time Lapse of Plant Growth (https://www.youtube.com/watch?v=eDA8rmUP5ZM&feature=youtu.be)
- Cancer Cell Behavior (http://questlc.org/phenomena/images/gif%20(76).gif?crc=4056454727)
- Cell Size (animation) (https://www.youtube.com/watch?v=l7kZjdeo0Cs)

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations and Designing Solutions	[CCC-4] Systems and System Models [CCC-5] Energy and Matter [CCC-6] Structure and Function [CCC-7] Stability and Change	**LS1.A: Structure and Function** Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	What happens to a person's heart rate as that person increases his or her activity level? (http://www.sciencewithmrjones.com/downloads/scientific_method/heart_rates_lab.pdf) **Diffusion Blues in Agar Cells** - Diffusion and osmosis are among the most commonly studied topics in biology. Virtually all living cells are, to varying degrees, dependent on these processes. This activity will enable students to explore the relationship between diffusion and cell size by experimenting with model "cells." https://www.flinnsci.com/api/library/Download/f9278a2a81444663a31a7c0815600f42 **Homeostasis and Negative Feedback – Concepts and Breathing Experiments** The activity begins with analysis and discussion questions that develop student understanding of homeostasis and

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. **LS1.B: Growth and Development of Organisms** In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that	negative feedback, the difference between negative and positive feedback, and the cooperation between the respiratory and circulatory systems to provide O_2 and remove CO_2 for cells all over the body. Then, students carry out and analyze an experiment which investigates how rate and depth of breathing are affected by negative feedback regulation of blood levels of CO_2 and O_2. Finally, students formulate a question concerning effects of exercise on breathing, design and carry out a relevant experiment, analyze and interpret their data, and relate their results to homeostasis during exercise. http://serendip.brynmawr.edu/exchange/waldron/breathing **Mitosis - How a Single Cell Develops into the Trillions of Cells in a Human Body** Students use model chromosomes and answer analysis and discussion questions to learn how mitosis ensures that each new cell gets a complete set of genes. Students also learn how genes on chromosomes influence phenotypic characteristics and how a single cell develops into the trillions of cells in a human body. http://serendip.brynmawr.edu/exchange/waldron/mitosis **The Floating Leaf Disk Assay for Investigating Photosynthesis** - quantitative procedure that students can use for exploring photosynthesis. https://cpb-us-east-1-

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		work together to meet the needs of the whole organism. **LS1.C: Organization for Matter and Energy Flow in Organisms** The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.	juc1ugur1qwqqqo4.stackpathdns.com/blogs.cornell.edu/dist/3/1009/files/2015/09/Floating-Leaf-Disk-Brad-Williamson.pdf (Supplemental instructional video) https://www.youtube.com/watch?v=ZnY9_wMZZWI **Who Took Jerell's iPod? -- An Organic Compound Mystery** (lab activity) In the lab, students learn how to test for triglycerides, glucose, starch, and protein and then use these tests to solve a mystery. The activity reinforces students understanding of the biological functions and food sources of these different types of organic compounds. http://serendip.brynmawr.edu/exchange/waldron/organic **How do biological organisms use energy?** - This analysis and discussion activity introduces students to the basic principles of how biological organisms use energy. The focus is on understanding the roles of ATP and cellular respiration. In addition, students apply the principles of conservation of energy and conservation of matter to avoid common errors and correct common misconceptions. http://serendip.brynmawr.edu/exchange/bioactivities/energy

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	

Life Science

Topic: Ecosystems: Interactions, Energy, and Dynamics	**High School**

Overview: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets. Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem. Examples of models could include simulations and mathematical models. Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise. Examples of human activities can include urbanization, building dams, and dissemination of invasive species. Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.

Guiding Questions:

- How (and why} do organisms interact with their environment and what are the effects of these interactions?
- How do organisms interact with the living and nonliving environments to obtain matter and energy?
- How do matter and energy move through an ecosystem?
- What happens to ecosystems when the environment changes?
- How do organisms interact in groups so as to benefit individuals?

Performance Expectations:

HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Example Phenomena/Engineering Problem:

- Predation (https://thewondrous.com/wp-content/uploads/2014/06/Spider-catches-cricket-with-web-using-its-legs.gif)
- Anaerobic Respiration (Bread Rising) (https://www.youtube.com/watch?v=HFGJrOHvIb8)
- *The Tragedy of the Commons*: Are Earth's Resources Inexhaustible? Human Impact (Overfishing) on Population Size (https://mrmeyergeography.files.wordpress.com/2014/02/sustainability-fishing.jpg)
- Group Behavior (https://upload.wikimedia.org/wikipedia/commons/e/ea/Large_fish_school.png)
- Pollution (https://giphy.com/gifs/word-use-emotiva-KJuzaesML4dwY/fullscreen)

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-5] Using Mathematics	[CCC-2] Cause and Effect [CCC-3] Scale, Proportion,	**PS3.D: Energy in Chemical Processes and Everyday Life** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.	**Understanding Relationships in Food Webs** Students construct their own understanding of the relationships that may be impacted by a disturbance. As students engage in the different tasks, they have opportunities to develop and use a variety of science and engineering practices and crosscutting concepts. The goal is for students to become citizens that can make informed and sustainable decisions about issues that

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
and Computational Thinking [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	and Quantity [CCC-4] Systems and System Models [CCC-5] Energy and Matter {CCC-7] Stability and Change	**LS2.A: Interdependent Relationships in Ecosystems** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Plants or algae form the lowest level of the food web. At each link upward in a	impact ecosystems. https://sites.google.com/site/marineecosystemdrptasks/ (http://ngss.nsta.org/Resource.aspx?ResourceID=619) **Food Webs, Energy Flow, Carbon Cycle, and Trophic Pyramids** - Students construct a food web for Yellowstone National Park, including producers, primary consumers, secondary consumers, decomposers, and trophic omnivores. Then, students analyze a trophic cascade that resulted when wolves were re-introduced to Yellowstone. Students learn how organic molecules move and are transformed in ecosystems as a result of the trophic relationships in food webs, photosynthesis, cellular respiration, and biosynthesis. http://serendip.brynmawr.edu/exchange/bioactivities/foodweb **Carbon Cycle (The Habitable Planet)** This lab uses a model of the carbon cycle to illustrate how carbon circulates through the atmosphere, biosphere, oceans, and crust. Students experiment with how human input to the cycle might change global outcomes to the year 2100 and beyond. http://www.learner.org/courses/envsci/interactives/carbon/

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	**See the Forest for the Trees** This resource from Science in the Classroom (http://www.scienceintheclassroom.org/research-papers/seeing-forest-trees) (AAAS), uses an authentic scientific paper and interactive web tools to help students investigate the phenomenon of forest cover change at different scales over time. Students analyze and use real data towards building understanding of ecosystem dynamics and resilience at different scales. http://ngss.nsta.org/Resource.aspx?ResourceID=907 **Group Behavior Project** Students develop a children's book describing group behavior as researched in a particular species. **Population Growth – Exponential and Logistic Models vs. Complex Reality** This multi-part analysis and discussion activity helps students to understand the exponential and logistic models of population growth, including the biological processes that result in exponential or logistic population growth. Students learn that these models are based on simplifying assumptions and explore how discrepancies between predicted and actual trends in population size can result when these simplifying assumptions are inaccurate for a real population.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		LS2.C: Ecosystem Dynamics, Functioning, and Resilience A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.	http://serendip.brynmawr.edu/exchange/bioactivities/pop **Some Similarities between the Spread of Infectious Disease and Population Growth** Students analyze a hypothetical example of exponential growth in the number of infected individuals. Then, a class simulation of the spread of an infectious disease shows a trend that approximates logistic growth. Students analyze examples of exponential and logistic population growth and learn about the biological processes that result in exponential or logistic population growth. Finally, students analyze how changes in the biotic or abiotic environment can affect population size; these examples illustrate the limitations of the exponential and logistic population growth models. http://serendip.brynmawr.edu/exchange/waldron/infectious

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		LS2.D: Social Interactions and Group Behavior Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. **LS4.D: Biodiversity and Humans** Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by	

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		preserving landscapes of recreational or inspirational value. **ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	

Life Science

Topic: Heredity: Inheritance and Variation of Traits	**High School**
Overview: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process. Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.	
Guiding Questions: • How are characteristics of one generation passed to the next? • How can individuals of the same species, and even siblings, have different characteristics? • How are the characteristics of one generation related to the previous generation? • Why (How) do individuals of the same species vary in how they look, function and behave?	
Performance Expectations: HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	

Example Phenomena/Engineering Problem:
• How are Traits Passed from Generation to Generation? These Two are Twins? (Traits) (https://i.pinimg.com/originals/01/fb/f8/01fbf8b9eaed3df3360d5e7904d2b7b6.jpg) • Variation of Traits (Biracial Family) (https://thesocietypages.org/socimages/2014/08/01/black-and-white-twins/)

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-1] Asking Questions and Defining Problems [SEP-4] Analyzing and Interpreting Data [SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect [CCC-3] Scale, Proportion, and Quantity	**LS1.A: Structure and Function** All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. **LS3.A: Inheritance of Traits** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. **LS3.B: Variation of Traits** In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although	**Mendelian Genetics Interactive Lab** http://labcenter.dnalc.org/labs/mendeliangenetics/mendeliangenetics_h.html **What are Traits? (video)** http://learn.genetics.utah.edu/content/basics/traits/ **UV, Mutations and DNA Repair** Students learn about the effects of UV light, mutations and DNA repair on the survival of prokaryotes and the risk of skin cancer. In the first experiment, students evaluate the effects of different durations of UV exposure on survival and population growth of Haloferax volcanii. This experiment also tests for photorepair of DNA damage. Students design the second experiment, which evaluates the effectiveness of sunscreen. In addition, students answer analysis and discussion questions that promote their understanding of molecular biology, cancer, and the interpretation of experimental results. http://serendip.brynmawr.edu/exchange/waldron/uvmutations

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	

Life Science

Topic: Biological Evolution: Unity and Diversity	**High School**

Overview: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning. Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species. Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

Guiding Questions:

- Are different species are related?
- How does genetic variation affect survival and reproduction?
- How does the environment influence populations of organisms over multiple generations?

Performance Expectations:

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Example Phenomena/Engineering Problem:

- Who are Humans Closest Relatives? Common Ancestry / Comparative Embryonic Development (http://antranik.org/wp-content/uploads/2011/06/comparative-embryology-of-vertebrates-2.jpg)
- Natural Selection (https://giphy.com/gifs/funny-bird-26DNjBssHWaUSC60U/fullscreen)
- Evolution (Human) (http://questlc.org/phenomena/images/evolution.gif?crc=4266716202)
- Evolution (students can relate) (https://giphy.com/gifs/timelapse-iphone-morph-3o85xnHXDgKM21daPm/fullscreen)
- Adaptation (https://upload.wikimedia.org/wikipedia/commons/7/72/Thornydevil.jpg)
- 5 Mass Extinctions (https://www.youtube.com/watch?v=o3S2Y444aY0)

Highlighted Science and Engineering Practices	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[EP-4] Analyzing and Interpreting Data [SEP-5] Using Mathematics and	[CCC-1] Patterns [CCC-2] Cause and Effect	**LS4.A: Evidence of Common Ancestry and Diversity** Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and	**What Can Embryos tell us About Evolution? (video clip)** https://www.youtube.com/watch?v=uAZmLYWEPGk **The Whale Fossil Record Shows Changes Over Time (interactive web activity)** http://www.indiana.edu/~ensiweb/lessons/whaleanat.html

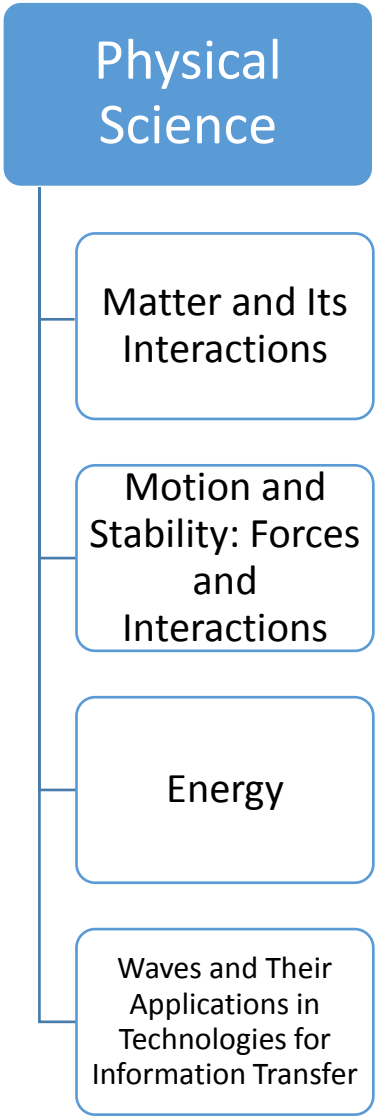
Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Computational Thinking [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating, and Communicating Information		differences in amino acid sequences and from anatomical and embryological evidence. **LS4.B: Natural Selection** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **LS4.C: Adaptation** Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4)	**Beaks as Tools: Selective Advantage in Changing Environments** This classroom experiment supports the film The Origin of Species: The Beak of the Finch. Students collect and analyze data to learn why even slight variations in beak size can make the difference between life and death. http://www.hhmi.org/biointeractive/beaks-tools-selective-advantage-changing-environments **City Moths Avoid the Light (article)** https://www.eurekalert.org/pub_releases/2016-04/uob-cma041316.php **Bozeman Biology Adaptations (video)** https://www.youtube.com/watch?v=-BzPjwL6JAs **How Eyes Evolved – Analyzing the Evidence** Students analyze evidence from comparative anatomy, mathematical modeling, and molecular biology. This evidence suggests a likely sequence of steps in the evolution of the human eye and the octopus eye. General concepts used to interpret this evidence include natural selection, fitness, and the difference between homology (similarity due to common descent) and analogy (similarity due to convergent evolution).

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different	http://serendip.brynmawr.edu/exchange/bioactivities/evoleye **Evolution in Fur Color in Mice – Mutation, Environment and Natural Selection** Students view a brief video that presents research findings concerning the roles of mutation and natural selection in the evolution of fur color in rock pocket mice. Students learn how the same trait can evolve independently in different populations and how analysis at multiple levels from the molecular to the ecological contributes to a better understanding of evolution by natural selection. http://serendip.brynmawr.edu/exchange/bioactivities/NaturalSelectionMice **Natural Selection: Directional Selection of Flower Colors – (Interactive)** https://www.ck12.org/search/?q=Natural%20Selection&source=ck12&grade=12

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		conditions, and the decline–and sometimes the extinction–of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. **LS4.D: Biodiversity and Humans** Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.	

Highlighted Science and Engineering Practices	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	

High School


Physical Science
Matter and Its Interactions
Motion and Stability: Forces and Interactions
Energy
Waves and Their Applications in Technologies for Information Transfer

Topic: Matter and Its Interactions **High School**

Overview: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen. Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved. Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. Emphasis is on the application of LeChatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products. Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques. Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.

Guiding Questions:

- How do particles combine to form the variety of matter one observes?
- How do substances combine or change (react) to make new substances?
- What forces hold nuclei together and mediate nuclear processes?

Performance Expectations:

HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Example Phenomena /Engineering Problem:

- A firefighter uses the fire tetrahedron which explains the nature of fire and what causes it in order to most effectively put out a wide range of fires safely.
- An icepack turns cold when the liquid pouch inside is ruptured**.**

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-5]	[CCC-1] Patterns [CCC-5] Energy and Matter [CCC-7]	**PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The	**Collapsing Water Bottle** Student observe a water bottle that suddenly compresses. They must then develop a model as to why this has occurred as well as identify the states of matter and forces in play.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Using Mathematics and Computational Thinking [SEP-6] Constructing Explanations and Designing Solutions	Stability and Change	repeating patterns of this table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **PS1.B: Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Periodicity** The students learn about periodicity through the establishment of their own "periodic" table. Given information, students must evaluate what they have and create a model of a periodic table. **Fission and Fusion** Students create models to show how fission and fusion could be made to occur in a controlled environment. Student models are then compared with peers to build a group model.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		PS1.C: Nuclear Processes Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	

Topic: Motion and Stability: Forces and Interactions	**High School**

Overview: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute. Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Guiding Questions:

- How can one predict an object's continued motion, change in motion, or stability?
- What underlying forces explain interactions?
- Why are some physical systems more stable than others?

Performance Expectations:

HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Example Phenomena/Engineering Problem:

- The speed of a skydiver falling to earth stops increase and stabilizes prior to opening a parachute.
- An astronautical engineer uses Newton's Laws to determine the speed at which the space shuttles booster rockets will fall to earth to determine at what time its parachutes need to be deployed.
- A bowling ball and a feather fall at the same rate of speed. https://www.youtube.com/watch?v=frZ9dN_ATew
- When placed into water, a Diet Coke can floats, but regular Coke sinks. https://www.youtube.com/watch?v=aR0b4QRhfU0
- An oceanographer wants to create a tag for marine life that will naturally float when it's detached from the animal.

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-3] Planning and Carrying out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-5] Using Mathematics and Computational Thinking	[CCC-1] Patterns [CCC-2] Cause and Effect [CCC-4] Systems and System Models [CCC-6] Structure and Function	**PS1.A: Structure and Properties of Matter** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS2.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved.	**Forces, Energy and Motion** Students build models to explore the relationship between energy, force, and motion. The concepts of potential and kinetic energy, gravity and speed are evaluated with a gravity fan. **Momentum and Newton's first law** Momentum and Newton's first law of inertia are explored with a collision test of a student-created car. The students must take into account all of the forces in play in order to create a product that successfully maintains its structure during a collision with an immovable object.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-6] Constructing Explanations and Designing Solutions [SEP-8] Obtaining, Evaluating and Communicating Information		If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. **PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. Attraction and repulsion between electric charges at the atomic	

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. **PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can	

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	

Physical Science

Topic: Energy	**High School**
Overview: Emphasis is on explaining the meaning of mathematical expressions used in the model. Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations. Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water. Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.	
Guiding Questions: • What is energy? • How is energy transferred between objects or systems? How are forces related to energy? • How do food and fuel provide energy?	
Performance Expectations: HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	

Example Phenomena/Engineering Problem:

- **https://www.youtube.com/watch?v=E00wkEE7WeQ**
  Fireworks exploding
- A camper is in need of a way to pack a substance that is easy to carry in a backpack but produces large amounts of energy when needed for heat and cooking.
- **https://www.youtube.com/watch?v=XKMdYbOfFzI&feature=youtu.be**
  An amusement park needs to develop an early warning system to detect lightning.
- **https://www.youtube.com/watch?v=T3AI1eQ50iE&feature=youtu.be**
  A culinary school is looking for a stove that will help prevent burns on their students while they learn to cook.

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-5] Using Mathematics and Computational Thinking	[CCC-2] Cause and Effect [CCC-4] Systems and System Models [CCC-5] Energy and Matter	**PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such	**Law of Conservation of Mass** Students utilize molecular model kits to build an understanding about how mass is conserved in all chemical reactions. Students then build a model that demonstrates and explains the process, which will be used throughout the course. **Conservation of Linear Momentum** The guided-inquiry activity challenges students to design a procedure to explore momentum conservation in a quantitative manner. For example, students may use an air track, gliders, and photogate timers to assess pre- and post-collision speeds of gliders of variable mass. Alternatively, students may use a stopwatch

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-6] Constructing Explanations and Designing Solutions		as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	with the aluminum track that was used in the introductory activity. Additional opportunities for inquiry, such as activities in which students determine the masses of colliding objects, are also presented.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system. Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		PS3.C: Relationship Between Energy and Forces When two objects interacting through a field change relative position, the energy stored in the field is changed. **PS3.D: Energy in Chemical Processes and Everyday Life** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	

Topic: Waves and Their Applications in Technologies for Information Transfer	**High School**
Overview: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft. Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.	
Guiding Questions: What are the characteristic properties and behaviors of waves? How can one explain the varied effects of light? What other forms of electromagnetic radiation are there? How are instruments that transmit and detect waves used to expand human senses?	
Performance Expectations: HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information. HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.	

Example Phenomena/Engineering Problem:

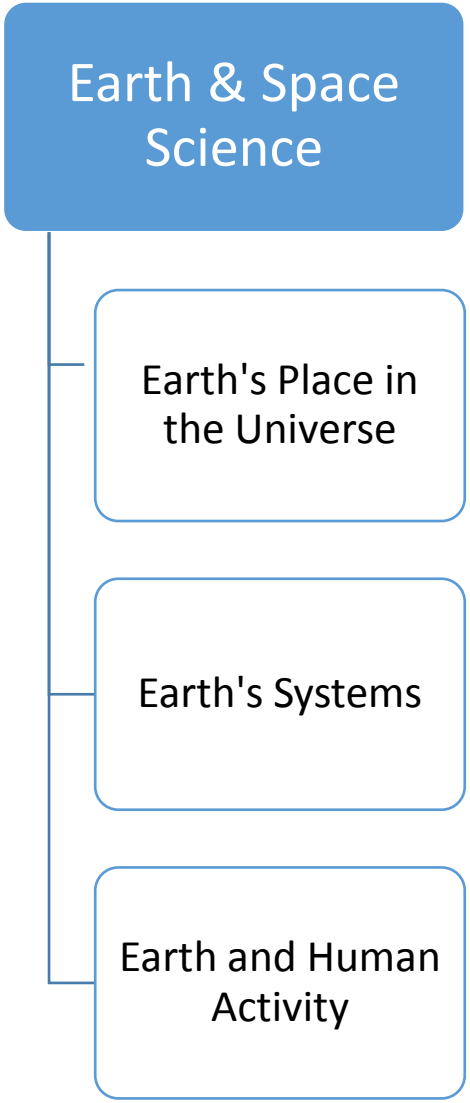
- Rainbow. https://www.youtube.com/watch?v=xyQjdF2EvLw
- An eyeglass company wants to understand how to improve distortion of images during certain types of light.
- Tacoma Narrows Bridge Collapse. https://archive.org/details/SF121
- An engineer wants to build an elevated walkway that crosses the Grand Canyon.

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-1] Asking Questions and Defining Problems [SEP-5] Using Mathematics and Computational Thinking [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating, and	[CCC-2] Cause and Effect [CCC-4] Systems and System Models [CCC-7] Stability and Change	**PS3.D: Energy in Chemical Processes and Everyday Life** Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. **PS4.A: Wave Properties** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Wave Properties** Using springs students, observe longitudinal and transverse waves, and learn important concepts such as frequency, amplitude, wavelength, and period. Students will then use this information to create models that represent and explain real world observations. **Wave Interference** Wave interference is investigated using simulated point-source circles of different "wavelengths." Constructive and destructive interference patterns are clearly seen. Students will use this information to create models that represent and explain real world observations.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Communicating Information		Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) **PS4.B: Electromagnetic Radiation** Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can	**Faraday's Law Activity** Students pass a magnet through a wire coil connected to an ammeter to determine if electric current is produced. Students will also evaluate different coils to develop an understanding of which type will generate the most current and why. Students quantitatively compare the effects of changing variables, such as magnet speed, coil number and magnetic strength to the amount of current generated. **Student Design Challenge** The students design the most effect coil possible. The students must be able to design, illustrate, build, evaluate, and present their product.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS4.C: Information Technologies and Instrumentation** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	

High School


Earth & Space Science
Earth's Place in the Universe
Earth's Systems
Earth and Human Activity

Earth & Space Science

Topic: Earth's Place in the Universe	**High School**

Overview: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries. Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium). Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions). Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

Guiding Questions:

- What is the universe, and what goes on in the stars?
- What are the predictable patterns caused by Earth's movement in the solar system?
- How do people reconstruct and date events in Earth's planetary history?

Performance Expectations:

HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.

HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Example Phenomena/Engineering Problem:

- Animation of a star forming from a Nebula in space. https://www.youtube.com/watch?v=YbdwTwB8jtc
  Astronomers look at celestial events in other parts of our galaxy to better predict what will occur within the Milky Way.
- Footage of a supernova as seen through the Hubble Telescope. https://www.youtube.com/watch?v=xIdJtIDReM8
  Astronomers use the footage of a supernova to better understand our galaxy.

Highlighted Science and Engineering Practices:	**Highlighted Cross Cutting Concepts**	**Disciplinary Core Ideas**	**Sample Instructional Strategies**
[SEP-2] Developing and Using Models [SEP-5] Using Mathematics and Computational Thinking [SEP-6] Constructing Explanations and Designing Solutions	[CCC-1] Patterns [CCC-3] Scale, Proportion, and Quantity [CCC-5] Energy and Matter [CCC-7] Stability and Change	**PS1.C: Nuclear Processes** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. **PS3.D: Energy in Chemical Processes and Everyday Life** Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.	**What is a half-life?** Activity based development of the concept of half-life that demonstrates the predictability of deterioration in radioactive isotopes. **Radioactive Dating** What determines the age of an object? Activity based learning that demonstrates that carbon dating has limitations. Also developed are alternative processes that are also used to determine the age of objects. **Vernier Gas Spectrum Tubes** Gases such as hydrogen, helium, neon and others are enclosed in tubes that can be charged to show the visible light that each emits.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluation, and Communicating Information		**PS4.B: Electromagnetic Radiation** Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. **ESS1.A: The Universe and Its Stars** The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured	**Flame Test Activity** Students observe the characteristic color of light emitted by metallic salts when placed in a flame. This activity then moves to show how the colors of the light emitted can help to identify elements. **Predicting Elements Present in Space** The use of prior activities and experimentation are used to evaluate the light, as well as the colors of the light, to predict what elements are present in observable space. **Kepler's Law and Planetary Orbits** Students construct ellipses and then explore the shape of a planet's orbit. This investigation utilizes Kepler's laws of planetary motion in a way that allows the students to build understanding through investigation. **Can Objects not from Earth teach us about the History of the Earth?** Students investigate the materials that have been collected from non-earth sources and compare them to what we now find on earth. By evaluating the similarities and differences, students can make predictions about what prehistoric earth might have been like.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. **ESS1.B: Earth and the Solar System** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may	**Pangaea and the World that Followed** Students will evaluate a model of Pangaea and be asked to predict and explain how the current map of the world was formed. Details in continental drift that demonstrate an understanding of how geological processes have altered the earth's rock record throughout history will be emphasized.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		change due to the gravitational effects from, or collisions with, other objects in the solar system. **ESS1.C: The History of Planet Earth** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.	

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		ESS2.B: Plate Tectonics and Large-Scale System Interactions Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.	

Earth & Space Science

Topic: Earth's Systems	**High School**

Overview: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent. Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments. Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms. Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.

Guiding Questions:

- How and why is Earth constantly changing?
- What causes earthquakes and volcanoes?
- How do the properties and movements of water affect its systems?
- What regulates weather and climate?
- How do living organisms alter Earth's processes and structures?

Performance Expectations:

HS-ESS2-1 Develop a model to illustrate how Earth is internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS2-2 Analyze geoscience data to make the claim that one change to the Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Example Phenomena /Engineering Problem:

- A hurricane forms in the Atlantic Ocean. https://www.youtube.com/watch?v=mm4m5f9ziA4
- https://www.youtube.com/watch?v=MyrFaAbvKo4
  People at a beach observe a tsunami approaching the shore and washing inland.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-7] Engaging in Argument from Evidence	[CCC-2] Cause and Effect [CCC-5] Energy and Matter [CCC-6] Structure and Function [CCC-7] Stability and Change	**ESS1.B: Earth and the Solar System** Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. The geologic record shows that changes to global and regional climate can be caused by interactions	**The Big Bang Theory** The phenomena known as the big bang is shown to the students and they are asked to develop a model as to how our universe, galaxy, solar system, and planet were created as a result of this event. **Pangaea and the World that Followed** Students will evaluate a model of Pangaea and be asked to predict and explain how the current map of the world was formed. Details in continental drift that demonstrate an understanding of how geological processes have altered the earth's rock record throughout history will be emphasized. **Water** Phenomena such as the formation of a water drop and a bug walking on water will be used to allow the students to

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. **ESS2.C: The Roles of Water in Earth's Surface Processes**	build an understanding of the uniqueness of water due to its physical and chemical properties of water.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. **ESS2.E: Biogeology**	

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.	

Earth & Space Science

Topic: Earth and Human Activity **High School**

Overview: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised. Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen. Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning. Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean). Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition). Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Guiding Questions:

- How do the Earth's surface processes and human activities affect each other?
- How do natural hazards affect individuals and societies?
- How do humans change the planet?

Performance Expectations:
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Example Phenomena/Engineering Problem:

- Follow the flow and amount of carbon dioxide in the environment. https://svs.gsfc.nasa.gov/12445
- A state evaluates the environmental impact of a new factory to be built on land that currently contains a densely, wooded forest.
- Scientists evaluate the environmental conditions that existed when the fires started and spread in order to help develop better prevention tactics in the future.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
[SEP-4] Analyzing and Interpreting Data [SEP-5]	[CCC-2] Cause and Effect [CCC-4]	**ESS2.D: Weather and Climate** Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by	**Predicting a Hurricane's Path** Students are given a starting point of a tropical storm. Then they are given data in increments that signify different days in the storm's progression. Using

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
Using Mathematics and Computational Thinking [SEP-6] Constructing Explanations and Designing Solutions [SEP-7] Engaging in Argument from Evidence	Systems and System Models [CCC-7] Stability and Change	global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. **ESS3.A: Natural Resources** Resource availability has guided the development of human society. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ESS3.B: Natural Hazards** Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. **ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	land structure locations, high/low pressures, water temperature, as well as other aspects students plot the course of the class created hurricane. This activity progresses to the formation and tracking of other weather occurrences such as thunderstorms and tornadoes. **Energy Production** Students evaluate all forms of energy to determine the environmental impact of each. Detail will also be given to determine how important cost impacts the energy choices that are made. **Human Impact Evaluation** The students will evaluate two sample bodies of water. One is in a rural setting that has little to no human impact and the second is of similar size in an urban setting with a great deal of human impact. The water quality, plant life, animal life and soil quality will be evaluated in each. Students will build models of each body of water.

Highlighted Science and Engineering Practices:	Highlighted Cross Cutting Concepts	Disciplinary Core Ideas	Sample Instructional Strategies
		Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ESS3.D: Global Climate Change** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. **ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	