



★  
Colorado  
Academic Standards

# Science



**COLORADO**  
Department of Education

ALL STUDENTS • ALL STANDARDS

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## Purpose of Science

“Science is facts; just as houses are made of stone, so is science made of facts; but a pile of stones is not a house, and a collection of facts is not necessarily science.”

--Jules Henri Poincaré (1854-1912) French mathematician

High expectations in education are essential for the U.S. to continue as a world leader in the 21st century. In order to be successful in postsecondary education, the workforce, and in life, students need a rigorous, age-appropriate set of standards that include finding and gathering information, critical thinking, and reasoning skills to evaluate information, and use information in social and cultural contexts. Students must learn to comprehend and process information, analyze and draw conclusions, and apply the results to everyday life.

A quality science education embodies 21st century skills and postsecondary and workforce readiness by teaching students critical skills and thought processes to meet the challenges of today’s world. Scientifically literate graduates will help to ensure Colorado’s economic vitality by encouraging the development of research and technology, managing and preserving our environmental treasures, and caring for the health and well-being of our citizens.

Science is both a body of knowledge that represents the current understanding of natural systems, and the process whereby that body of knowledge has been established and is continually extended, refined, and revised. Because science is both the knowledge of the natural world and the processes that have established this knowledge, science education must address both of these aspects.

At a time when pseudo-scientific ideas and outright fraud are becoming more common place, developing the skepticism and critical thinking skills of science gives students vital skills needed to make informed decisions about their health, the environment, and other scientific issues facing society. A major aspect of science is the continual interpretation of evidence. All scientific ideas constantly are being challenged by new evidence and are evolving to fit the new evidence. Students must understand the collaborative social processes that guide these changes so they can reason through and think critically about popular scientific information, and draw valid conclusions based on evidence, which often is limited. Imbedded in the cognitive process, students learn and apply the social and cultural skills expected of all citizens in school and in the workplace. For example, during class activities, laboratory exercises, and projects, students learn and practice self-discipline, collaboration, and working in groups.

The Colorado Academic Standards in science represent what all Colorado students should know and be able to do in science as a result of their preschool through twelfth-grade science education. Specific expectations are given for students who complete each grade from preschool through eighth grade and for high school. These standards outline the essential level of science content knowledge and the application of the skills needed by all Colorado citizens to participate productively in our increasingly global, information-driven society.

## Prepared Graduates in Science

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.
2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.
3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.
4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.
5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.
6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.
7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.
8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.
9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.
10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.
11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

# Standards in Science

Standards are the topical organization of an academic content area. The three standards of science, including the disciplinary core ideas, are:

## 1. Physical Science

Students know and understand common properties, forms, and changes in matter and energy.

PS1 Matter and Its Interactions

PS2 Motion and Stability: Forces and Interactions

PS3 Energy

PS4 Waves and Their Applications in Technologies for Information Transfer

## 2. Life Science

Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment.

LS1 From Molecules to Organisms: Structures and Processes

LS2 Ecosystems: Interactions, Energy, and Dynamics

LS3 Heredity: Inheritance and Variation of Traits

LS4 Biological Evolution: Unity and Diversity

## 3. Earth and Space Science

Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.

ESS1 Earth's Place in the Universe

ESS2 Earth's Systems

ESS3 Earth and Human Activity

## Science and Engineering Practices



1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

## Cross Cutting Concepts

1. *Patterns.* Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. *Cause and effect: Mechanism and explanation.* Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity.* In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models.* Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter: Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function.* The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. *Stability and change.* For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.



# How to Read the Colorado Academic Standards

CONTENT AREA			
Grade Level, Standard Category			
<b>Prepared Graduates:</b> The <i>PG Statements</i> represent concepts and skills that all students who complete the Colorado education system must master to ensure their success in postsecondary and workforce settings.			
<b>Grade Level Expectation:</b> The <i>GLEs</i> are an articulation of the concepts and skills for a grade, grade band, or range that students must master to ensure their progress toward becoming a prepared graduate.			
<u>Evidence Outcomes</u>		<u>Academic Context and Connections</u>	
The <i>EOs</i> describe the evidence that demonstrates that a student is meeting the GLE at a mastery level.		The <i>ACCs</i> provide context for interpreting, connecting, and applying the content and skills of the GLE. This includes the <a href="#">Colorado Essential Skills</a> , which are the critical skills needed to prepare students to successfully enter the workforce or educational opportunities beyond high school embedded within statute (C.R.S. 22-7-1005) and identified by the Colorado Workforce Development Committee.	
		The <i>ACCs</i> contain information unique to each content area. Content-specific elements of the <i>ACCs</i> are described below.	
Grade Level, Standard Category		2020 Colorado Academic Standards	GLE Code
			

## Academic Context and Connections in Science:

**Colorado Essential Skills and Science and Engineering Practices:** These statements describe how the learning of the content and skills described by the GLE and EOs connects to and supports the development of the [Colorado Essential Skills](#) named in the parentheses. The science and engineering practices are things that scientists employ as they investigate and build models and theories about the world. These terms are used to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice.

**Elaboration on the GLE:** This section provides greater context for the GLE through a description of the understanding about the core ideas that should be developed by students.

**Cross Cutting Concepts:** The crosscutting concepts have application across all domains of science. As such, they provide one way of linking across the domains through core ideas.



## Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

## Preschool Learning and Development Expectation:

1. Recognize that physical properties of objects and/or materials help us understand the world.

### Indicators of Progress

*By the end of the preschool experience (approximately 60 months/5 years old), students may:*

- a. Use senses to explore the properties of objects and materials (e.g., solids, liquids).
- b. Make simple observations, predictions, explanations, and generalizations based on real-life experiences.
- c. Collect, describe, predict and record information using words, drawings, maps, graphs and charts.
- d. Observe, describe, and discuss living things and natural processes.

### Examples of High-Quality Teaching and Learning Experiences

#### *Supportive Teaching Practices/ Adults May:*

1. Provide a variety of materials and objects (i.e., solids and liquids) to encourage children to observe, manipulate, sort, and describe physical properties (e.g., size, shape, color, texture, weight) using their five senses as well as simple tools (e.g., magnifiers, balance scales, funnels).
2. Provide opportunities for children to explore changes in matter (e.g., solids and liquids) when adding heat or cold, when mixing ingredients during cooking, when adding items to liquid (e.g., oil, pebbles).
3. Provide each child with materials for experiments.
4. Display child observations, predictions and projects.

#### *Examples of Learning/ Children May:*

1. Investigate changes in liquids and solids when substances are heated, cooled, combined etc.
2. Predict outcomes when altering materials (liquids and solids) and record using journals, charts, graphs, technology or drawings.
3. Participate in experiments, ask how and why questions.
4. Draw connections between classroom experiments/investigation and real world experiences (e.g., “The water turned to ice like the lake next to my house because it was cold”).



### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Preschool Learning and Development Expectation:

2. Recognize there are cause - and - effect relationships related to matter and energy.

### Indicators of Progress

*By the end of the preschool experience (approximately 60 months/5 years old), students may:*

- a. Recognize and investigate cause - and - effect relationships in everyday experiences (pushing, pulling, kicking, rolling or blowing objects).
- b. Notice change in matter.
- c. Observe, describe and discuss properties of materials and transformation of substances.
- d. Seek answers to questions and test predictions using simple experiments.

### Examples of High-Quality Teaching and Learning Experiences

#### *Supportive Teaching Practices/ Adults May:*

1. Provide opportunities for children to explore motion (e.g., fans and scarves, ramps and toy cars).
2. Provide opportunities for children to investigate energy (e.g., heat, light, sound; investigate shadows, sort musical instruments and discuss different sounds made by particular movements; explore transparent properties on a light table).
3. Provide opportunities for children to record observations in the changes of matter (e.g., ice melting at the sensory table).
4. Facilitate inquiry by asking how and why questions to encourage children to make predictions and chart results.

#### *Examples of Learning/ Children May:*

1. Discover the higher the incline in a ramp (in block area) makes the car go farther.
2. Explain that some magnets pull away and some come together.
3. Identify when a change in matter occurs (ice melting, icicles forming, etc.).
4. Identify how and why things move (e.g., using a balance, pushing structures over, how fast different objects move).
5. Ask questions related to why things happen.



### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Preschool Learning and Development Expectation:

1. Recognize that living things have unique characteristics and basic needs that can be observed and studied.

#### Indicators of Progress

*By the end of the preschool experience (approximately 60 months/5 years old), students may:*

- a. Observe, describe and discuss living things.
- b. Observe similarities and differences in the needs of living things.
- c. Observe and describe how natural habitats provide for the basic needs of plants and animals with respect to shelter, food, water, air and light.
- d. Ask and pursue questions through simple investigations and observations of living things.
- e. Collect, describe, and record information about living things through discussion, drawings, graphs, technology and charts.
- f. Identify differences between living and nonliving things.

#### Examples of High-Quality Teaching and Learning Experiences

*Supportive Teaching Practices/ Adults May:*

1. Provide opportunities for children to engage with live animals and plants along with toy/stuffed animals and plans and photographs/pictures throughout the classroom.
2. Read books about living and nonliving things, inquire about how we know if something is living or not.
3. Display worm farms, bird feeders, caterpillar/butterfly habitat, fish tank for observation.
4. Watching the fish, observe and discuss the movement of the gills, explaining this is how fish breathe under water.
5. Provide opportunities for children to use different materials (technology, journals, drawings, etc.) to observe living things.

*Examples of Learning/ Children May:*

1. Match photographs of different habitats to the things that occupy them (i.e., worms live in the ground; fish live in water).
2. Sequence a series of photographs/pictures of a plant's growth.
3. Sequence a series of photographs/pictures of the life cycle of a butterfly from caterpillar to chrysalis/cocoon to butterfly.
4. Document the life cycle of living thing.
5. Recognize that living things require water, air, food.





### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Preschool Learning and Development Expectation:

2. Recognize that living things develop in predictable patterns.

#### Indicators of Progress

*By the end of the preschool experience (approximately 60 months/5 years old), students may:*

- a. Identify the common needs such as food, air and water of familiar living things.
- b. Predict, explain and infer patterns based on observations and representations of living things, their needs and life cycles.
- c. Observe and document changes in living things over time using different modalities such as drawing, dramatization, describing or using technology.
- d. Recognize that plants and animals grow and change.

#### Examples of High-Quality Teaching and Learning Experiences

##### *Supportive Teaching Practices/ Adults May:*

1. Provide opportunities for observation and investigation of the characteristics of animals and plants over time.
2. Take nature walks.
3. Encourage children to identify similarities and differences between living things and document what each need to survive.
4. Provide opportunities for children to explore available outdoor habitats.
5. Provide opportunities for children to help feed the classroom pet, water the plants, etc.

##### *Examples of Learning/ Children May:*

1. Identify and describe through a variety of modalities the changes in living things overtime (e.g., bears hibernate when it is cold outside).
2. Investigate living things by caring for animals and plants in the classroom.
3. Document the human life cycle - babies grow into children, children grow to adults, adults get older.

### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Preschool Learning and Development Expectation:

1. The acquisition of concepts and facts related to the Earth materials and their uses.

#### Indicators of Progress

*By the end of the preschool experience (approximately 60 months/5 years old), students may:*

- a. Use senses and tools, including technology, to investigate materials, and observe processes and relationships to gather information and explore the environment.
- b. Inquire about the natural and physical environment.
- c. Observe and discuss common properties, differences and comparisons among objects.
- d. Participate in simple investigations to form hypothesis, gather observations, draw conclusions.
- e. Record observations using words, drawings, maps, graphs and charts.

#### Examples of High-Quality Teaching and Learning Experiences

##### *Supportive Teaching Practices/ Adults May:*

1. Engage children in exploring natural objects such as small rocks, soil, leaves, sand and other objects.
2. Provide soil and containers for planting.
3. Display rocks, stones and pebbles of different shapes and colors for sorting.
4. Ask questions and make comments that lead children to observe closely and think about how they could find out more.
5. Encourage children to compare and contrast types of earth materials.
6. Encourage children to ask question and seek answers through active exploration
7. Provide a variety of materials for children to document observations (e.g., tablets, computers, notebooks, poster paper).

##### *Examples of Learning/ Children May:*

1. Ask and pursue questions through simple investigations and observations of natural objects.
2. Explore rocks, soil and sand using a magnifier.
3. Use sense and simple tools to explore earth materials.
4. Discuss evidence from investigations and observations.

### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

### Preschool Learning and Development Expectation:

2. The acquisition of concepts and facts related to the natural and physical world and the understanding of naturally occurring relationships.

#### Indicators of Progress

*By the end of the preschool experience (approximately 60 months/5 years old), students may:*

- a. Predict, explain and infer patterns based on observations and evidence.
- b. Articulate findings through a variety of modalities (e.g., drawings, words, dramatizations).
- c. Recognizes familiar elements of the natural world and demonstrates an understanding that these may change over time (e.g., sun and moon, weather).
- d. Observe and describe patterns observed over the course of a number of days and nights (e.g., differences in the activities or appearance of plants and animals).

#### Examples of High-Quality Teaching and Learning Experiences

##### *Supportive Teaching Practices/ Adults May:*

1. Take nature walks to observe weather conditions.
2. Talk about weather conditions daily.
3. Provide opportunities to sort pictures of activities, clothing and toys according to the types of weather and seasons they correspond to (e.g., sled with snow, sunglasses in summer).
4. Talk about things that can be found in the day or night sky (e.g., sun, moon, clouds, stars).

##### *Examples of Learning/ Children May:*

1. Match types of clothing or activities to seasonal weather conditions (e.g., we use an umbrella when it is raining; we wear boots when it snows; we wear hats and gloves when it is cold outside).
2. Discuss current weather events that affect the community.
3. Observe and describe different types of clouds and moon phases.
4. Describe differences in weather patterns and day vs. night via drawing, dramatization or words.



### Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

### Grade Level Expectation:

1. Pushes and pulls can have different strengths and directions, and can change the speed or direction of an object's motion or start or stop it.

### Evidence Outcomes

#### *Students Can:*

- a. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (K-PS2-1) *(Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball and two objects colliding and pushing on each other.) (Boundary: Limited to different relative strengths or different directions, but not both at the same time. Does not include non-contact pushes or pulls such as those produced by magnets.)*
- b. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. (K-PS2-2) *(Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.) (Boundary: Does not include friction as a mechanism for change in speed.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. With guidance, plan and conduct an investigation in collaboration with peers (Planning and Carrying Out Investigations) (Personal: Initiative/Self-direction).
2. Analyze data from tests of an object or tool to determine if it works as intended (Analyzing and Interpreting data) (Entrepreneurial: Critical thinking/Problem solving).
3. Connections to Nature of Science: Scientists use different ways to study the world.

#### *Elaboration on the GLE:*

1. Students can answer the question: How can one predict an object's continued motion, changes in motion or stability?
2. PS2:A Forces and Motion: Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
3. PS2:B Types of Interactions: When objects touch or collide, they push on one another and can change motion.
4. PS3:C Relationship Between Energy and Forces: A bigger push or pull makes things speed up or slow down more quickly.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Simple tests can be designed to gather evidence to support or refute student ideas about causes.







### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

2. Sunlight affects the Earth's surface.

### Evidence Outcomes

#### *Students Can:*

- a. Make observations to determine the effect of sunlight on Earth's surface. (K-PS3-1) *(Clarification Statement: Examples of Earth's surface could include sand, soil, rocks and water) (Boundary: Temperature is limited to relative measures such as warmer/cooler.)*
- b. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area. (K-PS3- 2) *(Clarification Statement: Examples of structures could include umbrellas, canopies and tents that minimize the warming effect of the sun.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make observations (firsthand or from media) to collect data that can be used to make comparisons. (Planning and Carrying Out Investigations) (Personal: Personal responsibility)
2. Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)
3. Connections to Nature of Science: Scientists use different ways to study the world.

#### *Elaboration on the GLE:*

1. Students can answer the question: What is meant by conservation of energy? How is energy transferred between objects or systems?
2. PS3:B Conservation of Energy and Energy Transfer: Sunlight warms Earth's surface.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Events have causes that generate observable patterns.





### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Grade Level Expectation:

1. To live and grow, animals obtain food they need from plants or other animals, and plants need water and light.

### Evidence Outcomes

#### *Students Can:*

- a. Use observations to describe patterns of what plants and animals (including humans) need to survive. (K-LS1-1) (*Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and that all living things need water.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (Analyzing and Interpreting data) (Entrepreneurial: Critical thinking/Problem solving)
2. Connections to Nature of Science: Scientists look for patterns and order when making observations about the world

#### *Elaboration on the GLE:*

1. Students can answer the question: How do the structures of organisms enable life's functions?
2. LS1:C Organization for Matter and Energy Flow in Organisms: All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns in the natural and human designed world can be observed and used as evidence.



### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

1. Patterns are observed when measuring the local weather, including how humans and other organisms impact their environment.

### Evidence Outcomes

#### *Students Can:*

- a. Use and share observations of local weather conditions to describe patterns over time. (K-ESS2-1) *(Clarification Statement: Examples of qualitative observations could include descriptions of the weather [such as sunny, cloudy, rainy, and warm]; examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.) (Boundary: Quantitative observations limited to whole numbers and relative measures such as warmer/cooler.)*
- b. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. (K-ESS2-2) *(Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (Analyzing and Interpreting data) (Entrepreneurial: Critical thinking/Problem solving).
2. Construct an argument with evidence to support a claim. (Engaging in Argument from Evidence) (Personal: Personal responsibility).
3. Connections to Nature of Science: Scientists look for patterns and order when making observations about the world

#### *Elaboration on the GLE:*

1. Students can answer the question: What regulates weather and climate?
2. ESS2:D Weather and Climate: Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.
3. ESS2:E Biogeology: Plants and animals can change their environment.
4. ESS3:C Human Impacts on Earth Systems: Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air and other living things

#### *Cross Cutting Concepts:*

1. Pattern: Patterns in the natural world can be observed, used to describe phenomena and used as evidence.
2. Systems and System Models: Systems in the natural and designed world have parts that work together.





### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

2. Plants and animals meet their needs in their habitats and impact one another; people can prepare for severe weather.

### Evidence Outcomes

#### *Students Can:*

- a. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live. (K-ESS3-1)  
*(Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.)*
- b. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. (K-ESS3-2)  
*(Clarification Statement: Emphasis is on local forms of severe weather.)*
- c. Communicate solutions that will reduce the impact of humans on the land, water, air and/or other living things in the local environment. (K-ESS3-3)  
*(Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions based on observations to find more information about the designed world. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis).
2. Use a model to represent relationships in the natural world. (Developing and Using Models) (Personal: Initiative/Self-direction).
3. Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world. (Obtaining, Evaluating and Communicating Information) (Civic/Interpersonal: Communication).
4. Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas. (Obtaining, Evaluating and Communicating Information) (Civic/Interpersonal: Communication).



*Elaboration on the GLE:*

1. Students can answer the question: How do Earth's surface processes and human activities affect each other?
2. ESS3:A Natural Resources: Living things need water, air and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.
3. ESS3:B Natural Hazards: Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events.
4. ESS3:C Human Impacts on Earth Systems: Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air and other living things.

*Cross Cutting Concepts:*

1. Cause and Effect: Events have causes that generate observable patterns.
2. Systems and System Models: Systems in the natural and designed world have parts that work together.
3. Connections to Engineering, Technology, and Applications of Science: People encounter questions about the natural world every day. People depend on various technologies in their lives; human life would be very different without technology.



## Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

## Grade Level Expectation:

1. Sound can make matter vibrate and vibrating matter can make sound.

## Evidence Outcomes

### Students Can:

- Plan and conduct investigations to provide evidence that vibrating materials can make a sound and that sound can make materials vibrate. (1-PS4-1)  
*(Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.)*
- Make observations to construct an evidence-based account that objects can be seen only when illuminated. (1-PS4-2) *(Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.)*
- Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. (1-PS4-3)  
*(Clarification Statement: Examples of materials could include those that are transparent [such as clear plastic], translucent [such as wax paper], opaque [such as cardboard] and reflective [such as a mirror].)*
- Use tools and materials to design and build a device that used light or sound to solve the problem of communicating over a distance. (1-PS4-4)  
*(Clarification Statement: This performance expectation integrates transitional science content with engineering through a practice or disciplinary core idea.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

- Plan and conduct investigations collaboratively to produce evidence to answer a question. (Planning and Carrying Out Investigations) (Personal: Initiative/Self-direction)
- Make observations (firsthand or from media) to construct an evidence-based conclusion and use tools and materials provided to design and build devices. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)
- Scientific Investigations Use a Variety of Methods: Scientists use different ways to study the world. Science investigations begin with a question.

### Elaboration on the GLE:

- Students can answer the question: What are the characteristic properties and behaviors of waves?
- PS4:A Wave Properties: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave - observe, for example, a bobbing cork or seabird - except when the water meets the beach. Sound can make matter vibrate and vibrating matter can make sound.
- PS4:B Electromagnetic Radiation: Objects can be seen only when light is available to illuminate them. Very hot objects give off light (e.g., a fire, the sun).
- PS4:C Information Technologies and Instrumentation: People use their senses to learn about the world around them. Their eyes detect light, their ears detect sound, and they can feel vibrations by touch.



*Cross Cutting Concepts:*

1. Cause and Effect: Simple tests can be designed to gather evidence to support or refute student ideas about causes.





## Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

## Grade Level Expectation:

1. All organisms have external parts that they use to perform daily functions.

### Evidence Outcomes

#### *Students Can:*

- a. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow and meet their needs. (1-LS1-1) (*Clarification Statement: Examples of human problems that can be solved could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and detecting intruders by mimicking eyes and ears.*)
- b. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. (1-LS1-2) (*Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make [such as crying, cheeping and other vocalizations] and the responses of the parents [such as feeding, comforting and protecting the offspring].*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use materials to design a device that solves a specific problem or a solution to a specific problem. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
2. Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world. (Obtaining, Evaluating, and Communicating Information) (Civic/Interpersonal: Communication)

3. Connections to Nature of Science: Science Knowledge is Based on Empirical Evidence. Scientists look for patterns and order when making observations about the world.

#### *Elaboration on the GLE:*

1. Students can answer the question: How do the structures of organisms enable life's functions?
2. LS1:A Structure and Function: All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place and seek, find and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow and produce more plants.
3. LS1:B Growth and Development of Organisms: Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.
4. LS1:D Information Processing: Animals have body parts that capture and convey different kinds of information needed for growth and survival - for example, eyes for light, ears for sounds, and skin for temperature or touch. Animals respond to these inputs with behaviors that help them survive (e.g., find food, run from a predator). Plants also respond to some external inputs (e.g., turn leaves toward the sun).





*Cross Cutting Concepts:*

1. Structure and Function: The shape and stability of structures of natural and designed objects are related to their function(s).
2. Patterns: Patterns in the natural world can be observed, used to describe phenomena and used as evidence.





### Prepared Graduates:

7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.

### Grade Level Expectation:

2. Young organisms are very much, but not exactly, like their parents, and also resemble other organisms of the same kind.

### Evidence Outcomes

#### *Students Can:*

- a. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. (1-LS3-1)  
*(Clarification Statement: Examples of patterns could include features that plants or animals share. Examples of observations could include leaves from the same kind of plant that are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same. This performance expectation integrates traditional science content with engineering through a practice or disciplinary core idea.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Communication).

#### *Elaboration on the GLE:*

1. Students can answer the questions: How are the characteristics of one generation related to the previous generation? Why do individuals of the same species vary in how they look, function, and behave?
2. LS3:A Inheritance of Traits: Young animals are very much, but not exactly, like their parents. Plants also are very much, but not exactly, like their parents.
3. LS3:B Variation of Traits: Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns in the natural and human designed world can be observed, used to describe phenomena and used as evidence.





### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth’s place in it.

### Grade Level Expectation:

1. Patterns of movement of the sun, moon and stars as seen from Earth can be observed, described and predicted.

### Evidence Outcomes

#### *Students Can:*

- a. Use observations of the sun, moon, and stars to describe patterns that can be predicted. (1-ESS1-1) *(Clarification Statement: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky and set; and stars other than our sun are visible at night but not during the day.)*
- b. Make observations at different times of year to relate the amount of daylight to the time of year. (1-ESS1-2) *(Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.) (Boundary Statement: Limited to relative amounts of daylight, not quantifying the hours or time of daylight.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Plan and conduct investigations collaboratively to produce evidence to answer a question. (Planning and Carrying out Investigations) (Personal: Personal responsibility).
2. Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (Analyzing and Interpreting Data) (Entrepreneurial: Creativity/Innovation).

#### *Elaboration on the GLE:*

1. Students can answer the questions: What is the universe, and what goes on in stars? (ES1.A) What are the predictable patterns caused by Earth’s movement in the solar system? (ES1.B)
2. ESS1:A The Universe and its Stars: Patterns of the motion of the sun, moon and stars in the sky can be observed, described and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.
3. ESS1:B Earth and the Solar System: Seasonal patterns of sunrise and sunset can be observed, described and predicted.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns in the natural world can be observed, used to describe phenomena and used as evidence.
2. Scientific Knowledge Assumes an Order and Consistency in Natural Systems: Science assumes natural events happen today as they happened in the past.





### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

1. Matter exists as different substances that have observable different properties.

### Evidence Outcomes

#### *Students Can:*

- a. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. (2-PS1-1) *(Clarification Statement: Observations could include color, texture, hardness and flexibility. Patterns could include the similar properties that different materials share.)*
- b. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. (2-PS1-2) *(Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture and absorbency.) (Boundary Statement: Quantitative measurement is limited to length.)*
- c. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. (2-PS1-3) *(Clarification Statement: Examples of pieces could include blocks, building bricks or other assorted small objects.)*
- d. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. (2-PS1-4) *(Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf and heating paper.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question (Planning and Carrying Out Investigations) (Personal: Personal responsibility)
2. Analyze data from tests of an object or tool to determine if it works as intended (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
3. Make observations from several sources to construct an evidence-based account for natural phenomena (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis)
4. Construct an argument with evidence to support a claim (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
5. Connections to Nature of Science: Science Models, Laws, Mechanisms and Theories Explain Natural Phenomena: Science searches for cause - and - effect relationships to explain natural events.





*Elaboration on the GLE:*

1. Students can answer the question: How do particles combine to form the variety of matter one observes?
2. PS1:A Structure and Properties of Matter: Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces (e.g., blocks, construction sets). Objects or samples of a substance can be weighed, and their size can be described and measured.
3. PS1:B Chemical Reactions: Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing), and sometimes they are not (e.g., baking a cake, burning fuel).

*Cross Cutting Concepts:*

1. Patterns: Patterns in the natural and human - designed world can be observed.
2. Cause and Effect: Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes.
3. Energy and Matter: Objects may break into smaller pieces and be put together into larger pieces or may change shapes.
4. Connections to Engineering, Technology and Applications of Science: Influence of Science, Engineering and Technology on Society & the Natural World. Every human-made product is designed.





### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

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

### Evidence Outcomes

#### *Students Can:*

- a. Plan and conduct an investigation to determine if plants need sunlight and water to grow. (2-LS2-1) (*Boundary Statement: Limited to using one variable at a time.*)
- b. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. (2-LS2-2)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a simple model based on evidence to represent a proposed object or tool (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question (Planning and Carrying Out Investigations) (Civic/Interpersonal: Collaboration/Teamwork)
3. Connections to Nature of Science: Science Knowledge is Based on Empirical Evidence

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms interact with the living and nonliving environments to obtain matter and energy?
2. LS2:A Interdependent Relationships in Ecosystems: Animals depend on their surroundings to get what they need, including food, water, shelter and a favorable temperature. Animals depend on plants or other animals for food. They use their senses to find food and water, and they use their body parts to gather, catch, eat and chew the food. Plants depend on air, water, minerals (in the soil) and light to grow. Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals and sunlight.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Events have causes that generate observable patterns.
2. Structure and Function: The shape and stability of structures of natural and designed objects are related to their function(s).





### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

2. A range of different organisms lives in different places.

### Evidence Outcomes

#### *Students Can:*

- a. Make observations of plants and animals to compare the diversity of life in different habitats. (2-LS4-1) (*Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make observations to collect data that can be used to make comparisons. (Planning and Carrying Out Investigations) (Entrepreneurial: Creativity/Innovation)
2. Connections to Nature of Science: Science Knowledge is Based on Empirical Evidence

#### *Elaboration on the GLE:*

1. Students can answer the question: What evidence shows that different species are related?
2. LS4:D Biodiversity and Humans: There are many different kinds of living things in any area, and they exist in different places on land and in water.





### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

### Grade Level Expectation:

1. Some events on Earth occur quickly; others can occur very slowly.

### Evidence Outcomes

#### *Students Can:*

- a. Use information from several sources to provide evidence that Earth events can occur quickly or slowly. (2-ESS1-1) (*Clarification Statement: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make observations from several sources to construct an evidence-based account for natural phenomena. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do people reconstruct and date events in the Earth's planetary history?
2. ESS1:C The History of Planet Earth: Some events on Earth occur in cycles, like day and night, and others have a beginning and an end, like a volcanic eruption. Some events, like an earthquake, happen very quickly; others, such as the formation of the Grand Canyon, occur very slowly over a time period much longer than one can observe.

#### *Cross Cutting Concepts:*

1. Stability and Change: Things may change rapidly or slowly.







### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

2. Wind and water can change the shape of the land; models can show the shape and these changes to the land.

### Evidence Outcomes

#### *Students Can:*

- a. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. (2-ESS2-1) (*Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.*)
- b. Develop a model to represent the shapes and kinds of land and bodies of water in an area. (2-ESS2-2) (*Boundary Statement: Does not include quantitative scaling in models.*)
- c. Obtain information to identify where water is found on Earth and that it can be solid or liquid. (ESS2-3)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Compare multiple solutions to a problem. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis)
2. Develop a model to represent patterns in the natural world. (Developing and Using Models) (Personal: Initiative/Self-direction)
3. Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question. (Obtaining, Evaluating, and Communicating Information) (Civic/Interpersonal: Communication)

#### *Elaboration on the GLE:*

1. Students can answer the question: How and why is Earth constantly changing?
2. ESS2:A Earth Materials and Systems: Wind and water can change the shape of the land. The resulting landforms, together with the materials on the land, provide homes for living things.
3. ESS2:B Plate Tectonics and Large-Scale System Interactions: Rocks, soils, and sand are present in most areas where plants and animals live. There may also be rivers, streams, lakes and ponds. Maps show where things are located. One can map the shapes and kinds of land and water in any area.
4. ESS2:C The Roles of Water in Earth's Surface Processes: Water is found in the ocean, rivers, lakes and ponds. Water exists as solid ice and in liquid form. It carries soil and rocks from one place to another and determines the variety of life forms that can live in a particular location.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns in the natural world can be observed.
2. Stability and Change: Things may change slowly or rapidly.
3. Influence of Science, Engineering and Technology on Society and the Natural World: Developing and using technology has impacts on the natural world.
4. Connections to Nature of Science: Science Addresses Questions About the Natural and Material World. Scientists study the natural and material world.



### Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

### Grade Level Expectation:

1. Patterns of motion can be used to predict future motion.

### Evidence Outcomes

#### *Students Can:*

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

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions that can be investigated based on patterns such as cause and effect relationships. (Asking Questions and Defining Problems)  
(Entrepreneurial: Inquiry/Analysis)
2. Define a simple problem that can be solved through the development of a new or improved object or tool. (Asking Questions and Defining Problems)  
(Entrepreneurial: Inquiry/Analysis)
3. Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
4. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)



*Elaboration on the GLE:*

1. Students can answer the questions: How can one predict an object's continued motion, changes in motion or stability? What underlying forces explain the variety of interactions observed?
2. PS2:A Forces and Motion: Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces is used at this level). The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)
3. PS2:B Types of Interactions: Objects in contact exert forces on each other.

*Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified.
2. Patterns: Patterns of change can be used to make predictions.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

2. Objects in contact exert forces on each other; electric and magnetic forces between a pair of objects do not require contact.

### Evidence Outcomes

#### *Students Can:*

- a. Ask questions to determine cause - and - effect relationships of electric or magnetic interactions between two objects not in contact with each other. (3-PS2-3) *(Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause - and - effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.) (Boundary Statement: Limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.)*
- b. Define a simple design problem that can be solved by applying scientific ideas about magnets. (3-PS2-4) *(Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions that can be investigated based on patterns such as cause - and - effect relationships. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis).
2. Define a simple problem that can be solved through the development of a new or improved object or tool. (Asking Questions and Defining Problems) (Personal: Personal responsibility).
3. Plan and conduct an investigation that control variables and provide evidence to support explanations or design solutions. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis).

#### *Elaboration on the GLE:*

1. Students can answer the question: Why are some physical systems more stable than others?
2. PS2:B Types of Interactions: Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and for forces between two magnets on their orientation relative to each other.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause and effect relationships are routinely identified, tested and used to explain change.
2. Connections to Engineering, Technology and Applications of Science: Interdependence of Science, Engineering and Technology-Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process.





### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Grade Level Expectation:

1. Organisms have unique and diverse life cycles.

### Evidence Outcomes

#### *Students Can:*

- a. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction and death. (3-LS1-1) (*Clarification Statement: Changes organisms go through during their life form a pattern.*) (*Boundary Statement: Limited to those of flowering plants and does not include details of human reproduction.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop models to describe phenomena (Developing and Using Models) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the question: How do the structures of organisms enable life's functions?
2. LS1:B Growth and Development of Organisms: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns of change can be used to make predictions.



### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

2. Being part of a group helps animals obtain food, defend themselves and cope with changes.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an argument that some animals form groups that help members survive. (3-LS2-1)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an argument with evidence, data and/or a model. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms interact with the living and nonliving environments to obtain matter and energy?
2. LS2:D Social Interactions and Group Behavior: Being part of a group helps animals obtain food, defend themselves and cope with changes. Groups may serve different functions and vary dramatically in size.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified and used to explain change.



### Prepared Graduates:

7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.

### Grade Level Expectation:

3. Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.

### Evidence Outcomes

#### Students Can:

- a. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. (3-LS3-1) *(Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.) (Boundary Statement: Does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.)*
- b. Use evidence to support the explanation that traits can be influenced by the environment. (3-LS3-2) *(Clarification Statement: Examples of the environment affecting a trait could that include normally tall plants grown with insufficient water are stunted; and a pet dog that is given too much food and little exercise may become overweight.)*

### Academic Context and Connections

#### Colorado Essential Skills and Science and Engineering Practices:

1. Analyze and interpret data to make sense of phenomena using logical reasoning. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Use evidence (e.g., observations, patterns) to support an explanation. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

3. Use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

#### Elaboration on the GLE:

1. Students can answer the questions: How are the characteristics of one generation related to the previous generation? Why do individuals of the same species vary in how they look, function and behave?
2. LS3:A Inheritance of Traits: Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.
3. LS3:B Variation of Traits: Different organisms vary in how they look and function because they have different inherited information. The environment also affects the traits that an organism develops.

#### Cross Cutting Concepts:

1. Patterns: Similarities and differences in patterns can be used to sort and classify natural phenomena.
2. Cause and Effect: Cause - and - effect relationships are routinely identified and used to explain change.

## Prepared Graduates:

7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.

## Grade Level Expectation:

4. Some living organisms resemble organisms that once lived on Earth .

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. (3-LS4-1)  
*(Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas and fossils of extinct organisms.) (Boundary Statement: Does not include identification of specific fossils or present plants and animals and is limited to major fossil types and relative ages.)*
- b. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates and reproducing. (3-LS4-2)  
*(Clarification Statement: Examples of cause - and - effect relationships could be that plants that have larger thorns than other plants may be less likely to be eaten by predators; and animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze and interpret data to make sense of phenomena using logical reasoning. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving).

2. Use evidence (e.g., observations, patterns) to construct an explanation. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving).
3. Critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving).

#### *Elaboration on the GLE:*

1. Students can answer the questions: What evidence shows that different species are related? How does genetic variation among organisms affect survival and reproduction?
2. LS4:A Evidence of Common Ancestry and Diversity: Some kinds of plants and animals that once lived on Earth are no longer found anywhere. Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.
3. LS4:B Natural Selection: Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates and reproducing.

#### *Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Observable phenomena exist from very short to very long time periods.
2. Systems and System Models
3. Cause and Effect: Cause - and - effect relationships are routinely identified and used to explain change.





### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

5. Sometimes differences in characteristics between individuals of the same species provide advantages in survival and reproduction.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well and some cannot survive at all. (3-LS4-3) (*Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.*)
- b. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (3-LS4-4) (*Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food and other organisms.*) (*Boundary Statement: Limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze and interpret data to make sense of phenomena using logical reasoning. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Use evidence to construct an explanation. (Constructing Explanations and Designing Solutions) (Personal: Initiative/Self-direction)

3. Construct an argument with evidence. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
4. Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving).

#### *Elaboration on the GLE:*

1. Students can answer the questions: How does the environment influence populations of organisms over multiple generations? What is biodiversity, how do humans affect it, and how does it affect humans?
2. LS2.C Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's characteristics, temperature or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.
3. LS4:C Adaptation: For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.
4. LS4:D Biodiversity and Humans: Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified and used to explain change.
2. Systems and System Models: A system can be described in terms of its components and their interactions.



### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

1. Climate describes patterns of typical weather conditions over different scales and variations; historical weather patterns can be analyzed.

### Evidence Outcomes

#### *Students Can:*

- a. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. (3-ESS2-1) (*Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction. Obtain and combine information to describe climates in different regions of the world.*) (*Boundary Statement: Graphical displays are limited to pictographs and bar graphs. Does not include climate change.*)
- b. Obtain and combine information to describe climates in different regions of the world. (3-ESS2-2)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Obtain and combine information from books and other reliable media to explain phenomena. (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy).

#### *Elaboration on the GLE:*

1. Students can answer the question: What regulates weather and climate?
2. ESS2:D Weather and Climate: Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns of change can be used to make predictions.





### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

2. A variety of weather hazards result from natural process; humans cannot eliminate weather-related hazards but can reduce their impacts.

### Evidence Outcomes

#### *Students Can:*

- a. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. (3-ESS3-1) (*Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs and lightning rods.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the question: How do natural hazards affect individuals and societies?
2. ESS3:B Natural Hazards: A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified, tested and used to explain change.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

1. The faster an object moves the more energy it has.

### Evidence Outcomes

#### *Students Can:*

- a. Use evidence to construct an explanation relating the speed of an object to the energy of that object. (4-PS3-1) (*Clarification Statement: Examples of evidence relating speed and energy could include change of shape on impact or other results of collisions.*) (*Boundary Statement: Does not include quantitative measures of changes in speed of an object or on any precise or quantitative definition of energy.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use evidence (e.g., measurements, observations, patterns) to construct an explanation (Constructing Explanations and Designing Solutions)  
(Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the questions: What is energy?
2. PS3:A Definitions of Energy: The faster a given object is moving, the more energy it possesses. Energy can be moved from place to place by moving objects or through sound, light or electric currents.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Energy can be transferred in various ways and between objects.



### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

2. Energy can be moved from place to place.

### Evidence Outcomes

#### *Students Can:*

- a. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents. (4-PS3-2)  
*(Boundary Statement: Does not include quantitative measurement of energy.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause - and - effect relationships. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis).
2. Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (Planning and Carrying Out Investigations) (Personal: Personal responsibility).

#### *Elaboration on the GLE:*

1. Students can answer the questions: What is meant by conservation of energy? How is energy transferred between objects or systems?
2. PS3:B Conservation of Energy and Energy Transfer: Energy is present whenever there are moving objects, sound, light or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. Light also transfers energy from place to place. Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Energy can be transferred in various ways and between objects





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

3. When objects collide contact forces transfer so as to change objects' motion.

### Evidence Outcomes

#### *Students Can:*

- a. Ask questions and predict outcomes about the changes in energy that occur when objects collide. (4-PS3-3) (*Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.*) (*Boundary Statement: Does not include quantitative measures of energy.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause - and - effect relationships (Asking Questions and Defining Problems) (Personal: Personal responsibility).

#### *Elaboration on the GLE:*

1. Students can answer the question: How are forces related to energy?
2. PS3:C Relationships Between Energy and Forces: When objects collide, the contact forces transfer energy so as to change the objects' motions.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Energy can be transferred in various ways and between objects.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

4. Energy can be produced, used or released by converting stored energy.

### Evidence Outcomes

#### *Students Can:*

- a. Apply scientific ideas to design, test and refine a device that converts energy from one form to another. (4-PS3-4) (*Clarification Statement: Examples of evidence relating speed and energy could include change of shape on impact or other results of collisions.*) (*Boundary Statement: Does not include quantitative measures of changes in speed of an object or on any precise or quantitative definition of energy.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Apply scientific ideas to solve design problems. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis).

#### *Elaboration on the GLE:*

1. Students can answer the questions: How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?
2. PS3:D Energy in Chemical Processes and Everyday Life: The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Energy can be transferred in various ways and between objects.
2. Influence of Engineering, Technology and Science on Society and the Natural World: Engineers improve existing technologies or develop new ones.
3. Science is a Human Endeavor: Most scientists and engineers work in teams. Science affects everyday life.





### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

5. Waves are regular patterns of motion.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. (4-PS4-1)  
*(Clarification Statement: Examples of models could include diagrams, analogies and physical models using wire to illustrate wavelength and amplitude of waves.) (Boundary Statement: Does not include interference effects, electromagnetic waves, non-periodic waves or quantitative models of amplitude and wavelength.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model using an analogy, example or abstract representation to describe a scientific principle. (Developing and Using Models) ((Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the question: What are the characteristic properties and behaviors of waves?
2. PS4:A Wave Properties: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets the beach. Waves of the same type can differ in amplitude (height of waves) and wavelength (spacing between wave peaks).

#### *Cross Cutting Concepts:*

1. Patterns: Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.







### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

6. An object can be seen when light reflected from its surface enters the eyes.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. (4-PS4-2) (*Boundary Statement: Does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision or how the retina works.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model to describe phenomena. (Developing and Using Models) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the questions: What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there?
2. PS4:B Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified.





### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

7. Patterns can encode, send, receive and decode information.

### Evidence Outcomes

#### *Students Can:*

- a. Generate and compare multiple solutions that use patterns to transfer information. (4-PS4-3) *(Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1s and 0s representing black and white to send information about a picture and using Morse code to send text.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis).

#### *Elaboration on the GLE:*

1. Students can answer the question: How are instruments that transmit and detect waves used to extend human senses?
2. PS4:C Information Technologies and Instrumentation: Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information – convert it from digitized form to voice – and vice versa.

#### *Cross Cutting Concepts:*

1. Patterns: Similarities and Differences in patterns can be used to sort and classify designed products.
2. Interdependence of Science and Engineering, and Technology: Knowledge of relevant scientific concepts and research findings is important in engineering.





### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Grade Level Expectation:

1. Organisms have both internal and external structures that serve various functions.

#### Evidence Outcomes

##### *Students Can:*

- a. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior and reproduction. (4-LS1-1) (*Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lungs, brain and skin.*) (*Boundary Statement: Stress at this level is on understanding the macroscale systems and their functions, not the microscopic scale.*)
- b. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. (4-LS1-2) (*Clarification Statement: Emphasis is on systems information transfer.*) (*Boundary Statement: Does not include the mechanisms by which the brain stores and recalls information or the mechanism of how sensory receptors function.*)

#### Academic Context and Connections

##### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct and argument with evidence, data, and/or a model. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
2. Use a model to test interactions concerning the functioning of a natural system (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)

##### *Elaboration on the GLE:*

1. Students can answer the question: How do internal and external structures support the survival, growth, behavior and reproduction of plants and animals?
2. LS1:A Structure and Function: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior and reproduction.
3. LS1:D Information Processing: Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.

##### *Cross Cutting Concepts:*

1. Systems and System Models: A system can be described in terms of its components and their interactions.



### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

1. Earth has changed over time.

### Evidence Outcomes

#### *Students Can:*

- a. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. (4-ESS1-1) *(Clarification Statement: Examples of evidence from patterns could include rock layers with shell fossils above rock layers with plant fossils and no shells, indicating a change from water to land over time; and a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.) (Boundary Statement: Does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers, and should only include relative time.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Identify the evidence that supports particular points in an explanation. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)

#### *Elaboration on the GLE:*

1. Students can answer the question: How can water, ice, wind and vegetation change the land?
2. ESS1:C The History of the Planet Earth: Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns can be used as evidence to support an explanation.
2. Scientific Knowledge Assumes an Order and Consistency in Natural Systems: Science assumes consistent patterns in natural systems.



### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

2. Four major earth systems interact.

### Evidence Outcomes

#### *Students Can:*

- a. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. (4-ESS2-1) (*Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling and volume of water flow.*) (*Boundary Statement: Limited to a single form of weathering or erosion.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomena. (Planning and Carrying out Investigations) (Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the questions: What patterns of Earth's features can be determined with the use of maps? How do living organisms alter Earth's processes and structures?
2. ESS2:A Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms and gravity break rocks, soils and sediments into smaller particles and move them around.
3. ESS2:E Biogeology: Living things affect the physical characteristics of their regions.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified, tested, and used to explain change.





### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

3. Earth's physical features occur in patterns.

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data from maps to describe patterns of Earth's features. (4-ESS2-2) (*Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes and earthquakes.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze and interpret data to make sense of phenomena using logical reasoning. (Analyze and Interpret Data) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: Why do the continents move, and what causes earthquakes and volcanoes?
2. ESS2.B: Plate Tectonics and Large-Scale System Interactions: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns can be used as evidence to support an explanation.



### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

4. Energy and fuels that humans use are derived from natural sources and their use affects the environment in multiple ways.

### Evidence Outcomes

#### *Students Can:*

- a. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. (4-ESS3-1) (*Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Obtain and combine information from books and other reliable media to explain phenomena (Obtaining, Evaluating, and Communicating Information) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do humans depend on Earth's resources?
2. ESS3.A: Natural Resources: Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified and used to explain change.
2. Interdependence of Science, Engineering and Technology: Knowledge of relevant scientific concepts and research findings is important in engineering.
3. Influence of Science, Engineering and Technology on Society and the Natural World: Over time, people's needs and wants change, as do their demands for new and improved technologies.



### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

5. A variety of hazards result from natural process; humans cannot eliminate natural hazards but can reduce their impacts' effect.

### Evidence Outcomes

#### *Students Can:*

- a. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. (4-ESS3-2) *(Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.)(Boundary: Limited to earthquakes, floods, tsunamis, and volcanic eruptions.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do natural hazards affect individuals and societies?
2. ESS3.B: Natural Hazards: A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

#### *Cross Cutting Concepts:*

1. Interdependence of Science, Engineering and Technology: Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks and to meet societal demands.
2. Cause and Effect: Cause - and - effect relationships are routinely identified, tested, and used to explain change.







### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

1. Matter exists as particles that are too small to be seen; measurements of a variety of observable properties can be used to identify particular materials.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model to describe that matter is made of particles too small to be seen. (5-PS1-1) *(Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water and evaporating salt water. Does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.)*
- b. Make observations and measurements to identify materials based on their properties. (5-PS1-3) *(Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces and solubility; density is not intended as an identifiable property. Does not include density or distinguishing mass and weight.) (Boundary Statement: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use models to describe phenomena (Developing and Using Models) (Personal: Initiative/Self-direction).
2. Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon (Planning and Carrying Out Investigations) (Personal: Personal responsibility).

#### *Elaboration on the GLE:*

1. Students can answer the question: How do particles combine to form the variety of matter one observes?
2. PS1:A Structure and Properties of Matter: Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. Measurements of a variety of properties can be used to identify materials.

#### *Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Natural objects exist from the very small to the immensely large. Standard units are used to measure and describe physical quantities such as weight, time, temperature and volume.



### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

2. Chemical Reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.

### Evidence Outcomes

#### *Students Can:*

- a. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling or mixing substances, the total weight of matter is conserved. (5-PS1-1) (*Clarification Statement: Examples of reactions or changes could include phase changes, dissolving and mixing that form new substances. Does not include distinguishing mass and weight.*) (*Boundary Statement: Mass and weight are not distinguished at this grade level.*)
- b. Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (5-PS1-4)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Measure and graph quantities such as weight to address scientific and engineering questions and problems (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving).

#### *Elaboration on the GLE:*

1. Students can answer the questions: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?
2. PS1:B Chemical Reactions: No matter what reaction or change in properties occurs, the total weight of the substances does not change. (*Boundary Statement: Mass and weight are not distinguished at this grade level.*) When two or more different substances are mixed, a new substance with different properties may be formed.

#### *Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Standard units are used to measure and describe physical quantities such as weight, time, temperature and volume.
2. Scientific Knowledge to Assumes an Order and Consistency in Natural Systems: Science assumes consistent patterns in natural systems.
3. Cause and Effect: Cause - and - effect relationships are routinely identified, tested and used to explain change.





### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

3. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

### Evidence Outcomes

#### *Students Can:*

- a. Support an argument that the gravitational force exerted by Earth on objects is directed down. (5-PS2-1) (*Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.*) (*Boundary Statement: Does not include mathematical representation of gravitational force.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Support an argument with evidence, data or a model (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the question: What underlying forces explain the variety of interactions observed?
2. PS2:B Types of Interactions: The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships are routinely identified and used to explain change.





### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

4. The energy released from food was once energy from the sun.

### Evidence Outcomes

#### *Students Can:*

- a. Use models to describe that energy in animals' food (used for body repair, growth and motion and to maintain body warmth) was once energy from the sun. (5-PS3-1) (*Clarification Statement: Examples of models could include diagrams and flowcharts.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use models to describe phenomena (Developing and Using Models) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the questions: How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?
2. PS3:D Energy in Chemical Processes and Everyday Life: The energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water).

#### *Cross Cutting Concepts:*

1. Energy and Matter: Energy can be transferred in various ways and between objects.





### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

1. Plants acquire their material for growth chiefly from air and water.

### Evidence Outcomes

#### *Students Can:*

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

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Support an argument with evidence, data or a model (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms obtain and use the matter and energy they need to live and grow?
2. LS1:C Organization for Matter and Energy Flow in Organisms: Plants acquire their material for growth chiefly from air and water.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Matter is transported into, out of and within systems.



### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

2. Matter cycles between air and soil and among plants, animals and microbes as these organisms live and die.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (5-LS2-1) (*Clarification Statement: Emphasis is on the idea that matter that is not food [air, water, decomposed materials in soil] is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.) (Boundary Statement: Does not include molecular explanations.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model to describe phenomena (Developing and Using Models) (Personal: Initiative/Self-direction).
2. Connections to the Nature of Science: Science Models, Laws, Mechanisms and Theories Explain Natural Phenomena. Science explanations describe the mechanisms for natural events.

#### *Elaboration on the GLE:*

1. Students can answer the questions: How do organisms interact with the living and nonliving environments to obtain matter and energy? How do matter and energy move through an ecosystem?
2. LS2:A Interdependent Relationships in Ecosystems: The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.
3. LS2:B Cycles of Matter and Energy Transfer in Ecosystems: Matter cycles between the air and soil and among plants, animals and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid or solid) back into the environment.

#### *Cross Cutting Concepts:*

1. Systems and System Models: A system can be described in terms of its components and their interactions.



### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

### Grade Level Expectation:

1. Stars range greatly in size and distance from Earth, and this can explain their relative brightness.

### Evidence Outcomes

#### *Students Can:*

- a. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth. (5-ESS1-1) (*Clarification Statement: Limited to relative distances, not sizes, of stars. Does not include other factors that affect apparent brightness [such as stellar masses, age and stage].*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Support an argument with evidence, data or a model (Engaging in Argument from Evidence) (Civic/Interpersonal: Collaboration/Teamwork).

#### *Elaboration on the GLE:*

1. Students can answer the question: What is the universe, and what goes on in stars?
2. ESS1:A The Universe and its Stars: The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.

#### *Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Natural objects exist from the very small to the immensely large.





### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

### Grade Level Expectation:

2. Earth's orbit and rotation and the orbit of the moon around earth cause observable patterns.

### Evidence Outcomes

#### *Students Can:*

- a. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. (5-ESS1-2) (*Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.*) (*Boundary Statement: Does not include causes of seasons.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving).

#### *Elaboration on the GLE:*

1. Students can answer the question: What are the predictable patterns caused by Earth's movement in the solar system?
2. ESS1:B Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon and stars at different times of the day, month and year.

#### *Cross Cutting Concepts:*

1. Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.







### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

3. Earth's major systems interact in multiple ways to affect Earth's surface materials and processes.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere and/or atmosphere interact. (5-ESS2-1)  
*(Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.) (Boundary Statement: Limited to the interactions of two systems at a time.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model using an example to describe a scientific principle. (Developing and Using Models) (Personal: Initiative/Self-direction).

#### *Elaboration on the GLE:*

1. Students can answer the question: How do Earth's major systems interact? How do the properties and movements of water shape Earth's surface and affect its systems?
2. ESS2:A Earth Materials and Systems: Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

#### *Cross Cutting Concepts:*

1. Systems and System Models: A system can be described in terms of its components and their interactions.





### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

4. Most of Earth's water is in the ocean and much of Earth's freshwater in glaciers or underground.

### Evidence Outcomes

#### *Students Can:*

- a. Describe and graph the amounts and percentages of saltwater and freshwater in various reservoirs to provide evidence about the distribution of water on Earth. (5-ESS2-2) (*Boundary Statement: Limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Describe and graph quantities such as area and volume to address scientific questions (Using Mathematics and Computational Thinking)  
(Entrepreneurial: Critical thinking/Problem solving).

#### *Elaboration on the GLE:*

1. Students can answer the question: How do the properties and movements of water shape Earth's surface and affect its systems?
2. ESS2:C The Roles of Water in Earth's Surface Processes: Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands and the atmosphere.

#### *Cross Cutting Concepts:*

1. Scale, Proportion, and Quantity: Standard units are used to measure and describe physical quantities such as weight and volume.





### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

5. Societal activities have had major effects on land, ocean, atmosphere and even outer space

### Evidence Outcomes

#### *Students Can:*

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

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (Obtaining, Evaluating, and Communicating Information) (Civic/Interpersonal: Communication)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do humans change the planet?
2. ESS3:C Human Impacts on Earth Systems: Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

#### *Cross Cutting Concepts:*

1. Systems and System Models: A system can be described in terms of its components and their interactions.
2. Science Addresses Questions About the Natural and Material World: Science findings are limited to questions that can be answered with empirical evidence.





## Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

## Grade Level Expectation:

1. The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter and phases changes.

## Evidence Outcomes

### Students Can:

- Develop models to describe the atomic composition of simple molecules and extended structures. (MS-PS1-1) *(Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3-D ball and stick structures, or computer representations showing different molecules with different types of atoms.) (Boundary Statement: Does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure.)*
- Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (MS-PS1-2) *(Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.) (Boundary statement: Limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability and odor.)*
- Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (MS-PS1-3) *(Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could*

*include new medicine, foods and alternative fuels.) (Boundary Statement: Limited to qualitative information.)*

- Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (MS-PS1-4) *(Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide and helium.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

- Develop a model to predict and/or describe phenomena. (Developing and using models) (Personal: Initiative/Self-direction)
- Analyze and interpret data to determine similarities and differences in findings. (Analyzing and interpreting data) (Entrepreneurial: Inquiry/Analysis)
- Gather, read and synthesize information from multiple appropriate sources and assess the credibility, accuracy and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence (Obtaining, Evaluating, and Communication Information) (Professional: Information literacy)
- Connection to Nature of Science: Science knowledge is based upon logical and conceptual connections between evidence and explanations.



*Elaboration on the GLE:*

1. Students can answer the question: How do particles combine to form the variety of matter one observes?
2. PS1:A Structure and Properties of Matter: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating sub-units (e.g., crystals). Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. 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. 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.

*Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Time, space and energy phenomena can be observed at various scales using models to study systems that are too small or too large.
2. Patterns: Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
3. Structure and Function: Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
4. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural or designed systems.
5. Interdependence of Science, Engineering and Technology: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineering systems.
6. Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technology and any limitation on their use are driven by individual and 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.





### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

2. Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (MS-PS1-2) (*Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.*) (*Boundary statement: Limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability and odor.*)
- b. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. (MS PS 1-5) (*Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.*) (*Boundary Statement: Does not include the use of atomic masses, balancing symbolic equations or intermolecular forces.*)
- c. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. (MS PS1-6) (*Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.*) (*Boundary Statement: Limited to the criteria of amount, time and temperature of substance in testing the device.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model to describe unobservable mechanisms. (Developing and Using Models) (Entrepreneurial: Creativity/Innovation)
2. Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (Constructing Explanation and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
3. Connections to Nature of Science: Laws are regularities or mathematical descriptions of natural phenomena.

#### *Elaboration on the GLE:*

1. Students can answer the questions: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?
2. PS1:B Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. Some chemical reactions release energy, others store energy.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes. The transfer of energy can be tracked as energy flows through a designed or natural system.



### Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

### Grade Level Expectation:

3. Motion is described relative to a reference frame that must be shared with others and is determined by the sum of the forces acting on it. The greater the mass of the object, the greater the force needed to achieve the same change in motion.

### Evidence Outcomes

#### Students Can:

- a. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. (MS-PS-2-1) (*Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.*) (*Boundary Statement: Limited to vertical or horizontal interactions in one dimension.*)
- b. Plan an investigation to provide evidence that the change in an objects motion depends on the sum of the forces on the object and the mass of the object. (MS-PS-2-2) (*Clarification Statement: Emphasis is on balanced [Newton's First Law] and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion [Newton's Second Law], frame of reference and specification of units.*) (*Boundary Statement: Limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*)

### Academic Context and Connections

#### Colorado Essential Skills and Science and Engineering Practices:

1. Apply scientific ideas or principles to design an object, tool, process, or system. (Constructing Explanation and Designing Solutions) (Personal: Personal responsibility)
2. 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. (Planning and Carrying Out Investigations) (Personal: Initiative/Self-direction)

3. Connections to Nature of Science: Science is knowledge based upon logical and conceptual connections between evidence and explanations.

#### Elaboration on the GLE:

1. Students can answer the question: How can one predict an object's continued motion, changes in motion or stability?
2. PS2:A Forces and Motion: For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.





*Cross Cutting Concepts:*

1. **Systems and System Models:** Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy and matter flows within systems.
2. **Stability and Change:** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
3. **Connections to Engineering, Technology and Applications of Science:** The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources and economic conditions.





## Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

## Grade Level Expectation:

4. Forces that act a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object.

## Evidence Outcomes

### Students Can:

- a. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (MS-PS2-3) *(Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.) (Boundary Statement: Limited to questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.)*
- b. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (MS-PS2-4) *(Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.) (Boundary Statement: Does not include Newton's Law of Gravitation or Kepler's Laws.)*
- c. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. (MS-PS2-5) *(Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically charged strips of tape, and electrically-charged pith balls. Examples of investigations could include firsthand experiences or*

*simulations.) (Boundary Statement: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and when appropriate, frame a hypothesis based on observations and scientific principles. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)
2. Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (Engage in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
3. Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (Planning and Carrying Out Investigations) (Personal: initiative/Self-direction)
4. Connections to Nature of Science: Science knowledge is based upon logical and conceptual connections between evidence and explanations.



*Elaboration on the GLE:*

1. Students can answer the question: What underlying forces explain the variety of interactions observed?
2. PS2:B Types of Interactions: Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass — e.g., Earth and the sun. Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

*Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural or designed systems.
2. Systems and Systems Models: Models can be used to represent systems and their interactions—such as inputs, processes and outputs – and energy and matter flows within systems.



### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

5. Kinetic energy can be distinguished from the various forms of potential energy.

### Evidence Outcomes

#### *Students Can:*

- a. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and the speed of an object. (MS-PS3-1) *(Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.)*
- b. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (MS-PS-3-2) *(Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster car at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.) (Boundary Statement: Limited to two objects and electric, magnetic, and gravitational interactions.)*
- c. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS-PS3-3) *(Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.) (Boundary Statement: Does not include calculating the total amount of thermal energy transferred.)*
- d. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (MS-PS3-4) *(Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.) (Boundary Statement: Does not include calculating the total amount of thermal energy transferred.)*
- e. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5) *(Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.) (Boundary Statement: Does not include calculations of energy.)*



## Academic Context and Connections

### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. 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. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
3. Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis)
4. Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
5. 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.

### *Elaboration on the GLE:*

1. Students can answer the question: What is energy?
2. PS3:A Definitions of Energy: Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. A system of objects may also contain stored (potential) energy, depending on their relative positions. Temperature is a measure of the average kinetic energy of particles of matter. The relationships between the temperature and total energy of a system depends on the types, states, and amounts of matter present.

### *Cross Cutting Concepts:*

1. Scale, proportion and quantity: Proportional relationships (e.g., speed as the relation of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
2. Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

6. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states and amounts of matter.

### Evidence Outcomes

#### *Students Can:*

- a. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS PS3-3) (*Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.*) (*Boundary Statement: Does not include calculating the total amount of thermal energy transferred.*)
- b. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (MS-PS3-4) (*Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.*) (*Boundary Statement: Does not include calculating the total amount of thermal energy transferred.*)
- c. Construct, use, and present arguments to support the claim that when kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5) (*Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.*) (*Boundary Statement: Does not include calculations of energy.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. (Construct Explanations and Designing Solutions) (Civic/Interpersonal: Civic-Engagement)
2. 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. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
3. Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (Engaging in Argument from Evidence) (Entrepreneurial: Inquiry/Analysis)
4. Connections to Nature of Science: Scientific knowledge is based upon logical and conceptual connections between evidence and explanations.





*Elaboration on the GLE:*

1. Students can answer the questions: What is meant by conservation of energy? How is energy transferred between objects or systems?
2. PS3:B Conservation of Energy and Energy Transfer: When the motion energy of an object changes, there is inevitably some other change in energy at the same time. The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

*Cross Cutting Concepts:*

1. Energy and Matter: The transfer of energy can be tracked as energy flows through a designed or natural system. Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).
2. Scale, Proportion, and Quantity: Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

7. When two objects interact, each one exerts a force on the other that can cause energy to be transferred to and from the object.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (MS-PS3-2) (*Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster car at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.*) (*Boundary Statement: Limited to two objects and electric, magnetic, and gravitational interactions.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (Developing and Using Models) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: How are forces related to energy?
2. PS3:C Relationship Between Energy and Forces: When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. For example, when energy is transferred to an Earth-object system as an object is raised, the gravitational field energy of the system increases. This energy is released as the object falls; the mechanism of this release is the gravitational force. Likewise, two magnetic and electrically charged objects interacting at a distance exert forces on each other that can transfer energy between the interacting objects.

#### *Cross Cutting Concepts:*

1. Systems and System Models: Models can be used to represent systems and their interactions - such as inputs, processes, and outputs - and energy and matter flows within systems.





### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

8. A simple wave model has a repeating pattern with specific wavelength, frequency, and amplitude and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena which include light and sound.

### Evidence Outcomes

#### *Students Can:*

- a. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in the wave. (MS-PS4-1) (*Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.*) (*Boundary Statement: Does not include electromagnetic waves and is limited to standard repeating waves.*)
- b. Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials. (MS-PS4-2) (*Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.*) (*Boundary Statement: Limited to qualitative applications pertaining to light and mechanical waves.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use mathematical representations to describe and/or support scientific conclusions and design solutions. (Use Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
2. Connections to Nature of Science: Science knowledge is based upon logical and conceptual connections between evidence and explanations.

#### *Elaboration on the GLE:*

1. Students can answer the question: What are the characteristic properties and behaviors of waves?
2. PS4:A Wave Properties: A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted. Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet.

#### *Cross Cutting Concepts:*

1. Patterns: Graphs and charts can be used to identify patterns in data.





### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

9. A wave model of light is useful to explain how light interacts with objects through a variety of properties.

### Evidence Outcomes

#### *Students Can:*

- a. Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials. (MS-PS4-2) (*Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.*) (*Boundary Statement: Limited to qualitative applications pertaining to light and mechanical waves.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop and use a model to describe phenomena (Developing and Using Models) (Personal: Personal responsibility)

#### *Elaboration on the GLE:*

1. Students can answer the question: How can one explain the varied effects that involve light?
2. PS4:B Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. Lenses and prisms are applications of this effect. A wave model of light is useful for explaining brightness, color and the frequency dependent bending of light at a surface between media (prisms). However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

#### *Cross Cutting Concepts:*

1. Structure and Function: Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.





### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

10. Designed technologies can transmit digital information as wave pulses.

### Evidence Outcomes

#### *Students Can:*

- a. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. (MS-PS4-3) (*Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversion of stored binary patterns to make sound or text on a computer screen.*) (*Boundary Statement: Does not include binary counting or the specific mechanism of any given device.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (Obtaining, Evaluating, and Communicating Information) (Professional: Use information and communications technologies)

#### *Elaboration on the GLE:*

1. Students can answer the question: How are instruments that transmit and detect waves used to extend human senses?
2. PS4:C Information Technologies and Instrumentation: Appropriately designed technologies (e.g., radio, television, cell-phones, wired and wireless computer networks) make it possible to detect and interpret many types of signals that cannot be sensed directly. Designers of such devices must understand both the signal and its interactions with matter. Many modern communication devices use digitized signals (sent as wave pulses) as a more reliable way to encode and transmit information.

#### *Cross Cutting Concepts:*

1. Structure and Function: Structures can be designed to serve particular functions.
2. Connections to Engineering, Technology, and Applications of Science: Technologies extend the measurement, exploration, modeling and computational capacity of scientific investigations.
3. Connections to Nature of Science: Advances in technology influence the progress of science and science has influenced advances in technology.



## Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

## Grade Level Expectation:

1. All living things are made up of cells, which is the smallest unit that can be said to be alive.

### Evidence Outcomes

#### *Students Can:*

- a. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. (MS-LS1-1) *(Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and nonliving things, and understanding that living things may be made of one cell or many and varied cells.)*
- b. Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. (MS LS1-2) *(Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.) (Boundary Statement: Organelle structure/function relationships is limited to the cell wall and cell membrane. Function of the other organelles is limited to their relationship to the whole cell. Does not include the biochemical function of cells or cell parts.)*

- c. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (MS-LS1-3) *(Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.) (Boundary Statement: Does not include the mechanism of one body system independent of others. Limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
2. Develop and use a model to describe phenomena. (Developing and Using Models) (Civic/Interpersonal: Collaboration/Teamwork)
3. Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
4. Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)



*Elaboration on the GLE:*

1. Students can answer the question: How do the structures of organisms enable life's functions?
2. LS1.A Structure and Function: All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).

*Cross Cutting Concepts:*

1. Scale, Proportion, and Quantity: Phenomena that can be observed at one scale may not be observable at another scale.
2. Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function.
3. Systems and System Models: Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.





## Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

## Grade Level Expectation:

2. Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.

## Evidence Outcomes

### Students Can:

- a. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. (MS-LS1-4) *(Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.)*
- b. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (MS-LS1-5) *(Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large-breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.)*

*(Boundary Statement: Does not include genetic mechanisms, gene regulation or biochemical processes.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Use an oral and written argument supported by empirical evidence and scientific reasoning to support and refute an explanation or a model for a phenomenon or a solution to a problem. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
2. Construct a scientific explanation base on valid and reliable evidence obtained from sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)

### Elaboration on the GLE:

1. Students can answer the question: How do organisms grow and develop?
2. LS1:B Growth and Development of Organisms: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. Genetic factors as well as local conditions affect the growth of the adult plant.



*Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural systems.



## Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

## Grade Level Expectation:

3. Sustaining life requires substantial energy and matter inputs.

## Evidence Outcomes

### Students Can:

- a. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. (MS-LS1-6) (*Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.*) (*Boundary Statement: Does not include the biochemical mechanisms of photosynthesis.*)
- b. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. (MS-LS1-7) (*Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.*) (*Boundary Statement: Assessment does not include details of the chemical reactions for photosynthesis or respiration.*)

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

2. Develop and use a model to describe phenomena and unobservable mechanisms. (Developing and Using Models) (Personal: Initiative/Self-direction)

### Elaboration on the GLE:

1. Students can answer the question: How do organisms detect, process, and use information about the environment?
2. LS1:C Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
3. PS3:D Energy in Chemical Processes and Everyday Life: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

### Cross Cutting Concepts:

1. Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.



### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Grade Level Expectation:

4. Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain.

### Evidence Outcomes

#### *Students Can:*

- a. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. (MS-LS1-8)(*Boundary Statement: Does not include mechanisms for the transmission of this information.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy)
2. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence. Science knowledge is based upon logical connections between evidence and explanations.

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms detect, process, and use information about the environment?
2. LS1:D Information Processing: Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems and phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
2. Connections to Engineering, Technology and Applications of Science: Interdependence of Science, Engineering, and Technology. Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
3. Connections to Nature of Science: Science is a Human Endeavor. Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.







### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

5. Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. (MS-LS2-1) (*Clarification Statement: Emphasis is on cause - and - effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.*)
- b. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (MS-LS2-2) (*Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze and interpret data to provide evidence for phenomena. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms interact with the living and nonliving environments to obtain matter and energy?
2. LS2:A Interdependent Relationships in Ecosystems: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.



*Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural or designed systems.
2. Patterns: Patterns can be used to identify cause and effect relationships.
3. Connections to Engineering, Technology, and Applications of Science
4. Influence of Science, Engineering, and Technology on Society and the Natural World: The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
5. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. Science Addresses Questions About the Natural and Material World. Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.





### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

6. Ecosystems are sustained by the continuous flow of energy, originating primarily from the sun, and the recycling of matter and nutrients within the system.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (MS-LS2-3) (*Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.*) (*Boundary Statement: Assessment does not include the use of chemical reactions to describe the processes.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model to describe phenomena (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence. Science disciplines share common rules of obtaining and evaluating empirical evidence.

#### *Elaboration on the GLE:*

1. Students can answer the question: How do matter and energy move through an ecosystem?

2. LS2:B Cycle of Matter and Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the 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.

#### *Cross Cutting Concepts:*

1. Energy and Matter: The transfer of energy can be tracked as energy flows through a natural system.
2. 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.
3. Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World. The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.



### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

7. Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem

### Evidence Outcomes

#### *Students Can:*

- a. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. (MS-LS2-4) (*Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.*)
- b. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. (MS-LS2-5) (*Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem and evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)

2. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence. Science disciplines share common rules of obtaining and evaluating empirical evidence.

#### *Elaboration on the GLE:*

1. Students can answer the question: What happens to ecosystems when the environment changes?
2. LS2:C Ecosystem Dynamics, Functioning, and Resilience: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

#### *Cross Cutting Concepts:*

1. Stability and Change: Small changes in one part of a system might cause large changes in another part.
2. Connections to Nature of Science: Science Addresses Questions About the Natural and Material World. Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.



## Prepared Graduates:

7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.

## Grade Level Expectation:

8. Heredity explains why offspring resemble, but are not identical to, their parents and is a unifying biological principle. Heredity refers to specific mechanisms by which characteristics or traits are passed from one generation to the next via genes.

## Evidence Outcomes

### Students Can:

- a. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (MS-LS3-1) *(Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.) (Boundary Statement: Does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.)*
- b. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (MS-LS3-2) *(Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause - and - effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Develop and use a model to describe phenomena. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy)

### Elaboration on the GLE:

1. Students can answer the questions: How are the characteristics of one generation related to the previous generation? Why do individuals of the same species vary in how they look, function, and behave?
2. LS3:A Inheritance of Traits: Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.
3. LS3:B Variation of Traits: In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.





*Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural systems.
2. Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
3. Interdependence of Science, Engineering, and Technology: Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
4. Connections to Nature of Science: Science Addresses Questions About the Natural and Material World. Scientific knowledge can describe the consequences of actions but does not make the decisions that society takes.





### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

9. Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past.

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. (MS-LS4-1) (*Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.*) (*Boundary Statement: Does not include the names of individual species or geological eras in the fossil record.*)
- b. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. (MS-LS4-2) (*Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.*)
- c. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. (MS-LS4-3) (*Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.*) (*Boundary Statement: Comparisons are limited to gross appearance of anatomical structures in embryological development.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyzing data progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis and analyze and interpret data to determine similarities and differences in findings. (Analyzing and Interpreting Data) (Entrepreneurial: Inquiry/Analysis)
2. Constructing explanations and designing solutions to include constructing explanations and designing solutions supported by multiple sources. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)

#### *Elaboration on the GLE:*

1. Students can answer the question: What evidence shows that different species are related?
2. LS4:A Evidence of Common Ancestry and Diversity: The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.



*Cross Cutting Concepts:*

1. Patterns: Graphs, charts, and images can be used to identify patterns in data.
2. 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.







### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

10. Genetic variations among individuals in a population give some individuals an advantage in surviving and reproducing in their environment.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. (MS-LS4-4) *(Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.)*
- b. Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms. (MS-LS4-5) *(Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.)*
- c. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. (MS-LS4-6) *(Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.) (Boundary Statement: Does not include Hardy-Weinberg calculations.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
2. Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (Obtaining, Evaluating, and Communicating Information) (Professional: Information and Communications Technologies)

#### *Elaboration on the GLE:*

1. Students can answer the question: What evidence shows that different species are related?
2. LS4:B Natural Selection: Natural selection leads to the predominance of certain traits in a population, and the suppression of others. In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.



*Cross Cutting Concepts:*

1. Cause and Effect: Phenomena may have more than one cause, and some cause - and - effect relationships in systems can only be described using probability.
2. Connections to and Interdependence of Engineering, Technology, and Applications of Science: Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
3. Connections to Nature of Science: Science Addresses Questions About the Natural and Material World. Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.





### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

11. Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions.

### Evidence Outcomes

#### *Students Can:*

- a. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. (MS-LS4-6) (*Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.*) (*Boundary Statement: Does not include Hardy Weinberg calculations.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Use mathematical representations to support scientific conclusions and design solutions. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How does genetic variation among organisms affect survival and reproduction?
2. LS4:C Adaptation: Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Phenomena may have more than one cause, and some cause - and - effect relationships in systems can only be described using probability.
2. 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





### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

12. Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems.

### Evidence Outcomes

#### *Students Can:*

- a. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. (MS-LS2-5) (*Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: How does the environment influence populations of organisms over multiple generations?
2. LS4:D Biodiversity and Humans: Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on — or example, water purification and recycling.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns can be used to identify cause and effect relationships. - Graphs, charts, and images can be used to identify patterns in data.
2. Energy and matter: Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural system, the transfer of energy drives the motion and/or cycling of matter.
3. Interdependence of Science, Engineering, and Technology: Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
4. 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. Addresses Questions About the Natural and Material World. Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.





### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

### Grade Level Expectation:

1. Motion is predictable in both solar systems and galaxies.

### Evidence Outcomes

#### *Students Can:*

- a. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (MS-ESS1-1) *(Clarification Statement: Examples of models can be physical, graphical, or conceptual.)*
- b. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (MS-ESS1-2) *(Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical [such as the analogy of distance along a football field or computer visualizations of elliptical orbits] or conceptual [such as mathematical proportions relative to the size of familiar objects such as students' school or state].) (Boundary Statement: Does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop and use a model to describe phenomena. (Develop and Use Models) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: What is the universe, and what goes on in stars?
2. ESS1:A The Universe and Its Stars: Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns can be used to identify cause and-effect relationships.
2. Systems and system models: Models can be used to represent systems and their interactions.
3. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.



## Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

## Grade Level Expectation:

2. The solar system contains many varied objects held together by gravity. Solar system models explain and predict eclipses, lunar phases, and seasons.

## Evidence Outcomes

### Students Can:

- a. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (MS-ESS1-2) *(Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical [such as the analogy of distance along a football field or computer visualizations of elliptical orbits] or conceptual [such as mathematical proportions relative to the size of familiar objects such as students' school or state].) (Boundary Statement: Does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.)*
- b. Analyze and interpret data to determine scale properties of objects in the solar system. (MS-ESS1-3) *(Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers [such as crust and atmosphere], surface features [such as volcanoes], and orbital radius. Examples of data include statistical information, drawings and photographs, and models.) (Boundary Statement: Does not include recalling facts about properties of the planets and other solar system bodies.)*

- c. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (MS-ESS1-1) *(Clarification Statement: Examples of models can be physical, graphical, or conceptual.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Develop and use a model to describe phenomena. (Develop and Use Models) (Personal: Initiative/Self-direction)
2. Analyze and interpret data to determine similarities and differences in findings. (Analyze and Interpret Data) (Entrepreneurial: Inquiry/Analysis)

### Elaboration on the GLE:

1. Students can answer the question: What are the predictable patterns caused by Earth's movement in the solar system?
2. ESS1:B Earth and the Solar System: The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.



*Cross Cutting Concepts:*

1. Patterns: Patterns can be used to identify cause - and - effect relationships.
2. Scale: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
3. Modeling: Models can be used to represent systems and their interactions.
4. Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.
5. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.





### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

3. Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.

### Evidence Outcomes

#### *Students Can:*

- a. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. (MS-ESS1-4) (*Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent [such as the last Ice Age or the earliest fossils of homo sapiens] to very old [such as the formation of Earth or the earliest evidence of life]. Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.*) (*Boundary Statement: Does not include recalling the names of specific periods or epochs and events within them.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do people reconstruct and date events in Earth's planetary history?
2. ESS1:C The History of Planet Earth: The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

#### *Cross Cutting Concepts:*

1. Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.





## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

4. Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.

## Evidence Outcomes

### Students Can:

- a. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. (MS-ESS2-1) *(Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.) (Boundary Statement: Does not include the identification and naming of minerals.)*
- b. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (MS-ESS2-2) *(Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large [such as slow plate motions or the uplift of large mountain ranges] or small [such as rapid landslides or microscopic geochemical reactions], and how many geoscience processes [such as earthquakes, volcanoes, and meteor impacts] usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Develop and use a model to describe phenomena. (Developing and Using Models) (Personal: initiative/Self-direction)

### Elaboration on the GLE:

1. Students can answer the question: How do Earth's major systems interact?
2. ESS2:A Earth's Materials and Systems: All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

### Cross Cutting Concepts:

1. Stability and change: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.



### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

5. Plate tectonics is the unifying theory that explains movements of rocks at Earth's surface and geological history.

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. (MS-ESS2-3) (*Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents [including continental shelves], and the locations of ocean structures [such as ridges, fracture zones, and trenches].*) (*Boundary Statement: Does not include paleomagnetic anomalies in oceanic and continental crust.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze and interpret data to provide evidence for phenomena. (Analyzing and Interpreting Data) (Entrepreneurial: Inquiry/Analysis)
2. Connections to the Nature of Science: Scientific Knowledge is Open to Revision in Light of New Evidence. Science findings are frequently revised and/or reinterpreted based on new evidence.

#### *Elaboration on the GLE:*

1. Students can answer the question: Why do the continents move, and what causes earthquakes and volcanoes?
2. ESS2:B Plate Tectonics and Large-Scale Systems and Interactions: Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

#### *Cross Cutting Concepts:*

1. Patterns: Patterns in rates of change and other numerical relationships can provide information about natural systems.





## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

6. Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.

## Evidence Outcomes

### Students Can:

- a. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (MS-ESS2-2) *(Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large [such as slow plate motions or the uplift of large mountain ranges] or small [such as rapid landslides or microscopic geochemical reactions], and how many geoscience processes [such as earthquakes, volcanoes, and meteor impacts] usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.)*
- b. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. (MS-ESS2-4) *(Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.) (Boundary Statement: Does not include a quantitative understanding of the latent heats of vaporization and fusion.)*
- c. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. (MS-ESS2-5) *(Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather [defined by temperature, pressure, humidity, precipitation, and wind] at a fixed location to change over time and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students [such as weather maps, diagrams, and visualizations] or obtained through laboratory experiments [such as with condensation].) (Boundary Statement: Does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.)*
- d. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (MS-ESS2-6) *(Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps, and globes, or digital representations.) (Boundary Statement: Does not include the dynamics of the Coriolis effect.)*





## Academic Context and Connections

### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (Constructing explanations and designing solutions) (Entrepreneurial: Creativity/Innovation)
2. Develop a model to describe unobservable mechanisms. (Developing and using models) (Personal: Initiative/Self-direction)
3. Nature of Science: Influence of Science, Engineering, and Technology on Society and the Natural World. Science findings are frequently revised and/or reinterpreted based on new evidence.

### *Elaboration on the GLE:*

1. Students can answer the question: How do the properties and movements of water shape Earth's surface and affect its systems?
2. ESS2:C The Roles of Water in Earth's Surface Processes: The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. Water's movements — both on the land and underground — cause weathering and erosion, which change the land's surface features and

create underground formations. Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Global movements of water and its changes in form are propelled by sunlight and gravity. The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can only be predicted probabilistically. The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

### *Cross Cutting Concepts:*

1. Scale Proportion and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
2. Energy and Matter: Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.





## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

7. Complex interactions determine local weather patterns and influence climate, including the role of the ocean.

### Evidence Outcomes

#### *Students Can:*

- a. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. (MS-ESS2-5) (*Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather [defined by temperature, pressure, humidity, precipitation, and wind] at a fixed location to change over time and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students [such as weather maps, diagrams, and visualizations] or obtained through laboratory experiments [such as with condensation].*) (*Boundary Statement: Does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*)
- b. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (MS-ESS2-6) (*Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps, and globes, or digital representations.*) (*Boundary Statement: Does not include the dynamics of the Coriolis effect.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop and use a model to describe phenomena. (Developing and Using Models) (Entrepreneurial: Creativity/Innovation)
2. 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.

#### *Elaboration on the GLE:*

1. Students can answer the question: What regulates weather and climate?
2. ESS2:D Weather and Climate: 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. Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can only be predicted probabilistically. The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.
2. Systems and System Models: Models can be used to represent systems and their interactions — such as inputs, processes and outputs — and energy, matter, and information flows within systems.





### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

8. Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.

### Evidence Outcomes

#### *Students Can:*

- a. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. (MS-ESS3-1) *(Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum [locations of the burial of organic marine sediments and subsequent geologic traps], metal ores [locations of past volcanic and hydrothermal activity associated with subduction zones], and soil locations of active weathering and/or deposition of rock.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do humans depend on Earth's resources?
2. ESS3:A Natural Resources: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

#### *Cross Cutting Concepts:*

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



## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

## Grade Level Expectation:

9. Mapping the history of natural hazards in a region and understanding related geological forces.

### Evidence Outcomes

#### *Students Can:*

- a. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (MS-ESS3-2) *(Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes, such as earthquakes and volcanic eruptions, surface processes, such as mass wasting and tsunamis, or severe weather events, such as hurricanes, tornadoes, and floods. Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global, such as satellite systems to monitor hurricanes or forest fires, or local, such as building basements in tornado-prone regions or reservoirs to mitigate droughts.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze and interpret data to determine similarities and differences in findings. (Analyzing and Interpreting Data) (Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do natural hazards affect individuals and societies?
2. ESS3:B Natural Hazards: Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

#### *Cross Cutting Concepts:*

1. Patterns: Graphs, charts, and images can be used to identify patterns in data.
2. Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.





### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

10. Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things.

### Evidence Outcomes

#### *Students Can:*

- a. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. (MS-ESS3-3) *(Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage, such as the withdrawal of water from streams and aquifers or the construction of dams and levees; land usage, such as urban development, agriculture, or the removal of wetlands; and pollution, such as of the air, water, or land.)*
- b. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. (MS-ESS3-4) *(Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources [such as freshwater, mineral, and energy]. Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Apply scientific principles to design an object, tool, process or system. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis)
2. Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do humans change the planet?
2. ESS3.C Human Impacts on Earth Systems: Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.







*Cross Cutting Concepts:*

1. Cause and Effect: Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems.
2. Influence of Science, Engineering, and Technology on Society and the Natural World: All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
3. Science Addresses Questions About the Natural and Material World: Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.





### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

11. Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.

### Evidence Outcomes

#### *Students Can:*

- a. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. (MS-ESS3-5) (*Clarification Statement: Examples of factors include human activities [such as fossil fuel combustion, cement production, and agricultural activity] and natural processes [such as changes in incoming solar radiation or volcanic activity]. Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions to identify and clarify evidence of an argument (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do people model and predict the effects of human activities on Earth's climate?
2. ESS3:D Global Climate Change: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

#### *Cross Cutting Concepts:*

1. Stability and Change: Stability might be disturbed either by sudden events or gradual changes that accumulate over time.



## Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

## Grade Level Expectation:

1. The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter.

## Evidence Outcomes

### Students Can:

- a. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy levels of atoms. (HS-PS1-1)(Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.) (Boundary Statement: Limited to main group elements. Does not include quantitative understanding of ionization energy beyond relative trends.)
- b. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (HS-PS1-3)(Clarification Statement: Emphasis is on understanding the difference intermolecular versus intramolecular forces and the strengths of forces between particles but not naming specific intermolecular forces, such as dipole-dipole. Examples of particles could include ions, atoms, molecules, and networked materials, such as graphite. Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.) (Boundary Statement: Does not include Raoult's law calculations of vapor pressure or the names, shapes, or bond angles associated with VSEPR theory.)
- c. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (HS-PS1-4) (Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs

*showing the relative energies of reactants and products, and representations showing energy is conserved.) (Boundary Statement: Does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Use a model to predict the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data. (e.g., number of trials, cost, risk, time), and refine the design accordingly (Planning and Carrying Out Investigations) (Personal: Personal responsibility)

### Elaboration on the GLE:

1. Students can answer the question: How do particles combine to form the variety of matter one observes?



2. PS1:A Structure and Properties of Matter: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

*Cross Cutting Concepts:*

1. Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.





## Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

## Grade Level Expectation:

2. Chemical processes, their rates, their outcomes, and whether or not energy is stored or released can be understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.

## Evidence Outcomes

### Students Can:

- a. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (HS-PS1-2) *(Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.) (Boundary Statement: Limited to chemical reactions involving main group elements and combustion reactions).*
- b. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (HS-PS1-4) *(Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.) (Boundary Statement: Does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.)*
- c. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (HS-PS1-5) *(Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.) (Boundary Statement: Limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.)*
- d. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (HS-PS1-6) *(Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.) (Boundary Statement: Limited to specifying the change in only one variable at a time. Does not include calculating equilibrium constants and concentrations.)*
- e. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (HS-PS1-7) *(Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.) (Boundary Statement: Does not include complex chemical reactions or calculations involving limiting and excess reactants.)*





## Academic Context and Connections

### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic Engagement)
2. Develop a model based on evidence to illustrate the relationships between systems or between components of a system (Developing and Using Models) (Personal: Personal responsibility)
3. Use mathematical representations of phenomena to support claims (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

### *Elaboration on the GLE:*

1. Students can answer the questions: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?
2. PS1:B Chemical Reactions: Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

### *Cross Cutting Concepts:*

1. Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
2. Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
3. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.
4. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes the universe is a vast single system in which basic laws are consistent.





### Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

### Grade Level Expectation:

3. The strong nuclear interaction provides the primary force that holds nuclei together. Nuclear processes including fusion, fission, and radioactive decays of unstable nuclei involve changes in nuclear binding energies.

### Evidence Outcomes

#### *Students Can:*

- a. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. (HS-PS1-8) (*Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams and on the scale of energy released in nuclear processes relative to other kinds of transformations. Quantitative models for radioactive decay should not require mathematical manipulations of an exponential equation.*) (*Boundary Statement: Does not include quantitative calculation of energy released. Limited to alpha, beta, and gamma radioactive decays.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: What forces hold nuclei together and mediate nuclear processes?
2. PS1:C Nuclear Processes: Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.

#### *Cross Cutting Concepts:*

1. Energy and Matter: In nuclear processes, atoms are not conserved, but the total number of neutrons plus protons is conserved.





## Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

## Grade Level Expectation:

4. Newton's second law and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.

## Evidence Outcomes

### Students Can:

- Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. (HS-PS2-1) *(Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.) (Boundary Statement: Limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.)*
- Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. (HS-PS2-2) *(Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.) (Boundary Statement: Limited to systems of two macroscopic bodies moving in one dimension.)*
- Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. (HS-PS2-3) *(Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.) (Boundary Statement: Limited to qualitative evaluations and/or algebraic manipulations.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (Constructing Explanations and Designing Solution) (Personal: Personal responsibility)
- Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes the universe is a vast single system in which basic laws are consistent.
- Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena.

### Elaboration on the GLE:

- Students can answer the question: How can one predict an object's continued motion, changes in motion, or stability?
- PS2:A Forces and Motion: Newton's second law accurately predicts changes in the motion of macroscopic objects. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.





*Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Systems can be designed to cause a desired effect.
2. Systems and System Models: When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.





## Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

## Grade Level Expectation:

5. Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them.

## Evidence Outcomes

### Students Can:

- Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. (HS-PS2-4) *(Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.) (Boundary Statement: Limited to systems with two objects and basic algebraic substitution and/or manipulations.)*
- Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (HS-PS2-5) *(Boundary Statement: Limited to designing and conducting investigations with provided materials and tools.)*
- Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (HS-PS2-6) *(Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.) (Boundary Statement: Limited to provided molecular structures of specific designed materials.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (Plan and Carry Out an Investigation) (Entrepreneurial: Inquiry/Analysis)
- Use mathematical representations of phenomena to describe explanations. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
- Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (Obtaining, Evaluating, and Communicating Information) (Professional: Information and Communications Technologies)
- Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena.



*Elaboration on the GLE:*

1. Students can answer the question: What underlying forces explain the variety of interactions observed?
2. PS2:B Types of Interactions: Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

*Cross Cutting Concepts:*

1. Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
2. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
3. Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.





## Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

## Grade Level Expectation:

6. Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.

## Evidence Outcomes

### Students Can:

- Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. (HS-PS3-1) *(Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.) (Boundary Statement: Limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.)*
- Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects). (HS-PS3-2) *(Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.)*
- Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (HS-PS3-3) *(Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices and on the ability of energy to be transferred but not on the efficiency of energy transfer. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.) (Boundary Statement: Quantitative evaluations are limited to*

*total output for a given input, and are limited to devices constructed with materials provided to students.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Personal responsibility)
- Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

### Elaboration on the GLE:

- Students can answer the question: What is energy?
- PS3:A Definitions of Energy: Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.





*Cross Cutting Concepts:*

1. System and System Models: Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
2. Constructing Explanations and Designing Solutions: Design, evaluate, and/or refine a solution to complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.
3. Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Energy cannot be created or destroyed — only moves between one place and another place, between objects and/or fields, or between systems.
4. Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World. Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
5. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes the universe is a vast single system in which basic laws are consistent.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

7. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

### Evidence Outcomes

#### *Students Can:*

- a. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. (HS-PS3-1) *(Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.) (Boundary Statement: Limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.)*
- b. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). (HS-PS3-4) *(Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.) (Boundary Statement: Limited to investigations based on materials and tools provided to students.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
2. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the questions: What is meant by conservation of energy? How is energy transferred between objects or systems?



2. PS3:B Conservation of Energy and Energy Transfer: Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system. Uncontrolled systems always evolve toward more stable states — that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

*Cross Cutting Concepts:*

1. Systems and Systems Models: When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
2. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes the universe is a vast single system in which basic laws are consistent.





### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

8. Force fields (gravitational, electric, and magnetic) contain energy and can transmit energy across space from one object to another.

### Evidence Outcomes

#### *Students Can:*

- a. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. (HS-PS3-5) (*Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.*) (*Boundary Statement: Limited to systems containing two objects.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: How are forces related to energy?
2. PS3:C Relationship Between Energy and Forces: When two objects interacting through a field change relative position, the energy stored in the field is changed.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.







### Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

### Grade Level Expectation:

9. Although energy cannot be destroyed, it can be converted to less useful forms as it is captured, stored and transferred.

### Evidence Outcomes

#### *Students Can:*

- a. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (HS-PS3-3)  
*(Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices, including the identification of different energy types [starting points] and how they are transferred. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.) (Boundary Statement: Quantitative evaluation is limited to total output for a given input. Limited to devices constructed with materials provided to students.)*
- b. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). (HS-PS3-4) *(Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.) (Boundary Statement: Limited to investigations based on materials and tools provided to students.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Design, evaluate, and/or refine a solution to complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)
2. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (Planning on Carrying Out Investigations) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the questions: How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?
2. PS3:D Energy in Chemical Processes and Everyday Life: Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.

#### *Cross Cutting Concepts:*

1. Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
2. Systems and Systems Models: When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.



## Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

## Grade Level Expectation:

10. Waves have characteristic properties and behaviors.

### Evidence Outcomes

#### *Students Can:*

- Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. (HS-PS4-1) (*Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.*) (*Boundary Statement: Limited to algebraic relationships and describing those relationships qualitatively.*)
- Evaluate questions about the advantages of using a digital transmission and storage of information. (HS-PS4-2) (*Clarification Statement: Examples of advantages [compared to waves] could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)
- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
- Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

#### *Elaboration on the GLE:*

- Students can answer the question: What are the characteristic properties and behaviors of waves?
- PS4:A Wave Properties: The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (*Boundary Statement: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.*)



*Cross Cutting Concepts:*

1. Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
2. Systems and Systems Models: When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.





## Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

## Grade Level Expectation:

11. Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.

## Evidence Outcomes

### Students Can:

- a. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (HS-PS4-3) *(Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.) (Boundary Statement: Does not include using quantum theory.)*
- b. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (HS-PS4-4) *(Clarification Statement: Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Some examples may include: sunscreen SPF, lasers stimulating particular material to resonate at a particular frequency, and a discussion of how color is perceived as it relates to frequency. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.)*

- c. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (HS-PS4-5) *(Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.) (Boundary Statement: Limited to qualitative information and does not include band theory.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
2. Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (Obtaining, Evaluating, and Communicating Information) (Entrepreneurial: Inquiry/Analysis)



3. Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

*Elaboration on the GLE:*

1. Students can answer the questions: What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there?
2. PS4:B Electromagnetic Radiation: Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

*Cross Cutting Concepts:*

1. Cause and Effect: Cause - and - effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect.
2. Systems and System Models: Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.
3. Connections to Engineering, Technology, and Applications of Science: Interdependence of Science, Engineering, and Technology. Science and engineering complement each other in the cycle known as research and development (R&D).
4. Influence of Engineering, Technology, and Science on Society and the Natural World: Modern civilization depends on major technological systems.





### Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

### Grade Level Expectation:

12. Multiple technologies that are part of everyday experiences are based on waves and their interactions with matter.

### Evidence Outcomes

#### *Students Can:*

- a. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (HS-PS4-5) *(Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.)*  
*(Boundary Statement: Limited to qualitative information. Does not include band theory.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Communicate technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy)
2. Influence of Engineering, Technology, and Science on Society and the Natural World: Modern civilization depends on major technological systems.

#### *Elaboration on the GLE:*

1. Students can answer the question: How are instruments that transmit and detect waves used to extend human senses?
2. PS4:C Information Technologies and Instrumentation: Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Systems can be designed to cause a desired effect.
2. Connections to Engineering, Technology, and Applications of Science: Interdependence of Science, Engineering, and Technology: Science and engineering complement each other in the cycle known as research and development (R&D).





## Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

## Grade Level Expectation:

1. DNA codes for the complex hierarchical organization of systems that enable life's functions.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (HS-LS1-1) (*Boundary Statement: Does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.*)
- b. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (HS-LS1-2) (*Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.*) (*Boundary Statement: Does not include interactions and functions at the molecular or chemical reaction level.*)
- c. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. (HS-LS1-3) (*Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.*) (*Boundary Statement: Does not include the cellular processes involved in the feedback mechanism.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop and use a model based on evidence to illustrate the relationship between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of traits, cost, risk, time), and refine the design accordingly. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
3. Construct an explanation based on valid and reliable evidence obtained from a variety sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Global/Cultural awareness)



*Elaboration on the GLE:*

1. Students can answer the question: How do the structures of organisms enable life's functions?
2. LS1:A Structure and Function: Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

*Cross Cutting Concepts:*

1. Systems and System Models: Models (e.g., physical, mathematical, computer) can be used to simulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales.
2. Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components to reveal the structure's function and/or to solve a problem.
3. Stability and Change: Feedback (negative or positive) can stabilize or destabilize a system.







### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Grade Level Expectation:

2. Growth and division of cells in complex organisms occurs by mitosis, which differentiates specific cell types.

### Evidence Outcomes

#### *Students Can:*

- a. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (HS-LS1-4)  
*(Boundary Statement: Does not include specific gene control mechanisms or rote memorization of the steps of mitosis.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use a model based on evidence to illustrate the relationships between systems or between components of systems. (Developing and Using Models) (Professional: Information and Communications Technologies)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms grow and develop?
2. LS1:B Growth and Development of Organisms: In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

#### *Cross Cutting Concepts:*

1. Systems and System Models: Models (e.g., physical, mathematical, computer) can be used to stimulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales.
2. Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components to reveal the structure's function and/or to solve a problem.
3. Stability and Change: Feedback (negative or positive) can stabilize or destabilize a system.





### Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

### Grade Level Expectation:

3. Organisms use matter and energy to live and grow.

### Evidence Outcomes

#### *Students Can:*

- a. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (HS-LS1-5) *(Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.) (Boundary Statement: Does not include specific biochemical steps.)*
- b. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (HS-LS1-6) *(Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.) (Boundary Statement: Does not include the details of the specific chemical reactions or identification of macromolecules.)*
- c. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. (HS-LS1-7) *(Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use a model based on evidence to illustrate the relationships between systems or between components of systems. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world would operate today as they did the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)



*Elaboration on the GLE:*

1. Students can answer the question: How do organisms obtain and use the matter and energy they need to live and grow?
2. LS1:C Organization for Matter and Energy Flow in Organisms: The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and release energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.

*Cross Cutting Concepts:*

1. Energy and matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.





## Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

## Grade Level Expectation:

4. Organisms interact with the living and nonliving components of the environment to obtain matter and energy.

### Evidence Outcomes

#### *Students Can:*

- a. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. (HS-LS2-1) (*Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.*)
- b. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. (HS-LS2-2) (*Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (Using Mathematical and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

2. Connections to Nature of Science: Scientific Knowledge is open to revision in light of new evidence. Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms interact with the living and nonliving environments to obtain matter and energy?
2. LS2:A Interdependent Relationships in Ecosystems: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
3. LS2:C Ecosystem Dynamics, Functioning, and Resilience: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.





*Cross Cutting Concepts:*

1. Scale, Proportion, and Quantity: The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.





### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

5. Matter and energy necessary for life are conserved as they move through ecosystems.

### Evidence Outcomes

#### *Students Can:*

- a. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. (HS-LS2-3) *(Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.)*
- b. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. (HS-LS2-4) *(Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.)*
- c. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (HS-LS2-5) *(Clarification Statement: Examples of models could include simulations and mathematical models.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Revising Solution) (Entrepreneurial: Creativity/Innovation)
2. Use mathematical representations of phenomena or design solutions to support claims. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
3. Develop a model based on evidence to illustrate the relationships between systems or components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
4. Connections to Nature of Science: Scientific Knowledge is open to revision in light of new evidence. Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.



*Elaboration on the GLE:*

1. Students can answer the question: How do matter and energy move through an ecosystem?
2. LS2:B Cycles of Matter and Energy Transfer in Ecosystems: Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
3. LS2:B Cycles of Matter and Energy Transfer in Ecosystems: Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
4. PS3:D Energy in Chemical Processes: The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.

*Cross Cutting Concepts:*

1. Systems and System Models: Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.
2. Energy and Matter: Energy drives the cycling of matter within and between systems. Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.





## Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

## Grade Level Expectation:

6. A complex set of interactions determine how ecosystems respond to disturbances.

### Evidence Outcomes

#### *Students Can:*

- a. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. (HS-LS2-6) (*Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.*)
- b. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. (HS-LS2-7) (*Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)
2. Arguments may also come from current scientific or historical episodes in science. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)

3. Connections to Nature of Science: Scientific Knowledge is open to revision in light of new evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

#### *Elaboration on the GLE:*

1. Students can answer the question: What happens to ecosystems when the environment changes?
2. LS2:C Ecosystem Dynamics, Functioning, and Resilience: Anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, over-exploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.
3. LS4:D Biodiversity and Humans: Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, over-exploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

#### *Cross Cutting Concepts:*

1. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.







### Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

### Grade Level Expectation:

7. Organisms interact in groups to benefit the species.

### Evidence Outcomes

#### *Students Can:*

- a. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce. (HS-LS2-8) (*Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. (Engaging in Arguments from Evidence) (Personal: Initiative/Self-direction)
2. Connections to Nature of Science: Scientific knowledge is open to revision in light of new evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

#### *Elaboration on the GLE:*

1. Students can answer the question: How do organisms interact in groups so as to benefit individuals?
2. LS2:D Social Interactions and Group Behavior: Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects



### Prepared Graduates:

7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.

### Grade Level Expectation:

8. The characteristics of one generation are dependent upon the genetic information inherited from previous generations.

### Evidence Outcomes

#### *Students Can:*

- a. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1) (*Clarification Statement: Does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Ask questions that arise from examining models or a theory to clarify relationships. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the question: How are the characteristics of one generation related to the previous generation?
2. LS1:A Structure and Function: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.
3. LS3:A Inheritance of Traits: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.



### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

9. Variation between individuals results from genetic and environmental factors.

### Evidence Outcomes

#### *Students Can:*

- a. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3) (*Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.*)
- b. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (HS-LS3-2) (*Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (Engaging in Argument from Evidence) (Civic/Interpersonal: Collaboration/Teamwork)
2. Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)

3. Connections to Nature of Science: Science is a human endeavor.

Technological advances have influenced the progress of science and science has influenced advances in technology. Science and engineering are influenced by society and society is influenced by science and engineering.

#### *Elaboration on the GLE:*

1. Students can answer the question: Why do individuals of the same species vary in how they look, function, and behave?
2. LS3:B Variation of Traits: In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

10. Evidence of common ancestry and diversity between species can be determined by examining variations including genetic, anatomical and physiological differences.

### Evidence Outcomes

#### *Students Can:*

- a. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1)  
*(Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (Analyzing and Interpreting Data)  
(Entrepreneurial: Critical thinking/Problem solving)
2. Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

#### *Elaboration on the GLE:*

1. Students can answer the question: Why do individuals of the same species vary in how they look, function, and behave?
2. LS4:A Evidence of Common Ancestry and Diversity: Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

#### *Cross Cutting Concepts:*

1. Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
2. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

11. Genetic variation among organisms affects survival and reproduction.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (HS-LS4-2) (*Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.*) (*Boundary Statement: Does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*)
- b. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. (HS-LS4-3) (*Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.*) (*Boundary Statement: Limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (Analyzing and Interpreting Data) (Entrepreneurial: Inquiry/Analysis)
2. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How does genetic variation among organisms affect survival and reproduction?
2. LS4:B Natural Selection: Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.



*Cross Cutting Concepts:*

1. Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
2. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.





### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

12. The environment influences survival and reproduction of organisms over multiple generations.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. (HS-LS4-4) *(Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.)*
- b. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (HS-LS4-5) *(Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
2. Arguments may also come from current or historical episodes in science. Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)



*Elaboration on the GLE:*

1. Students can answer the question: How does the environment influence populations of organisms over multiple generations?
2. LS4:C Adaptation: Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

*Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
2. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.







### Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

### Grade Level Expectation:

13. Humans have complex interactions with ecosystems and have the ability to influence biodiversity on the planet.

### Evidence Outcomes

#### *Students Can:*

- a. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (HS-LS4-6) (*Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Create or revise a simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking)  
(Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: What is biodiversity, how do humans affect it, and how does it affect humans?
2. LS4:D Biodiversity and Humans: Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.



## Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

## Grade Level Expectation:

1. All stars, including the sun, undergo stellar evolution, and the study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

## Evidence Outcomes

### Students Can:

- a. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. (HS-ESS1-1) *(Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.) (Boundary Statement: Does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.)*
- b. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. (HS-ESS1-2) *(Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases [from the spectra of electromagnetic radiation from stars], which matches that predicted by the Big Bang theory [3/4 hydrogen and 1/4 helium].)*

- c. Communicate scientific ideas about the way stars, over their life cycle, produce elements. (HS-ESS1-3) *(Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.) (Boundary Statement: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.)*

## Academic Context and Connections

### Colorado Essential Skills and Science and Engineering Practices:

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Professional: Resilience/Perseverance).
3. Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically.) (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy)



4. Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

*Elaboration on the GLE:*

1. Students can answer the question: What is the universe and what goes on in stars?
2. ESS1:A The Universe and Its Stars: The star called the sun is changing and will burn out over a life span of approximately 10 billion years. The sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

*Cross Cutting Concepts:*

1. Scale, Proportion, and Quantity: The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
2. Energy and Matter: Energy cannot be created or destroyed — only moved between one place and another place, between objects and/or fields, or between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
3. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.





### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

### Grade Level Expectation:

2. Explanations of and predictions about the motions of orbiting objects are described by the laws of physics.

### Evidence Outcomes

#### *Students Can:*

- a. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. (HS-ESS1-4) (*Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.*) (*Boundary Statement: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Use mathematical or computational representations of phenomena to describe explanations. (Using Mathematical and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: What are the predictable patterns caused by Earth's movement in the solar system?
2. ESS1:B Earth and the Solar System: Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, both occurring over tens to hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of ice ages and other gradual climate changes.

#### *Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).





### Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth’s place in it.

### Grade Level Expectation:

3. The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth’s early history and the relative ages of major geologic formations.

### Evidence Outcomes

#### *Students Can:*

- a. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. (HS-ESS1-5) *(Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges, a result of plate spreading, and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate, a result of past plate interactions.)*
- b. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history. (HS-ESS1-6) *(Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials [obtained by radiometric dating of meteorites, moon rocks, and Earth’s oldest minerals], the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
2. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
3. Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.





*Elaboration on the GLE:*

1. Students can answer the question: How do people reconstruct and date events in Earth's planetary history?
2. ESS1:C The History of Planet Earth: Continental rocks, which can be older than 4 billion years, are generally much older than rocks on the ocean floor, which are less than 200 million years old. Although active geological processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

*Cross Cutting Concepts:*

1. Patterns: Empirical evidence is needed to identify patterns.
2. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.





## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

4. Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes, and these effects occur on different time scales, from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

## Evidence Outcomes

### Students Can:

- a. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (HS-ESS2-1) *(Clarification Statement: Emphasis is on how the appearance of land features [such as mountains, valleys, and plateaus] and sea-floor features [such as trenches, ridges, and seamounts] are a result of both constructive forces [such as volcanism, tectonic uplift, and orogeny] and destructive mechanisms [such as weathering, mass wasting, and coastal erosion].) (Boundary Statement: Does not include memorization of the details of the formation of specific geographic features of Earth's surface.)*
- b. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. (HS-ESS2-2) *(Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.)*
- c. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (HS-ESS2-3) *(Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field [as constraints on convection in the outer core], and identification of the composition of Earth's layers from high-pressure laboratory experiments.)*
- d. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (HS-ESS2-4) *(Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.) (Boundary Statement: Results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.)*





## Academic Context and Connections

### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. Use a model to provide mechanistic accounts of phenomena. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
3. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence. Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems. Science includes the process of coordinating patterns of evidence with current theory.

### *Elaboration on the GLE:*

1. Students can answer the question: How do Earth's major systems interact?
2. ESS2:A Earth's Materials and Systems: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

### *Cross Cutting Concepts:*

1. Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Feedback (negative or positive) can stabilize or destabilize a system.
2. Energy and Matter: Energy drives the cycling of matter within and between systems.
3. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.







### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

5. Plate tectonics can be viewed as the surface expression of mantle convection, which is driven by heat from radioactive decay within Earth's crust and mantle.

### Evidence Outcomes

#### *Students Can:*

- a. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (HS-ESS2-1) *(Clarification Statement: Emphasis is on how the appearance of land features [such as mountains, valleys, and plateaus] and sea-floor features [such as trenches, ridges, and seamounts] are a result of both constructive forces [such as volcanism, tectonic uplift, and orogeny] and destructive mechanisms [such as weathering, mass wasting, and coastal erosion].) (Boundary Statement: Does not include memorization of the details of the formation of specific geographic features of Earth's surface.)*
- b. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (HS-ESS2-3) *(Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Civic/Interpersonal: Collaboration/Teamwork)

#### *Elaboration on the GLE:*

1. Students can answer the question: Why do the continents move, and what causes earthquakes and volcanoes?
2. ESS2:B Plate Tectonics and Large Scale Interactions: Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.



*Cross Cutting Concepts:*

1. **Stability and Change:** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
2. **Energy and Matter:** Energy drives the cycling of matter within and between systems.
3. **Connections to Engineering, Technology, and Applications of Science:** Interdependence of Science, Engineering, and Technology. Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.
4. **Influence of Engineering, Technology, and Science on Society and the Natural World:** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.





### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

6. The planet's dynamics are greatly influenced by water's unique chemical and physical properties.

### Evidence Outcomes

#### *Students Can:*

- a. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (HS-ESS2-5) *(Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization [by testing the solubility of different materials] or melt generation (by examining how water lowers the melting temperature of most solids.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do the properties and movements of water shape Earth's surface and affects its systems?
2. ESS2:C The Roles of Water in Earth's Surface Processes: The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

#### *Cross Cutting Concepts:*

1. Structure and Function: The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.





## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

7. The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.

## Evidence Outcomes

### Students Can:

- a. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. (HS-ESS2-2) *(Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.)*
- b. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (HS-ESS2-4) *(Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.) (Boundary Statement: Results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.)*
- c. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. (HS-ESS2-6) *(Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere [including humans], providing the foundation for living organisms.)*
- d. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth. (HS-ESS2-7) *(Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.) (Boundary Statement: Does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.)*





## Academic Context and Connections

### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (Analyzing and Interpreting Data)  
(Entrepreneurial: Critical thinking/Problem solving)
2. Use a model to provide mechanistic accounts of phenomena and develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models)  
(Personal: Initiative/Self-direction)
3. Construct an oral and written argument or counter-arguments based on data and evidence. (Engaging in Argument from Evidence)  
(Civic/Interpersonal: Collaboration/Teamwork)
4. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

### *Elaboration on the GLE:*

1. Students can answer the question: What regulates weather and climate?
2. ESS2:D Weather and Climate: The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere

### *Cross Cutting Concepts:*

1. Stability and Change: Feedback (negative or positive) can stabilize or destabilize a system. Much of science deals with constructing explanations of how things change and how they remain stable.
2. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
3. Energy and Matter: The total amount of energy and matter in closed systems is conserved.





### Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

### Grade Level Expectation:

8. The biosphere and Earth's other systems have many interconnections that cause a continual co-evolution of Earth's surface and life on it.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth. (HS-ESS2-7) *(Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.) (Boundary Statement: Does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an oral and written argument or counter-arguments based on data and evidence. (Engaging in Argument from Evidence) (Professional: Information and Communications Technologies)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do living organisms alter Earth's processes and structures?
2. ESS2:E Biogeology: The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.

#### *Cross Cutting Concepts:*

1. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.





## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth’s surface processes interact.

## Grade Level Expectation:

9. Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. (HS-ESS3-1) *(Clarification Statement: Examples of key natural resources include access to fresh water [such as rivers, lakes, and groundwater], regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes [such as volcanic eruptions and earthquakes], surface processes [such as tsunamis, mass wasting, and soil erosion], and severe weather [such as hurricanes, floods, and droughts]. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.)*
- b. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. (HS-ESS3-2) *(Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources [such as minerals and metals] where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining [for coal, tar sands, and oil shales] and pumping [for petroleum and natural gas]. Science knowledge indicates what can happen in natural systems — not what should happen.)*

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)
2. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations). (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do humans depend on Earth’s resources?
2. ESS3:A Natural Resources: Resource availability has guided the development of human society. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.





*Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
2. Connections to Nature of Science: Science Addresses Questions About the Natural and Material World. Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.







### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

### Grade Level Expectation:

10. Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.

### Evidence Outcomes

#### *Students Can:*

- a. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. (HS-ESS3-1) (*Clarification Statement: Examples of key natural resources include access to fresh water [such as rivers, lakes, and groundwater], regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes [such as volcanic eruptions and earthquakes], surface processes [such as tsunamis, mass wasting, and soil erosion], and severe weather [such as hurricanes, floods, and droughts]. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do natural hazards affect individuals and societies?
2. ESS3:B Natural Hazards: Natural hazards and other geologic events have shaped the course of human history, and have significantly altered the sizes of human populations and have driven human migrations.

#### *Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.





## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

## Grade Level Expectation:

11. Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.

### Evidence Outcomes

#### *Students Can:*

- a. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. (HS-ESS3-3) (*Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.*) (*Boundary Statement: Computational simulation is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*)
- b. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. (HS-ESS3-4) (*Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use [such as for urban development, agriculture, and livestock, or surface mining]. Examples for limiting future impacts could range from local efforts [such as reducing, reusing, and recycling resources] to large-scale geoengineering design solutions [such as altering global temperatures by making large changes to the atmosphere or ocean].*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
2. Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Global/Cultural awareness)

#### *Elaboration on the GLE:*

1. Students can answer the question: How do humans change the planet?
2. ESS3:C Human Impacts on Earth's Systems: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

#### *Cross Cutting Concepts:*

1. Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Feedback (negative or positive) can stabilize or destabilize a system.
2. Connections to Nature of Science: Science is a Human Endeavor. Science is a result of human endeavors, imagination, and creativity.



### Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth’s surface processes interact.

### Grade Level Expectation:

12. Global climate models used to predict future climate change continue to improve our understanding of the impact of human activities on the global climate system.

### Evidence Outcomes

#### *Students Can:*

- a. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth’s systems. (HS-ESS3-5) (*Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes [such as precipitation and temperature] and their associated impacts [such as on sea level, glacial ice volumes, or atmosphere and ocean composition].*) (*Boundary Statement: Limited to one example of a climate change and its associated impacts.*)
- b. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (HS-ESS3-6) (*Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.*) (*Boundary Statement: Does not include running computational representations but is limited to using the published results of scientific computational models.*)

### Academic Context and Connections

#### *Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze data using computational models in order to make valid and reliable scientific claims. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (Using Mathematics and Computational Thinking) (Professional: Information and Communications Technologies)
3. Connections to Nature of Science: Scientific Investigations Use a Variety of Methods. Science investigations use diverse methods and do not always use the same set of procedures to obtain data. New technologies advance scientific knowledge.
4. Scientific Knowledge is Based on Empirical Evidence: Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

#### *Elaboration on the GLE:*

1. Students can answer the question: How do people model and predict the effects of human activities on Earth’s climate?
2. ESS3:D Global Climate Change: Though the magnitudes of humans’ impacts are greater than they have ever been, so too are humans’ abilities to model, predict, and manage current and future impacts. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities, as well as to changes in human activities.





*Cross Cutting Concepts:*

1. **Stability and Change:** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
2. **Systems and System Models:** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

