SEEd Swap Workshop

2017

6th Grade
Welcome to the 2017 SEEd Swap Teacher Workshop

It’s an exciting time for the world of science instruction; advances in cognitive and pedagogical research are reshaping the way we think about engaging students in science and engineering. The state of Utah has reflected these improvements in the new 6-8th grade SEEd (Science and Engineering Education) Standards, which will be implemented across the state during the 2017-2018 school year. While this change is exciting, it also poses significant challenges. The SEEd standards are built on Disciplinary Core Ideas, as were the previous standards. The new components include the explicit integration of Science and Engineering Practices into every single standard, and the framing of ideas within Crosscutting Concepts to allow instructors to help students organize their thoughts. These three components, called ‘dimensions,’ when anchored to instruction that allows students to explore phenomena they encounter in the world, allows students to act as sense-makers and science/engineering practitioners.

In order to provide 6-8th grade teachers with professional learning support to successfully implement the new standards, the Center for Science and Mathematics Education (CSME) is offering a week-long workshop focusing on the content that has ‘swapped,’ or is new to each grade – the “SEEd Swap.”

**USBE Credit:**
80% documented attendance, taken 2x daily by your instructor, as well as an accurate CACTUS ID number on record, are required to earn 3 USBE credits.

**Supply Stipend**
A $150 check will be issued to each attendee who
Completed the pre-assessment by the July 29th deadline
Attend 100% of the workshop
Complete the post-assessment between noon on Aug. 4 and midnight Aug. 8th.

**Curricular Resources**
The majority of the resources found in this book will be available online at the Center for Science and Mathematics Education website: https://csme.utah.edu/resources/k12curriculum/
Megan Black

Megan Black is an elementary science curriculum specialist in Granite School District. She taught science for twelve years working with students in grades 4 - 9, but most often 6th grade. Megan was on the 6th grade SEEd standards writing committee and has been involved with developing the 6th Grade SEEd OER textbook. She is interested in developing curriculum and instructional strategies that engage students as scientists as they explore and figure out the natural world around them.

Sarah Braden, Post Doc Fellow

Sarah K. Braden started her career in education as a high school biology, physics, and English as a Second Language (ESL) teacher. Dr. Braden is currently an Assistant Professor of English Language Learner education in The School of Teacher Education and Leadership at Utah State University. Her research centers on understanding language socialization phenomena and promoting equity in the sciences.

Ben Breinholt, Professional Educator at Granite School District

I am a Utah native and have lived in the Salt Lake area primarily. I worked over twenty-five years as an outside sales representative in the private sector before I was inspired to go back to school to become a school teacher. I have been a sixth-grade teacher for the past eleven years at West Valley Elementary. Through the opportunities provided by Granite School District I have received my ESL and Math Endorsements, a Master of Education, and most recently my STEM Endorsement. I feel extremely fortunate to be a teacher and love working with kids and my colleagues.

Brad Carroll, Professor Emeritus - Physics, Weber State University

Brad Carroll began his career as a high school math and physics teacher in Bakersfield, California. After receiving his Ph.D. in astrophysics from the University of Colorado, Brad spent time as a postdoc at the University of Rochester before joining the Physics Dept. at Weber State University in 1985. At WSU, Brad collaborated with faculty in the Dept. of Chemistry to develop a unique physical science course for elementary education majors. He also co-authored An Introduction to Modern Astrophysics, the standard undergraduate astrophysics text. Brad retired in 2015 after 30 years at WSU, 10 of them as chair of the Physics Department. In retirement, he continues to teach with the Physics Department and Honors Program, and is working on the third edition of his astrophysics text.
Jordan Gerton, Director of CSME and Associate Professor of Physics

I received my Bachelor’s degree in Engineering Physics from the University of Arizona and my Master’s and Doctorate degrees in Physics from Rice University. I have had a number of formative experiences over the years that have stoked my passion for math and science education and have driven me to leadership roles in these areas. Math and Science are among the most important and impactful human pursuits, and I am committed to helping students of all ages and backgrounds develop a passion for and proficiency in these enabling disciplines.

Holly Godsey

Dr. Holly Godsey is the Director of Student Success and Teacher Development at the CSME and an Associate Professor (Lecturer) in the Department of Geology and Geophysics. She has a BS and PhD in Geology from the University of Utah and an MS in Oceanography (Marine Geology and Geochemistry) from the University of Michigan. Since 2004, she has been involved with several science education projects that connect faculty, graduate and undergraduate students to K-12 teachers and students to inspire, empower and educate learners from across generations and disciplines.

Maura Hanenberger

Maura Hahnenberger is an Assistant Professor in the Geosciences Department at Salt Lake Community College. At SLCC she teaches and advises in the Atmospheric Sciences and Geography programs in both face to face and online settings. Maura is the founder of the WaterGirls outreach program which provides middle school girls with field experiences conducting water science. She also serves on the boards of the SLCC Chapter of the Utah Women in Higher Education Network, Utah Chapter of the American Meteorological Society, and the Earth Science Women’s Network.

Emily Harward, 7th & 8th Grade Science & Biology Teacher at Granite Schools

Emily was lucky to grow up in the Salt Lake Valley, with opportunities to spend time exploring nature. She graduated from the University of Utah in 2004, and has been teaching science at Evergreen Junior High in Granite District ever since. For Emily, the most rewarding part of teaching is developing lessons and activities that provide a pathway for students to develop their own understanding and make sense of the world they live in.
Patrice Kurnarth

Patrice received her B.S. in Biology from Ithaca College and worked in academia for a few years at Yale University and UC Berkeley. She earned her Ph.D. in Biology from the University of Utah in 2016. During her doctoral thesis, Patrice worked with middle school science teachers in the Salt Lake valley for two years as part of a GK-12 graduate school fellowship funded by the National Science Foundation. This experience was truly transformative for Patrice because she learned about pedagogical theory and experienced first-hand the set-backs and successes of teaching.

Jaleigh Mecham, 6th grade teacher at Granite School District

My name is Jaeleigh Mecham. I graduated from the University of Utah in 2013 with a bachelor’s degree in Elementary Education with a minor in Spanish Teaching. I have endorsements in Early Childhood, ESL, and STEM. I have been at Fox Hills Elementary for 4 years. In my spare time I love to be active outdoors! Hiking, biking, and camping are some of my favorites.

Candace Penrod, District Science Supervisor at SLC School District

Candace’s teaching career began in California in elementary education. Upon moving to Utah, she transitioned to secondary science teaching, followed by several years as instructional coach. She is currently the District Science Supervisor for Salt Lake City School District. Candace obtained a Master in Education from the University of Utah in 2009 and a Master of Science in Earth Science Teaching from the University of Utah. Candace is passionate about K-12 science education and continually seeks for opportunities to improve science teaching and student learning at all levels.

Scott Roskelley, Science Assement Specialist at Utah State Board of Education

Scott was born and raised in Chicago, Illinois and from a young age loved science. He holds degrees in wildlife biology, marine biology, teaching and learning, and educational administration. Never expecting to work in education, Scott fell into teaching in 2001 as he entered the alternative route to licensure in Utah. Scott worked for 15 years in the Jordan School District, mostly teaching middle school. Now as the state science assessment specialist, he is responsible for working with Utah teachers to develop the new end-of-year assessment for the new SEEd standards.
James Ruff

I am an evolutionary biologist studying basic evolutionary topics including sexual selection, and the forces maintaining genetic diversity in populations; furthermore, I apply evolutionary principles and techniques to questions concerning nutrition, toxicology, and pharmaceutical safety assessment. I am passionate about science education and prefer to focus on the process of science relative to the ‘fruits’ of the process. In this vein, I incorporate study designs, data analysis and writing into each of my courses. I have been a teaching fellow at both elementary and middle schools in SLCSD.

Holly Vancouwenberghe

Hi! My name is Holly VanCouwenberghe and I am a 6th grade teacher at Hillsdale Elementary School. I am entering my 13th year of teaching, and have taught 4th grade, 5th grade, and 6th grade, but I have been mostly in 6th. I have a bachelor’s degree in Elementary Education, Master’s in Educational Psychology, and endorsements in Early Childhood Education, English Language Learning, and STEM.

Sara Yearsley

Sara is an Earth Science teacher as Weber school district.

Tamara Young, Academic Advisor in the Department of Physics & Astronomy

Tamara’s interest in physics began in high school. As an undergraduate at Utah State University, Tamara’s studies focused on nuclear and particle physics. Tamara taught science and math for several years in the public education system. After grad school, Tamara again taught science and math in the public education system. For the last couple years, Tamara has taught astronomy at SLCC, participated in course curriculum development with CSME, and taught a computational astronomy course for Master’s students in Physics Teaching. Tamara is the academic advisor in the Department of Physics & Astronomy at the University of Utah. She also engages in public outreach and education, and loves to talk about physics.
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SCIENCE WITH ENGINEERING EDUCATION (SEEd) STANDARDS FOR UTAH

Adopted December 2015 by the Utah State Board of Education
Science Literacy for All Students

Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. Engineering combines the fields of science, technology, and mathematics to provide solutions to real-world problems. The nature and process of developing scientific knowledge and understanding includes constant questioning, testing, and refinement, which must be supported by evidence and has little to do with popular consensus. Since progress in the modern world is tied so closely to this way of knowing, scientific literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientific understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands-on, active experiences throughout the instruction of the science curriculum. These standards help students find value in developing novel solutions as they engage with complex problems.

Three Dimensions of Science

Science education includes three dimensions of science understanding: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Every standard includes each of the three dimensions; **Science and Engineering Practices are bolded**, Crosscutting Concepts are underlined, and Disciplinary Core Ideas are in normal font. Standards with *specific engineering expectations are italicized.*

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Organization of Standards
The Utah SEEd standards² are organized into strands, which represent significant areas of learning within content areas. Within each strand are standards. A standard is an articulation of the demonstrated proficiency to be obtained. A standard represents an essential element of the learning that is expected. While some standards within a strand may be more comprehensive than others, all standards are essential for mastery.

Grade Six |
Utah Science With Engineering Education (SEEd) Standards
The sixth grade SEEd standards provide a framework for student understanding of the cycling of matter and the flow of energy through the study of observable phenomena on Earth. Students will explore the role of energy and gravity in the solar system as they compare the scale and properties of objects in the solar system and model the Sun-Earth-Moon system. These strands also emphasize heat energy as it affects some properties of matter, including states of matter and density. The relationship between heat energy and matter is observable in many phenomena on Earth, such as seasons, the water cycle, weather, and climates. Types of ecosystems on Earth are dependent upon the interaction of organisms with each other and with the physical environment. By researching interactions between the living and non-living components of ecosystems, students will understand how the flow of energy and cycling of matter affects stability and change within their environment.

² Most SEEd Standards are based on the Next Generation Science Standards: http://www.nextgenscience.org
Strand 6.1: STRUCTURE AND MOTION WITHIN THE SOLAR SYSTEM

The solar system consists of the Sun, planets, and other objects within Sun’s gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

- **Standard 6.1.1** Develop and use a model of the Sun-Earth-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. Examples of models could be physical, graphical, or conceptual.

- **Standard 6.1.2** Develop and use a model to describe the role of gravity and inertia in orbital motions of objects in our solar system.

- **Standard 6.1.3** Use computational thinking to analyze data and determine the scale and properties of objects in the solar system. Examples of scale could include size and distance. Examples of properties could include layers, temperature, surface features, and orbital radius. Data sources could include Earth and space-based instruments such as telescopes and satellites. Types of data could include graphs, data tables, drawings, photographs, and models.
Strand 6.2: ENERGY AFFECTS MATTER

Matter and energy are fundamental components of the universe. Matter is anything that has mass and takes up space. Transfer of energy creates change in matter. Changes between general states of matter can occur through the transfer of energy. Density describes how closely matter is packed together. Substances with a higher density have more matter in a given space than substances with a lower density. Changes in heat energy can alter the density of a material. Insulators resist the transfer of heat energy, while conductors easily transfer heat energy. These differences in energy flow can be used to design products to meet the needs of society.

■ **Standard 6.2.1** Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and carbon dioxide (CO₂).

■ **Standard 6.2.2** Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

■ **Standard 6.2.3** Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

■ **Standard 6.2.4** Design an object, tool, or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing, analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.
Strand 6.3: EARTH’S WEATHER PATTERNS AND CLIMATE

All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth's weather and drives the water cycle. Uneven heating across Earth's surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

■ **Standard 6.3.1** Develop a model to describe how the cycling of water through Earth’s systems is driven by energy from the Sun, gravitational forces, and density.

■ **Standard 6.3.2** Investigate the interactions between air masses that cause changes in weather conditions. Collect and analyze weather data to provide evidence for how air masses flow from regions of high pressure to low pressure causing a change in weather. Examples of data collection could include field observations, laboratory experiments, weather maps, or diagrams.

■ **Standard 6.3.3** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Examples of models could include Utah regional weather patterns such as lake-effect snow and wintertime temperature inversions.

■ **Standard 6.3.4** Construct an explanation supported by evidence for the role of the natural greenhouse effect in Earth's energy balance, and how it enables life to exist on Earth. Examples could include comparisons between Earth and other planets such as Venus and Mars.
Strand 6.4: STABILITY AND CHANGE IN ECOSYSTEMS

The study of ecosystems includes the interaction of organisms with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources, such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

- **Standard 6.4.1** Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

- **Standard 6.4.2** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments, such as competition, predation, and mutualism.

- **Standard 6.4.3** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

- **Standard 6.4.4** Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

- **Standard 6.4.5** Evaluate competing design solutions for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize obtaining, evaluating, and communicating information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.
INTRODUCTION | GRADE 7

Science Literacy for All Students
Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. Engineering combines the fields of science, technology, and mathematics to provide solutions to real-world problems. The nature and process of developing scientific knowledge and understanding includes constant questioning, testing, and refinement, which must be supported by evidence and has little to do with popular consensus. Since progress in the modern world is tied so closely to this way of knowing, scientific literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientific understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands-on, active experiences throughout the instruction of the science curriculum. These standards help students find value in developing novel solutions as they engage with complex problems.

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¹ NRC Framework K–12 Science Education: http://www.nap.edu/catalog.php?record_id=13165
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**Grade Seven**
**Utah Science With Engineering Education (SEEd) Standards**
The seventh grade SEEd standards look for relationships of cause and effect which enable students to pinpoint mechanisms of nature and allow them to make predictions. Students will explore how forces can cause changes in motion and are responsible for the transfer of energy and the cycling of matter. This takes place within and between a wide variety of systems, from simple, short-term forces on individual objects to the deep, long-term forces that shape our planet. In turn, Earth’s environments provide the conditions for life as we know it. Organisms survive and reproduce only to the extent that their own mechanisms and adaptations allow. Evidence for the evolutionary histories of life on Earth is provided through the fossil record, similarities in the various structures among species, organism development, and genetic similarities across all organisms. Additionally, mechanisms shaping Earth are understood as forces affecting the cycling of Earth’s materials. Questions about cause and effect and the ongoing search for evidence in science, or science’s ongoing search for evidence, drive this storyline.

² Most SEEd Standards are based on the Next Generation Science Standards: http://www.nextgenscience.org
Strand 7.1: FORCES ARE INTERACTIONS BETWEEN MATTER

Forces are push or pull interactions between two objects. Changes in motion, balance and stability, and transfers of energy are all facilitated by forces on matter. Forces, including electric, magnetic, and gravitational forces, can act on objects that are not in contact with each other. Scientists use data from many sources to examine the cause and effect relationships determined by different forces.

■ **Standard 7.1.1** *Carry out an investigation* which provides evidence that a change in an object’s motion is dependent on the mass of the object and the sum of the forces acting on it. *Various experimental designs should be evaluated to determine how well the investigation measures an object’s motion.* Emphasize conceptual understanding of Newton’s First and Second Laws. Calculations will only focus on one-dimensional movement; the use of vectors will be introduced in high school.

■ **Standard 7.1.2** Apply Newton’s Third Law to *design a solution to a problem involving the motion of two colliding objects in a system*. Examples could include collisions between two moving objects or between a moving object and a stationary object.

■ **Standard 7.1.3** *Construct a model* using observational evidence to describe the nature of fields existing between objects that exert forces on each other even though the objects are not in contact. Emphasize the cause and effect relationship between properties of objects (such as magnets or electrically-charged objects) and the forces they exert.

■ **Standard 7.1.4** *Collect and analyze data* to determine the factors that affect the strength of electric and magnetic forces. Examples 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 of increasing the number or strength of magnets on the speed of an electric motor.

■ **Standard 7.1.5** *Engage in argument from evidence* to support the claim that gravitational interactions within a system are attractive and dependent upon the masses of interacting objects. Examples of evidence for arguments could include mathematical data generated from various simulations.
Strand 7.2: CHANGES TO EARTH OVER TIME

Earth’s processes are dynamic and interactive, and are the result of energy flowing and matter cycling within and among Earth’s systems. Energy from the sun and Earth’s internal heat are the main sources driving these processes. Plate tectonics is a unifying theory that explains crustal movements of Earth’s surface, how and where different rocks form, the occurrence of earthquakes and volcanoes, and the distribution of fossil plants and animals.

- **Standard 7.2.1** Develop a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks.

- **Standard 7.2.2** Construct an explanation based on evidence for how processes have changed Earth’s surface at varying time and spatial scales. Examples of processes that occur at varying time scales could include slow plate motions or rapid landslides. Examples of processes that occur at varying spatial scales could include uplift of a mountain range or deposition of fine sediments.

- **Standard 7.2.3** Ask questions to identify constraints of specific geologic hazards and evaluate competing design solutions for maintaining the stability of human-engineered structures, such as homes, roads, and bridges. Examples of geologic hazards could include earthquakes, landslides, or floods.

- **Standard 7.2.4** Develop and use a scale model of the matter in the Earth’s interior to demonstrate how differences in density and chemical composition (silicon, oxygen, iron, and magnesium) cause the formation of the crust, mantle, and core.

- **Standard 7.2.5** Ask questions and analyze and interpret data about the patterns between plate tectonics and:
  1. The occurrence of earthquakes and volcanoes.
  2. Continental and ocean floor features.
  3. The distribution of rocks and fossils.

Examples could include identifying patterns on maps of earthquakes and volcanoes relative to plate boundaries, the shapes of the continents, the locations of ocean structures (including mountains, volcanoes, faults, and trenches), and similarities of rock and fossil types on different continents.

- **Standard 7.2.6** Make an argument from evidence for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating, such as superposition, uniformitarianism and recognizing unconformities.
Strand 7.3: STRUCTURE AND FUNCTION OF LIFE

Living things are made of smaller structures, which function to meet the needs of survival. The basic structural unit of all living things is the cell. Parts of a cell work together to function as a system. Cells work together and form tissues, organs, and organ systems. Organ systems interact to meet the needs of the organism.

■ Standard 7.3.1 Plan and carry out an investigation that provides evidence that the basic structures of living things are cells. Emphasize that cells can form single-celled or multicellular organisms, and that multicellular organisms are made of different types of cells.

■ Standard 7.3.2 Develop and use a model to describe the function of a cell in living systems and the way parts of cells contribute to cell function. Emphasize the cell as a system, including the interrelating roles of the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

■ Standard 7.3.3 Construct an explanation using evidence to explain how body systems have various levels of organization. Emphasize understanding that cells form tissues, tissues form organs, and organs form systems specialized for particular body functions. Examples could include relationships between the circulatory, excretory, digestive, respiratory, muscular, skeletal, and nervous systems. Specific organ functions will be taught at the high school level.
Strand 7.4: REPRODUCTION AND INHERITANCE

The great diversity of species on Earth is a result of genetic variation. Genetic traits are passed from parent to offspring. These traits affect the structure and behavior of organisms, which affect the organism’s ability to survive and reproduce. Mutations can cause changes in traits that may affect an organism. As technology has developed, humans have been able to change the inherited traits in organisms, which may have an impact on society.

- **Standard 7.4.1** Develop and use a model to explain the effects that different types of reproduction have on genetic variation, including asexual and sexual reproduction.

- **Standard 7.4.2** Obtain, evaluate, and communicate information about specific animal and plant adaptations and structures that affect the probability of successful reproduction. Examples of adaptations could include nest building to protect young from the cold, herding of animals to protect young from predators, vocalization of animals and colorful plumage to attract mates for breeding, 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.

- **Standard 7.4.3** Develop and use a model to describe why genetic mutations may result in harmful, beneficial, or neutral effects to the structure and function of the organism. Emphasize the conceptual idea that changes to traits can happen because of genetic mutations. Specific changes of genes at the molecular level, mechanisms for protein synthesis, and specific types of mutations will be introduced at the high school level.

- **Standard 7.4.4** Obtain, evaluate, and communicate information about the technologies that have changed the way humans affect the inheritance of desired traits in organisms. Analyze data from tests or simulations to determine the best solution to achieve success in cultivating selected desired traits in organisms. Examples could include artificial selection, genetic modification, animal husbandry, and gene therapy.
Strand 7.5: CHANGES IN SPECIES OVER TIME

Genetic variation and the proportion of traits within a population can change over time. These changes can result in evolution through natural selection. Additional evidence of change over time can be found in the fossil record, anatomical similarities and differences between modern and ancient organisms, and embryological development.

- **Standard 7.5.1** **Construct an explanation** that describes how the genetic variation of traits in a population can affect some individuals’ probability of surviving and reproducing in a specific environment. Over time, specific traits may increase or decrease in populations. Emphasize the use of proportional reasoning to support explanations of trends in changes to populations over time. Examples could include camouflage, variation of body shape, speed and agility, or drought tolerance.

- **Standard 7.5.2** **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.

- **Standard 7.5.3** **Construct explanations** that describe the patterns of body structure similarities and differences between modern organisms, and between ancient and modern organisms, to infer possible evolutionary relationships.

- **Standard 7.5.4** **Analyze data** to compare patterns in the embryological development across multiple species to identify similarities and differences not evident in the fully formed anatomy.
INTRODUCTION | GRADE 8

Science Literacy for All Students
Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. Engineering combines the fields of science, technology, and mathematics to provide solutions to real-world problems. The nature and process of developing scientific knowledge and understanding includes constant questioning, testing, and refinement, which must be supported by evidence and has little to do with popular consensus. Since progress in the modern world is tied so closely to this way of knowing, scientific literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientific understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands-on, active experiences throughout the instruction of the science curriculum. These standards help students find value in developing novel solutions as they engage with complex problems.

Three Dimensions of Science
Science education includes three dimensions of science understanding: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Every standard includes each of the three dimensions; Science and Engineering Practices are bolded, Crosscutting Concepts are underlined, and Disciplinary Core Ideas are in normal font. Standards with specific engineering expectations are italicized.

<table>
<thead>
<tr>
<th>Scientific and Engineering Practices</th>
<th>Crosscutting Concepts</th>
<th>Disciplinary Core Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions or defining problems</td>
<td>Patterns</td>
<td>Earth and Space Science</td>
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<tr>
<td>Developing and using models</td>
<td>Cause and effect: mechanism and explanation</td>
<td>Life Science</td>
</tr>
<tr>
<td>Planning and carrying out investigations</td>
<td>Scale, proportion, and quantity</td>
<td>Physical Science</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>Systems and system models</td>
<td>Engineering</td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
<td>Energy and matter: flows, cycles, and conservation</td>
<td></td>
</tr>
<tr>
<td>Constructing explanations and designing solutions</td>
<td>Structure and function</td>
<td></td>
</tr>
<tr>
<td>Engaging in argument from evidence</td>
<td>Stability and change</td>
<td></td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 NRC Framework K–12 Science Education: http://www.nap.edu/catalog.php?record_id=13165
Organization of Standards
The Utah SEEd standards\(^2\) are organized into strands, which represent significant areas of learning within content areas. Within each strand are standards. A standard is an articulation of the demonstrated proficiency to be obtained. A standard represents an essential element of the learning that is expected. While some standards within a strand may be more comprehensive than others, all standards are essential for mastery.

Grade Eight |
Utah Science with Engineering Education (SEEd) Standards
The eighth grade SEEd standards describe the constant interaction of matter and energy in nature. Students will explore how matter is arranged into either simple or complex substances. The strands emphasize how substances store and transfer energy, which can cause them to interact physically and chemically, provide energy to living organisms, or be harnessed and used by humans. Matter and energy cycle and change in ecosystems through processes that occur during photosynthesis and cellular respiration. Additionally, substances that provide a benefit to organisms, including humans, are unevenly distributed on Earth due to geologic and atmospheric systems. Some resources form quickly, allowing them to be renewable, while other resources are nonrenewable. Evidence reveals that Earth systems change and affect ecosystems and organisms in positive and negative ways.

\(^2\) Most SEEd Standards are based on the Next Generation Science Standards: [http://www.nextgenscience.org](http://www.nextgenscience.org)
Strand 8.1: MATTER AND ENERGY INTERACT IN THE PHYSICAL WORLD

The physical world is made of atoms and molecules. Even large objects can be viewed as a combination of small particles. Energy causes particles to move and interact physically or chemically. Those interactions create a variety of substances. As molecules undergo a chemical or physical change, the number of atoms in that system remains constant. Humans use energy to refine natural resources into synthetic materials.

■ Standard 8.1.1 **Develop a model** to describe the scale and proportion of atoms and molecules. Emphasize developing atomic models of elements and their numbers of protons, neutrons, and electrons, as well as models of simple molecules. Topics like valence electrons, bond energy, ionic complexes, ions, and isotopes will be introduced at the high school level.

■ Standard 8.1.2 **Obtain** information about various properties of matter, **evaluate** how different materials’ properties allow them to be used for particular functions in society, and **communicate** your findings. Emphasize general properties of matter. Examples could include color, density, flammability, hardness, malleability, odor, ability to rust, solubility, state, or the ability to react with water.

■ Standard 8.1.3 **Plan and conduct an investigation** and then **analyze and interpret the data** to identify patterns in changes in a substance’s properties to determine whether a chemical reaction has occurred. Examples could include changes in properties such as color, density, flammability, odor, solubility, or state.

■ Standard 8.1.4 **Obtain and evaluate information** to describe how synthetic materials come from natural resources, what their functions are, and how society uses these new materials. Examples of synthetic materials could include medicine, foods, building materials, plastics, and alternative fuels.

■ Standard 8.1.5 **Develop a model** that uses **computational thinking** to illustrate cause and effect relationships in particle motion, temperature, density, and state of a pure substance when heat energy is added or removed. Emphasize molecular-level models of solids, liquids, and gases to show how adding or removing heat energy can result in phase changes, and focus on calculating the density of a substance’s state.

■ Standard 8.1.6 **Develop a model** to describe how the total number of atoms does not change in a chemical reaction, indicating that matter is conserved. Emphasize demonstrations of an understanding of the law of conservation of matter. Balancing equations and stoichiometry will be learned at the high school level.

■ Standard 8.1.7 **Design, construct, and test** a device that can affect the rate of a phase change. **Compare and identify the best characteristics of competing devices and modify them based on data analysis** to improve the device to better meet the criteria for success.
Strand 8.2: ENERGY IS STORED AND TRANSFERRED IN PHYSICAL SYSTEMS

Objects can store and transfer energy within systems. Energy can be transferred between objects, which involves changes in the object’s energy. There is a direct relationship between an object’s energy, mass, and velocity. Energy can travel in waves and may be harnessed to transmit information.

- **Standard 8.2.1** Use computational thinking to analyze data about the relationship between the mass and speed of objects and the relative amount of kinetic energy of the objects. Emphasis should be on the quantity of mass and relative speed to the observable effects of the kinetic energy. Examples could include a full cart vs. an empty cart or rolling spheres with different masses down a ramp to measure the effects on stationary masses. Calculations of kinetic and potential energy will be learned at the high school level.

- **Standard 8.2.2** Ask questions about how the amount of potential energy varies as distance within the system changes. Plan and conduct an investigation to answer a question about potential energy. Emphasize comparing relative amounts of energy. Examples could include a full cart vs. an empty cart or rolling spheres with different masses down a ramp to measure the effects on stationary masses. Calculations of kinetic and potential energy will be learned at the high school level.

- **Standard 8.2.3** Engage in argument to identify the strongest evidence that supports the claim that the kinetic energy of an object changes as energy is transferred to or from the object. Examples could include observing temperature changes as a result of friction, applying force to an object, or releasing potential energy from an object.

- **Standard 8.2.4** Use computational thinking to describe a simple model for waves that shows the pattern of wave amplitude being related to wave energy. Emphasize describing waves with both quantitative and qualitative thinking. Examples could include using graphs, charts, computer simulations, or physical models to demonstrate amplitude and energy correlation.

- **Standard 8.2.5** Develop and use a model to describe the structure of waves and how they are reflected, absorbed, or transmitted through various materials. Emphasize both light and mechanical waves. Examples could include drawings, simulations, and written descriptions of light waves through a prism; mechanical waves through gas vs. liquids vs. solids; or sound waves through different mediums.

- **Standard 8.2.6** Obtain and evaluate information to communicate the claim that the structure of digital signals are a more reliable way to store or transmit information than analog signals. Emphasize the basic understanding that waves can be used for communication purposes. Examples could include using vinyl record vs. digital song files, film cameras vs. digital cameras, or alcohol thermometers vs. digital thermometers.
Strand 8.3: LIFE SYSTEMS STORE AND TRANSFER MATTER AND ENERGY

Living things use energy from their environment to rearrange matter to sustain life. Photosynthetic organisms are able to transfer light energy to chemical energy. Consumers can break down complex food molecules to utilize the stored energy and use the particles to form new, life-sustaining molecules. Ecosystems are examples of how energy can flow while matter cycles through the living and nonliving components of systems.

- **Standard 8.3.1** Plan and conduct an investigation and use the evidence to construct an explanation of how photosynthetic organisms use energy to transform matter. Emphasize molecular and energy transformations during photosynthesis.

- **Standard 8.3.2** Develop a model to describe how food is changed through chemical reactions to form new molecules that support growth and/or release energy as matter cycles through an organism. Emphasis is on describing that during cellular respiration molecules are broken apart and rearranged into new molecules, and that this process releases energy.

- **Standard 8.3.3** Ask questions to obtain, evaluate, and communicate information about how changes to an ecosystem affect the stability of cycling matter and the flow of energy among living and nonliving parts of an ecosystem. Emphasize describing the cycling of matter and flow of energy through the carbon cycle.
Strand 8.4: INTERACTIONS WITH NATURAL SYSTEMS AND RESOURCES

Interactions of matter and energy through geologic processes have led to the uneven distribution of natural resources. Many of these resources are nonrenewable, and per-capita use can cause positive or negative consequences. Global temperatures change due to various factors, and can cause a change in regional climates. As energy flows through the physical world, natural disasters can occur that affect human life. Humans can study patterns in natural systems to anticipate and forecast some future disasters and work to mitigate the outcomes.

- **Standard 8.4.1** *Construct a scientific explanation* based on evidence that shows that the uneven distribution of Earth's mineral, energy, and groundwater resources is caused by geological processes. Examples of uneven distribution of resources could include Utah's unique geologic history that led to the formation and irregular distribution of natural resources like copper, gold, natural gas, oil shale, silver, and uranium.

- **Standard 8.4.2** *Engage in argument supported by evidence* about the effect of per-capita consumption of natural resources on Earth's systems. Emphasize that these resources are limited and may be non-renewable. Examples of evidence include rates of consumption of food and natural resources such as freshwater, minerals, and energy sources.

- **Standard 8.4.3** *Design a solution* to monitor or mitigate the potential effects of the use of natural resources. *Evaluate* competing design solutions using a systematic process to determine how well each solution meets the criteria and constraints of the problem. Examples of uses of the natural environment could include agriculture, conservation efforts, recreation, solar energy, and water management.

- **Standard 8.4.4** *Analyze and interpret data* on the factors that change global temperatures and their effects on regional climates. Examples of factors could include agricultural activity, changes in solar radiation, fossil fuel use, and volcanic activity. Examples of data could include graphs of the atmospheric levels of gases, seawater levels, ice cap coverage, human activities, and maps of global and regional temperatures.

- **Standard 8.4.5** *Analyze and interpret patterns* of the occurrence of natural hazards to forecast future catastrophic events, and investigate how data are used to develop technologies to mitigate their effects. Emphasize how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow prediction, but others, such as earthquakes, may occur without warning.
<table>
<thead>
<tr>
<th>Element of Classroom Practice</th>
<th>Content-driven Teacher-centered</th>
<th>Closer...</th>
<th>Closer still...</th>
<th>3-Dimensional Student-centered</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Instruction</strong> (teacher TELLING, vs. eliciting student lang.)</td>
<td>75-100%</td>
<td>50-75%</td>
<td>25-50%</td>
<td>&lt;25%</td>
</tr>
<tr>
<td><strong>Use of Phenomena</strong></td>
<td>Offered as an example of a disciplinary core idea after direct instruction</td>
<td>Cookbook labs conducted before direct instruction</td>
<td>Student-built experiments before direct instruction</td>
<td>Exploring a phenomena motivates creation of experiment/model to explore content</td>
</tr>
<tr>
<td>Teacher uses <strong>questioning</strong> to motivate student thought/discussion</td>
<td>&lt;25%</td>
<td>25-50%</td>
<td>50-75%</td>
<td>75-100%</td>
</tr>
<tr>
<td>% that students are generating language (vs. copying notes/reading script)</td>
<td>&lt;25%</td>
<td>25-50%</td>
<td>50-75%</td>
<td>75-100%</td>
</tr>
<tr>
<td>Classroom community’s relationship to knowledge</td>
<td>Teacher has it, students work to get it from teacher</td>
<td>Teacher has it, creates experiences to show students (instead of tell)</td>
<td>Teacher has it, facilitates students to ‘discover’ it, as well</td>
<td>The world is full of it, and students can discover it with the support of teacher</td>
</tr>
<tr>
<td>Addressing misconceptions</td>
<td>Teacher tells students not to have misconceptions</td>
<td>Teacher creates discrepant event to challenge misconceptions</td>
<td>Students experience facilitated discrepant event that challenges their misconceptions</td>
<td>Student experiments allow meaning making, and misconceptions are acknowledged and corrected</td>
</tr>
<tr>
<td><strong>3-Dimensional Instruction</strong></td>
<td>CCCs not present “Scientific Method” taught as a numbered list of steps</td>
<td>Students name SEPs and use CCCs to organize ideas</td>
<td>Students engage with phenomenon and plan investigations</td>
<td>Students use SEPs to engage with phenomena, and use CCCs to organize ideas.</td>
</tr>
</tbody>
</table>
### Implementing 3D Instruction - A 4-Year Timeline

#### Year 1

### Classroom Culture
- Encourage a culture of questioning: offer equal positive feedback for student questions and answers.
- Explicitly support students to argue about ideas rather than with each other, and using evidence to support their arguments/ideas/opinions.

### Three Dimensions
- Resist teaching the “Scientific Method” in one unit at the start of the year. This creates a misconception that science proceeds in a linear list of steps, rather than a responsive, iterative deployment of practices based on the learning/communication that a situation requires.
- Explicitly name the science/engineering practice each lesson utilizes in front of students.
- Note how students engage with the science/engineering practice; as you reflect on lessons, think about what scaffolding techniques may be useful to help future students develop these skills.
- Introduce scientific modeling as formative assessment: pick a lesson or two where you can have students create explanatory models to show how they understand the concepts. Reflect on what went well and what scaffolding and questioning techniques may be useful in the future.

### Lesson Planning and Implementation
- Flip the order of instruction for lessons that include an investigation: let the students start with the investigation, allow them to make sense of their observations, and then introduce vocabulary and/or follow with direct instruction.
- For a few lessons, start with a relevant phenomenon that students can investigate.
- During some lessons, let students come up with questions about the topic being studied. Record student questions for future planning on that topic.

### Assessment
- Use the questions, models, and hypothesis that students generate as formative assessments throughout lessons to gauge student understanding.

### Professional Planning
- Keep a written reflection of what is working and what isn’t as you begin to implement pieces of the 3D model; record student questions, ideas for phenomena, scaffolding techniques, etc.
- Collect and learn about phenomena that you may be able to use in future lessons.
- Consider tasks/activities that you currently use; which could be further used/adapted to work within the 3D model, and which are not in line with the vision of NGSS?
- Engage in professional development opportunities, including building a community of teachers with whom you can plan/work to implement 3D instruction.

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Emily Harward

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### Year 2

#### Classroom Culture
- Incorporate partner, small group and whole group discussions; use scaffolding techniques and talk moves to make discussions meaningful and promote equity and student responsibility.
- Continue to cultivate a classroom culture where questioning and the process of learning is valued over products and right answers. Support students to publicly voice and change ideas when presented with new information.

#### Three Dimensions
- Use scaffolded approaches to help students equitably engage in the science practices; emphasize to students the science practice that they are engaged in.
- Start incorporating CCCs into lessons; when using a CCC, identify the CCC to students. Consider asking students to explain their understanding in terms of the CCC in writing prompts.
- Continue to use scientific modeling, deliberately asking students to model when modeling helps to build conceptual understanding. Providing scaffolds to help students create explanatory initial models from their background knowledge and assumptions when a new phenomenon is introduced.

#### Lesson Planning and Implementation
- Lessons begin with, and are based on, a phenomenon that students can investigate.
- Teacher anticipates and plans questions and strategies to guide students through exploration of phenomena.
- Student questions are incorporated into lessons; during lessons, students are investigating questions that they have generated.

#### Assessment
- Continue to use formative assessments daily.
- Use explanatory models, arguments supported by evidence, student questions and investigations as formative assessments.

#### Professional Planning
- Continue to participate in professional development and PLCs
- Write down how lessons and phenomena connect with each other; use these reflections to start building complete 3D lessons and storylines that you can use next year

#### Unit Planning and Storylines
- Start using an anchor phenomenon for a few units; throughout the unit, students gather and reason through information that will help them explain the anchor phenomenon
### Year 3

#### Classroom Culture
- Resist immediately correcting student misconceptions/answering all student questions. Instead, provide opportunities for students to gather and reason through authentic information to come to evidence-based explanations that address their own questions/misconceptions.
- Continue to cultivate a classroom culture where questioning and the process of learning is valued over products and right answers.
- Foster a climate where students reason through information both individually and in groups, and in which students know that making mistakes and coming up with “wrong” answers is a normal part of scientific exploration.

#### Three Dimensions
- Each lesson contains a clearly articulated SEP, CCC and DCI.

#### Lesson Planning and Implementation
- Questions generated during one lesson are used to plan the following lesson; anticipate student questions and use them to guide the planning process.
- Each lesson provides an opportunity for students to gather information, reason through the information they have collected, and communicate their ideas.

#### Assessment
- Continue to use formative assessments, including explanatory models, arguments supported by evidence, student questions and investigations.
- Use summative assessments which include all three dimensions; students show that they know the DCI through the lens of a given CCC, and also show proficiency in the SEP.

#### Professional Planning
- Continue to participate in professional development and PLCs, and explicitly commit time to plan and evaluate 3-Dimensional instruction.
- Continue to reflect on what is working and what is not; use reflections to inform future lesson and storyline planning.

#### Unit Planning and Storylines
- Start building and using storylines for some topics; each storyline should include an anchor phenomenon and several learning episodes with supporting phenomena that build students' knowledge/skills to explain the anchor phenomenon.
### Classroom Culture

- Implement strategies that help promote equity in the classroom, including strategies that allow all students to participate in small group and whole group discussions, small group investigations and sense-making activities.
- Continue to cultivate a classroom culture where questioning and the process of learning is valued over products and right answers.
- Continue to foster a climate where students reason through information both individually and in groups, and in which students know that making mistakes and coming up with “wrong” answers is a normal part of scientific exploration.

### Three Dimensions

- Each lesson contains an SEP, CCC and DCI.
- Plan and review storyline and lesson plans to ensure that students engage with several different SEPs and CCCs throughout the course.

### Lesson Planning and Implementation

- Use questions deliberately; pre-plan (in writing) the open-ended questions you will use to promote student engagement and understanding throughout the lesson; know why/when/how you will question students.
- Build lessons which provide an opportunity for students to gather information, reason through the information they have collected, and communicate their ideas in ways that are scientifically authentic.

### Assessment

- Continue to use formative assessments, including explanatory models, arguments supported by evidence, student questions and investigations.
- Summative assessments include all three dimensions; students show that they know the DCI through the lens of a given CCC, and also show proficiency in the SEP.

### Professional Planning

- Continue to participate in PD and PLCs, focusing on staying current on content.
- Use reflections in lesson and storyline planning.

### Unit Planning and Storylines

- The year is built as an overarching storyline made of smaller, interconnected ones. Each storyline includes an anchor phenomenon and learning episodes that build students’ knowledge/skills to explain the anchor phenomenon.
- Reflect on storylines as you teach and after you complete each; determine what changes could lead to improved student understanding in the future.
The solar system consists of the Sun, planets, and other objects within Sun’s gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

### Strand 6.1: STRUCTURE AND MOTION WITHIN THE SOLAR SYSTEM

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.

Earth and the Solar System
- This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

### Strand 6.1.1: EARTH’S PLACE IN THE UNIVERSE

Students who demonstrate understanding can:

**Develop and use a model** of the Sun-Earth-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. Examples of models could be physical, graphical, or conceptual.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing and Using Models</td>
<td>The Universe and Its Stars</td>
<td>Patterns</td>
</tr>
<tr>
<td>Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</td>
<td>• Patterns can be used to identify cause-and-effect relationships.</td>
<td></td>
</tr>
<tr>
<td>• Develop and use a model to describe phenomena.</td>
<td><strong>Earth and the Solar System</strong></td>
<td>Connections to Nature of Science</td>
</tr>
<tr>
<td></td>
<td>• This model of the solar system can explain eclipses of the sun and the moon.</td>
<td><strong>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</strong></td>
</tr>
<tr>
<td></td>
<td>Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.</td>
<td>• Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.</td>
</tr>
</tbody>
</table>

### 1. Components of the model

A. To make sense of a given phenomenon involving, students develop a model (e.g., physical, conceptual, graphical) of the Earth-moon-sun system in which they identify the relevant components, including:

i. Earth, including the tilt of its axis of rotation.
ii. Sun.
iii. Moon.
iv. Solar energy.

B. Students indicate the accuracy of size and distance (scale) relationships within the model, including any scale limitations within the model.

### 2. Relationships

A. In their model, students describe* the relationships between components, including:

i. Earth rotates on its tilted axis once an Earth day.
ii. The moon rotates on its axis approximately once a month.
iii. Relationships between Earth and the moon:
   1. The moon orbits Earth approximately once a month.
   2. The moon rotates on its axis at the same rate at which it orbits Earth so that the side of the moon that faces Earth remains the same as it orbits.
   3. The moon’s orbital plane is tilted with respect to the plane of the Earth’s orbit around the sun.
iv. Relationships between the Earth-moon system and the sun:
   1. Earth-moon system orbits the sun once an Earth year.
   2. Solar energy travels in a straight line from the sun to Earth and the moon so that the side of Earth or the moon that faces the sun is illuminated.
   3. Solar energy reflects off of the side of the moon that faces the sun and can travel to Earth.
   4. The distance between Earth and the sun stays relatively constant throughout the Earth’s orbit.
   5. Solar energy travels in a straight line from the sun and hits different parts of the curved Earth at different angles — more directly at the equator and less directly at the poles.
   6. The Earth’s rotation axis is tilted with respect to its orbital plane around the sun. Earth maintains the same relative orientation in space, with its North Pole pointed toward the North Star throughout its orbit.
The solar system consists of the Sun, planets, and other objects within Sun’s gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

Strand 6.1: STRUCTURE AND MOTION WITHIN THE SOLAR SYSTEM

Students who demonstrate understanding can:

Develop and use a model of the Sun-Earth-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. Examples of models could be physical, graphical, or conceptual.

3. Connections

A. Students use patterns observed from their model to provide causal accounts for events, including:

i. Moon phases:
   1. Solar energy coming from the sun bounces off of the moon and is viewed on Earth as the bright part of the moon.
   2. The visible proportion of the illuminated part of the moon (as viewed from Earth) changes over the course of a month as the location of the moon relative to Earth and the sun changes.
   3. The moon appears to become more fully illuminated until “full” and then less fully illuminated until dark, or “new,” in a pattern of change that corresponds to what proportion of the illuminated part of the moon is visible from Earth.

   ii. Eclipses:
      1. Solar energy is prevented from reaching the Earth during a solar eclipse because the moon is located between the sun and Earth.
      2. Solar energy is prevented from reaching the moon (and thus reflecting off of the moon to Earth) during a lunar eclipse because Earth is located between the sun and moon.
      3. Because the moon’s orbital plane is tilted with respect to the plane of the Earth’s orbit around the sun, for a majority of time during an Earth month, the moon is not in a position to block solar energy from reaching Earth, and Earth is not in a position to block solar energy from reaching the moon.

   iii. Seasons:
      1. Because the Earth’s axis is tilted, the most direct and intense solar energy occurs over the summer months, and the least direct and intense solar energy occurs over the winter months.
      2. The change in season at a given place on Earth is directly related to the orientation of the tilted Earth and the position of Earth in its orbit around the sun because of the change in the directness and intensity of the solar energy at that place over the course of the year.
         a. Summer occurs in the Northern Hemisphere at times in the Earth’s orbit when the northern axis of Earth is tilted toward the sun. Summer occurs in the Southern Hemisphere at times in the Earth’s orbit when the southern axis of Earth is tilted toward the sun.
         b. Winter occurs in the Northern Hemisphere at times in the Earth’s orbit when the northern axis of Earth is tilted away from the sun. Summer occurs in the Southern Hemisphere at times in the Earth’s orbit when the southern axis of Earth is tilted away from the sun.

B. Students use their model to predict:

i. The phase of the moon when given the relative locations of the Earth, sun, and moon.

ii. The relative positions of the Earth, sun, and moon when given a moon phase.

iii. Whether an eclipse will occur, given the relative locations of the Earth, sun, and moon and a position on Earth from which the moon or sun can be viewed (depending on the type of eclipse).

iv. The relative positions of the Earth, sun, and moon, given a type of eclipse and a position on Earth from which the moon/sun can be viewed.

v. The season on Earth, given the relative positions of Earth and the sun (including the orientation of the Earth’s axis) and a position on Earth.

vi. The relative positions of Earth and the sun when given a season and a relative position (e.g. far north, far south, equatorial) on Earth.
Strand 6.1: STRUCTURE AND MOTION WITHIN THE SOLAR SYSTEM

The solar system consists of the Sun, planets, and other objects within Sun’s gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

Strand 6.1.2: Earth’s Place in the Universe

Students who demonstrate understanding can:

Develop and use a model to describe the role of gravity and inertia in orbital motions of objects in our solar system.

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<th>Science and Engineering Practices</th>
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<tr>
<td>Developing and Using Models</td>
<td>The Universe and Its Stars</td>
<td>Patterns</td>
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<tr>
<td>Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</td>
<td>• Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.</td>
<td>• Models can be used to represent systems and their interactions.</td>
</tr>
<tr>
<td>• Develop and use a model to describe phenomena.</td>
<td><strong>Earth and the Solar System</strong></td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td>• 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.</td>
<td>Connections to Nature of Science</td>
</tr>
<tr>
<td></td>
<td>• The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.</td>
<td>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</td>
</tr>
</tbody>
</table>

1. **Components of the model**
   
   A. To make sense of a given phenomenon involving, students develop a model (e.g., physical, conceptual, graphical) of the Earth-moon-sun system in which they identify the relevant components, including:
      i. Gravity.
      ii. The solar system as a collection of bodies, including the sun, planets, moons, and asteroids.
      iii. The Milky Way Galaxy as a collection of stars (e.g., the sun) and their associated systems of objects.
      iv. Other Galaxies in the universe.
   
   B. Students indicate the relative spatial scales of solar systems and galaxies in the model.

2. **Relationships**
   
   A. Students describe* the relationships and interactions between components of the solar and galaxy systems, including:
      i. Gravity as an attractive force between solar system and galaxy objects that:
         1. Increases with the mass of the interacting object increases.
         2. Decreases as the distances between objects increases.
      ii. The orbital motion of objects in our solar system (e.g., moons orbit around planets, all objects within the solar system orbit the sun)
      iii. The orbital motion, in the form of a disk, of vast numbers of stars around the center of the Milky Way.
      iv. That our solar system is on of many systems orbiting the center of the larger system of the Milky Way Galaxy.
      v. The Milky Way is one of many galaxy systems in the universe.

3. **Connections**
   
   A. Students use the model to describe* that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects.
Strand 6.1: STRUCTURE AND MOTION WITHIN THE SOLAR SYSTEM

The solar system consists of the Sun, planets, and other objects within Sun’s gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

Strand 6.1.2: Earth’s Place in the Universe

Students who demonstrate understanding can:

**Develop and use a model** to describe the role of gravity and inertia in orbital motions of objects in our solar system.

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<tr>
<th><strong>B.</strong></th>
<th>Students use the model to describe* that gravity causes a pattern of smaller/less massive objects orbiting around larger/more massive objects at all system scales in the universe, including that:</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.</td>
<td>Gravitational forces from planets cause smaller objects (e.g., moons) to orbit around planets.</td>
</tr>
<tr>
<td>ii.</td>
<td>The gravitational force of the sun causes the planets and other bodies to orbit around it, holding the solar system together.</td>
</tr>
<tr>
<td>iii.</td>
<td>The gravitational forces from the center of the Milky Way causes stars and stellar systems to orbit around the center of the galaxy.</td>
</tr>
<tr>
<td>iv.</td>
<td>The hierarchy pattern of orbiting systems in the solar system was established early its history as the disk of dust and gas was driven by gravitational forces to form moon-planet and planet-sun orbiting systems.</td>
</tr>
</tbody>
</table>

| **C.** | Students use the model to describe* that objects too far away from the sun do not orbit it because the sun’s gravitational force on those objects is too weak to pull them into orbit. |

| **D.** | Students use the model to describe* what a given phenomenon might look like without gravity (e.g., smaller planets would move in straight paths through space, rather than orbiting a more massive body). |
The solar system consists of the Sun, planets, and other objects within Sun’s gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

Strand 6.1.3: Earth’s Place in the Universe

Students who demonstrate understanding can:

Use computation thinking to analyze data and determine the scale and properties of objects in the solar system.

Examples of scale could include size and distance. Examples of properties could include layers, temperature, surface features, and orbital radius. Data sources could include Earth and space-based instruments such as telescopes and satellites. Types of data could include graphs, data tables, drawings, photographs, and models.

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<td>Analyzing and Interpreting Data</td>
<td>Earth and the Solar System</td>
<td>Scale, Proportion, and Quantity</td>
</tr>
<tr>
<td>Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis and investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.</td>
<td>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.</td>
<td>Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</td>
</tr>
<tr>
<td>• Analyze and interpret data to determine similarities and differences in findings.</td>
<td></td>
<td>Connections to Engineering, Technology, and Applications of Science</td>
</tr>
</tbody>
</table>

1. Organizing Data
   A. Students organize given data on solar system objects (e.g., surface features, object layers, orbital radii) from various Earth-and space-based instruments to allow for analysis and interpretation (e.g., transforming tabular data into pictures, diagrams, graphs, or physical models that illustrate changes in scale).
   B. Students describe* that different representations illustrate different characteristics of objects in the solar system, including differences in scale.

2. Identifying Relationships
   A. Students use quantitative analyses to describe* similarities and differences among solar system objects by describing patterns of features of those objects at different scales, including:
      i. Distance from the sun.
      ii. Diameter.
      iii. Surface features (e.g., size of volcanoes)
      iv. Structure.
      v. Composition (e.g., ice versus rock versus gas)
   B. Students identify advances in solar system science made possible by improved engineering (e.g., knowledge of the evolution of the solar system from lunar exploration and space probes) and new developments in engineering made possible by advances in science (e.g., space-based telescopes from advances in optics and aerospace engineering).

3. Interpreting data
   A. Students use the patterns they find in multiple types of data at varying scales to draw conclusions about the identifying characteristics of different categories of solar system objects (e.g., planets, meteors, asteroids, comets) based on their features, composition, and locations within the solar system (e.g., most asteroids are rocky bodies between Mars and Jupiter, while most comets reside in orbits farther from the sun and are composed mostly of ice).
   B. Students use patterns in data as evidence to describe* that two objects may be similar when viewed at one scale (e.g., diameter or number of natural satellites).
   C. Students use the organization of data to facilitate drawing conclusions about the patterns of scale properties at more than one scale, such as those that are too large or too small to directly observe.
6.2: ENERGY AFFECTS MATTER

Matter and energy are fundamental components of the universe. Matter is anything that has mass and takes up space. Transfer of energy creates change in matter. Changes between general states of matter can occur through the transfer of energy. Density describes how closely matter is packed together. Substances with a high density have more matter in a given space than substances with a lower density. Changes in heat energy can alter the density of a material. Insulators resist the transfer of heat energy, while conductors easily transfer heat energy. These differences in energy flow can be used to design products to meet the needs of society.

Strand 6.2.1: MATTER AND ITS INTERACTIONS

Students who demonstrate understanding can:

**Develop models** to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and Carbon dioxide (CO₂).

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<td>Developing and Using Models</td>
<td>Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).</td>
<td>Scale, Proportion, and Quantity • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</td>
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1. **Components of the Model**
   A. Students develop models of atomic composition of simple molecules and extended structures that vary in complexity. In the models, students identify the relevant components, including:
   i. Individual atoms.
   ii. Molecules.
   iii. Extended structures with repeating subunits.
   iv. Substances (e.g., solids, liquids, and gases at the macro level)

2. **Relationships**
   A. In the model, students describe relationships between components, including:
   i. Individual atoms, from two to thousands, combine to form molecules, which can be made up of the same type or different types of atom.
   ii. Some molecules can connect to each other.
   iii. In some molecules, the same atoms of different elements repeat; in other molecules, the same atom of a single element repeats.

3. **Connections**
   A. Students Use Models to describe that:
   i. Pure substances are made up of a bulk quantity of individual atoms or molecules. Each pure substance is made up of one of the following:
      1. Individual atoms of the same type that are connected to form extended structures.
      2. Individual atoms of different types that repeat to form extended structures (e.g., sodium chloride).
      3. Individual atoms that are not attracted to each other (e.g., helium).
      4. Molecules of different types of atoms that are not attracted to each other (e.g., carbon dioxide).
      5. Molecules of different types of atoms that are attracted to each other to form extended structures (e.g., sugar, nylon).
      6. Molecules of the same type of atom that are not attracted to each other (e.g., oxygen).
   ii. Students use the models to describe how the behavior of bulk substances depends on their structures at atomic and molecular levels, which are too small to see.
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**Strand 6.2.1: MATTER AND ITS INTERACTIONS**

Students who demonstrate understanding can: Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

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**Science and Engineering Practices**

**Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to predict and/or describe phenomena.

---

**Disciplinary Core Ideas**

**Structure and Properties of Matter**

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

**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.
- The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.

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**Crosscutting Concepts**

**Scale, Proportion, and Quantity**

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
### 6.2: ENERGY AFFECTS MATTER

Matter and energy are fundamental components of the universe. Matter is anything that has mass and takes up space. Transfer of energy creates change in matter. Changes between general states of matter can occur through the transfer of energy. Density describes how closely matter is packed together. Substances with a high density have more matter in a given space than substances with a lower density. Changes in heat energy can alter the density of a material. Insulators resist the transfer of heat energy, while conductors easily transfer heat energy. These differences in energy flow can be used to design products to meet the needs of society.

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#### 3. Connections

A. Students use their model to provide a causal account of the relationship between the addition or removal of thermal energy from a substance and the change in the average kinetic energy of the particles in the substance.

B. Students use their model to provide a causal account of the relationship between:
   i. The temperature of the system.
   ii. Motions of molecules in the gaseous phase.
   iii. The collisions of those molecules with other materials, which exerts a force called pressure.

C. Students use their model to provide a causal account of what happens when thermal energy is transferred into a system, including that:
   i. An increase in kinetic energy of the particles can cause:
      1. An increase in the temperature of the system as the motion of the particles relative to each other increases, or
      2. A substance to change state from a solid to a liquid or from a liquid to a gas.
   ii. The motion of molecules in a gaseous state increases, causing the moving molecules in the gas to have greater kinetic energy, thereby colliding with molecules in surrounding materials with greater force (i.e., the pressure of the system increases).

D. Students use their model to provide a causal account of what happens when thermal energy is transferred from a substance, including that:
   i. Decreased kinetic energy of the particles can cause:
      1. A decrease in the temperature of the system as the motion of the particles relative to each other decreases, or
      2. A substance to change state from a gas to a liquid or from a liquid to a solid.
   ii. The pressure that a gas exerts decreases because the kinetic energy of the gas molecules decreases, and the slower molecules exert less force in collisions with other molecules in surrounding materials.

E. Students use their model to provide a causal account for the relationship between changes in pressure of a system and changes of the states of materials in the system.
   i. With a decrease in pressure, a smaller addition of thermal energy is required for particles of a liquid to change to gas because particles in the gaseous state are colliding with the surface of the liquid less frequently and exerting less force on the particles in the liquid, thereby allowing the particles in the liquid to break away and move into the gaseous state with the addition of less energy.
   ii. With an increase in pressure, a greater addition of thermal energy is required for particles of a liquid to change to gas because particles in the gaseous state are colliding with the surface of the liquid more frequently and exerting greater force on the particles in the liquid, thereby limiting the movement of particles from the liquid to gaseous state.
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**Strand 6.2.4: ENERGY**

Students who demonstrate understanding can:

**Plan and carry out an investigation** to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

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<td><strong>Planning and Carrying out Investigations.</strong> Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.</td>
<td><strong>Definitions of Energy</strong> • 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.</td>
<td><strong>Scale, Proportion, and Quantity</strong> • Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provided information about the magnitude of properties and processes.</td>
</tr>
<tr>
<td>• Plan an investigation individually and collaboratively and in the design: identify independent and dependent variables and controls what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.</td>
<td><strong>Conservation of Energy and Energy Transfer</strong> • The amount of energy transfer needed to change the temperature of a matter sample by given amount depends on the nature of matter, the size of the sample, and the environment.</td>
<td></td>
</tr>
</tbody>
</table>

**Connections to Nature of Science**

**Scientific Knowledge is Based on Empirical Evidence**

• Science knowledge is based upon logical and conceptual connections between evidence and explanations.

1. **Identifying the phenomenon under investigation.**
   A. Students identify the phenomenon under investigation involving thermal energy transfer.
   B. Students describe the purpose of the investigation, including determining the relationships among the following factors:
      I. The transfer of thermal energy.
      II. The type of matter.
      III. The mass of the matter involved in thermal energy transfer.
      IV. The change in the average kinetic energy of the particles.

2. **Identifying the evidence to address the purpose of the investigation**
   A. Individually or collaboratively, students develop an investigation plan that describes* the data to be collected and the evidence to be derived from the data, including:
      i. That the following data are to be collected:
         1. Initial and final temperatures of the materials used in the investigation.
         2. Types of matter used in the investigation.
         3. Mass of matter used in the investigation.
      ii. How the collected data will be used to:
         1. Provide evidence of proportional relationships between changes in temperature of materials and the mass of those materials.
         2. Relate the changes in temperature in the sample to the types of matter and to the change in the average kinetic energy of the particles.
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**Strand 6.2.4: ENERGY**

Students who demonstrate understanding can:

**Plan and carry out an investigation** to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

### 3. Planning the Investigation

A. In the investigation plan, students describe:
   
i. How the mass of the materials are to be measured and in what units.
   
ii. How and when the temperatures of the materials are to be measured and in what units.
   
iii. Details of the experimental conditions that will allow the appropriate data to be collected to address the purpose of the investigation (e.g., time between temperature measurements, amounts of sample used, types of materials used), including appropriate independent and dependent variables and controls.
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**Strand 6.2.4: ENERGY**

Students who demonstrate understanding can: **Design** and object, tool, or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing, analyze data from testing, and propose modifications for optimizing the **design solution**. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

### 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.

### Conservation of Energy and Energy Transfer
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

### 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 the other relevant knowledge that is likely to limit possible solutions. (secondary)

### 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)

### Crosscutting Concepts

**Energy and Matter**
- The transfer of energy can be tracked as energy flows through a designed or natural system.

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| **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. | **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. | **Energy and Matter**
- The transfer of energy can be tracked as energy flows through a designed or natural system. |
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| **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) | | |

1. **Using scientific knowledge to generate design solutions**
   - A. Given a problem to solve that requires either minimizing or maximizing thermal energy transfer, students design and build a solution to the problem. In the designs, students:
     - i. Identify that thermal energy is transferred from hotter objects to colder objects.
     - ii. Describe different types of materials used in the design solution and their properties (e.g., thickness, heat conductivity, reflectivity) and how these materials will be used to minimize or maximize thermal energy transfer.
     - iii. Specify how the device will solve the problem.

2. **Relationships**
   - A. Students describe the given criteria and constraints that will be taken into account in the design solution:
     - i. Students describe criteria, including:
       1. The minimum or maximum temperature difference that the device is required to maintain.
       2. The amount of time that the device is required to maintain this difference.
       3. Whether the device is intended to maximize or minimize the transfer of thermal energy.
     - ii. Students describe constraints, which may include:
       1. Materials.
       2. Safety.
       3. Time.
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**Strand 6.2.4: ENERGY**

Students who demonstrate understanding can: **Design** and object, tool, or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing, analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

3. **Connections**
   - A. Students test the device to determine its ability to maximize or minimize the flow of thermal energy, using the rate of temperature change as a measure of success.
   - B. Students use their knowledge of thermal energy transfer and the results of the testing to evaluate the design systematically against the criteria and constraints.
6.3: EARTH’S WEATHER PATTERNS AND CLIMATE

All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth’s weather and drives the water cycle. Uneven heating across Earth’s surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

Strand 6.3.1: EARTH’S SYSTEMS

Students who demonstrate understanding can: Develop a model to describe how the cycling of water through Earth’s systems is driven by energy from the Sun, gravitational forces, and density.

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</tr>
<tr>
<td>Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</td>
<td>• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.</td>
<td>• Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.</td>
</tr>
<tr>
<td></td>
<td>• Global movements of water and its charges in form and propelled by sunlight and gravity.</td>
<td></td>
</tr>
</tbody>
</table>

1. **Components of the model**
   A. To make sense of a phenomenon, students develop a model in which they identify the relevant components:
      i. Water (liquid, solid, and in the atmosphere).
      ii. Energy in the form of sunlight.
      iii. Gravity.
      iv. Atmosphere.
      v. Landforms.
      vi. Plants and other living things.

2. **Relationships**
   A. In their model, students describe* the relevant relationships between components, including:
      i. Energy transfer from the sun warms water on Earth, which can evaporate into the atmosphere.
      ii. Water vapor in the atmosphere forms clouds, which can cool and condense to produce precipitation that falls to the surface of Earth.
      iii. Gravity causes water on land to move downhill (e.g., rivers and glaciers) and much of it eventually flows into oceans.
      iv. Some liquid and solid water remains on land in the form of bodies of water and ice sheets.
      v. Some water remains in the tissues of plants and other living organisms, and this water is released when the tissues decompose.
**6.3: EARTH’S WEATHER PATTERNS AND CLIMATE**

All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth’s weather and drives the water cycle. Uneven heating across Earth’s surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

**Strand 6.3.1: EARTH’S SYSTEMS**

Students who demonstrate understanding can:

**Develop a model** to describe how the cycling of water through Earth’s systems is driven by energy from the Sun, gravitational forces, and density.

<table>
<thead>
<tr>
<th>Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Students use the model to account for both energy from light and the force of gravity driving water cycling between oceans, the atmosphere, and land, including that:</td>
</tr>
<tr>
<td>1. Energy from the sun drives the movement of water from the Earth (e.g., oceans, landforms, plants, into the atmosphere through transpiration and evaporation.</td>
</tr>
<tr>
<td>2. Water vapor in the atmosphere can cool and condense to form rain or crystallize to form snow or ice, which returns to Earth when pulled down by gravity.</td>
</tr>
<tr>
<td>3. Some rain falls back into the ocean, and some rain falls on land. Water that falls on land can:</td>
</tr>
<tr>
<td>1. Be pulled down by gravity to form surface waters such as rivers, which join together and generally flow back into the ocean.</td>
</tr>
<tr>
<td>2. Evaporate back into the atmosphere.</td>
</tr>
<tr>
<td>3. Be taken up by plants, which release it through transpiration and also eventually through decomposition.</td>
</tr>
<tr>
<td>4. Be taken up by animals, which release it through respiration and also eventually through decomposition.</td>
</tr>
<tr>
<td>5. Freeze (crystallize) and/or collect in frozen form, in some cases forming glaciers or ice sheets.</td>
</tr>
<tr>
<td>6. Be stored on land in bodies of water or below ground in aquifers.</td>
</tr>
</tbody>
</table>

B. Students use their model to describe that the transfer of energy between water and its environment drives the phase changes that drive water cycling through evaporation, transpiration, condensation, crystallization, and precipitation.

C. Students use the model to describe how gravity interacts with water in different phases and locations to drive water cycling between the Earth’s surface and atmosphere.
All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth’s weather and drives the water cycle. Uneven heating across Earth’s surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

**Strand 6.3.2: EARTH’S SYSTEMS**

Students who demonstrate understanding can: 

**Investigate** the interactions between air masses that cause changes in weather conditions. Collect and analyze weather data to provide evidence for how air masses flow from regions of high pressure to low pressure causing a change in weather. Examples of data collection could include field observations, laboratory experiments, weather maps, or diagrams.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
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</thead>
<tbody>
<tr>
<td>Planning and Carrying Out Investigations</td>
<td>The Roles of Water in Earth’s Surface processes</td>
<td>Cause and Effect</td>
</tr>
<tr>
<td>Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.</td>
<td>• The complex patterns of the changes and the movement of water in the atmosphere determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.</td>
<td>• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td>
</tr>
<tr>
<td>• Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.</td>
<td>• Because these patterns are so complex, weather can only be predicted probabilistically.</td>
<td></td>
</tr>
</tbody>
</table>

1. **Identifying the phenomenon under investigation**
   A. From the given investigation plan, students describe the phenomenon under investigation, which includes the relationships between air mass interactions and weather conditions.
   B. Students identify the purpose of the investigation, which includes providing evidence to answer questions about how motions and complex interactions of air masses result in changes in weather conditions [note: examples of students regarding mechanisms are limited to relationships between patterns of activity of air masses and changes in weather].

2. **Identifying the evidence to address the purpose of the investigation**
   A. From a given investigation plan, students describe the data to be collected and the evidence to be derived from the data that would indicate relationships between air mass movement and changes in weather, including:
      i. Patterns in weather conditions in a specific area (e.g., temperature, air pressure, humidity, wind speed) over time.
      ii. The relationship between the distribution and movement of air masses and landforms, ocean temperatures, and currents.
      iii. The relationship between observed large-scale weather patterns and the location or movement of air masses, including patterns that develop between air masses (e.g., cold fronts may be characterized by thunderstorms).
   B. Students describe how the evidence to be collected will be relevant to determining the relationship between patterns of activity of air masses and changes in weather conditions.
   C. Students describe that because weather patterns are so complex and have multiple causes, weather can be predicted only probabilistically.

3. **Planning the investigation**
   A. Students describe the tools and methods used in the investigation, including how they are relevant to the purpose of the investigation.

4. **Collecting the data**
   A. According to the provided investigation plan, students make observations and record data, either firsthand and/or from professional weather monitoring services.
6.3: EARTH’S WEATHER PATTERNS AND CLIMATE

All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth’s weather and drives the water cycle. Uneven heating across Earth’s surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

Strand 6.3.3: EARTH’S SYSTEMS

Students who demonstrate understanding can:
**Develop and use a model** to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Examples of models could include Utah regional weather patterns such as lake-effect snow and wintertime temperature inversions.

<table>
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<tbody>
<tr>
<td>Developing and Using Models</td>
<td>The Roles of Water in Earth’s Surface processes: Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. <strong>Weather and Climate</strong> 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. 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.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.</td>
</tr>
</tbody>
</table>

1. **Components of the model**
   A. To make sense of a phenomenon, students develop a model in which they identify the relevant components of the system, with inputs and outputs, including:
      i. The rotating Earth.
      ii. The atmosphere.
      iii. The ocean, including the relative rate of thermal energy transfer of water compared to land or air.
      iv. Continents and the distribution of landforms on the surface of the Earth.
      v. Global distribution of ice.
      vi. Distribution of living things
      vii. Energy
         1. Radiation from the sun as an input.
         2. Thermal energy that exists in the atmosphere, water, land, and ice (as represented by temperature).
6.3: EARTH’S WEATHER PATTERNS AND CLIMATE

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2. **Relationships**

   A. In the model, students identify and describe the relationships between components of the system, including:
      
      i. Differences in the distribution of solar energy and temperature changes, including:
         1. Higher latitudes receive less solar energy per unit of area than do lower latitudes, resulting in temperature differences based on latitude.
         2. Smaller temperature changes tend to occur in oceans than on land in the same amount of time.
         3. In general, areas at high elevations have lower average temperatures than do areas at lower elevations.
         4. Features on the Earth’s surface, such as the amount of solar energy reflected back into the atmosphere or the absorption of solar energy by living things, affect the amount of solar energy transferred into heat energy.
      
      ii. Motion of ocean waters and air masses (matter):
         1. Fluid matter (i.e., air, water) flows from areas of higher density to areas of lower density (due to temperature or salinity). The density of a fluid can vary for several different reasons (e.g., changes in salinity and temperature of water can each cause changes in density). Differences in salinity and temperature can, therefore, cause fluids to move vertically and, as a result of vertical movement, also horizontally because of density differences.
      
      iii. Factors affecting the motion of wind and currents:
         1. The Earth’s rotation causes oceanic and atmospheric flows to curve when viewed from the rotating surface of Earth (Coriolis force).
         2. The geographical distribution of land limits where ocean currents can flow.
         3. Landforms affect atmospheric flows (e.g., mountains deflect wind and/or force it to higher elevation).
      
      iv. Thermal energy transfer:
         1. Thermal energy moves from areas of high temperature to areas of lower temperature either through the movement of matter, via radiation, or via conduction of heat from warmer objects to cooler objects.
         2. Absorbing or releasing thermal energy produces a more rapid change in temperature on land compared to in water.
         3. Absorbing or releasing thermal energy produces a more rapid change in temperature in the atmosphere compared to either on land or in water so the atmosphere is warmed or cooled by being in contact with land or the ocean.
6.3: EARTH’S WEATHER PATTERNS AND CLIMATE

All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth’s weather and drives the water cycle. Uneven heating across Earth’s surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

Strand 6.3.3: EARTH’S SYSTEMS

Students who demonstrate understanding can:

**Develop and use a model** to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Examples of models could include Utah regional weather patterns such as lake-effect snow and wintertime temperature inversions.

3. **Connections**

A. Students use the model to describe:
   i. The general latitudinal pattern in climate (higher average annual temperatures near the equator and low average annual temperatures at higher latitudes) caused by more direct light (greater energy per unit of area) at the equator (more solar energy) and less direct light at the poles (less solar energy).
   ii. The general latitudinal pattern of drier and wetter climates caused by the shift in the amount of air moisture during precipitation from rising moisture-rich air and the sinking of dry air.
   iii. The pattern of differing climates in continental areas as compared to the oceans. Because water can absorb more solar energy for every degree change in temperature compared to land, there is a greater and more rapid temperature change on land than in the ocean. At the centers of landmasses, this leads to conditions typical of continental climate patterns.
   iv. The pattern that climates near large water bodies, such as marine coasts, have comparatively smaller changes in temperature relative to the center of the landmass. Land near the oceans can exchange thermal energy through the air, resulting in smaller changes in temperature. At the edges of landmasses, this leads to marine climates.
   v. The pattern that climates at higher altitudes have lower temperatures than climates at lower altitudes. Because of the direct relationship between temperature and pressure, given the same amount of thermal energy, air at lower pressures (higher altitudes) will have lower temperatures than air at higher pressures (lower altitudes).
   vi. Regional patterns of climate (e.g., temperature or moisture) related to a specific pattern of water or air circulation, including the role of the following in contributing to the climate pattern:
      1. Air or water moving from areas of high temperature, density, and/or salinity to areas of low temperature, density, and/or salinity.
      2. The Earth’s rotation, which affects the atmospheric and oceanic circulation.
      3. The transfer of thermal energy with the movement of matter.
      4. The presence of landforms (e.g., the rain shadow effect).

B. Students use the model to describe the role of each of its components in producing a given regional climate.
### 6.3: EARTH’S WEATHER PATTERNS AND CLIMATE

All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth’s weather and drives the water cycle. Uneven heating across Earth’s surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

### Strand 6.3.4:

Students who demonstrate understanding can:

**Construct and explanation supported by evidence** for the role of the natural greenhouse effect in Earth’s Energy balance, and how it enables life to exist on Earth. Examples could include comparisons between Earth and other planets such as Venus and Mars.

No evidence statements available as of July 2017
The study of ecosystems includes the interaction of organisms with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

Strand 6.4.1: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

Students who demonstrate understanding can:
- **Analyze data** to provide evidence for the effects of resource availability on organisms and populations in an ecosystem.
- **Ask questions** to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

### Science and Engineering Practices

#### Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to provide evidence for phenomena.

#### Disciplinary Core Ideas

**Interdependent Relationships in Ecosystems**

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth organisms and population increases are limited by access to resources.

#### Crosscutting Concepts

**Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>1. Organizing data</strong></td>
<td><strong>Disciplinary Core Ideas</strong></td>
</tr>
<tr>
<td>A. Students organize the given data (e.g., using tables, graphs, and charts) to allow for analysis and interpretation of relationships between resource availability and organisms in an ecosystem, including:</td>
<td><strong>Interdependent Relationships in Ecosystems</strong></td>
</tr>
<tr>
<td>i. Populations (e.g., sizes, reproduction rates, growth information) of organisms as a function of resource availability.</td>
<td>• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.</td>
</tr>
<tr>
<td>ii. Growth of individual organisms as a function of resource availability.</td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td>• Growth organisms and population increases are limited by access to resources.</td>
</tr>
<tr>
<td><strong>2. Identifying relationships</strong></td>
<td></td>
</tr>
<tr>
<td>A. Students analyze the organized data to determine the relationships between the size of a population, the growth and survival of individual organisms, and resource availability.</td>
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<tr>
<td>B. Students determine whether the relationships provide evidence of a causal link between these factors.</td>
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<tr>
<td><strong>3. Interpreting data</strong></td>
<td></td>
</tr>
<tr>
<td>A. Students analyze and interpret the organized data to make predictions based on evidence of causal relationships between resource availability, organisms, and organism populations. Students make relevant predictions, including:</td>
<td></td>
</tr>
<tr>
<td>i. Changes in the amount and availability of a given resource (e.g., less food) may result in changes in the population of an organism (e.g., less food results in fewer organisms).</td>
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<tr>
<td>ii. Changes in the amount or availability of resource (e.g., more food) may result in changes in the growth of individual organisms (e.g., more food results in faster growth).</td>
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<tr>
<td>iii. Resource availability drives competition among organisms, both within a population as well as between populations.</td>
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<tr>
<td>iv. Resource availability may have effects on a population’s rate of reproduction.</td>
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</tbody>
</table>
## 6.4: STABILITY AND CHANGE IN ECOSYSTEMS

The study of ecosystems includes the interaction of organism with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

### Strand 6.4.2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

Students who demonstrate understanding can:

**Construct an explanation** that predicts patterns of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments, such as competition, predation, and mutualism.

<table>
<thead>
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<th>Science and Engineering Practices</th>
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<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constructing Explanations and Designing Solutions</strong></td>
<td><strong>Interdependent Relationships in Ecosystems</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.</td>
<td>• 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.</td>
<td>• Patterns can be used to identify cause and effect relationships.</td>
</tr>
</tbody>
</table>

1. **Articulating the explanation of phenomena**
   - A. Students articulate a statement that relates the given phenomenon to a scientific idea, including that similar patterns of interactions occur between organisms and their environment, regardless of the ecosystem or the species involved.
   - B. Students use evidence and reasoning to construct an explanation for the given phenomenon.

2. **Evidence**
   - A. Students identify and describe the evidence (e.g., from students’ own investigations, observations, reading material, archived data) necessary for constructing the explanation, including evidence that:
     - i. Competitive relationships occur when organisms within an ecosystem compete for shared resources (e.g., data about the change in population of a given species when a competing species is introduced).
     - ii. Predatory interactions occur between organisms within an ecosystem.
     - iii. Mutually beneficial interactions occur between organisms within an ecosystem. Organisms involved in these mutually beneficial interactions can become so dependent upon one another that they cannot survive alone.
     - iv. Resource availability, or lack thereof, can affect interactions between organisms (e.g., organisms in a resource-limited environment may have a competitive relationship, while those same organisms may not be in competition in a resource-rich environment).
     - v. Competitive, predatory, and mutually beneficial interactions occur across multiple, different, ecosystems.
   - B. Students use multiple valid and reliable sources for the evidence.
The study of ecosystems includes the interaction of organism with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

**Strand 6.4.2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Students who demonstrate understanding can:

**Construct an explanation** that predicts patterns of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments, such as competition, predation, and mutualism.

3. **Reasoning.**

   A. Students identify and describe quantitative or qualitative patterns of interactions among organisms that can be used to identify causal relationships within ecosystems, related to the given phenomenon.

   B. Students describe that regardless of the ecosystem or species involved, the patterns of interactions (competitive, mutually beneficial, predator/prey) are similar.

   C. Students use reasoning to connect the evidence and support an explanation. In their reasoning, students use patterns in the evidence to predict common interactions among organisms in ecosystems as they relate to the phenomenon, (e.g., given specific organisms in a given environment with specified resource availability, which organisms in the system will exhibit competitive interactions). Students predict the following types of interactions:

   i. Predatory interactions.

   ii. Competitive interactions.

   iii. Mutually beneficial interactions.
6.4: STABILITY AND CHANGE IN ECOSYSTEMS

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**Strand 6.4.3: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Students who demonstrate understanding can:

**Develop a model** to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

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<th>Science and Engineering Practices</th>
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<td><strong>Developing and Using Models</strong></td>
<td><strong>Cycle of matter and Energy Transfer in Ecosystems</strong></td>
<td><strong>Energy and Matter</strong></td>
</tr>
<tr>
<td>Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</td>
<td>• Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.</td>
<td>• The transfer of energy can be tracked as energy flows through a natural system.</td>
</tr>
</tbody>
</table>

**Connections to Nature of Science**

**Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

1. **Components of the model**
   
   A. To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
   
   i. Organisms that can be classified as producers, consumers, and/or decomposers.
   
   ii. Nonliving parts of an ecosystem (e.g., water, minerals, air) that can provide matter to living organisms or receive matter from living organisms.
   
   iii. Energy
   
   B. Students define the boundaries of the ecosystem under consideration in their model (e.g., pond, part of a forest, meadow; a whole forest, which contains a meadow, pond, and stream).

2. **Relationships**

   A. In the model, students describe relationships between components within the ecosystem, including:
   
   i. Energy transfer into and out of the system.
   
   ii. Energy transfer and matter cycling (cycling of atoms):
      
       1. Among producers, consumers, and decomposers (e.g., decomposers break down consumers and producers via chemical reactions and use the energy released from rearranging those molecules for growth and development).
      
       2. Between organisms and the nonliving parts of the system (e.g., producers use matter from the nonliving parts of the ecosystem and energy from the sun to produce food from nonfood materials).
6.4: STABILITY AND CHANGE IN ECOSYSTEMS

The study of ecosystems includes the interaction of organism with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

Strand 6.4.3: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

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3. Connections

A. Students use the model to describe the cycling of matter and flow of energy among living and nonliving parts of the defined system, including:
   i. When organisms consume other organisms, there is a transfer of energy and cycling of atoms that were originally captured from the nonliving parts of the ecosystem by producers.
   ii. The transfer of matter (atoms) and energy between living and nonliving parts of the ecosystem at every level within the system, which allows matter to cycle and energy to flow within and outside of the system.

B. Students use the model to track energy transfer and matter cycling in the system based on consistent and measurable patterns, including:
   i. That the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
   ii. That matter and energy are conserved through transfers within and outside of the ecosystem.
The study of ecosystems includes the interaction of organisms with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water, and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

**Strand 6.4.4: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Students who demonstrate understanding can:

**Construct an argument supported by evidence** that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engaging in Argument from Evidence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ecosystem Dynamics, Functioning, and Resilience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stability and Change</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Small changes in one part of a system might cause large changes in another part.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Scientific Knowledge is Based on Empirical Evidence**

• Science disciplines share common rules of obtaining and evaluating empirical evidence.

1. **Supported claims**
   
   A. Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.

2. **Identifying scientific evidence**
   
   A. Students identify and describe the given evidence (e.g., evidence from data, scientific literature) needed for supporting the claim, including evidence about:
      
      i. Changes in the physical or biological components of an ecosystem, including the magnitude of the changes (e.g., data about rainfall, fires, predator removal, species introduction).
      
      ii. Changes in the populations of an ecosystem, including the magnitude of the changes (e.g., changes in population size, types of species present, and relative prevalence of a species within the ecosystem).
      
      iii. Evidence of causal and correlational relationships between changes in the components of an ecosystem with the changes in populations.
   
   B. Students use multiple valid and reliable sources of evidence.

3. **Evaluating and critiquing the evidence**
   
   A. Students evaluate the given evidence, identifying the necessary and sufficient evidence for supporting the claim.
   
   B. Students identify alternative interpretations of the evidence and describe* why the evidence supports the student’s claim.
6.4: STABILITY AND CHANGE IN ECOSYSTEMS

The study of ecosystems includes the interaction of organisms with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water, and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

**Strand 6.4.4: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Students who demonstrate understanding can:

**Construct an argument supported by evidence** that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

4. **Reasoning and synthesis**

   A. Students use reasoning to connect the appropriate evidence to the claim and construct an oral or written argument about the causal relationship between physical and biological components of an ecosystem and changes in organism populations, based on patterns in the evidence. In the argument, students describe a chain of reasoning that includes:

   i. Specific changes in the physical or biological components of an ecosystem cause changes that can affect the survival and reproductive likelihood of organisms within that ecosystem (e.g., scarcity of food or the elimination of a predator will alter the survival and reproductive probability of some organisms).

   ii. Factors that affect the survival and reproduction of organisms can cause changes in the populations of those organisms.

   iii. Patterns in the evidence suggest that many different types of changes (e.g., changes in multiple types of physical and biological components) are correlated with changes in organism populations.

   iv. Several consistent correlational patterns, along with the understanding of specific causal relationships between changes in the components of an ecosystem and changes in the survival and reproduction of organisms, suggest that many changes in physical or biological components of ecosystems can cause changes in populations of organisms.

   v. Some small changes in physical or biological components of an ecosystem are associated with large changes in a population, suggesting that small changes in one component of an ecosystem can cause large changes in another component.
The study of ecosystems includes the interaction of organisms with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water, and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

**Strand 6.4.5: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Students who demonstrate understanding can:
Evaluate competing design solutions for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize obtaining, evaluating, and communicating information of differing design solutions. Examples could include policies affecting ecosystems.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
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</thead>
<tbody>
<tr>
<td>Engaging in Argument from Evidence</td>
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<td>Stability and Change</td>
</tr>
<tr>
<td>Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).</td>
<td>• 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.</td>
<td>• Small changes in one part of a system might cause large changes in another part.</td>
</tr>
<tr>
<td>• Evaluate competing design solutions based on jointly developed and agreed upon design criteria.</td>
<td><strong>Biodiversity and Humans</strong></td>
<td><strong>Connections to Engineering, Technology, and Applications of Science</strong></td>
</tr>
<tr>
<td></td>
<td>• 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)</td>
<td><strong>Influence of Science, Engineering, and Technology on Society and the Natural World</strong></td>
</tr>
<tr>
<td><strong>Developing Possible Solutions</strong></td>
<td>• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary)</td>
<td>• The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.</td>
</tr>
<tr>
<td><strong>Identifying the given design solution and supporting evidence</strong></td>
<td></td>
<td><strong>Connections to Nature of Science</strong></td>
</tr>
<tr>
<td>A. Students identify and describe:</td>
<td></td>
<td><strong>Science Addresses Questions About the Natural and Material World</strong></td>
</tr>
<tr>
<td>i. The given competing design solutions for maintaining biodiversity and ecosystem services.</td>
<td></td>
<td>• Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.</td>
</tr>
<tr>
<td>ii. The given problem involving biodiversity and/or ecosystem services that is being solved by the given design solutions, including information about why biodiversity and/or ecosystem services are necessary to maintaining a healthy ecosystem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. The given problem involving biodiversity and/or ecosystem services that is being solved by the given design solutions, including information about why biodiversity and/or ecosystem services are necessary to maintaining a healthy ecosystem.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.4: STABILITY AND CHANGE IN ECOSYSTEMS

The study of ecosystems includes the interaction of organism with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

**Strand 6.4.5: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Students who demonstrate understanding can:

Evaluate competing design solutions for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize obtaining, evaluating, and communicating information of differing design solutions. Examples could include policies affecting ecosystems.

<table>
<thead>
<tr>
<th>2.</th>
<th>Identifying scientific evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Students identify and describe the additional evidence (in the form of data, information, or other appropriate forms) that is relevant to the problem, design solutions, and evaluation of the solutions, including:</td>
</tr>
<tr>
<td>i.</td>
<td>The variety of species (biodiversity) found in the given ecosystem.</td>
</tr>
<tr>
<td>ii.</td>
<td>Factors that affect the stability of the biodiversity of the given ecosystem.</td>
</tr>
<tr>
<td>iii.</td>
<td>Ecosystem services (e.g., water purification, nutrient recycling, prevention of soil erosion) that affect the stability of the system.</td>
</tr>
<tr>
<td>B.</td>
<td>Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.</th>
<th>Evaluating and critiquing the design solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>In their evaluations, students use scientific evidence to:</td>
</tr>
<tr>
<td>i.</td>
<td>Compare the ability of each of the competing design solutions to maintain ecosystem stability and biodiversity.</td>
</tr>
<tr>
<td>ii.</td>
<td>Clarify the strengths and weaknesses of the competing designs with respect to each criterion and constraint (e.g., scientific, social, and economic considerations).</td>
</tr>
<tr>
<td>iii.</td>
<td>Assess possible side effects of the given design solutions on other aspects of the ecosystem, including the possibility that a small change in one component of an ecosystem can produce a large change in another component of the ecosystem.</td>
</tr>
</tbody>
</table>
Integrating Science Practices Into Assessment Tasks

The Next Generation Science Standards call for the development of “three-dimensional science proficiency,” that is, students’ integrated understanding of disciplinary core ideas, science and engineering practices, and crosscutting concepts. To assess three-dimensional science proficiency requires multicomponent tasks (National Research Council, 2014). These are sets of tasks linked by a common scenario, phenomenon, or engineering design challenge.

Developing three-dimensional science assessments is challenging. Most current assessments focus on testing students’ knowledge of science facts. Few focus on having students apply their understanding of disciplinary core ideas in the context of engaging in a science or engineering practice. Fewer still make connections to crosscutting concepts.

These “task format” tables included in this document are tools to help teachers and district leaders design three-dimensional assessment tasks. They are based on the language of A Framework for K-12 Science Education and the NGSS Evidence Statements, focusing on all eight science practices and two engineering practices. These task formats represent different ways that assessment tasks can be written to engage students in science practice. They do not specify precisely which disciplinary core ideas are to be integrated into tasks, a process that would be determined by an analysis of the disciplinary core ideas.

The different formats get at different aspects of the focal science and engineering practice. In addition, some formats are likely to be more demanding cognitively for students. The idea of presenting multiple formats is to give task developers a sense of the range of tasks that can be written. A good “test” (comprised of multiple tasks) of a student’s grasp of a particular practice, in the context of a disciplinary core idea and crosscutting concept, would draw on multiple formats.

These task formats provide some specific suggestions for the intellectual work associated with the science and engineering practices. However, there are many possible ways of engaging in relevant forms of the intellectual work for the practices. It is important in instruction and assessment that the practices not become fixed, narrow routines or procedures.

An example multi-component assessment task is included on page 16 of this document.

How to Read a Template Task

<table>
<thead>
<tr>
<th>Format</th>
<th>Task Requirements for Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Present students with a textual description of an investigation of an observable phenomenon, then Ask students to formulate a scientific question relevant to investigating that phenomenon.</td>
</tr>
</tbody>
</table>

Task(s) for students to complete
<table>
<thead>
<tr>
<th>Format</th>
<th>Task Requirements for Students</th>
</tr>
</thead>
</table>
| 1      | Present students with a scientific phenomenon and questions related to that phenomenon, *then*  
|        | Ask students to identify which questions are testable scientific questions. |
| 2a     | Present students with an observable scientific phenomenon to be explained, *then*  
|        | Ask students to formulate descriptive questions about the phenomenon they observed. |
| 2b     | Present students with a scientific phenomenon to be explained, *then*  
|        | Ask students to formulate a scientific question to investigate the phenomenon. |
| 2c     | Present students with a scientific phenomenon to be explained, *then*  
|        | Ask students to generate a scientific question relevant to investigating that phenomenon,  
|        | *and*  
|        | Ask students to describe what evidence is needed to answer the question they generated. |
| 3a     | Present students with a scientific phenomenon to be explained and a scientific question, *then*  
|        | Ask students what questions we need to answer along the way to answer the scientific question,  
|        | *and*  
|        | Ask students to describe what evidence is needed to answer those questions might and  
|        | how they help build toward an explanation of the phenomenon. |
| 3b     | Present students with a scientific phenomenon to be explained and a scientific question, *then*  
|        | Ask students to evaluate whether or not the question is relevant to explaining the phenomenon.  
|        | If the question is relevant, ask students to describe what evidence is needed to answer that question. |
| 4      | Present students with a textual description of an investigation of an observable phenomenon, a scientific question, and a set of data and findings, *then*  
|        | Ask students to formulate a follow-up question to extend the investigation. |
| 5      | Present students with a scenario of a scientific argument in the context of an investigation, *then*  
<p>|        | Ask students to generate questions they would ask to clarify the argument or to ask for elaboration of the ideas presented in the argument. |</p>
<table>
<thead>
<tr>
<th></th>
<th>Present students with a scientific phenomenon to be explained and a scientific question, then Ask students to revise the question to make it investigable with available resources in the classroom.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Present students with a scientific phenomenon to be explained and with a question or a set of questions, then Ask students to evaluate and explain whether or not the question(s) is empirically testable.</td>
</tr>
</tbody>
</table>
## Potential Task Formats: Defining Problems (Engineering)

<table>
<thead>
<tr>
<th>Format</th>
<th>Task Requirements for Students</th>
</tr>
</thead>
</table>
| 1      | Present students with a textual description of a scenario of a need or desire of society and/or the natural world and a defined problem, *then*  
*Ask students to describe why the problem is a major global challenge.* |
| 2      | Present students with a textual description of a scenario of a need or desire of society and/or the natural world that includes quantitative and qualitative data, *then*  
*Ask students to describe the problem, *and*  
*Ask students to interpret quantitative and qualitative data to describe the major consequences of the problem if it remains unsolved.* |
| 3      | Present students with a textual description of a scenario of a need or desire of society and/or the natural world and with excerpts from related scientific research, *then*  
*Ask students to describe how each piece of scientific research is relevant background research for defining the problem.* |
| 4      | Present students with a textual description of a scenario of a need or desire of society and/or the natural world and a defined problem, *then*  
*Ask students to define the components and relationships between the components of the system in which the problem is embedded, *and*  
*Ask students to define the boundaries of that system and what is and is not part of the system.* |
| 5      | Present students with a textual description a defined problem and with experts of scientific research and popular texts, *then*  
*Ask students to analyze and describe the societal needs and wants relative to the problem.* |
| 6a     | Present students with a textual description of a scenario of a need or desire of society and/or the natural world, *then*  
*Ask students to describe the problem, *and*  
*Ask students to define the criteria and constraints for acceptable solutions to the problem.* |
| 6b     | Present students with a textual description of a scenario of a need or desire of society and/or the natural world, *then*  
*Ask students to describe the problem,*  
*Ask students to define the criteria and constraints for acceptable solutions to the problem,*  
*and*  
*Ask students what evidence is needed to know whether or not a solution fits within the defined criteria and constraints.* |
<p>| 7 | Present students with a textual description of a scenario of a need or desire of society and/or the natural world along with design criteria and constraints, <em>then</em> Ask students to plan an investigation that would allow them to better understand the design space for the problem. |</p>
<table>
<thead>
<tr>
<th>Format</th>
<th>Task Requirements for Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Present two models to students, then &lt;br&gt; Ask them to compare the models to identify both common and unique model components, relationships, and mechanisms.</td>
</tr>
<tr>
<td>2</td>
<td>Present students with an illustration or drawing of a scientific process or system, then &lt;br&gt; Ask students to label the components, interactions, and mechanisms in the model, and &lt;br&gt; Write a description of what is shown in the drawing.</td>
</tr>
<tr>
<td>3</td>
<td>Present students with a model of an observable scientific process or system and some evidence about how the system behaves that does not fit the model, then &lt;br&gt; Ask students to revise the model to better fit available evidence.</td>
</tr>
<tr>
<td>4</td>
<td>Present students with a textual description of an observable scientific phenomenon, then &lt;br&gt; Ask students to draw and label the model components, interactions among components, and mechanisms in the model, and &lt;br&gt; Ask students to write an explanation for the phenomenon, using the model as supporting evidence.</td>
</tr>
<tr>
<td>5</td>
<td>Present students with a textual description of an observable scientific phenomenon, then &lt;br&gt; Ask students to draw a model that helps explain how this phenomenon occurs by applying their understanding of a disciplinary core idea, and &lt;br&gt; Write a prediction about something that might happen in the future that could be explained by the model.</td>
</tr>
<tr>
<td>6</td>
<td>Present students with two different models for the same observable phenomenon, then &lt;br&gt; Ask students to compare the two models with respect to their accuracy, and &lt;br&gt; Apply what they know about a disciplinary core idea to justify their answer.</td>
</tr>
<tr>
<td>7</td>
<td>Present students with two different models for the same observable phenomenon, then &lt;br&gt; Ask students to develop a test to determine which model better fits available evidence.</td>
</tr>
<tr>
<td>8</td>
<td>Provide students with a digital modeling tool that is intended to represent a system or process in which the mechanisms are not visible to the naked eye, then &lt;br&gt; Ask students to use the modeling tool to identify and describe model components, interactions, and mechanisms.</td>
</tr>
</tbody>
</table>
### Potential Task Formats: Planning and Carrying Out Investigations (Science)

#### Relevant definitions
- An **investigation plan** encompasses a description of data sources and measures to be used, procedures for observing and recording data, and, where relevant, a plan for how observations will be sampled.
- A **data source** refers to a type of data only (“We would need data on the size of the white-colored moth population” or “We would need data comparing the color of tail feathers in birds in the mountains and in the city”)

<table>
<thead>
<tr>
<th>Format</th>
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</tr>
</thead>
</table>
| 1      | Present students with a scientific phenomenon to be explained, then  
|        | Ask students to identify questions to ask, and  
|        | Ask students to evaluate different ways of observing and/or measuring to answer those questions, and  
|        | Ask students to conduct the investigation by observing and/or measuring and then making comparisons between data collected. |
| 2      | Present students with a scientific phenomenon to be explained, a scientific question, and an investigation plan, then  
|        | Ask students to perform the investigation plan and collect and record data. |
| 3      | Present students with a scientific phenomenon (or scientific model) to be explained and a scientific question, then  
|        | Ask students to create an investigation plan to investigate the scientific phenomenon (or model), and  
|        | Ask students to describe how the investigation will generate relevant patterns of evidence for answering the scientific question or for supporting the model. |
| 4      | Present students with a scientific phenomenon (or a scientific model) to be explained, then  
|        | Ask students to generate a scientific question to investigate the phenomenon (or model) with resources available in the classroom (or with a given list of resources), and  
|        | Ask students to identify the variables needed in the investigation to explain the phenomenon (or model), and  
|        | Ask students to characterize each variable as dependent or independent and to explain any variables to be controlled and why. |
| 5      | Present students with a scientific phenomenon to be explained, a scientific question, and an investigation plan, then  
|        | Ask students to describe how the data will be collected precisely, and  
|        | Ask students to how much data is needed to be reliable. |
|   | Present students with a scientific phenomenon to be explained, a scientific question, and a description of the type of investigation to be conducted, then  
|   | Ask students to describe the possible confounding variables, and  
|   | Ask students to write an investigation plan that addresses the confounding variables.  
| 7 | Present students with a scientific phenomenon to be explained, a scientific question, and investigation plan, and data collected from the investigation, then  
|   | Ask students analyze how well the data collected generated relevant evidence to answer the scientific question, and  
|   | Ask students to revise the investigation plan to be more relevant and to generate more accurate and precise data.  
| 8 | Present students with a scientific question, then  
|   | Ask students to generate ideas about data sources they would need to answer the question, and  
|   | Ask students to say how the data sources are relevant to answering the question  
| 9 | Present students with a scientific question and a list of data sources they could gather to answer the question, then  
|   | Ask students to select which data sources are most relevant to answering the question, and  
|   | Ask students to say how the data are relevant to answering the question  

### Potential Task Formats: Analyzing and Interpreting Data

**Relevant definitions**
- A *pattern of evidence* from data is what the data say (“The population of white-colored moths disappeared in cities,” or “The birds’ tail feathers are whiter in the mountains than in the city”)

<table>
<thead>
<tr>
<th>Format</th>
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</tr>
</thead>
</table>
| 1      | Present students with recorded observations of the natural world, *then*  
*Ask them to describe a pattern or relationship they can infer from the observations* |
| 2      | Describe an investigation, the phenomenon under investigation, and one or more recorded observations from the investigation, *then*  
*Ask students to organize, represent, and analyze the data in at least two different ways, and Ask students to compare how the representations and analyses help them to identify patterns in the data.* |
| 3      | Describe an investigation, the phenomenon under investigation, and one or more recorded observations from the investigation, *then*  
*Ask students to use grade-level appropriate mathematics and/or statistics to analyze patterns the data, and Ask students to draw conclusions supported by their mathematical analysis.* |
| 4      | Describe an investigation, the phenomenon under investigation, and recorded observations from the investigation that are directly relevant to explaining the phenomenon, *then*  
*Ask students to organize the data and describe how this organization helps them to analyze the data, and Ask students to identify and describe the patterns they see in the organized data, and/or Ask students to student to describe how the patterns of evidence in the data help to explain the phenomenon.* |
| 5      | Describe an investigation, the phenomenon under investigation, a hypothesis about the phenomenon that the investigation was intended to test, and multiple recorded observations from the investigation, *then*  
*Ask students to organize the data and describe how this organization helps them to see whether the evidence supports the hypothesis, and Draw a conclusion about whether the data are consistent with the hypothesis.* |
| 6      | Describe an investigation, the phenomenon under investigation, and recorded observations from the investigation from multiple groups of investigators, *then*  
*Ask students to organize (e.g., tabulate, graph, or statistically summarize) the data, and Ask students to identify outliers in the different data sets, and Develop hypotheses about what sources of error might have caused the outliers.* |
<table>
<thead>
<tr>
<th>7</th>
<th>Present a causal explanation of a phenomenon developed from either an experiment or from a simulation, empirical data from the experiment or simulation, then Ask students to decide whether the data presented provide causal or correlational evidence, and Ask students to assess whether the data are consistent with the causal explanation presented.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Describe an investigation, the phenomenon under investigation, one or more recorded observations from the investigation, the results of analyses, and an interpretation of the data, then Ask students to assess whether the interpretation is consistent with the data and the analysis, or Ask students to evaluate how the interpretation is affected by variation or uncertainty in the data.</td>
</tr>
<tr>
<td>Format</td>
<td>Task Requirements for Students</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Present students with multiple objects, <em>then</em>&lt;br&gt;Ask students to construct quantitative attributes (e.g., measurements of heights) of the objects, <em>and</em>&lt;br&gt;Display the data using simple graphs.</td>
</tr>
<tr>
<td>2</td>
<td>Present students with a dataset from an investigation, the question the investigation is intended to answer, <em>then</em>&lt;br&gt;Ask students to identify features of the dataset (e.g., range, average) that should be analyzed in order to answer the question.</td>
</tr>
<tr>
<td>3</td>
<td>Present students with a textual description and measured quantities of an observable scientific phenomenon, <em>then</em>&lt;br&gt;Ask students to develop a grade-level appropriate equation or algorithm that corresponds to the textual description, <em>and</em>&lt;br&gt;Explain how the equation or algorithm represents the textual description.</td>
</tr>
<tr>
<td>4</td>
<td>Present students with a textual description, measured quantities of data, and a grade-level appropriate mathematical equation of an observable scientific phenomenon, <em>then</em>&lt;br&gt;Ask students to make a prediction about the state of the phenomenon in the future that the equation can be used to support, <em>and</em>&lt;br&gt;Ask students to write an explanation for the prediction, using the mathematical model as supporting evidence.</td>
</tr>
<tr>
<td>5</td>
<td>Engage students in using a simulation of an observable scientific phenomenon, <em>then</em>&lt;br&gt;Ask students to compare the simulation results with real-world data, <em>and</em>&lt;br&gt;Write an argument for whether or not the simulation makes sense using the comparison as supporting evidence.</td>
</tr>
<tr>
<td>6</td>
<td>Present students with a large data set from an investigation, the question the data are intended to answer, and computer tools (e.g., a spreadsheet) for analyzing the data set, <em>then</em>&lt;br&gt;Ask students to develop statistical summaries of the data set that help them answer the question about the dataset.</td>
</tr>
</tbody>
</table>
# Potential Task Formats: Constructing Explanations (Science)

**Relevant definition**
- “Scientific explanations are accounts that link scientific theory with specific observations or phenomena... Very often the theory is first represented by a specific model for the situation in question, and then a model-based explanation is developed.” (NRC Framework, 2012).

<table>
<thead>
<tr>
<th>Format</th>
<th>Task Requirements for Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe a phenomenon to students along with relevant evidence (which can come from a media source), <em>then</em>  &lt;br&gt; Ask students to write an evidence-based account of what causes the phenomena.</td>
</tr>
<tr>
<td>2</td>
<td>Describe a phenomenon to students along with some related qualitative or quantitative data/observations, <em>then</em>  &lt;br&gt; Ask students produce an explanation about the mechanism for the phenomena using their interpretation of the data as evidence.</td>
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<tr>
<td>3</td>
<td>Describe a phenomenon to students and present qualitative or quantitative data for independent and dependent variables, <em>then</em>  &lt;br&gt; Ask students to produce a causal account that explains how the independent variables relate to the dependent variables.</td>
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<tr>
<td>4</td>
<td>Describe a phenomenon to students along with a related set of evidence and an explanation that includes multiple scientific principles, <em>then</em>  &lt;br&gt; Ask students to say which pieces of evidences support particular components of the explanation.</td>
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<tr>
<td>5</td>
<td>Present students with a model or representation of an observable scientific process or system, <em>then</em>  &lt;br&gt; Ask students to write a causal explanation for a relevant phenomenon using the model as supporting evidence.</td>
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<tr>
<td>6</td>
<td>Describe a phenomenon and present students with a causal explanation of it, <em>then</em>  &lt;br&gt; Ask students to identify gaps or weaknesses in how it scientifically explains the phenomenon based on their level of scientific understanding.</td>
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<tr>
<td>7</td>
<td>Describe a phenomenon and present students with a range of evidence obtained from a variety of sources (empirical investigations, models, theories, simulations, peer review), <em>then</em>  &lt;br&gt; Ask students to articulate (construct) a causal explanation for the phenomena, <em>and</em>  &lt;br&gt; Describe how the evidence relates to the mechanisms or principles they have included.</td>
</tr>
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### Potential Task Formats: Designing Solutions (Engineering)

<table>
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<tr>
<th>Format</th>
<th>Task Design for Students</th>
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</table>
| 1      | Describe or showcase a human problem, desire, or need along with design criteria and constraints, *then*  
|        | Ask students to sketch or describe a design approach that develops a possible solution to the problem.  
|        | *and*  
|        | Ask them to explain how the relevant scientific ideas are taken into account within their design. |
| 2      | Describe or showcase a human problem, desire, or need along with design criteria and constraints, *then*  
|        | Ask students to sketch and prototype a design that is a possible solution to the problem using relevant materials. (Performance Task) |
| 3      | Describe a designed system and data from a failure scenario associated with the design, *then*  
|        | Ask them to analyze the data and identify the scientific causes of the failure. Possibly ask them to sketch or describe a design iteration that might be an improvement to the design. |
| 4      | Describe a design in active development and a scenario where the design team has encountered a design tension between two or more criteria perhaps also related to the project constraints, *then*  
|        | Ask students how they would proceed with the design work to develop a working system. (The goal is to see if students think about considering trade-offs and prioritizing one design criteria over another in order to accomplish a working design.) |
### Potential Task Formats: Engaging in Argument from Evidence

<table>
<thead>
<tr>
<th>Format</th>
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</thead>
</table>
| 1      | Present two different arguments related to a phenomenon, one with evidence and one without, *then*  
        | Ask students to identify the argument that is more scientific and ask them why they think that is the case. |
| 2      | Describe a phenomenon to students, *then*  
        | Ask students to articulate (construct) a claim about that phenomenon, and  
        | Identify evidence that supports the claim, *and*  
        | Articulate the scientific principle(s) that connect each piece of evidence to the claim. |
| 3      | Present students with a claim about a phenomenon, *then*  
        | Ask students to identify evidence that supports the claim, *and*  
        | Articulate the scientific principle(s) that connect each piece of evidence to the claim. |
| 4      | Present students with a claim *and* evidence about a phenomenon, *then*  
        | Ask students to assess how well the evidence supports the claim. |
| 5a, 5b | Present students with a claim *and* evidence *and* reasoning about a phenomenon, *then*  
        | Ask students to assess the reasoning of a given link between claim and evidence or  
        | Ask students to assess the logical link between claim and evidence. |
| 6a, 6b | Describe a situation in which two or more explanations are offered for a phenomenon, *then*  
        | Ask students to identify the different claims at issue (easier), or  
        | Ask students to identify different claims and the evidence with each claim (harder). |
| 7a, 7b | Present students with a claim, a list of data sources that are relevant to the claim (but not what the data say), *then*  
        | Ask students to identify (select from a list) a pattern of evidence from the data that would  
        | **support** the claim, or  
        | Ask students to identify (select from a list) what pattern of evidence from the data would  
        | **refute** the claim. |
| 8a, 8b, 8c, 8d | Present students with a claim *and* a pattern of evidence relevant to the claim, *then*  
        | Ask students to assess whether the evidence is logically consistent with the claim, *or*  
        | Ask students to assess whether the evidence is consistent with a scientific theory or model they have studied, *or*  
        | Ask students to generate ideas about additional evidence needed to support the claim, *or*  
        | Ask students to generate ideas about additional evidence needed to support the claim. |
### Potential Task Formats: Obtaining, Evaluating, and Communicating Information

**Relevant definitions**
- A “scientific text” is any form of scientific communication including but not limited to prose, graphs, videos, posters, symbols, and mathematics.

<table>
<thead>
<tr>
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</table>
| 1      | Present students with a set of grade-appropriate texts related to a scientific phenomenon, then  
         Ask students to synthesize the information from across the texts, and/or  
         Ask students to compare and contrast information across the texts to determine which are most relevant to explaining the phenomenon. |
| 2      | Present students with a set of grade-appropriate texts related to a scientific phenomenon, then  
         Ask students to construct an explanation of the phenomenon and/or ask questions about the phenomenon based on combined information from relevant texts. |
| 3      | Present students with textual description a scientific phenomenon or of an investigation of a scientific phenomenon, then  
         Ask students use multiple forms of scientific texts to communicate about the phenomenon to a given audience or an audience of their choosing. |
| 4      | Present students with a set of grade-appropriate scientific literature and/or media reports related to a scientific phenomenon, then  
         For each text, ask students to analyze and write about the validity and reliability of the information in the text (e.g., data, hypotheses, conclusions). |
Green anoles are a type of lizard that live in trees in Florida. In the 1950s, a similar species of lizards called brown anoles invaded Florida from Cuba. We know two things about the two species of anoles:

a. They live in similar habitats and eat similar food.
b. They are known to eat the newly hatched lizards of the other species.

Scientists conducted two investigations to determine whether or not the population of green anoles was evolving due to the invasion of brown anoles. First, they introduced brown anoles to three islands and left three islands alone. Then they measured the average height green anoles could be found in the trees (perch height) before and after introducing the invasive brown anoles. Here is a graph of the data they collected on perch height:
1. What pattern do you see in the perch height data?
After the brown anoles invaded, over time, the green anoles average perch height increased.

2. When the brown anoles invaded, scientists noted that they ate similar food and lived in similar habitats as the
green anoles, why does this matter for the survival of the green anoles?
The brown anole competed for space and food resources of the green anole thus the green anoles that were
able to live in higher in the trees with larger and stickier feet were able to survive.

3. Why might being able to go higher in trees be an advantage for survival?
Higher up in the trees the green anoles experience less competition for resources and greater safety from the
brown anoles eating their offspring.

4. The scientists noted that the anoles did adapt because of variation in foot pads and sticky scales. Describe the
pattern of the average number of sticky scales and average foot pad size traits of anoles on invaded and unin-
vaded islands.
The anoles’ foot pads are larger and the anoles have more sticky scales on islands that were invaded by brown
anoles. These are the same islands in which the green anoles have a higher average perch height.

5. Complete the graphs below showing how you think the proportion of green anoles with larger foot pads in
the population changed over time on the invaded and uninvaded islands.
Using your graphs and the data above, what explains the patterns you see between invaded and uninvaded islands?

The green anoles on the invaded islands survived if they were able to climb and perch at higher heights. They could do this because they had larger foot pads and more sticky scales on their feet. Therefore over time, the population of green anoles that survived and reproduced had a higher average foot pad size and a larger number of sticky scales on their feet.

6. Write an explanation for how natural selection led to the adaptation of the population of green anoles when the brown anoles invaded their habitats in Florida.

When the brown anoles invaded the habitats of the green anoles in Florida, they competed for food and habitat therefore impacting the survival of the green anoles. The green anoles that were able to survive could climb higher. Therefore they passed on those traits to the next generation and over time the population of green anoles could climb higher on average because of larger toe pads and more sticky scales on their feet.

The story and data (journal article and supplemental materials) were adapted from study of brown and green anoles by Yoel Stuart and colleagues at the University of Texas Austin. Yoel Stuart researches ecology and evolution, including how the two interact over time. Many species today cope with dramatic changes in their environment brought about by climate change, habitat destruction and the introduction of invasive species. In response to ecological changes such as these, Stuart examines the role of rapid evolution.
Utah Assessment Phenomena “YES” Test

Is it a phenomenon?

✓ Is “it” observable to students?
✓ Does “it” stimulate the curiosity in the student?
✓ Will “it” have relevant and accessible data, images, simulations, and/or text with which students could use science and engineering practices to demonstrate science knowledge through investigations and/or assessment clusters?
✓ Does “it” support students in making sense of or build on other’s ideas?
✓ Will “it” require students to develop an understanding of the assessed SEEd standard?
✓ Is “it” compelling to students from non-dominant communities (e.g. English language learners, students with special needs, students from cultural groups underrepresented in STEM, etc.)?

If you are unable to answer “YES” to any of the statements, then perhaps what you are considering is not a phenomenon. Each additional “YES” strengthens “it” for use on the assessment.

(Adapted from Phenomena “YesTest”, Next Gen Education, LLC – December, 2016)
3-D Science and Common Core Overlap

Math
- **MP1.** Make sense of problems and persevere in solving them
- **MP2.** Reason abstractly and quantitatively
- **MP6.** Attend to precision
- **MP7.** Look for and make use of structure
- **MP8.** Look for and express regularity in repeated reasoning

Science
- **SP1.** Ask questions and define problems
- **SP3.** Plan and carry out investigations
- **SP4.** Analyze and interpret data
- **SP5.** Use mathematics and computational thinking
- **SP6.** Construct explanations and design solutions

ELA
- **EP1.** Support analysis of a range of grade-level complex texts with evidence
- **MP3 and EP3.** Construct viable and valid arguments from evidence and critique reasoning of others
- **SP7.** Engage in argument from evidence
- **EP2.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience
- **EP4.** Build and present knowledge through research by integrating, comparing, and synthesizing ideas from text
- **EP5.** Build upon the ideas of others and articulate their own clearly when working collaboratively
- **EP6.** Use English structures to communicate context specific messages
Preparing Students for a Lifetime of Success

How will we prepare students for academic success?

Many states have adopted new standards based on the Next Generation Science Standards (NGSS) because they understand that a robust science education in middle school will pave the way for increased opportunities in high school, college, and future careers.

The NGSS enable teachers to offer all students interactive instruction that promotes analysis and interpretation of data, critical thinking, problem solving, and connections across science disciplines—with a high set of expectations for achievement in grades 6–8.

A quality science education can help expand opportunities for all students.

The science standards complement English/Language Arts and mathematics standards, enabling classroom instruction to reflect a clearer picture of the real world, where solving problems often requires skills and knowledge from multiple disciplines. Further, these standards are designed to benefit and engage all students, whether they currently lack access to a quality science education or already excel in science subjects.

What is our vision for science education?

The NGSS reflect the latest research and advances in modern science. In order to equip students to think critically, analyze information, and solve complex problems, the standards are arranged such that—from elementary through high school—students have multiple opportunities to build on the knowledge and skills gained during each grade, by revisiting important concepts and expanding their understanding of connections across scientific domains. Parents should understand that while some content might be similar to the past, it may look different from how they were taught.

As the science standards are implemented in schools and districts, they will enable students to:

- Develop a deeper understanding of science beyond memorizing facts, and
- Experience similar scientific and engineering practices as those used by professionals in the field.
How will students learn science in the classroom?

Each year, students should be able to demonstrate greater capacity for connecting knowledge across, and between, the physical sciences, life sciences, earth and space sciences, and engineering design.

During grades 6-8, your child will begin to form deeper connections between concepts previously learned in grades K-5, such as collecting evidence and drawing conclusions, understanding relationships between objects, and critical thinking that leads to designing effective solutions for problems.

Upon completion of grades 6-8, your child should have a deeper understanding of:

- Physical and chemical interactions that affect the world around us;
- Factors that affect organism survival and reproduction;
- Factors that influence the Earth and our solar system; and
- How to optimize design solutions.

Physical Sciences

Physical sciences during grades 6-8 may explore topics including atomic chemistry, forces and fields, thermal energy, and the wave model. Such lessons will help prepare students for advanced classes—like physics, forensics, or chemistry—that they might encounter in high school and/or college.

Life Sciences

Life Sciences during grades 6-8 may explore topics including cells, gene variation, biodiversity, and adaptation. Such lessons will help prepare students for advanced classes—like biology, physiology, and genetics—that they might encounter in high school and/or college.

Earth and Space Sciences

Earth and space sciences during grades 6-8 may explore topics including the solar system, the Earth’s history, and energy flows. Such lessons will help prepare students for advanced classes—like astronomy, environmental science, or geology—that they might encounter in high school and/or college.

Engineering Design

Engineering design during grades 6-8 may explore how students can refine criteria and constraints when designing engineering solutions. Such lessons will help prepare students for advanced classes—like mechanics, robotics, or engineering-enriched science courses—that they might encounter in high school and/or college.

For additional information about academic expectations for students in Grades 6-8, visit www.nextgenscience.org/parentguides.

How can you support your child’s success?

Although this new approach to teaching and learning K-12 science is different than the past, you can still actively support your child’s success in the classroom!

1. Speak to your child’s teacher(s) or principal about how these important changes affect your school.
2. Ask your child’s teacher thoughtful questions based on the information provided in this brochure.
3. Learn how you can help the teacher(s) reinforce classroom instruction at home.
**Classroom activities in Middle School will look less like this:**

<table>
<thead>
<tr>
<th>Physical Sciences</th>
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<tbody>
<tr>
<td>Students memorize Newton’s Law of Gravity.</td>
<td>Students gather and analyze evidence about gravity’s effect on objects with different masses.</td>
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<tr>
<td>Students follow scripted chemistry experiments.</td>
<td>Students use chemistry knowledge to design and explain a heat pack.</td>
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<tr>
<td>Students memorize the difference between Fahrenheit and Celsius.</td>
<td>Students construct arguments about the relationship between particle motion and temperature.</td>
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<tr>
<th>Life Sciences</th>
<th>Life Sciences</th>
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<tbody>
<tr>
<td>Students memorize the equation for photosynthesis.</td>
<td>Students explain the chemistry behind photosynthesis and how it relates to the growth of a plant.</td>
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<tr>
<td>Students build a model of a cell out of gelatin and label its parts.</td>
<td>Students design a new cell to optimize a particular function, such as energy production.</td>
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<tr>
<td>Students draw an ecosystem on paper.</td>
<td>Students conduct research to identify significant changes in local ecosystem(s).</td>
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<tr>
<th>Earth &amp; Space Sciences</th>
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<tr>
<td>Students memorize the water cycle.</td>
<td>Students analyze real data to determine how water moves through the cycle.</td>
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<tr>
<td>Students build a papier-mâché volcano.</td>
<td>Students conduct research to learn how scientists observe and monitor volcanic activity on a continuous or near-real-time basis.</td>
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<tr>
<td>Students paint and position Styrofoam balls to represent planets in the solar system.</td>
<td>Students give presentations describing evidence that gravity controls the motion of the planets around the sun.</td>
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<thead>
<tr>
<th>Engineering Design</th>
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<tbody>
<tr>
<td>Students learn engineering separately from other science disciplines.</td>
<td>Students consider or apply engineering design principles throughout each science course.</td>
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<tr>
<td>Engineering lessons are only offered to some students.</td>
<td>Engineering lessons are offered to all students and each student is encouraged to connect lessons to their own personal experiences.</td>
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<tr>
<td>Students use trial and error to build a bridge out of popsicle sticks.</td>
<td>Students research various bridge designs, select a design that best aligns to their scientific knowledge about forces, and finally test their selected design.</td>
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</table>
About NGSS: Reshaping Science Education for All Students

To better prepare American students for college and careers, schools need to ensure that quality science education is accessible to all students—regardless of ethnicity or zip code.

In an effort to bolster America’s competitive edge in an increasingly global economy, 26 states led the development of the Next Generation Science Standards (NGSS) by working with teachers, higher education, business, and practicing scientists. This collaborative process produced a set of high quality, college- and career-ready K-12 academic standards that set meaningful expectations for student performance and achievement in science. The NGSS are rich in both content and practice and arranged in a coherent manner across all disciplines and grades.

Fact: “Standards” are not “curriculum”. “Standards” provide clarity about what students should know and be able to do by the end of each grade level. “Curriculum” refers to how students meet those expectations. Please contact your child’s teacher or school if you have questions about their curriculum.

Three Dimensions of Science Learning

The NGSS emphasizes three distinct, yet equally important dimensions that help students learn science. Each dimension is integrated into the NGSS and—combined—the three dimensions build a powerful foundation to help students build a cohesive understanding of science over time.

Standard behaviors that scientists and engineers use to explain the world or solve problems

Fundamental scientific knowledge

Frameworks for scientific thinking across disciplines

Support your child’s success in the classroom!
## COMMUNITY RESOURCE PANEL

### 6TH GRADE

### GREAT SALT LAKE INSTITUTE

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaimi Butler</td>
<td>Coordinator</td>
<td>Great Salt Lake Institute</td>
</tr>
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<table>
<thead>
<tr>
<th>Website</th>
<th>Email</th>
<th>Phone</th>
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<tbody>
<tr>
<td>greatsaltlakeinstitute.org</td>
<td><a href="mailto:gslinstitute@westminstercollege.edu">gslinstitute@westminstercollege.edu</a></td>
<td>801-834-1209</td>
</tr>
</tbody>
</table>

### Which best describes your resource?
Out-of-classroom teacher professional development, Field trip/s, 3D-aligned curriculum, interactive informational resources

### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.
Great Salt Lake Institute at Westminster College loves to help our local teachers! Our resources include online interactive curriculum with worksheets and wet lab ideas, 6th grade 3D curriculum created by district science specialists in partnership with GSL experts, web-quests and more. Most importantly, we want to help you take your students to the lake. Use field trip guides modeled after successful trips to various lake locations to plan your own field trip. We will lend you supplies if you need (but we think you will have everything you need). If you have further questions or need other ideas please call or e-mail and we can help connect you with our salty neighbor!

### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one): Many! The Great Salt Lake in itself is a phenomenon, and it’s full of others that you can bring into your classroom for investigation - brine shrimp alone could support many, many science experiences!

### Cost:
Free

### Standard:
6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5

### When is the best time to schedule your resource?
No scheduling necessary (web-based resource)

### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?
Asking questions and defining problems., Developing and using models., Planning and carrying out investigations., Analyzing and interpreting data., Engaging in argument from evidence.

### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?
Asking questions and defining problems., Developing and using models., Planning and carrying out investigations., Analyzing and interpreting data., Engaging in argument from evidence.

### What cross-cutting concepts are the most useful for understanding your resource?
Cause and effect, Systems and system models, Stability and change
### ASPIRE (U OF U PHYSICS)

| Name: | Julie Callahan  
| Charlie Jui  
| John Matthews |
| Title: | Project Coordinator |
| Organization: | Aspire |
| Website: | aspire.cosmic-ray.org |
| Email: | cosmic.callahan@gmail.com |
| Phone: | 801-971-2055 |

#### Which best describes your resource?
Out-of-classroom teacher professional development, Field trip/s, Guest lecturer, Classroom kits/toolboxes to check out, Guest classroom lab/activity facilitation

#### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.
The Lunar Phases activity is a hands-on model, activity and lesson plan developed for the 6th grade. Students partner to model and observe the apparent change of the shape of the moon through a lunar month, depending on the perspective of the viewers. Immersive activities are supplemented with manipulative cards and lessons that broaden understanding of the Lunar Phases and their relationship to the Lunar Calendar. This lesson is available with a visiting presenter, as a professional teacher development workshop (we help you develop your own kit), or a kit you may check out from us. Models, lessons and supplemental online resources complete this lesson and activity. Additional Seasons activities also available.

#### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)
Lunar Phases, Lunar Calendar

#### Cost:
$0-$40

#### Standard:
6.1.1

#### When is the best time to schedule your resource?
No scheduling necessary (web-based resource), Fall, Winter, Spring

#### What is the best method to schedule your resource?
Email, Call

#### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?
Asking questions and defining problems., Developing and using models., Planning and carrying out investigations., Engaging in argument from evidence., Obtaining, evaluating, and communicating information.

#### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?
Asking questions and defining problems., Developing and using models., Planning and carrying out investigations., Engaging in argument from evidence., Obtaining, evaluating, and communicating information.

#### What cross-cutting concepts are the most useful for understanding your resource?
Scale, proportion, and quantity, Systems and system models
# Research Quest (NHMU)

**Name:** Bonnie Jean Knighton  
**Title:** Education Program Specialist  
**Organization:** Research Quest, Natural History Museum of Utah  
**Website:** researchquests.org; nhmu.edu/educators  
**Email:** bknighton@nhmu.utah.edu  
**Phone:** 801-587-5707

**Which best describes your resource?** 3D-aligned curriculum, Digital Resource

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

Research Quest is an exciting new program created by the Museum that gives middle school students the chance to engage in authentic online investigations. We bring real research questions and actual artifacts from our collections to students, thanks to incredible 3D and game technologies every bit as cool as the newest smartphone apps. Students explore fossils from the Cleveland-Lloyd Dinosaur Quarry, videos of our paleontologists, and more as they analyze evidence and develop their own theories.

**What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one):**  
Fossil evidence from NHMU's collection

**Cost:** Free  
**Standard:** 7.2.2, 7.5.3

**When is the best time to schedule your resource?** No scheduling necessary (web-based resource)  
**What is the best method to schedule your resource?** No scheduling necessary (web-based resource)

**What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?**  
Asking questions and defining problems., Analyzing and interpreting data., Constructing explanations and designing solutions., Engaging in argument from evidence., Obtaining, evaluating, and communicating information.

**What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?**  
Asking questions and defining problems., Analyzing and interpreting data., Engaging in argument from evidence., Obtaining, evaluating, and communicating information., None - my resource is not for students.

**What cross-cutting concepts are the most useful for understanding your resource?**  
Cause and effect, Structure and function
| Name: | Molly Malone  
Louisa Stark | Title: Sr. Education Specialist  
Director | Organization: Genetic Science Learning Center |
|---|---|---|---|
| Website: | Website:  
http://learn.genetics.utah.edu/content/basics/inheritance/  
http://learn.genetics.utah.edu/content/basics/reproduction/  
http://learn.genetics.utah.edu/content/evolution/heredity/Build-a-Bird_16-10-18.pdf | Email: molly.malone@utah.edu | Phone: 801-585-3470 |

Which best describes your resource? 3D-aligned curriculum

Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

- The following collection of activities from the Learn.Genetics website can be used together to compare asexual and sexual reproduction, and the resulting genetic variation that each type of reproduction generates (or not).
- What is Inheritance? (http://learn.genetics.utah.edu/content/basics/inheritance/) is a brief multimedia piece that introduces inheritance that visually tracks genetic variation.
- Sexual vs. Asexual Reproduction (http://learn.genetics.utah.edu/content/basics/reproduction/) tasks students with reading short descriptions of the reproductive strategies of several different organisms and choosing which type of reproduction, asexual, sexual, or both, the organism employs. It can be helpful for students to create a Venn diagram upon which to list key features of asexual and sexual reproduction and which of those features overlap.
- Build a Bird (http://learn.genetics.utah.edu/content/evolution/heredity/Build-a-Bird_16-10-18.pdf) This paper model of sexual reproduction uses real pigeon traits to demonstrate how two parents can produce highly varied offspring. Students recombine parental chromosomes, make gametes, then randomly combine two gametes. Finally, they decode the resulting allele combinations to draw the traits of a pigeon offspring. A typical classroom generates quite a lot of genetic variation in the resulting pigeon population.

What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)
Sexual and Asexual reproduction, Genetic Variation in Pigeons

Cost: Free  
Standard: 7.4.1

When is the best time to schedule your resource? No scheduling necessary (web-based resource)

What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?
Developing and using models., Obtaining, evaluating, and communicating information.

What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?
Developing and using models.

What cross-cutting concepts are the most useful for understanding your resource?
Cause and effect
**GENETIC SCIENCE LEARNING CENTER - 7.2.3**

<table>
<thead>
<tr>
<th>Name: Molly Malone</th>
<th>Title: Sr. Education Specialist</th>
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<tbody>
<tr>
<td>Louisa Stark</td>
<td>Director</td>
</tr>
<tr>
<td>Website: <a href="http://learn.genetics.utah.edu/content/cells/">http://learn.genetics.utah.edu/content/cells/</a>; <a href="http://teach.genetics.utah.edu/content/cells/">http://teach.genetics.utah.edu/content/cells/</a></td>
<td>Email: <a href="mailto:molly.malone@utah.edu">molly.malone@utah.edu</a></td>
</tr>
<tr>
<td></td>
<td>Organization: Genetic Science Learning Center</td>
</tr>
<tr>
<td></td>
<td>Phone: 801-585-3470</td>
</tr>
</tbody>
</table>

**Which best describes your resource?** 3D-aligned curriculum

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

The Amazing Cells curriculum module on the Learn.Genetics and Teach.Genetics websites includes online multimedia and printable paper-based activities that explore the dynamic world of the cell. The module’s activities engage students in learning about the structure and function of cell organelles, how cells communicate and respond, and include the popular Cell Size and Scale interactive that compares the size of the cell to various biological structures. The Teach.Genetics website ([http://teach.genetics.utah.edu/content/cells/](http://teach.genetics.utah.edu/content/cells/)) includes downloadable worksheets that are associated with the online multimedia pieces or interactive activities on Learn.Genetics ([http://learn.genetics.utah.edu/content/cells/](http://learn.genetics.utah.edu/content/cells/)) to guide student learning and help highlight important information about the cell. Also included are instructions for a quick kinesthetic model of cell communication (Pathways with Friends). All of the materials in the Amazing Cells curriculum module can be used together, or independently, in any configuration or series.

**What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)**

Cells, Cell Communication, The Fight or Flight Response

**Cost:** Free  

**Standard:** 7.2.3

**When is the best time to schedule your resource?** No scheduling necessary (web-based resource)

**What is the best method to schedule your resource?** No scheduling necessary (web-based resource)

**What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?**

Obtaining, evaluating, and communicating information

**What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?**

Developing and using models.

**What cross-cutting concepts are the most useful for understanding your resource?** Structure and function, Stability and change
# 8TH GRADE

**GENETIC SCIENCE LEARNING CENTER - 8.3.2**

<table>
<thead>
<tr>
<th>Name: Molly Malone Louisa Stark</th>
<th>Title: Sr. Education Specialist Director</th>
<th>Organization: Genetic Science Learning Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Website: <a href="http://learn.genetics.utah.edu/content/metabolism/">http://learn.genetics.utah.edu/content/metabolism/</a> and <a href="http://teach.genetics.utah.edu/content/metabolism/">http://teach.genetics.utah.edu/content/metabolism/</a></td>
<td>Phone: 801-585-3470</td>
<td></td>
</tr>
<tr>
<td>Email: <a href="mailto:molly.malone@utah.edu">molly.malone@utah.edu</a></td>
<td><strong>Which best describes your resource?</strong> 3D-aligned curriculum</td>
<td></td>
</tr>
</tbody>
</table>

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

- What happens to food after we eat it and how exactly does it fuel the body? What processes happen inside the body at the cellular and molecular level that enable us to obtain and use the energy we need to live? The From Food to Fuel online curriculum supplement materials explore the molecular physiology of digestion, metabolism and energy, and the regulation of these processes by hormones. The materials emphasize the cellular processes that assemble and disassemble molecules from food sources, creating and using energy in the process. In addition, the materials explain the molecular signaling by hormones that direct the uptake and storage of energy and what makes us feel hungry.

- The materials include interactive animations, activities, and graphics-rich web pages. Supplemental materials for teachers provide background information, classroom activities that support and extend the online learning and ideas for classroom implementation.

**What real-world phenomenon does your resource help bring into classrooms? (please feel free to list, if more than one)**

Digestion and Metabolism

**Cost:** Free  
**Standard:** 8.3.2

**When is the best time to schedule your resource?** No scheduling necessary (web-based resource)

**What is the best method to schedule your resource?** No scheduling necessary (web-based resource)

**What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?**

- Asking questions and defining problems.
- Obtaining, evaluating, and communicating information.

**What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?**

- Asking questions and defining problems.
- Developing and using models.
- Obtaining, evaluating, and communicating information.

**What cross-cutting concepts are the most useful for understanding your resource?**

Energy and matter
# 6th, 7th, & 8th Grade

## U of U Physics Outreach

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam Beehler</td>
<td>Lecture Demonstration Specialist</td>
<td>Department of Physics and Astronomy, University of Utah</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Website</th>
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<tbody>
<tr>
<td><a href="http://engagement.utah.edu/">http://engagement.utah.edu/</a></td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:beeehler@physics.utah.edu">beeehler@physics.utah.edu</a></td>
<td>801-581-6602</td>
</tr>
</tbody>
</table>

### Which best describes your resource? Field trip/s

#### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

The Lecture Demonstration Facility exists to aid in the teaching of physics and astronomy to undergraduate and graduate students in the field of physics and astronomy, as well as non-majors taking physics and astronomy here on campus. When this wonderful resource of demonstration equipment is not being used for university courses, there is potential for it to be shared with others. Adam Beehler has offered many a lecture presentation where he uses the demonstration equipment to give folks a glimpse into how physics and astronomy can help us understand the world around us in new ways. These presentations will reveal how science can open our eyes to the beauty and excitement of the natural world.

#### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)

Physics is the science of how things work, so my demonstrations try to emphasize that physics IS life. I have demonstrations that reveal the science behind the following real-world topics: MECHANICS (forces, motion, momentum, energy, etc.); FLUIDS (density, pressure, liquids, gases, fluid dynamics, etc.); OSCILLATIONS & WAVES (pendula, sound, instruments, resonance, superposition, etc.); THERMODYNAMICS (heat, heat transfer, gas laws, entropy, etc.); ELECTRICITY & MAGNETISM (charges, circuits, fields, forces, etc.); OPTICS (reflection, refraction, diffraction, interference, color, eye, etc.); MODERN PHYSICS (photoelectric effect, MRIs, X-rays, radioactivity, etc.); and ASTRONOMY (orbits, eclipses, telescopes, etc.).

### Cost?

Free

<table>
<thead>
<tr>
<th>6th Grade Standards:</th>
<th>7th Grade Standards:</th>
<th>8th Grade Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1.1, 6.1.2, 6.2.2, 6.2.3, 6.2.4, 6.3.4</td>
<td>7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5</td>
<td>8.1.5, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5, 8.2.6</td>
</tr>
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</table>

### When is the best time to schedule your resource? Fall, Winter, Spring

### What is the best method to schedule your resource? Email

### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?

- Asking questions and defining problems.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?

- Asking questions and defining problems.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

### What cross-cutting concepts are the most useful for understanding your resource?

Patterns, Cause and effect, Energy and matter, Structure and function, Stability and change
## Great Salt Lake Institute 6-8

<table>
<thead>
<tr>
<th>Name:</th>
<th>Jaimi Butler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>Coordinator</td>
</tr>
<tr>
<td>Organization:</td>
<td>Great Salt Lake Institute</td>
</tr>
<tr>
<td>Website:</td>
<td>greatsaltlakeinstitute.org</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:gslinstitute@westminstercollege.edu">gslinstitute@westminstercollege.edu</a></td>
</tr>
<tr>
<td>Phone:</td>
<td>801-832-2308</td>
</tr>
</tbody>
</table>

### Which best describes your resource?
Thinking partner to help create curriculum and field trips to Great Salt Lake

### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.
We have extensive knowledge of Great Salt Lake art, research and history but are a small organization with no capacity or expertise to build curriculum. We would love to help you as you plan your field trips and lessons to incorporate the PHENOMENal GSL!

### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)
Great Salt Lake: ecosystems, industry, art, history, science research, recreation, field trips, birds,

### Cost:
Free

### Standard:
applies to many

### When is the best time to schedule your resource?
Winter

### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?
Asking questions and defining problems., Developing and using models., Planning and carrying out investigations., Analyzing and interpreting data., Constructing explanations and designing solutions., Engaging in argument from evidence., Obtaining, evaluating, and communicating information.

### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?

### What cross-cutting concepts are the most useful for understanding your resource?
Patterns, Cause and effect, Scale, proportion, and quantity, Systems and system models, Energy and matter, Stability and change
## U of U - Science Outreach

### Name:
- Samantha Davis
- Mark Hale
- Wil Mace
- Pam Hofmann
- Krista Carlson

### Title:
- Director of Student Success
- Seismograph Station
- Geology and Geophysics
- Mining Engineering
- Metallurgical Engineering

### Organization:
- University of Utah

### Website: www.cmes.utah.edu; https://www.cmes.utah.edu/outreach/index.php

### Email: Samantha.j.davis@utah.edu

### Phone: 801-585-5176

### Which best describes your resource?
- Field trip/s, Guest lecturer, Classroom kits/toolboxes to check out, Guest classroom lab/activity facilitation

### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

Let us introduce your students to new and exciting scientific research occurring in the College of Mines and Earth Sciences. The Classroom Experience can be tailored to support your curriculum and can be adjusted for junior high through high school students. We can provide meaningful classroom discussion about degrees within the College of Mines and Earth Sciences and the benefits of pursuing a career in the related fields. We can also provide Classroom Experiments, which our outreach team will bring to your classroom and complete with your students! In addition we also invite you to bring your students for field trips or encourage individual students to come visit our campus, buildings, and laboratories to learn about the College of Mines and Earth Sciences. Students will be able to experience our cutting edge equipment as well as learn about our degree programs and future career possibilities!

### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)
We educate students and the community with the knowledge of discovering, managing, and transforming the world’s resources while maintaining the world’s atmosphere to create a sustainable planet. Students will learn about our atmosphere, specifically weather and inversion, geology though the study of solid Earth, the rocks of which it is composed, and the processes by which they change, metallurgical engineering teaches how rocks are transformed into metals and products we use everyday, and mining engineering help students determine the safest, most effective, sustainable methods of recovering the earth’s mineral resources to sustain modern civilization.

### Cost?
- Free

### 6th Grade Standards: 6.3.1, 6.3.2, 6.3.3

### 7th Grade Standards: 7.2.1, 7.2.2, 7.2.3, 7.2.4, 7.2.5, 7.2.6

### 8th Grade Standards: 8.1.1, 8.1.2, 8.1.4, 8.2.5, 8.4.1, 8.4.2, 8.4.3, 8.4.4, 8.4.5

### When is the best time to schedule your resource? Fall, Winter, Spring

### What is the best method to schedule your resource? Email

### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?
- Asking questions and defining problems.

### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?

### What cross-cutting concepts are the most useful for understanding your resource?
- Cause and effect, Scale, proportion, and quantity
**IUTAH**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Ellen Eiriksson</th>
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</thead>
<tbody>
<tr>
<td>Title:</td>
<td>Outreach and Diversity Coordinator</td>
</tr>
<tr>
<td>Organization:</td>
<td>iUTAH Education</td>
</tr>
<tr>
<td>Website:</td>
<td>iutahepscor.org</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:eleen.eiriksson@usu.org">eleen.eiriksson@usu.org</a></td>
</tr>
<tr>
<td>Phone:</td>
<td>801-587-8121</td>
</tr>
</tbody>
</table>

### Which best describes your resource? Book/teacher materials

#### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

- Water Runs Through This Book creates a sense of wonder and mystery about water, presenting unusual information - regional, global and astronomical - and then describes ways to conserve this resource that is essential to life - from birth to death.
- Written for readers young and old who are interested in participating through art or action to increase water awareness and water conservation. Through photographs, verse, and narration, this book celebrates the most essential ingredient to life: water.
- Author and educator Nancy Bo Flood and award-winning photographer Jan Sonnenmair combine imagination and information to explore this ever-changing yet essential element in a book that strengthens and promotes an educated, inclusive and water-wise community in Utah.
- Water Runs Through This Book is much more than an exploration of how water impacts life on Earth. It is a guide for how readers of all ages can become conservationists and protectors of this endangered resource.
- Free online teacher resources include a book guide, discussion questions, Reader's Theater, and additional recommended reading.

#### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)

- Water science, management, use and misuse

#### Cost?

- The book is $19.95, the online teacher resources are free (also iUTAH has copies of the book that can be provided for free to workshop attendees)

<table>
<thead>
<tr>
<th>6th Grade Standards:</th>
<th>7th Grade Standards:</th>
<th>8th Grade Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2.1, 6.2.2, 6.3.1, 6.3.2, 6.3.3, 6.3.4, 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5</td>
<td>N/A</td>
<td>8.4.1, 8.4.2, 8.4.3, 8.4.4</td>
</tr>
</tbody>
</table>

#### When is the best time to schedule your resource?

- No scheduling necessary (web-based resource)

#### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?

- Asking questions and defining problems, Engaging in argument from evidence.

#### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?

- Asking questions and defining problems, Engaging in argument from evidence, Obtaining, evaluating, and communicating information.

#### What cross-cutting concepts are the most useful for understanding your resource?

- None - my resource doesn't involve teacher PD.
# U OF U Seismograph Station

<table>
<thead>
<tr>
<th>Name: John Hale</th>
<th>Title: Earthquake Information Specialist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul Roberson</td>
<td>Earthquake Information Specialist</td>
</tr>
<tr>
<td></td>
<td><strong>Organization:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Website:</strong> quake.utah.edu, ussc.utah.gov, <a href="http://www.iris.edu/hq/audience/educators">http://www.iris.edu/hq/audience/educators</a></td>
</tr>
<tr>
<td></td>
<td><strong>Email:</strong> <a href="mailto:jmhale@seis.utah.edu">jmhale@seis.utah.edu</a></td>
</tr>
<tr>
<td></td>
<td><strong>Phone:</strong> 801-581-6274</td>
</tr>
</tbody>
</table>

### Which best describes your resource? Field trip/s

Tours are open for grades 5 and up. Most tours last 45-60min for up to 25 participants at a time. Tours are available Monday – Friday 9am - 3pm

### Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

Tours are open for grades 5 and up. Most tours last 45-60min for up to 25 participants at a time. Tours are available Monday – Friday 9am - 3pm

Topics covered during most tours include:

- What is a Seismograph Station and where are they?
- Why we use different types of instruments and telemetry?
- How do we locate an earthquake?
- How do we determine magnitudes?
- Where do we have earthquakes in Utah and Yellowstone, how many, and how big?
- Earthquake hazard in Utah and Yellowstone.
- UUSS role in earthquake response through ShakeMap and the Utah Department of Public Safety.
- Earthquake safety and preparedness.

### What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)

Earthquake hazard in Utah and Yellowstone.

### Cost:

Free

### Standard: 7.2.2, 7.2.3, 7.2.5

### When is the best time to schedule your resource? Fall, Winter, Spring

### What is the best method to schedule your resource? Call

### What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?

- Asking questions and defining problems,
- Analyzing and interpreting data.

### What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?

- Analyzing and interpreting data,
- Engaging in argument from evidence,
- Obtaining, evaluating, and communicating information.

### What cross-cutting concepts are the most useful for understanding your resource?

- Patterns,
- Cause and effect,
- Scale, proportion, and quantity,
- Stability and change
## TRACY AVIARY - PROFESSIONAL DEVELOPMENT

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
<th>Website</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michelle Mileham</td>
<td>Director of Education</td>
<td>Tracy Aviary</td>
<td><a href="http://tracyaviary.org/learning/">http://tracyaviary.org/learning/</a></td>
<td><a href="mailto:michellem@tracyaviary.org">michellem@tracyaviary.org</a></td>
<td>801-596-8500 ext.116</td>
</tr>
<tr>
<td>Anne Terry</td>
<td>Education Manager, General Inquiries &amp; Teacher PD</td>
<td></td>
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<tr>
<td>Annie Young</td>
<td>Senior Educator, Guided Tour &amp; Field Trips</td>
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<tr>
<td>Marina Astin</td>
<td>Educator, School and Community Outreach</td>
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</table>

**Which best describes your resource?** Out-of-classroom teacher professional development

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

This fun-filled, interactive educator training is ideal for classroom teachers, environmental educators, school administrators, after-school program staff, youth group/service organization leaders, or anyone who loves birds and wants to teach others about them. The Flying WILD program trains formal and non-formal educators to facilitate hands-on, standards-based activities that promote understanding of scientific concepts and engage students in environmental stewardship. Workshop attendees will receive their own copy of the 350+ page Flying WILD: An Educator’s Guide to Celebrating Birds and more.

**What real-world phenomenon does your resource help bring into classrooms?** (please feel free to list, if more than one)

Ecosystems, interactions between humans and wildlife

**Cost?** $30

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<tr>
<th>6th Grade Standards:</th>
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<td>6.4.1, 6.4.2, 6.4.3, 6.4.4</td>
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<td>8.3.3</td>
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</table>

**When is the best time to schedule your resource?** Fall, Spring

**What is the best method to schedule your resource?** Sign-up/register via website

**What Science and Engineering Practice(s) does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?**

- Asking questions and defining problems.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Using mathematics and computational thinking.
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

**What Science and Engineering Practice(s) does your resource allow STUDENTS to engage in?**

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

**What cross-cutting concepts are the most useful for understanding your resource?**

Patterns, Scale, proportion, and quantity; Systems and system models; Stability and change
TRACY AVIARY - FIELD TRIPS

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michelle Mileham</td>
<td>Director of Education</td>
<td>Tracy Aviary</td>
</tr>
<tr>
<td>Anne Terry</td>
<td>Education Manager, General Inquiries &amp; Teacher PD</td>
<td></td>
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<tr>
<td>Annie Young</td>
<td>Senior Educator, Guided Tour &amp; Field Trips</td>
<td></td>
</tr>
<tr>
<td>Marina Astin</td>
<td>Educator, School and Community Outreach</td>
<td></td>
</tr>
<tr>
<td>Website: <a href="http://tracyaviary.org/learning/">http://tracyaviary.org/learning/</a></td>
<td>Email: <a href="mailto:michellem@tracyaviary.org">michellem@tracyaviary.org</a></td>
<td>Phone: 801-596-8500 ext.118</td>
</tr>
</tbody>
</table>

Which best describes your resource? Field Trip/s

Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

Join Tracy Aviary educators for guided tours and programs while visiting our grounds. Programs are typically 45-60 minutes and focus on birds with unique conservation stories, wetlands and birds that flourish in these important habitats, and more! You are also welcome to book a custom tour so the program can match what students are learning in the classroom.

What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)
Habitats and animals that rely on healthy habitats, conservation

Cost? $30-50 per program + admission; some scholarships available

6th Grade Standards: 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5
7th Grade Standards: 7.4.2, 7.4.4, 7.5.1
8th Grade Standards: 8.1.4, 8.3.3

When is the best time to schedule your resource? Fall, winter, Spring

What is the best method to schedule your resource? Email, Call, Sign-up/register via website

What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?
Asking questions and defining problems., Constructing explanations and designing solutions., Engaging in argument from evidence., Obtaining, evaluating, and communicating information.

What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?
Asking questions and defining problems., Analyzing and interpreting data., Constructing explanations and designing solutions., Obtaining, evaluating, and communicating information.

What cross-cutting concepts are the most useful for understanding your resource?
Patterns, Cause and effect, Systems and system models, Structure and function, Stability and change
| Name: Michelle Mileham  
| Anne Terry  
| Annie Young  
| Marina Astin | Title: Director of Education  
| Education Manager, General Inquiries & Teacher PD  
| Senior Educator, Guided Tour & Field Trips  
| Educator, School and Community Outreach | Organization: Tracy Aviary |

**Website:** [http://tracyaviary.org/learning/](http://tracyaviary.org/learning/)  
**Email:** michellem@tracyaviary.org  
**Phone:** 801-596-8500 ext.118

**Which best describes your resource?** Guest classroom lab/activity facilitation

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

During our Soaring Science Programs, Tracy Aviary educators bring hands-on activities to your classroom or community group to explore topics such as adaptations through art, how extraordinary eggs are, migration, and wetlands and how to protect these incredible habitats. You can also book one of our Nature in the City programs, during which educators bring activities to school yards or local parks to help students explore and discover the nature right in their backyards through eco-art, stream exploration, nature walks, and map-making. All programs are 45-60 minutes long and are limited to groups of 30 participants (back-to-back programs can be scheduled to accommodate larger classes).

**What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)**

Ecosystems, migration, conservation, environmental stewardship

**Cost?** $60 for first program; $25 for additional simultaneous or consecutive programs. Some scholarships available.

| 6th Grade Standards: 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5 | 7th Grade Standards: 7.4.2, 7.5.1, 7.5.2, 7.5.4 | 8th Grade Standards: 8.3.3 |

**When is the best time to schedule your resource?** Fall, Winter, Spring

**What is the best method to schedule your resource?** Email, Call, Sign-up/register via website

**What Science and Engineering Practice/s does your resource allow TEACHERS to engage in? (if your resource includes teacher PD)?**

Asking questions and defining problems., Analyzing and interpreting data., Constructing explanations and designing solutions., Obtaining, evaluating, and communicating information.

**What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?**

Asking questions and defining problems., Developing and using models., Analyzing and interpreting data., Constructing explanations and designing solutions., Engaging in argument from evidence., Obtaining, evaluating, and communicating information.

**What cross-cutting concepts are the most useful for understanding your resource?**

Patterns, Cause and effect, Systems and system models, Structure and function, Stability and change
**CENTER FOR THE LIVING CITY - TEACHING OBSERVATION**

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kat Nix</td>
<td>Jane Jacobs Fellow</td>
<td>Center for the living city</td>
</tr>
<tr>
<td>Chelsea Gauthier</td>
<td>Associate Director</td>
<td></td>
</tr>
<tr>
<td>Website</td>
<td>Email</td>
<td>Phone</td>
</tr>
<tr>
<td>centerforthelivingcity.org</td>
<td><a href="mailto:kat@centerforthelivingcity.org">kat@centerforthelivingcity.org</a></td>
<td>801-645-1432</td>
</tr>
</tbody>
</table>

**Which best describes your resource?** curriculum to be adapted

Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.

Engage students in observing their community through the lens of urban ecology! This program uses the power of observation to teach students science and engineering concepts, utilize systems thinking, and asks the students to see the interconnectedness of the ecosystems they are a part of. As students observe phenomena, they begin to understand cities and communities as living breathing ecosystems. With the ebb and flow of energy, water, waste, and food systems within cities, the opportunities for observation and creative problem solving are endless. Cities are constantly evolving; through observation students will see the design and engineering practices that are already in place and propose their own solutions for challenges and opportunities for the future. As the population of Utah is growing at unprecedented rates, we will need our future students and change-makers to understand and propose solutions to challenges such as rapid urbanization, housing, water and air quality, and the preservation of our night skies. In the efforts of becoming the change-makers of tomorrow, today students will have the opportunity to host a Jane Jacobs walk to connect with members of their community and discuss ways to preserve, heal, repair, or transform the places they care about.

What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)

- Communities as a living organism and ecological system
- Ecological systems
- Energy flows
- Dark Skies (light pollution)

**Cost?** Free

<table>
<thead>
<tr>
<th>6th Grade Standards:</th>
<th>7th Grade Standards:</th>
<th>8th Grade Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.4.5</td>
<td>N/A</td>
<td>8.2.5, 8.3.3</td>
</tr>
</tbody>
</table>

When is the best time to schedule your resource? No scheduling necessary (web-based resource)

What is the best method to schedule your resource? No scheduling necessary (web-based resource)

What Science and Engineering Practice/s does your resource allow **TEACHERS** to engage in? (if your resource includes teacher PD)?

- Asking questions and defining problems.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Constructing explanations and designing solutions.
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

What Science and Engineering Practice/s does your resource allow **STUDENTS** to engage in?

- Asking questions and defining problems.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Constructing explanations and designing solutions.
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

What cross-cutting concepts are the most useful for understanding your resource?

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change
<table>
<thead>
<tr>
<th><strong>U OF U SCIENCE AND ENGINEERING FAIR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name:</strong> Jody Oostema</td>
</tr>
<tr>
<td><strong>Website:</strong> New Website Coming Soon</td>
</tr>
<tr>
<td><strong>Email:</strong> new email coming soon</td>
</tr>
<tr>
<td><strong>Phone:</strong> 801-585-9109</td>
</tr>
<tr>
<td><strong>Title:</strong> Program Manager</td>
</tr>
<tr>
<td><strong>Organization:</strong> UofU Science and Engineering Fair/ CSME</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Which best describes your resource?</strong></th>
<th>Out-of-classroom teacher professional development, Student and parent resources</th>
</tr>
</thead>
</table>

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

The sky is the limit to what we can provided! I offer teacher trainings in the fall and will come to any school to do a private science fair workshop. Email questions about student projects can be sent in and if you can come up with a plan or idea, I will help you implement it!

<table>
<thead>
<tr>
<th><strong>What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Cost:</strong> Free</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard:</strong> Can apply to all</td>
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</table>

<table>
<thead>
<tr>
<th><strong>When is the best time to schedule your resource?</strong></th>
<th>no scheduling necessary (web-based resource)</th>
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<thead>
<tr>
<th><strong>What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?</strong></th>
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</thead>
<tbody>
<tr>
<td>Asking questions and defining problems., Developing and using models., Planning and carrying out investigations., Analyzing and interpreting data., Using mathematics and computational thinking., Constructing explanations and designing solutions., Engaging in argument from evidence., Obtaining, evaluating, and communicating information., None - my resource is not for students.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th><strong>What cross-cutting concepts are the most useful for understanding your resource?</strong></th>
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<tbody>
<tr>
<td>Cause and effect, Scale, proportion, and quantity, Stability and change</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Name: Paul Ricketts</th>
<th>Title: Observatory Director</th>
<th>Organization: South Physics Observatory, University of Utah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Julie Callahan</td>
<td>Email: <a href="mailto:observatory@physics.utah.edu">observatory@physics.utah.edu</a></td>
<td>Phone: 801-597-1442</td>
</tr>
<tr>
<td>Website: web.utah.edu/astro</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Which best describes your resource?** Out-of-classroom teacher professional development, Field trip/s, Guest lecturer, Guest classroom lab/activity facilitation

**Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.**

Astronomy based lectures and demos as well as telescope use for star parties and solar viewing. Also physics based demos and hands on learning.

**What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)**

Physics, Astronomy

**Cost? Free**

**6th Grade Standards:** 6.1.1, 6.1.2, 6.1.3, 6.2.1, 6.2.2, 6.2.3

**7th Grade Standards:** 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5

**8th Grade Standards:** 8.1.1, 8.1.2, 8.1.3, 8.1.4, 8.1.5, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5, 8.2.6, 8.3.1, 8.3.2

**When is the best time to schedule your resource?** Fall, Winter, Spring

**What Science and Engineering Practice/s does your resource allow TEACHERS to engage in (if your resource includes teacher PD)?**


**What Science and Engineering Practice/s does your resource allow STUDENTS to engage in?**


**What cross-cutting concepts are the most useful for understanding your resource?**

Cause and effect, Scale, proportion, and quantity, Systems and system models, Energy and matter, Structure and function, Stability and change
<table>
<thead>
<tr>
<th><strong>HAWKWATCH INTERNATIONAL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name:</strong> Nikki Wayment</td>
</tr>
<tr>
<td>Janet Nelson</td>
</tr>
<tr>
<td>Annette Hansen</td>
</tr>
<tr>
<td><strong>Title:</strong> Education and Outreach Director</td>
</tr>
<tr>
<td><strong>Organization:</strong> Hawkwatch</td>
</tr>
<tr>
<td><strong>Website:</strong> hawkwatch.org;</td>
</tr>
<tr>
<td>hawkcount.org; allaboutbirds.org</td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:nwayment@hawkwatch.org">nwayment@hawkwatch.org</a></td>
</tr>
<tr>
<td><strong>Phone:</strong> 801-484-6808</td>
</tr>
<tr>
<td><strong>Which best describes your resource?</strong> Out-of-classroom teacher professional development, Classroom kits/toolboxes to check out, Guest classroom lab/activity facilitation, 3D-aligned curriculum</td>
</tr>
<tr>
<td><strong>Please provide a brief (200 word) description of your resource for the summary document that we will give to teachers.</strong> We use actual HawkWatch International data with specific activities to help teachers understand how and why data is collected, why it's valuable and how it is used in the real world. Our activities help students understand how data is organized, how to look for patterns, and how to make predictions or statements based on the data.</td>
</tr>
<tr>
<td><strong>What real-world phenomenon/a does your resource help bring into classrooms? (please feel free to list, if more than one)</strong> N/A</td>
</tr>
<tr>
<td><strong>Cost?</strong> depends on multiple variables</td>
</tr>
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