SOUTH CAROLINA
DEPARTMENT OF EDUCATION

Eighth Grade Performance Targets

for the
South Carolina College- and Career-Ready Science Standards 2021

For use 2025-2026

July 2025

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Contents

Purpose and Use

Science is a way of understanding the physical universe using observation and experimentation to explain natural phenomena. Science also refers to an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines. As science educators we must take a 3-dimensional approach in facilitating student learning. By addressing content, science and engineering practices and crosscutting concepts, students can have relevant and evidence-based instruction that can help solve current and future problems.

This document is intended as a guide for discerning and describing features of students and their work who have met the stated Performance Expectation (PE). This document is not intended to be read from cover to cover, but to be used, when needed, to support teacher professional learning and curriculum decisions. This is not intended for student use, and thus is not written in student-friendly language. This is not a curriculum or a means to limit instruction in the classroom. Although each PE states a dedicated Science and Engineering Practice (SEP) and Crosscutting Concept (CCC), students will need to use the whole range of SEPs and CCCs to achieve success by the end of instruction.

Three-dimensional science learning requires discipline specific communication skills. This means that effective science learning occurs when students are expected to speak, listen, read, and write in ways that are appropriate to science. With each Performance Target, there are question/sentence stems and terminology to support student discourse about phenomena to help teachers facilitate the acquisition of science discourse. Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding. The terms and stems in this section are intended to provide a baseline for teachers, neither list is exhaustive nor complete.

In addition to the doing (SEP), thinking (CCC), and learning of science knowledge outlined here, students will also require a working knowledge of grade-level appropriate tools and techniques of science. Students should know and recognize how scientists and engineers use these tools and techniques, not just identify them. Students should be able to use these tools to gather data, describe how these tools gather data, and/or interpret data sampled from them. These tools and techniques for Grade 8 include all those previously identified and add or emphasize:

- beaker
- coiled metal spring
- digital balance
- graduated cylinder
- graduated syringe
- magnets
- meter stick
- simple circuits
- spring scale
- thermometer
- timing device
- triple beam balance

Document Updates

July 2025

- All Performance Expectation statements have been reformatted to call out each of the dimensions as follows:
    - Science and Engineering Practice – **bold**
    - Crosscutting Concept – *italicize*
    - Disciplinary Core Idea – regular
- The watermark from previous versions of this resource has been replaced with the wording "For use 2025-2026" on the title page and in the footer. This change was made to improve accessibility of this resource.
- Because scientific notation is no longer an expectation of the math standards, the following PEs have a new statement related to the use and application of scientific notation.
    - 8-PS2-4
    - 8-PS4-1
    - 8-PS4-3
    - 8-LS3-1
    - 8-ESS1-2
    - 8-ESS1-3
- Additional terminology
    - 8-PS4-1
        - water wave
    - 8-LS4-2
        - gross

June 2024

- Updated watermark to 2024-2025.
- Adjusted formatting and grammar.

PS2 – Motion and Stability: Forces and Interactions

8-PS2-1. Apply Newton's third law **to design a solution to a problem** involving the motion of *two colliding objects*.

> ***Clarification Statement:*** Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.
> ***State Assessment Boundary:*** Assessment is limited to vertical or horizontal interactions in one dimension.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific ideas, principles, to design an object, tool, process, or system.	**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). **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (*secondary*)	**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.

Observable features of student performance by the end of the course:

1. **Using scientific knowledge to generate design solutions**
    a. Students demonstrate an understanding of Newton's Third Law, including:
        i. identify the objects and forces involved in the collision and
        ii. describe the force, in terms of magnitude and direction, exerted by each object.
    b. Students design a solution to reduce the effects of a collision between two objects. In the design, students:
        i. Identify and describe the system components involved in the collision,
        ii. describe the force, in terms of magnitude and direction, exerted on the second object by the first,
        iii. describe how Newton's Third Law is impacted by the solutions, including the increases and/or decreases in forces, and/or
        iv. identify and describe the technologies (limited to: human-made material or device) used in the solution.
2. **Describing criteria and constraints, including quantification when appropriate**
    a. Students describe the constraints and criteria that will be considered in the design solution.
        i. Students describe criteria, including:
            1. decreasing or increasing the post-collision movement as it related to:
                a. change in object shape,
                b. damage to objects,
                c. direction, and/or
                d. distance.
        ii. Students describe the constraints, which could include:
            1. cost,
            2. materials,
            3. safety, and
            4. time.
3. **Evaluating potential solutions**
    a. Students determine how the designed solution can be affected by the constraints of the problem and the limits of technological advances.
    b. Students use their understanding of Newton's Third Law to determine how well the solution meets the criteria and constraints.
    c. Students describe the value of the device for society based on needs and desires.

8-PS2-1 Academic Language

Question/Sentence Stems

- The key parts of the designed system of _________ are _________.
- I/We can optimize my/our solution by _________.
- In the system, _________ and _________ work together to _________.
- _________ are some similarities and differences among the solutions. The optimal system should include _________ because of _________.
- My design shows Newton's Third Law in its design because _________.
- My system meets the criteria because _________.
- The motion of the two objects _________ over time because _________. My designed system solves the problem because _________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- acceleration
- action/reaction
- balanced force
- collision
- conservation of momentum
- constraint
- criteria
- direction of a force
- energy transfer
- force
- friction
- gravity
- impact
- inertia
- iteration
- law of conservation of energy
- lift
- magnitude
- net force
- Newton
- prototype
- pull
- push
- thrust
- transfer
- unbalanced force
- vector

8-PS2-2. Plan an investigation to provide evidence that *the change in* an object's motion depends on the sum of the forces on the object and the mass of the object.

> ***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.
> ***State Assessment Boundary:*** Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. 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 examples of data are needed to support a claim.	**PS2.A: Forces and Motion** 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 (inertia). 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. The positions of objects and the directions of forces and motions must be described using a qualitative comparison and scalar quantities. In order to share information with other people, a reference frame must also be shared.	**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.

*Force diagrams are system models for balanced and unbalanced forces. Students can model the forces acting on an object using arrow length to represent the magnitude of the force measured in newtons (for example: 1 cm = 10 N) and arrowhead direction to indicate force direction.

Observable features of student performance by the end of the course:

1. **Identifying the phenomenon under investigation**
    a. Students identify the phenomenon under investigation involving the change in motion of an object in terms of an identified reference point.
    b. Students describe the purpose of the investigation, including determining the relationships among the following factors:
        i. balanced or unbalanced forces acting on the object (for example: force diagrams). and
        ii. mass of the object.
2. **Identifying the evidence to address the purpose of the investigation**
    a. Students describe the data that will be collected and the evidence to be derived from the data, including:
        i. the mass, motion, and forces acting on the object (for example: force diagrams),
        ii. the effect of balanced forces on the motion of an object (F=0),
        iii. the effect of unbalanced force on the motion of an object over time (F≠ 0), and
        iv. the relationship between the change in motion of an object, unbalanced forces, and object mass.
    b. Students identify how the evidence collected will be relevant to the purpose of the investigation.
3. **Planning the investigation**
    a. Students describe the investigation plans, including:
        i. how the motion of an object will be measured, including the reference point, time units, and distance units,
        ii. how the mass of the object is to be measured – including units,
        iii. the forces acting on the object, including balanced and unbalanced forces (for example: force diagrams)
        iv. independent variable, dependent variable, and controls, and
        v. the number of trials.

8-PS2-2 Academic Language

Question/Sentence Stems

- The system of _______ is [stable/unstable] because _______(describe the forces). Evidence from my investigation to support my claim is _______.
- Patterns from my investigation show that the motion is stable when _______(describe the forces) and unstable when _______(describe the forces).
- _______(Describe the evidence from the investigation) shows that a _______(larger, smaller, identical) change in motion is caused by_______(describe the relationship of mass or force).

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- acceleration
- applied force
- balanced force
- collision
- force
- force diagram
- friction
- gravity
- inertia
- mass
- momentum
- net force
- Newton's Laws of Motion
- position over time
- pull
- push
- unbalanced force
- velocity

8-PS2-3. Analyze and interpret *data to determine the factors that affect* the strength of electric and magnetic forces.

> ***Clarification Statement:*** Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.
> ***State Assessment Boundary:*** Assessment is limited to data examples using proportional reasoning and algebraic thinking, rather than mathematical computations.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze displays of data to identify linear and nonlinear relationships.	**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.	**Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

Observable features of student performance by the end of the course:

1. **Organizing data**
    a. Students organize data about the factors that affect the strength of electric and magnetic forces, including:
        i. the magnitude of electric currents and/or other factors that affect the electric current (for example: number of turns in a wire coil),
        ii. distance between interacting objects,
        iii. orientation of interacting objects,
        iv. magnitude of magnetic strength and electrical charges of interacting objects, and/or
        v. magnetic forces.

2. **Identifying relationships**
    a. Students analyze datasets to identify patterns (limited to differences and similarities, cause-and-effect relationships) of factors that affect the strength of electric and magnetic forces.
3. **Interpreting data**
    a. Students use analyzed data to determine the factors that affect the strength of electric and magnetic forces.
    b. Students support their interpretation(s) of data by describing the relationships between the factor(s) of interest and the strength of the relevant force.

8-PS2-3 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- Even though I/we cannot see _______, it explains why _______ is happening.
- The pattern of _______ in the data shows that even a small change of _______ can cause a big effect of _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- attraction
- charge
- conductor
- electric charge
- electric current
- electric field
- electromagnet
- electromagnetic field
- frequency
- induction
- insulator
- permanent magnet
- polarity
- repulsion
- resistance
- voltage

8-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of *interacting objects and the distance between them*.

> ***Clarification Statement:*** Examples of evidence for arguments could include data generated from simulations or digital tools, and charts displaying mass, strength of interaction, distance between objects, and orbital periods of objects within the solar system.
>
> ***State Assessment Boundary:*** Assessment does not include Newton's law of gravitation or Kepler's laws.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds from K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. 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.	**PS2.B: Types of Interactions** The magnitude of the gravitational force depends on the masses and distances between interacting objects. Long-range gravitational interactions govern the evolution and maintenance of large-scale structures in the universe and the patterns of motion within them.	**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.

*Because gravitational interactions can happen across large distances, students may need to understand and apply the conventions of scientific notation when working with quantities of measurement and their calculations.

Observable features of student performance by the end of the course:

1. **Supported claims**
    a. Students make, support, or refute a claim that gravitational interactions are attractive and depend on the masses of the interacting objects and the distance between them.

2. **Identifying the scientific evidence**
    a. Students identify and describe the evidence used to construct, support or refute a claim (for example: data, media, text, visual displays), including:
        i. masses of the objects in the relevant system(s),
        ii. distance between the center of mass of objects in the relevant system(s), and
        iii. relative magnitude and direction of the forces between objects in the relevant system(s).
3. **Evaluating and critiquing the evidence**
    a. Students evaluate the evidence and identify its strengths and weaknesses, including:
        i. types of sources,
        ii. sufficiency, including validity and reliability, of the evidence to make and defend the claim, and
        iii. any alternative interpretations of the evidence and why the evidence supports or does not support the claim.
4. **Reasoning and synthesis**
    a. Students use the following chain of reasoning to connect the appropriate evidence to construct, support, or refute a claim:
        i. Systems of objects can be modeled as a set of masses interacting at a distance via gravitational forces.
        ii. In systems of objects, larger masses experience and exert proportionally larger gravitational forces.
        iii. In systems of objects, the greater the distance between the center of mass the gravitational force is proportionally smaller.
        iv. In all evidence collected so far, gravitational force is attractive.

8-PS2-4 Academic Language

Question/Sentence Stems

- In the system, _______ and _______ interact in _______ way.
- If you change _______ in the system, _______ will occur.
- The key components of the system are _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- attraction
- distance
- ellipse
- force
- force field
- galaxy
- gravitational field
- gravity
- magnitude
- mass
- orbit
- period
- proportional
- satellite
- solar system

8-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects *exerting forces on each other* even though the objects are not in contact.

> ***Clarification Statement:*** Examples of this phenomenon could include the interactions of magnets and electrically charged objects. Examples of investigations could include first-hand experiences or simulations.
> ***State Assessment Boundary:*** Assessment is limited to electric and magnetic fields and limited to qualitative evidence for the existence of fields.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Planning and Carrying Out Investigations Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. 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.	**PS2.B: Types of Interactions** Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be illustrated by their effect on a test object (a charged object, or a ball, respectively).	**Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

Observable features of student performance by the end of the course:

1. **Identifying the phenomenon under investigation**
    a. Students identify the phenomenon under investigation involving the interactions between objects at a distance.
    b. Students describe the purpose of the investigation, to collect evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

2. **Identifying evidence to address the purpose of the investigation**
    a. Students describe the data that will be collected to provide evidence that:
        i. two interacting objects can exert forces on each other even though they are not in contact,
        ii. distinguishes between electric and magnetic forces, and/or
        iii. the cause of the force on one object is the interaction with the second object (for example: evidence for the force disappears when the second object is removed).
3. **Planning the investigation**
    a. Students describe the reasoning for the following investigative conditions:
        i. changing the distance between objects,
        ii. changing the charge or magnetic orientation of objects, and
        iii. changing the magnitude of the charge on an object or the strength of the magnetic field.
    b. Students describe the investigation plans, including:
        i. how to indicate or measure the presence of electric or magnetic forces,
        ii. independent variable, dependent variable, and controls, and
        iii. the number of trials.
4. **Collecting the data**
    a. Students make and record observations of:
        i. motion of objects,
        ii. suspension of objects,
        iii. simulations of objects that produce either electric or magnetic fields through space and the effect of moving those objects closer together or farther apart, and
        iv. a push or pull exerted on the hand of an observer holding an object.
    b. Students evaluate collected data to determine whether the resulting evidence meets the goals of the investigation, including evidence that fields exist between objects that are not in contact.

8-PS2-5 Academic Language

Question/Sentence Stems

- When I/we change _______ in the system, _______ is affected. My model shows this by _______.
- _______ in my model shows that even a small change of _______ can cause a big effect of _______.
- Even though I/we cannot see _______, it explains why _______is happening. I represent this in my model through _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- ampere
- charged particle
- conductor
- direction
- electric charge
- electric current
- electric field
- electric force
- electric potential
- electromagnet
- electromagnetic field
- electrostatic
- frequency
- gravity
- induction
- insulator
- magnetic field
- magnetic force
- magnitude
- negative charge
- neutral charge
- permanent magnet
- polarity
- positive charge
- repulsion
- resistance
- static electricity
- voltage
- volts

PS4 – Waves and Their Applications in Technologies for Information Transfer

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

> ***Clarification Statement:*** Emphasis is on describing waves with both qualitative and quantitative thinking.
> ***State Assessment Boundary:*** Assessment does not include electromagnetic waves and is limited to standard repeating waves. Assessment does not include relationships between the speed of waves and their frequency or wavelength.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 6-8 level builds on K-5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Use mathematical representations to describe and/or support scientific conclusions and design solutions.	**PS4.A: Wave Properties** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** Graphs and charts can be used to identify patterns in data.

*To facilitate the student understanding necessary to successfully achieve the PE 8-PS4-3, students will need a working understanding of the electromagnetic spectrum, including frequency, wavelength, and wave speed. This conflicts with the SAB for 8-PS4-1. The electromagnetic spectrum is introduced through PE 6-PS4-2.

*Because frequencies and wavelengths can span large/small scales, students may need to understand and apply the conventions of scientific notation when working with quantities of measurement and their calculations.

Observable features of student performance by the end of the course:

1. **Representation**
   a. Students develop/use mathematical wave models (for example: graphs, data tables) of a phenomenon, including:
      i. waves represent repeating quantities,
      ii. frequency as the number of times the pattern repeats in a given amount of time (for example: waves per second),
      iii. amplitude as the maximum displacement or distance from equilibrium (limited to: distance from rest to crest position or distance from trough to rest position),
      iv. wave speed as the distance a wave travels in a given amount of time (speed = wavelength * frequency), and
      v. wavelength as the distance between successive crests, troughs, or any one point on a wave to the location of the same point on the next wave (for example: the distance between the tops of a series of water waves).
2. **Mathematical modeling**
   a. Students apply the simple mathematical wave model (for example: graphs, data tables) to a physical system or phenomenon to describe relationships between the wave model characteristics and physical observations (for example: in sound waves as experienced by humans, frequency corresponds to sound pitch, amplitude corresponds to sound volume).
3. **Analysis**
   a. Students develop/use simple mathematical wave models (for example: graphs, data tables) to identify patterns in data, including:
      i. That the energy of the wave is proportional to the square of the amplitude (for example: if the height of a water wave is doubled, each wave will have four times the energy).
      ii. That the amount of energy transferred by waves in a given time is proportional to frequency (for example: if twice as many water waves hit the shore each minute, then twice as much energy will be transferred to the shore).
   b. Students predict the change in energy of the wave if any property of the wave is changed.

8-PS4-1 Academic Language

Question/Sentence Stems

- The observed pattern supports the conclusion that_______ is (caused by/related to) _______, because _______. The model shows this by _______.
- In order to explain the _______ pattern in the data, the model shows _______.
- The model shows the pattern of _______is changing over time by _______.
- The following predictions can be made about _______ when using the pattern of _______ found in the data. Evidence of _______ in the model supports my decision.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- amplitude
- crest
- force
- frequency
- kinetic energy
- mechanical wave
- medium
- oscillate
- proportional
- resting position
- sound wave
- speed
- trough
- water wave
- wavelength

8-PS4-3. Communicate information to support the claim that digital devices are used to improve our understanding of *how waves transmit information*.

> ***Clarification Statement:*** Emphasis is on a basic understanding that waves can be used for communication purposes and digitized signals are a more reliable way to encode and transmit information than analog. When in digitized form, information can be recorded, stored for future recovery, and transmitted over long distances without significant degradation. 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.
> ***State Assessment Boundary:*** Assessment does not include binary counting nor the specific mechanism of any given device.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods. Integrate qualitative scientific and technical information in different forms of text that are contained in media and visual displays to clarify claims and findings.	**PS4.C: Information Technologies and Instrumentation** Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. **ETS2.B: Influence of Science, Engineering, and Technology on Society and the Natural World** Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.	**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.

*Students will need a working understanding of the electromagnetic spectrum to be able to explain the wave behavior utilized by digital devices. This conflicts with the State Assessment boundary for PE 8-PS4-1. The electromagnetic spectrum is introduced through PE 6-PS4-2.

*Because digital devices can be used to transmit information across long distances, students may need to understand and apply the conventions of scientific notation when working with quantities of measurement and their calculations.

Observable features of student performance by the end of the course:

1. **Communication**
    a. Students use and cite at least two different credible sources (for example: texts, graphics, video, digital) to communicate scientific information about at least two different technologies (past, present, and future) that can be used for communication purposes. At least one device should provide evidence that using waves to carry digital signals is a more reliable way to encode and transmit information than using waves to carry analog signals.
2. **Connections**
    a. Students identify and communicate information about the devices, including:
        i. how each device operates,
        ii. the wave behavior (limited to absorption, reflection, transmission) utilized by the device, and
        iii. qualitatively describe how digitized signals are more reliable than analog, including:
            1. recorded reliably,
            2. stored for future recovery, and
            3. transmitted over long distances without significant degradation.
    b. Students describe how the digitization of a technology has advanced science and scientific investigations (for example: digital probes, audio recordings).

8-PS4-3 Academic Language

Question/Sentence Stems

- In the system, _______ and _______ interact in _______ way.
- If you change _______ in the system, _______ will occur.
- The key components of the system are _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- analog signal
- coded
- communicate
- computer
- conversion/convert
- decode
- device
- digital signal
- digitize
- electricity
- electromagnetic radiation
- electromagnetic wave
- emit
- encode
- machine
- microwave
- radiation
- radio wave
- ultraviolet

LS1 – From Molecules to Organisms: Structures and Processes

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

> ***Clarification Statement:*** Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). 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.	**LS1.B: Growth and Development of Organisms** Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.	**Cause and Effect** Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Observable features of student performance by the end of the course:

1. **Supported claims**
    a. Students make, support, or refute a claim that characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction.

2. **Identifying scientific evidence**
    a. Students identify and describe the evidence (for example: data and scientific literature) used to support or refute a claim, including the following:
        i. characteristic animal behaviors that increase the probability of reproduction,
        ii. specialized plant structures that increase the probability of reproduction, and
        iii. relationships between:
            1. specialized plant structures and the probability of successful reproduction of plants that have those structures,
            2. animal behaviors and the probability of successful reproduction of animals that exhibit those behaviors, and
            3. plant reproduction and animal behaviors related to plant reproduction.
3. **Evaluating and critiquing the evidence**
    a. Students evaluate and identify the strengths and weaknesses of the evidence, including:
        i. types of source,
        ii. sufficiency, including validity and reliability, of the evidence to make and defend the claim, and
        iii. any alternative interpretations of the evidence and why the evidence supports or does not support the students claim.
4. **Reasoning and synthesis**
    a. Students use the following chain of reasoning to connect the appropriate evidence:
        i. Many characteristic animal behaviors affect the likelihood of reproductive success.
        ii. Many specialized plant structures affect the likelihood of reproductive success.
        iii. Animal behavior can play a role in the likelihood of reproductive success in plants.
        iv. Reproductive success has several causes and contributing factors so the relationships between any of these characteristics (separately or together) and reproductive likelihood can be reflected in terms of probability.

8-LS1-4 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- adaptation
- behavior
- breeding
- genetic
- herding
- inherited
- mating
- nectar
- offspring
- organism
- parent
- plumage
- pollen
- probability
- reproduction
- structure
- variation
- vocalization

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

Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include how drought or flooding affects 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.

State Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. 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.	**LS1.B: Growth and Development of Organisms** Genetic factors as well as local conditions affect the growth of the adult plant. The growth of an animal is controlled by genetic factors, food intake, and interactions with other organisms, and each species has a typical adult size range.	**Cause and Effect** Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Observable features of student performance by the end of the course:

1. **Articulating the explanation of phenomena**
    a. Students articulate a statement that describes/explains how both environmental and genetic factors influence the growth of organisms.
2. **Evidence**
    a. Students identify and describe the evidence necessary for constructing explanations, including:
        i. environmental factors (for example: availability of light, space, water, size of habitat) that can influence growth,
        ii. genetic factors (for example: breeds of plants and animals and their typical sizes) that can influence growth, and
        iii. changes in the growth of organisms as specific environmental and/or genetic factors.
    b. Students use multiple valid and reliable sources of evidence, including student investigations.
3. **Reasoning**
    a. Students use the following chain of reasoning to connect the evidence and support or refute an explanation for how both environmental and genetic factors influence the growth of organisms:
        i. Organism growth is influenced by multiple environmental (for example: drought, changes in food availability) and genetic (for example: specific breed) factors.
        ii. Both environmental and genetic factors can influence organisms simultaneously, so organism growth is the result of environmental and genetic factors working together (for example: water availability influences the height dwarf fruit trees will grow).
        iii. Organism growth can have several environmental and genetic causes, the contributions of specific causes or factors to organism growth can be described using probability (for example: not every fish in a large pond grows to the same size).

8-LS1-5 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- biotic
- conditions
- development
- deoxyribose nucleic acid (DNA)
- environment
- gene
- gene expression
- genetics
- genome
- genotype
- growth
- habitat
- phenotype

LS3 – Heredity: Inheritance and Variation of Traits

8-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the *structure and function* of the organism.

> ***Clarification Statement:*** Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.
> ***State Assessment Boundary:*** Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop and use a model to describe phenomena.	**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. **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.	**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.

*Students will need a working understanding of the structure of deoxyribose nucleic acid (DNA) and the central dogma of molecular biology to demonstrate proficiency for the PE 8-LS3-1. The specific biomechanical steps of these processes (for example: transcription, translation) are beyond the scope of this PE.

*Because genetic data (DNA base pair counts) can be large, students may need to understand and apply the conventions of scientific notation when working with quantities of measurement and their calculations.

Observable features of student performance by the end of the course:

1. **Components of the model**
    a. Students develop/use a model (conceptual, graphical, physical) and identify the relevant components, including:
        i. genes, located on chromosomes,
        ii. proteins, and
        iii. traits of organisms.
2. **Relationships**
    a. Students develop/use a model to describe the relationships between components, including:
        i. Every gene has a certain structure, which determines the structure of a specific set of proteins.
        ii. Protein structure influences protein function (for example: the structure of some blood proteins allows them to attach to oxygen, the structure of a normal digestive protein allows it to break down a particular food molecule).
        iii. Observable organism traits (for example: structural, functional, behavioral) result from the activity of proteins.
3. **Connections**
    a. Students develop/use a model to describe that structural changes to genes (limited to mutations) may result in observable effects at the level of the organism, including why structural changes to genes:
        i. may affect protein structure and function,
        ii. may affect how proteins contribute to observable structure and functions in organisms, and
        iii. may result in trait changes that are beneficial, harmful, or neutral for the organism in its current environment.
    b. Students develop/use a model to describe that changes to protein function can cause beneficial, neutral, or harmful changes in the structure and function of organisms (in their current environment).

8-LS3-1 Academic Language

Question/Sentence Stems

- The _______ structures help _______ to function because _______.
- I/we think that the _______ structures in the system (choose the system) function _______.
- The ______ structures are present in _______ and are related to the function _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- allele
- beneficial
- chromosome
- deoxyribose nucleic acid (DNA)
- dominant trait
- environment
- fertilization
- gene
- genetic
- genome
- genotype
- harmful
- karyotype
- mutation
- neutral
- offspring
- organism
- parent
- Pedigree
- phenotype
- pollination
- Punnett square
- recessive trait
- ribonucleic acid (RNA)
- silent mutation
- trait
- transcription
- translation
- zygote

8-LS3-2. Develop and use a model to describe why asexual reproduction *results in* offspring with identical genetic information and sexual reproduction *results in* offspring with genetic variation.

> ***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.
> ***State Assessment Boundary:*** Assessment should be limited to Punnett squares of monohybrid cross.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop and use a model to describe phenomena.	**LS1.B: Growth and Development of Organisms** Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (*secondary*) **LS3.A: Inheritance of Traits** Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **LS3.B: Variation of Traits** In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. In asexual reproduction, an organism's DNA is replicated and passed to its offspring creating a genetic copy of the parent.	**Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural systems.

Observable features of student performance by the end of the course:

1. **Components of the model**
    a. Students develop/use a model (for example: Punnett squares, pedigrees, simulations) and identify relevant components, including:
        i. parent and offspring alleles and
        ii. genotypes (for example: homozygous, heterozygous, dominant, recessive).
    b. Students develop/use a model (for example: Punnett squares, pedigrees, simulations) to describe the relationships between components, including:
        i. Chromosome pairs, including genetic variants, in asexual reproduction for:
            1. parents and
            2. offspring.
        ii. Chromosome pairs, including genetic variants, in sexual reproduction for:
            1. parents and
            2. offspring.
2. **Relationships**
    a. Students develop/use a model to describe the relationships between components, including:
        i. During reproduction (both sexual and asexual), parents transfer genetic information in the form of genes to their offspring.
        ii. Under normal conditions, offspring have the same number of chromosomes, and therefore genes, as their parents.
        iii. During asexual reproduction, a single parent's chromosomes (one set) are the source of genetic material in the offspring.
        iv. During sexual reproduction, two parents (two sets of chromosomes) contribute genetic material to the offspring.
3. **Connections**
    a. Students develop/use a model to describe how asexual and sexual reproduction result in different amounts of genetic variation in offspring relative to their parents, including:
        i. In asexual reproduction:
            1. Offspring have a single source of genetic information, and their chromosomes are complete copies of each single parent pair of chromosomes.
            2. Offspring chromosomes are identical to parent chromosomes.

   ii. In sexual reproduction:
      1. Offspring have two sources of genetic information (limited to two sets of chromosomes) that contribute to each final pair of chromosomes in the offspring.
      2. Both parents are likely to contribute different genetic information, so offspring chromosomes reflect a combination of genetic material from two sources and therefore contain new combinations of genes (genetic variation) that make offspring chromosomes distinct from those of either parent.

b. Students use relationships found in the model between type of reproduction and the resulting genetic variation to predict that more genetic variation occurs in organisms that reproduce sexually compared to organisms that reproduce asexually.

8-LS3-2 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _____ caused _____, the following evidence is needed ____.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- allele
- asexual reproduction
- budding
- cell division
- chromosome
- development
- deoxyribose nucleic acid (DNA)
- dominant trait
- egg cell
- fertilize
- gamete
- gene
- genetic variation
- genotype
- germination
- heredity
- heterozygous
- homozygous
- meiosis
- mitosis
- phenotype
- plant structure
- propagation
- protein
- Punnett square
- recessive trait
- reproductive system
- sexual reproduction
- sperm cell
- transmission

LS4 – Biological Evolution: Unity and Diversity

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

> ***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.
> ***State Assessment Boundary:*** Assessment does not include the names of individual species or geological eras in the fossil record.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze and interpret data to determine similarities and differences in findings.	**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. **ESS2.E: Biogeology** Sudden changes in conditions (e.g., meteor impacts, major volcanic eruptions) have caused mass extinctions, but these changes, as well as more gradual ones, have ultimately allowed other life forms to flourish. (*secondary*)	**Patterns** Graphs, charts, and images can be used to identify patterns in data.

Observable features of student performance by the end of the course:

1. **Organizing data**
    a. Students organize data including appearance of specific organisms in the fossil record as a function of time determined by their locations in the sedimentary layers or rock ages [Law of Superposition].
2. **Identifying relationships**
    a. Students identify:
        i. patterns between a set of sedimentary layers and the relative ages of those layers,
        ii. time period(s) during which a fossil organism is present in the fossil record,
        iii. time period(s) during which changes in the presence or absence of large numbers of organisms or specific types of organisms are observed in the fossil record (for example: a fossil layer with very few organisms immediately next to a fossil layer with many types of organisms), and
        iv. patterns of change in the level of complexity of anatomical structures in organisms in the fossil record, as a function of time.
3. **Interpreting data**
    a. Students analyze data to describe:
        i. when mass extinctions occurred,
        ii. when organisms or types of organisms emerged, went extinct, or evolved, and/or
        iii. the long-term increase in the diversity and complexity of organisms on Earth.

8-LS4-1 Academic Language

Question/Sentence Stems

- I/We can observe (notice) the pattern of _______ presented in the data collected.
- I/We can observe (notice) the pattern of _______ in the data presented.
- The pattern seen in the collected data allows me/us to conclude (know) that ______.
- The observed pattern supports the conclusion that _______ is caused by _______, because _______.
- The pattern of _______ is changing over time.
- The following predictions can be made about _______ when using the pattern of _______ found in the data.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- analogous
- anatomical
- ancestor
- ancestry
- common ancestor
- convergent
- descent with modification
- divergent
- diversity
- evolve
- extant
- extinct
- fossil
- fossil record
- geologic
- geologic time scale
- homologous
- mass extinction
- mineral
- multicellular
- natural laws
- organism
- radioactive dating
- sedimentary rock
- species
- trait
- unicellular
- uniformitarianism
- volcanic rock

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

Clarification Statement: Emphasis is on explanations of the ancestral relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.

State Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.	**LS4.A: Evidence of Common Ancestry and Diversity** Anatomical similarities and differences among modern organisms and between modern and fossil organisms in the fossil record enable the reconstruction of the history and the inference of lines of ancestral relationships.	**Patterns** Patterns can be used to identify cause- and-effect relationships.

Observable features of student performance by the end of the course:

1. **Articulating the explanation of phenomena**
    a. Students articulate a statement that anatomical similarities and differences among organisms can be used to infer evolutionary relationships, including:
        i. among modern organisms and/or
        ii. between modern and fossil organisms.

2. **Evidence**
    a. Students identify and describe the evidence necessary for constructing the explanation, including:
        i. Similarities and differences in gross appearance of anatomical structure patterns in and between:
            1. modern, living organisms (for example: skulls of modern crocodiles, skeletons of birds; features of modern whales and elephants) and/or
            2. fossilized organisms (for example: skulls of fossilized crocodiles, fossilized dinosaurs)
    b. Students use multiple valid and reliable sources of evidence.
3. **Reasoning**
    a. Students use the following chain of reasoning to connect the evidence and support or refute an explanation:
        i. Organisms that share a pattern of gross anatomical features are likely to be more closely related than are organisms that do not share a pattern of anatomical features, due to the relationship between genetic makeup and anatomy.
        ii. Changes over time in the gross anatomical features observable in the fossil record can be used to infer lines of evolutionary descent by linking extinct organisms to living organisms through a series of fossilized organisms that share a basic set of gross anatomical features.

8-LS4-2 Academic Language

Question/Sentence Stems

- I/We can observe (notice) the pattern of _______ presented in the data collected.
- I/We can observe (notice) the pattern of _______ in the data presented.
- The pattern seen in the collected data allows me/us to conclude (know) that _______.
- The observed pattern supports the conclusion that _______ is caused by _______, because _______.
- The pattern of _______ is changing over time.
- The following predictions can be made about _______ when using the pattern of _______ found in the data.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- analogous
- anatomy
- ancestry
- ancient
- convergent
- divergent
- diversity
- evolve
- extinct
- extinction
- fossil
- fossil record
- gross
- homologous
- mineral
- organism
- radioactive dating
- species
- structure
- vestigial

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

> ***Clarification Statement:*** In a specific environment impacted by different factors, some traits provide advantages that make it more probable that an organism will be able to survive and reproduce there.
> ***State Assessment Boundary:*** Assessment is limited to using simple probability statements and proportional reasoning to construct explanations.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.B: Natural Selection** Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Observable features of student performance by the end of the course:

1. **Articulating the explanation for phenomena**
    a. Students articulate an explanation about the relationship between inheritance of traits and increasing the chances of successful reproduction and survival (natural selection).

2. **Evidence**
    a. Students identify and describe the evidence necessary for constructing the explanation, including:
        i. Individuals in a species have genetic variation that can be passed on to their offspring.
        ii. The probability of a specific organism surviving and reproduction in a specific environment.
        iii. The relationship between traits (limited to: specific variation of a characteristic) and the probability of survival and organism fitness.
        iv. The particular genetic variation (associated with those traits) that are carried by that organism.
    b. Students use multiple valid and reliable sources of evidence, including student investigation.
3. **Reasoning**
    a. Students use the following chain of reasoning to connect the evidence and support or refute an explanation:
        i. Any population in an identified environment contains a variety of available, inheritable genetic traits.
        ii. In a specific environment (for example: different environments may have limited food availability, predators, nesting site availability, light availability), some traits increase organism fitness.
        iii. Within a population, there is a relationship between the variation of traits and the probability of organism fitness.
        iv. Variation of traits is a result of genetic variations within the population.
        v. The proportion of individual organisms in a population that have genetic variations and traits that increase fitness will increase from generation to generation due to natural selection.
            1. Conversely, the proportion of individuals that have genetic variations and traits that decrease fitness in a particular environment will be less likely to survive, and the proportion of organisms with disadvantageous traits will decrease from generation to generation due to natural selection.

8-LS4-4 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that _____ caused _______ is _______. I/We know this because ______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abundance
- adaptation
- advantageous
- allele
- asexual reproduction
- beneficial
- camouflage
- detrimental
- distribution
- diversity
- deoxyribose nucleic acid (DNA)
- dominant traits
- drought tolerance
- environment
- evolution
- evolve
- fitness
- frequency
- gene
- genetic variation
- harmful
- natural selection
- neutral
- predation
- probability
- proportional
- recessive traits
- sexual reproduction
- trend
- variation

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

Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and on the impacts these technologies have on society and scientific discoveries.
State Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. 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.	**LS4.B: Natural Selection** 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 onto offspring. **ETS2.A: 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.	**Cause and Effect** Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Observable features of student performance by the end of the course:

1. **Obtaining information**
    a. Students gather and synthesize information from at least two sources (for example: data, media, text, visual displays) about at least two technologies that have changed how humans have influenced the inheritance of desirable traits in plants and animals through artificial selection (for example: gene therapy, genetic modification, selective breeding).

2. **Evaluating information**
    a. Students evaluate the information based on:
        i. the credibility, accuracy, and bias of each publication and the methods used to generate and collect the evidence,
        ii. the ability of the information to support or refute explanations about how artificial selection technologies have changed the way that humans influence the inheritance of desirable traits in organisms, and
        iii. the cause-and-effect relationship in how traits occur in organisms has led to advances in technologies that increase the probability of being able to influence the inheritance of desirable traits in organisms.

8-LS4-5 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that ______ caused ______ is ______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _____ caused _____, the following evidence is needed ____.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- adaptation
- animal husbandry
- artificial selection
- biotechnology
- breeding
- chromosome
- cloning
- deoxyribose nucleic acid (DNA)
- evolution
- gene therapy
- genetic engineering
- genetic modification
- genetic variation
- genetically modified organism
- genome sequencing
- hereditary
- inherit
- mutagen
- mutation
- natural selection
- offspring
- plant propagation
- proteins
- reproduction
- resources
- selective breeding

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

> ***Clarification Statement:*** Emphasis on student explanation of trends in data using mathematical models, probability statements, and proportional reasoning to support explanations of trends of population changes.
> ***State Assessment Boundary:*** Assessment does not include Hardy Weinberg calculations.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Using Mathematics and Computational Thinking Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to 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.	**LS4.C: Adaptation** Adaptation by natural selection occurring 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.	**Cause and Effect** Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Observable features of student performance by the end of the course:

1. **Representation**
    a. Students articulate an explanation of the phenomena they will support, including:
        i. Characteristics of a species' change over time (limited to: over generations) through adaptation by natural selection in response to changes in environmental conditions.
        ii. Traits that increase fitness in a new environment become more common within a population in that environment.
        iii. Traits that decrease fitness in a new environment become less common within a population in that environment.
        iv. When environmental shifts are too extreme, populations do not have time to adapt and may become extinct.

   b. Students develop/use mathematical and/or computational models (for example: trends, averages, histograms, graphs, spreadsheets) to identify and describe the components that are relevant to support or refute an explanation, including:
      i. population changes gathered from historical data or simulations,
      ii. distribution of specific traits over time from data and/or simulations, and
      iii. environmental conditions (for example: climate, resource availability) over time from data and/or simulations

2. **Mathematical and/or computational modeling**
   a. Students develop/use a mathematical and/or computational model to identify relationships in the data and/or simulations, including:
      i. changes and trend over time in the distribution of traits within a population,
      ii. multiple cause-and-effect relationships between environmental conditions and natural selection in a population, and
      iii. the increase or decrease of some traits within a population can have more than one environmental cause.

3. **Analysis**
   a. Students analyze a mathematical and/or computational model to and synthesize their analysis with scientific information to describe that:
      i. the distribution of traits in populations change over time in response to changes in environmental conditions,
      ii. species adapt through natural selection, and
      iii. this results in the distribution of traits within a population and the probability that any given organism will carry a particular trait.
   b. Students use the analysis of the mathematical and/or computational model (including proportional reasoning) as evidence to support, revise, or refute a claim, including:
      i. Through natural selection, traits that increase fitness are more common in a population than those that do not.
      ii. Populations are not always able to adapt and survive because adaptation by natural selection occurs over generations.
      iii. Because there are multiple contributing cause-and-effect relationships, for each different cause it is not possible to predict with 100% certainty what will happen.

8-LS4-6 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that ______ caused ______ is _______. I/We know this because ______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _____ caused _____, the following evidence is needed ____.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greate depth of conceptual understanding.

- adaptation
- advantageous
- asexual reproduction
- beneficial
- camouflage
- climate
- competition
- disadvantageous
- distribution
- diversity
- drought tolerance
- environment
- evolution
- gene
- generation
- genetic variation
- harmful
- inherit
- morphology
- natural selection
- neutral
- population
- predation
- probability
- proliferation
- ratio
- sexual reproduction
- species
- trait
- trend
- variation

ESS1 – Earth's Place in the Universe

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

Clarification Statement: Examples of models can be physical, graphical, or conceptual.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop and use a model to describe phenomena.	**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. **ESS1.B: Earth and the Solar System** This model of the solar system can explain tides (including spring and neap), eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** Patterns can be used to identify cause- and- effect relationships.

Observable features of student performance by the end of the course:

1. **Components of the model**
    a. Students develop/use a model (conceptual, graphical, physical) and identify the relevant components, including:
        i. Earth, including the tilt of its axis of rotation,
        ii. Sun,
        iii. Moon, and
        iv. light (solar energy)

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

2. **Relationships**
    a. Students develop/use a model and describe the relationships between components, including:
        i. Earth rotates on its tilted axis once an Earth-day (24 hours).
        ii. The Moon rotates on its axis approximately once an Earth-month.
        iii. Relationships between Earth and the Moon:
            1. The Moon orbits Earth approximately once a month.
            2. The Moon rotates on its axis at the same rate it orbits Earth so that the side of the Moon that faces the Earth remains the same.
            3. The Moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the Sun.
        iv. Relationships between the Earth-Moon system and the Sun:
            1. Earth-Moon system orbits the Sun once an Earth year.
            2. Light from the Sun travels in a straight line from the Sun to Earth and the Moon so that the side of the Earth or Moon that faces the Sun is illuminated.
            3. Light from the Sun reflects off the surface of the Moon that faces the Sun and can travel to Earth by reflection.
            4. Solar distance is less in January and greater in June. This provides evidence that solar distance is not a factor in seasons.
            5. Light from the Sun (solar energy) travels in a straight line from the Sun and hits different parts of the curved Earth at different angles:
                a. more directly at the equator and
                b. less directly at the poles.
            6. The Earth's rotation axis is tilted 23.3◦ with respect to its orbital plane around the Sun. Earth maintains the same relative orientation in space, with its North Pole pointed toward the North Star throughout its orbit.

3. **Connections**
    a. Students develop/use a model to observe patterns for events, including:
        i. Moon phases:
            1. Light from the Sun reflects off the Moon and is viewed in Earth as the bright part of the Moon.
            2. The visible portion of the Moon (as viewed from Earth) changes over the course of a month as the location of the Moon relative to Earth and the Sun changes.
            3. The Moon appears to become more fully illuminated (waxing) until "full" and then less fully illuminated (waning) until "new" in a pattern of change that corresponds to what proportion of the Moon is visible from Earth.

ii. Eclipses:
    1. Light from the Sun is prevented from reaching Earth during a solar eclipse because the Moon is located between the Sun and Earth.
    2. Light from the Sun is prevented from reaching the Moon during a lunar eclipse because Earth is located between the Sun and the Moon.
    3. Because the Moon's orbital plane is tilted with respect to Earth's orbital plane, for most of the time during and Earth month:
        a. The Moon is rarely in a position to block solar energy from reaching Earth.
        b. Earth is rarely in a position to block solar energy from reaching the Moon.

iii. Seasons:
    1. Because the Earth's axis is tilted, the most direct and intense solar energy occurs over the summer months and least direct and intense solar energy occurs over the winter months.
    2. The directness and intensity of solar energy at a given place on Earth causes seasonal changes. Seasonal changes are directly related to the orientation of the tilted Earth and the position of Earth in its orbit around the Sun.
        a. Summer occurs in the Northern Hemisphere when the northern axis of Earth is tilted toward the Sun (direct solar energy). Summer occurs in the Southern Hemisphere when the southern axis is tilted toward the Sun.
        b. Winter occurs in the Norther Hemisphere when the northern axis is tilted away from the Sun (indirect solar energy). Winter occurs in the Southern Hemisphere when the southern axis is tilted away from the Sun.

iv. Tides:
    1. The Earth and Moon exert a gravitational pull on each other. On Earth, the Moon's gravitational pull causes the oceans to bulge out (tidal bulge) on the side of Earth facing the moon (due to the Moon's gravitational pull) and the side of the Earth opposite the moon (tidal bulge due to inertia).
        a. A coastal point on Earth located within the bulge would experience a high tide.
        b. A coastal point on Earth located within the low point would experience a low tide.

2. Flooding (water flowing inland) and ebbing (water flowing seaward) tides happen as Earth's landmasses rotate through the tidal bulges.
    a. Tides are also affected by landforms and depths of the ocean in different locations.
3. Twice an Earth-month, when the Earth, Sun, and Moon are in line (full moon or new moon), their combined gravitational force and:
    a. A coastal point on Earth may experience an exceptionally high tide (spring tide).
        i. *Colloquially referred to as king tides.
    b. A coastal point on Earth may experience an exceptionally low tide where water has been displaced.
4. Twice an Earth-month, the Sun is at a right angle to the Moon (first or last/third quarter moon), their opposing gravitational forces result in moderate tides with very little difference between high and low tide (neap tide).

b. Students develop/use a model to predict:
    i. The phase of the Moon when given the relative locations of the Earth, Sun, and Moon.
    ii. The relative positions of the Earth, Sun, and Moon when given a Moon phase.
    iii. Whether an eclipse will occur, given the relative locations of the Earth, Sun, and Moon and a position on Earth from which the Moon or Sun can be viewed (depending on the type of eclipse).
    iv. The relative positions of the Earth, Sun, and Moon, given a type of eclipse and a position on Earth from which the Sun or Moon can be viewed.
    v. The season on Earth, given the relative positions of the Earth and Sun (including the orientation of the Earth's axis) and a position on Earth.
    vi. The relative positions of Earth and the Sun when given a season and relative position (for example: far north, far south, equatorial) on Earth.
    vii. The type of tide and or tidal range experienced at a specified coastal point on Earth, given the relative positions of the Earth, Sun, and Moon.
    viii. The type of tide and or tidal range experienced at a specified coastal point on Earth given a phase of the moon (limited to: new, full, first quarter, last/third quarter).
    ix. The relative positions of the Earth, Sun, and Moon given the type of tide and/or tidal range of a specified coastal point on Earth.

8-ESS1-1 Academic Language

Question/Sentence Stems

- I can observe (notice) the pattern of ________ presented in the data collected.
- The pattern seen in the collected data allows me to conclude (know) that ________.
- The observed pattern supports the conclusion that_______ is caused by _______, because________.
- The pattern of ______is changing over time.
- The following predictions can be made about ______when using the pattern of _______ found in the data.
- _______ are some similarities and differences among the above.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- aphelion
- apogee
- axis
- crescent
- cyclic
- direct
- Earth
- eclipse
- ecliptic
- ellipse
- equinox
- far side
- first quarter moon
- full moon
- gibbous
- gravity
- high tide
- illuminate
- indirect
- inertia
- last/third quarter moon
- low tide
- lunar
- Moon
- natural satellite
- neap tide
- near side
- new moon
- orbit
- penumbra
- perigee
- perihelion
- planet
- pole
- reflect
- revolution
- revolve
- rotation
- season
- shadow
- solar
- solar distance
- solstice
- spring tide
- Sun
- system
- syzygy
- terminator
- tidal bulge
- tidal range
- tide
- totality
- umbra
- waning
- waxing

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

> ***Clarification Statement:*** Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).
>
> ***State Assessment Boundary:*** Assessment does not include Kepler's laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop and use a model to describe phenomena.	**ESS1.A: The Universe and Its Stars** Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun, planets, their moons, and other celestial objects that are held in orbit around the sun by its gravitational pull on them. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	**Systems and System Models** Models can be used to represent systems and their interactions.

*Because distances between celestial bodies are vast, students may need to understand and apply the conventions of scientific notation when working with quantities of measurement and their calculations.

Observable features of student performance by the end of the course:

1. **Components of the model**
    a. Students develop/use a model and identify the relative components, including:
        i. gravity,
        ii. the solar system as a collection of bodies, including the Sun, planets, Moons, and asteroids,
        iii. the Milky Way galaxy as a collection of stars (for example: the Sun) and their associated systems of objects, and
        iv. other galaxies in the universe.
    b. Students develop/use a model to describe the relative spatial scales of solar systems, galaxies, and/or their components.
2. **Relationships**
    a. Students develop/use a model to describe the relationships between components, including:
        i. Gravity as an attractive force between solar system and galaxy objects that:
            1. increases as the mass of the interacting objects increases, and
            2. decreases as the distance between objects increases.
        ii. The orbital motion of objects in our solar system (for example: moons orbit around planets, all objects within the solar system orbit the Sun).
        iii. The rates of planetary revolution demonstrate the varied gravitational pull of the Sun on different planets in our solar system.
        iv. The orbital motion, in the form of a disk, of vast numbers of stars around the center of the Milk Way.
        v. That our solar system is one of many systems orbiting the center of the larger system of the Milky Way galaxy.
        vi. The Milky Way is one of many galaxy systems in the universe.

3. **Connections**
    a. Students develop/use a model to describe that gravity is a predominantly inward-pulling force that can keep smaller/less massive object in orbit around larger/more massive objects.
    b. Students develop/use a model to describe that gravity (a predominantly inward-pulling force) causes a pattern of smaller/less massive objects orbiting around larger/more massive objects at all system scales in the universe, including:
        i. Gravitational forces from planets cause smaller objects (for example: moons) to orbit around planets.
        ii. The gravitational force of the Sun causes the planets and other bodies to orbit around it, holding the system together.
        iii. The gravitational forces from the center of the Milky Way cause stars and stellar systems to orbit around the center of the galaxy.
        iv. The hierarchy pattern of orbiting systems in the solar system was established early in its history as the disk of dust and gas was driven by gravitational forces to form moon-planet and planet-star orbiting systems.
    c. Students develop/use a model of our solar system to describe that objects too far away from the Sun do not orbit it because the Sun's gravitational force on those objects is too weak.
    d. Students develop/use a model to predict what a system might look like without gravity (for example: smaller objects would move in straight paths through space rather than orbiting a more massive object).

8-ESS1-2 Academic Language

Question/Sentence Stems

- The key components of the system are_______.
- In the system, ____________ and ____________ are shown in the model.
- In the system, __________ and _________ work together to________.
- In the system, ____________ and ______________ interact in ________________ way.
- If you change ___________ in the system, __________ will occur.
- In the system, ___________ is not shown in the model. This is not shown because__________________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- force
- gravitational pull
- inertia
- mass
- moon
- orbit
- orbital motion
- planet (and names)
- solar system
- velocity

8-ESS1-3. Evaluate information to determine *scale properties of* objects in the solar system.

Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of a celestial 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.
State Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. Integrate qualitative and/or quantitative scientific and/or technical information in text with that contained in media and visual displays to clarify claims and findings.	**ESS1.B: Earth and the Solar System** The solar system consists of the sun, planets, their moons, and other celestial objects that are held in orbit around the sun by its gravitational pull on them. **ETS2.A: 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.	**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.

*Because distances between celestial bodies are vast, students may need to understand and apply the conventions of scientific notation when working with quantities of measurement and their calculations.

Observable features of student performance by the end of the course:

1. **Communication**
   a. Students obtain and communicate information from at least two credible published sources (for example: data, media, models, text, visual displays) about scale properties of objects in our solar system, including:
      i. gravitational relationships,
      ii. orbital distance,
      iii. orbital radius,
      iv. orbital velocity,
      v. physical features (for example: surface composition, evidence of volcanic activity),
      vi. sizes (for example: planet diameters), and/or
      vii. solar distance.
2. **Connections**
   a. Students identify and communicate (for example: develop a scale model) evidence for scale properties of objects in our solar system.
      i. For example, a model of the solar system where 10 cm = 1 astronomical unit (AU).

8-ESS1-3 Academic Language

Question/Sentence Stems

- The scale of the model of ________ is ________ compared to the actual objects.
- To understand the phenomenon of ______, I can use a scale of _______ in my model.
- I need to use a scaled model because ________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- asteroid (belt)
- atmosphere
- dwarf planet
- gas giant
- gravitational relationship
- inner planet
- Moon
- orbital distance
- orbital velocity
- outer planet comet
- planetary rings
- properties
- satellite
- scale (size and distance)
- solar distance
- solar system
- Sun
- terrestrial planet

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