Student Assessment Services

MASSACHUSETTS DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION

CURRICULUM & INSTRUCTION

Science and Technology/Engineering (STE)

Instructional Guidelines 3rd-5th Grade

Purpose

This document provides additional guidance around the instruction and assessment of the 3rd–5th grade standards in the Massachusetts Science and Technology/Engineering (STE) Curriculum Framework. This guidance is aligned with the assessment expectations of the next-generation MCAS test and includes information about the Science and Engineering Practices (SEPs) and the Disciplinary Core Ideas (DCIs) in the Massachusetts standards. The selected standards (SEPs & DCIs) **represent a sample** of the standards in the curriculum framework and should **not be** used as a complete curriculum guide. These standards were selected based on frequently asked questions from the field and **should not be considered more important than other standards**. The information provided in this document is not an exhaustive list of what will be assessed on the 5th grade MCAS test. This document will be updated as necessary. Contact STEM@mass.gov with questions about this document.

Contents

Science and Technology/Engineering (STE)

Introduction

How to Use this Document: Each standard in the Curriculum Framework starts with a Science and Engineering Practice (SEP) and includes a Disciplinary Core Idea (DCI), science and engineering content knowledge. This document is divided into two sections. The first section is sorted by the SEPs and provides examples of how the DCIs may be integrated with the SEPs. The second section is sorted by content domain (Earth and Space, Life, Physical, and Technology/Engineering). Use both sections to clarify the content in selected standards and to reflect on how you are integrating all the SEPs into your instruction and assessment.

Science and Engineering Practices (SEPs): The SEPs are the skills students should be practicing in the classroom daily to explain phenomena. Reference the practice matrix in the 2016 Massachusetts STE Curriculum Framework to learn how the SEPs progress from pre-K to grade 12. Examples of how the SEPs may be integrated with DCIs are included in this guide to support instruction and assessment. Multiple practices may be assessed on MCAS with the DCI of a particular standard, even if that practice is not listed in the standard. The MCAS bundles the SEPs into three practice categories, which are listed in the table below.

Science and Engineering Practices Assessed on MCAS

MCAS Practice Category	Science and Engineering Practices
A. Investigations and Questioning	Asking Questions and Defining Problems Planning and Carrying Out Investigations
B. Mathematics and Data	Analyzing and Interpreting Data Using Mathematics and Computational Thinking
C. Evidence, Reasoning, and Modeling	Developing and Using Models Constructing Explanations and Designing Solutions Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information

Disciplinary Core Ideas (DCIs) Learning Progressions: See the standards navigator or (DCI) progression matrix for additional information on the conceptual relationship between content in the standards within and across grades. These tools allow for targeted pre-assessment, contextualization, and/or identification of boundaries for any standard that is being taught. This can be an efficient way to visualize how elementary and middle school standards lead to high school standards.

Science and Technology/Engineering (STE)

Science and Engineering Practice (SEPs)

Practice Category A. Investigations and Questioning

Practice 1. Asking Questions and Defining Problems
Practice 3. Planning and Carrying Out Investigations

Additional Guidelines

Students should be able to:

- Ask questions about what would happen if a variable were changed and differentiate testable questions from non-testable questions. A testable question can be answered by completing an investigation or experiment. Investigations often examine how a change in one variable/factor affects another variable/factor.
    - Differentiate between testable and non-testable questions about the structures of animals or plants that promote survival, growth, and reproduction. An example of a testable question is: "How does the number of leaves affect the growth of a plant?" An example of a non-testable question is: "Why are leaves green?" (4-LS1-1)
    - Ask questions about how changes in a habitat might affect the ability of an organism living in that habitat to survive and reproduce, such as how a new species being introduced to a habitat might affect existing species living there. (3-LS4-4)

- Define a simple design problem, including several criteria for success and constraints. Criteria are requirements of a successful design solution. Constraints are limitations on the design solution. Constraints include the available materials, the cost of the materials, and the amount of time there is to develop a solution.
    - Identify criteria for success and constraints for a design problem that reduces how much damage weather causes to a structure. For example, if a house was going to be built near a river, a criterion for success might include that the house be built so it is not damaged by flood water and constraints might include the time to build the house and the cost of the building materials. A design solution might be building the house on stilts or on higher ground. (3-ESS3-1 & 3.3-5-ETS1-1)
    - Identify criteria for success and constraints for designing a school composter. For example, criteria could include that the composter must break down food waste quickly, must be able to hold all the food waste produced by a school cafeteria, and must be located close to the school cafeteria. Constraints could include the materials available to construct the composter (e.g., wood, plastic, metals) and the amount of time available to build the composter. (5-LS2-2-MA)

Science and Technology/Engineering (STE)

- Plan an investigation by determining which variables will be controlled, the types of materials and tools that will be needed, and how data or observations will be collected. When variables are controlled, they are kept the same throughout the investigation. It is necessary to control variables to determine how one variable affects another variable. The tools students may use to make measurements and observations during an investigation include a thermometer, a scale, a ruler, a tape measure, a graduated cylinder, a stopwatch, a magnifying lens, and a camera (for example, use a camera to record and view a slow-motion video).
    - Plan an investigation to test the water resistance of several materials to determine which material is best to use in a design solution. Make a data table for measurements and observations that will be made. (3.3-5-ETS1-2)
    - Order the steps of an investigation to determine that the total mass of water does not change when water evaporates. The steps of the investigation could include measuring the initial mass of the water, container, and lid, allowing some water to evaporate in the closed system, and measuring the mass of the system after some water evaporates. (5-PS1-2)
    - Plan an investigation to answer the question, "How can we make muddy water clear?" The students' plan should include a list of materials needed, including measurement tools, and how they will set up a data table. (5-ESS3-2-MA)

- Conduct an investigation and make observations or measurements to produce data from a fair test. To complete a fair test, only one variable/factor is changed at a time while the rest of the conditions are kept the same (controlled). Students should be familiar with both metric units and U.S. Customary units.
    - Use a simulation or complete an investigation to determine how changing the strength of a force on an object affects the motion of the object. Complete a fair test by only changing the strength of one force on the object during the investigation. (3-PS2-1)
    - Complete multiple trials in an investigation by colliding a ball with a foam block at different speeds to determine how the speed of the ball relates to the [kinetic] energy of the ball. Students should make their investigation a fair test by always using the same ball and foam block. The student could change the speed of the ball by letting it roll down a ramp at different angles. (4-PS3-1 & 4-PS3-3)
    - Conduct an investigation to determine the effect of different levels of light on plant growth, while controlling other variables such as the amount of water and the air temperature. (5-LS1-1)

- Test different prototypes to determine which prototype best solves the design problem. Prototypes are working models that can be tested and are made to scale. Students are expected to demonstrate knowledge of the purpose and characteristics of a prototype and to explain how a prototype could be tested, given a design problem.
    - Test multiple toy car prototypes to determine which prototype best meets the design criteria,[1] such as the car that traveled fastest down a ramp. Explain how the prototypes were tested. (4.3-5-ETS1-3)
    - Test different models of a barrier to protect a structure in a stream table from erosion. Students are expected to set up fair tests[2] in which they only change the type of barrier while keeping other variables constant. (4.3-5-ETS1-3 & 4-ESS2-1)

[1] See page 3 in the section on Practice Category A for more information about criteria and constraints.
[2] See the section above for more information about fair tests.

Science and Technology/Engineering (STE)

Practice Category B. Mathematics and Data

Practice 4. Analyzing and Interpreting Data
Practice 5. Using Mathematical and Computational Thinking

Additional Guidelines

Students should be able to:

- Analyze data to make sense of phenomena using mathematical reasoning or computation. Mathematical reasoning includes recognizing patterns and an understanding of averages, negative temperatures, simple percentages, and volume. Computation includes finding differences and sums, such as finding temperatures differences and modeling conservation of mass. Computation of averages, computation of percentages, and computations with negative numbers are not expected at this grade level. Students should be familiar with both metric units and U.S. Customary units.
    - Analyze qualitative data from multiple trials of an investigation to determine the relationship between the strength of the forces between two magnets and the distance between the magnets. (3-PS2-3)
    - Calculate the mass of a mixture of two substances in a closed system using the original mass of each substance. (5-PS1-2)
    - Compare data about the distance (e.g., in light years) between the Sun and Earth with the distances between other stars and Earth to determine that the Sun is much closer to Earth than other stars. (5-ESS1-1)

- Create or analyze graphs and tables to compare different design solutions to solve an engineering problem.
    - Organize and compare data collected about different prototypes[3] to discuss which prototype best solves a design problem. (3.3-5-ETS1-2)
    - Analyze data from a fair test[4] of an object to determine the object's failure points. For example, data could include how much force can be applied to a structure before it breaks. (4.3-5-ETS1-3)
    - Organize and compare data collected about different setups of a mirror (angle, placement, distance from object) to determine which setup best solves the problem of needing to see an object around a corner. (4-PS4-2)

- Create or use graphs and tables to reveal patterns that indicate relationships.
    - Graphically represent and interpret data to reveal a pattern in the length of a shadow throughout a day. (5-ESS1-2)
    - Organize simple climate data for different regions around the world into tables to show patterns. Climate data may include average precipitation and average high and low temperatures by season. (3-ESS2-2)
    - Analyze a graph showing the sizes of multiple plant populations living in the same environment to determine how well each population is surviving. Use the graph and a diagram of each plant (including stems, roots, leaves, flowers, and fruits) to describe patterns in the characteristics of each plant and its ability to survive. (3-LS4-3)

[3] See page 4 in the section on Practice Category A for more information about prototypes.
[4] See page 4 in the section on Practice Category A for more information about fair tests.

Science and Technology/Engineering (STE)

Practice Category C. Evidence, Reasoning, and Modeling

Practice 2. Developing and Using Models
Practice 6. Constructing Explanations and Designing Solutions
Practice 7. Engaging in Argument from Evidence
Practice 8. Obtaining, Evaluating, and Communicating Information

Additional Guidelines

Students should be able to:

- Develop or revise a model based on evidence that shows the relationships among variables.
    - Draw diagrams to model the energy transferred when a drumstick collides with a drum. Show the movement of the drumstick before the collision using arrows and label the kinetic energy of the drumstick. Show the sound produced by the collision and label energy transfers that take place (e.g., sound and heat/thermal energy transfer from the drum to the air). (4-PS3-2 & 4-PS3-3)
    - Draw a model that shows how light and water affect photosynthesis in plants, such as a plant in more sunlight growing taller compared with a plant grown in less sunlight. (5-LS1-1)
    - Complete a model of a mountain to show the effects of weathering and erosion over time (e.g., going from a jagged top to a smoother top). Students should show how the mountain changes shape, by including how environmental factors wear down rocks, break rocks apart, and move sediment down the mountain over a long period of time. Environmental factors can include wind, precipitation, flowing water, frost wedging, tree root wedging, and temperature. Use arrows, symbols, and labels to show the processes of weathering and erosion. (4-ESS1-1 & 4-ESS2-1)

- Use a model to examine cause and effect relationships concerning the functioning of a natural or designed system.
    - Use a computer simulation model that shows an object being pulled in opposite directions to explain the relationship between the forces and the object's motion. (3-PS2-1)
    - Use a model to show how plant and animal populations in a meadow change when an apartment building is constructed in the area. The model of the area could be pictures or a diorama showing before and after conditions. (3-LS4-4)
    - Test a prototype[5] of a pet door that opens as a weight moves toward the ground. Explain the cause-and-effect relationship of energy conversions, including how stored energy is converted into kinetic energy (energy of motion). (4-PS3-4)

[5] See page 4 in the section on Practice Category A for more information about prototypes.

Science and Technology/Engineering (STE)

- Use evidence to construct or support an explanation or design a solution to a problem. Evidence includes data, such as observations and measurements. An explanation describes the cause of a phenomenon.
    - Use data from several windmill designs to make a claim about which windmill design best meets the design criteria[6] and support the claim with data. (3.3-5-ETS1-2)
    - Use evidence to support an explanation about the function of a specific trait or structure of an organism. Examples may include camouflage of certain organisms or a structure found in a fossilized organism (such as sharp or flat teeth). (4-LS1-1)
    - Use evidence from tests to design a solution for preventing damage to buildings from blizzards. Tests may include comparing different types of construction materials or design features, such as reinforcing roof strength. (4-ESS3-2)

- Apply scientific ideas to solve design problems.
    - Select the location and orientation of magnets in a prototype[7] of an organizational system for classroom supplies based on an understanding of why magnets attract or repel. (3-PS2-3 and 3-PS2-4)
    - Improve the design of a composter using knowledge about what decomposers typically need for survival (e.g., air, moisture, and food). (5-LS2-2-MA)

- Construct an explanation of observed relationships.
    - Construct an explanation about why people on Earth experience day and night using observations of the apparent movement of the Sun across the sky. (5-ESS1-2)
    - Make a claim that sound waves carry energy and support the claim with evidence. Evidence may include observing sand move on a covered bowl when a speaker inside the bowl is playing music. (4-PS4-1)
    - Use the feeding relationships between organisms in a food web of a pond ecosystem to construct an explanation that the energy a fish uses to swim was once energy from producers in the lake. (5-PS3-1)

[6] See page 3 in the section on Practice Category A for more information about criteria and constraints.
[7] See page 4 in the section on Practice Category A for more information about prototypes.

Science and Technology/Engineering (STE)

- Engage in argumentation by citing relevant evidence to support or critique a procedure, claim, or model. Argumentation is the process by which evidence-based conclusions and solutions are reached. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits.
    - Explain which evidence supports a claim that matter is conserved when mixing a saltwater solution. Evidence includes the masses of the water, salt, and saltwater solution. (5-PS1-2)
    - Use a diagram of sedimentary rock layers to make a claim that the environment in an area has changed over time (e.g., from a lake to a forest) and use fossil evidence to support the claim. (3-LS4-1)
    - Compare the properties of an unidentified substance with data collected about several known substances, to identify the unidentified substance. Substances could include sugar, salt, baking soda, and corn starch. Properties may include solubility, volume, whether the substance forms bubbles when mixed with vinegar, color, weight, and response to magnetic forces. Determine whether properties are useful or not useful in identifying the substances. Explain whether more information is needed to identify the substance. (5-PS1-3)

- Compare and refine arguments[8] based on an evaluation of the evidence.
    - Evaluate two competing claims about whether people can see in the dark. For example, one student may claim people can see in the dark because they can see outside at night, while another student claims people cannot see in the dark because they cannot see anything in a dark room. Use observable evidence and scientific reasoning (light must reflect off an object and enter a person's eye for the object to be seen) to evaluate the claims. (4-PS4-2)
    - Examine evidence and then make a claim about whether a town should build a wind or solar farm to produce electricity for the town. Support the claim with evidence and scientific reasoning. Evidence may include the average number of sunny days, the average number of windy days, and the amount of energy that would be produced. Incorporate new information, such as material availability, and revise the claim as needed. (5-ESS3-1)
    - Determine which evidence supports a claim that bean plant height is influenced by environmental factors (such as sunlight, water, and nutrients). Determine if there is enough evidence to fully support the claim. (3-LS3-2)

- Communicate scientific or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.
    - Organize and present information that supports a claim about the climate region of a particular place. Presentation formats may include models, photographs, tables, and graphs. For example, graphs showing the average temperatures and average precipitation for different seasons in Nome, AK and photographs showing Nome, AK in different seasons could be used to support a claim that Nome, AK has an Arctic climate. (3-ESS2-2)
    - Organize and present the results of an investigation of several water filter prototypes.[9] The presentation may include a written summary of the investigation and its findings, along with supporting data, such as a data table with measurements (e.g., clarity of filtered water on a scale of 1-4, time to filter water, volume of water filtered) and photographs showing the levels of clarity. (5-ESS3-2-MA)

[8] See the section above for more information about argumentation.
[9] See page 4 in the section on Practice Category A for more information about prototypes.

Science and Technology/Engineering (STE)

Disciplinary Core Ideas (DCIs)

Earth and Space Science

ESS1. Earth's Place in the Universe ESS2. Earth's Systems
4-ESS1-1. Use evidence from a given landscape that includes simple landforms and rock layers to support a claim about the role of erosion or deposition in the formation of the landscape over long periods of time. *Clarification Statements: Examples of evidence and claims could include rock layers with shell fossils above rock layers with plant fossils and no shells, indicating a change from deposition on land to deposition in water over time; and a canyon with rock layers in the walls and a river in the bottom, indicating that a river eroded the rock over time. Examples of simple landforms can include valleys, hills, mountains, plains, and canyons. Focus should be on relative time. State Assessment Boundary: Specific details of the mechanisms of rock formation or specific rock formations and layers are not expected in state assessment.* **4-ESS2-1. Make observations and collect data to provide evidence that rocks, soils, and sediments are broken into smaller pieces through mechanical weathering and moved around through erosion by water, ice, wind, and vegetation.** *Clarification Statements: Mechanical weathering processes can include frost wedging, abrasion, and tree root wedging. Erosion can include movement by blowing wind, flowing water, and moving ice. State Assessment Boundary: Chemical processes are not expected in state assessment.* *Note: These two standards were moved together to show the relationships among weathering, erosion, and deposition.*

Additional Guidelines

Students should be able to:

- Describe how erosion moves sediment away from an area, which can help to create landforms, and how deposition adds sediments to an area, which can result in building up landforms.
- Describe how weathering can break rock into sediments and how the sediments may erode and be deposited in a new location.
- Construct an explanation for how wind, glaciers, surface runoff, streams, rivers, and ocean waves erode (move) sediments.
- Use evidence from diagrams or descriptions to explain how landforms have formed or changed over time through weathering, erosion, and deposition. Examples of landforms and how they have changed include:
    - Mountains: Some mountains have more rounded tops as a result of weathering and erosion.
    - Beaches: Some types of sand on beaches are the result of weathering of rocks and deposition of sediments.
    - Valleys and canyons: Rivers and glaciers help to form valleys by eroding rock formations and carrying the sediments downstream.
    - Floodplains: Form over time from nearby rivers flooding and depositing sediments (mud, soil, and clay), often resulting in nutrient-rich soil.
- Analyze models of sedimentary rock layers to construct explanations about how environments change over long periods of time and how newer rock layers form on top of older rock layers as a result of sediments being deposited.

Science and Technology/Engineering (STE)

ESS1. Earth's Place in the Universe
5-ESS1-2. Use a model to communicate Earth's relationship to the Sun, Moon, and other stars that explain (a) why people on Earth experience day and night, (b) patterns in daily changes in length and direction of shadows over a day, and (c) changes in the apparent position of the Sun, Moon, and stars at different times during a day, over a month, and over a year. *Clarification Statement: Models should illustrate that the Earth, Sun, and Moon are spheres; include orbits of the Earth around the Sun and of the Moon around Earth; and demonstrate Earth's rotation about its axis. State Assessment Boundary: Causes of lunar phases or seasons or use of Earth's tilt are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Revise, analyze, or complete a model of the Sun-Earth-Moon system to show that Earth revolves around the Sun each year, Earth rotates around its own axis each day, and the Moon orbits Earth approximately once a month.
- Revise, analyze, or complete a model of the Sun-Earth system to show the locations on Earth that are experiencing day or night at a particular time.
- Analyze the pattern of the apparent shape of the Moon to predict a future shape and to conclude that the Moon orbiting Earth causes the pattern.
- Explain that the Sun emits its own light but that the Moon only reflects light from the Sun, using the apparent changes in the shape of the Moon as evidence.
- Revise or complete a model that shows and describes how shadows change in length and direction throughout a day.
- Recognize that different stars are visible in the sky at different times of the year due to Earth's changing position around the Sun.

Science and Technology/Engineering (STE)

ESS2. Earth's Systems
3-ESS2-1. Use graphs and tables of local weather data to describe and predict typical weather during a particular season in an area. *Clarification Statements: Examples of weather data could include temperature, amount and type of precipitation (e.g., rain, snow), wind direction, and wind speed.* **3-ESS2-2. Obtain and summarize information about the climate of different regions of the world to illustrate that typical weather conditions over a year vary by region.** *Clarification Statement: Examples of information can include climate data (average temperature, average precipitation, average wind speed) or comparative descriptions of seasonal weather for different regions. State Assessment Boundary: An understanding of climate change is not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Analyze and interpret weather data including temperature (°F or °C), type and amount of precipitation (in. or cm), wind speed (mi. per hr), relative humidity (low, moderate, high), and cloud cover (cloudy, partly cloudy, clear) to describe weather in an area.
- Make a claim about typical weather conditions in an area using knowledge of weather patterns in different climate regions. Climate regions include:
    - Desert -has low precipitation and extreme temperatures
    - Arctic -has little precipitation and low temperatures
    - Temperate forest/grassland -has moderate precipitation and moderate temperatures
    - Tropical rainforest -has high precipitation and high temperatures
- Analyze and interpret climate data to compare the climates of different regions and to predict typical weather conditions over a year. Climate data may include average high and low temperatures, average precipitation, and types of precipitation.

ESS2. Earth's Systems
4-ESS2-2. Analyze and interpret maps of Earth's mountain ranges, deep ocean trenches, volcanoes, and earthquake epicenters to describe patterns of these features and their locations relative to boundaries between continents and oceans.

Additional Guidelines

Students should be able to:

- Analyze and interpret maps of Earth that show the location of mountain ranges, ocean trenches, volcanoes, or earthquakes to support a claim about the most likely location of a plate boundary.
- Analyze and interpret maps showing the locations of Earth's plates and make predictions about the location of mountain ranges, ocean trenches, volcanoes, and earthquakes.

Science and Technology/Engineering (STE)

ESS3. Earth and Human Activity
3-ESS3-1. Evaluate the merit of a design solution that reduces the damage caused by weather.* *Clarification Statement: Examples of design solutions to reduce weather-related damage could include a barrier to prevent flooding, a wind-resistant roof, and a lightning rod.* **4-ESS3-2. Evaluate different solutions to reduce the impacts of a natural event such as an earthquake, blizzard, or flood on humans.*** *Clarification Statement: Examples of solutions could include an earthquake-resistant building or a constructed wetland to mitigate flooding.*

Additional Guidelines

Students should be able to:

- Compare benefits and drawbacks of using different design solutions to reduce the damage caused by weather or the impact from a natural event. Additional natural events may include floods, hurricanes, blizzards, earthquakes, extreme heat, heavy snow, strong wind, and fires.
- Use evidence to support a claim about which type(s) of building materials provide the most protection against a weather or natural event. Examples of materials include concrete, wood, glass, and metal.
- Construct explanations for how different types of landscaping features can reduce the damage caused by weather and natural events. Landscaping features may include sloping landscape, plantings, sand dunes, rock walls, sea walls, wetlands, and drainage.

ESS3. Earth and Human Activity
5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. *Clarification Statement: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities. State Assessment Boundary: Social science aspects of practices such as regulation or policy are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Communicate ways to protect a natural resource in their local community.
- Evaluate and compare ways communities can reduce human impact on Earth's resources and environment. Examples include:
  - reducing use of energy sources that pollute, such as by investing in renewable energy resources or reducing the number of cars that use fossil fuel.
  - making buildings more energy efficient by adding insulation or adding weather sealing around doors and windows
  - improving air quality by reducing car emissions or reducing air pollution from power plants and factories.
  - improving drinking water quality by reducing chemical runoff from agriculture and factories.
  - collecting rainwater to reduce the use of groundwater.
  - protecting natural areas, including developing more parks and forests.
  - reducing, reusing, recycling, or composting materials.
- Analyze data about which types of materials have less impact on Earth's resources, such as comparing plastic, paper, and reusable cloth shopping bags or comparing the use of digital files and paper files to store information.

Science and Technology/Engineering (STE)

Life Science

LS1. From Molecules to Organisms: Structures and Processes
3-LS1-1. Use simple graphical representations to show that different types of organisms have unique and diverse life cycles. Describe that all organisms have birth, growth, reproduction, and death in common but there are a variety of ways in which these happen. *Clarification Statements: Examples can include different ways plants and animals begin (e.g., sprout from a seed, born from an egg), grow (e.g., increase in size and weight, produce new part), reproduce (e.g., develop seeds, root runners, mate and lay eggs that hatch), and die (e.g., length of life). Plant life cycles should focus on those of flowering plants. Describing variation in organism life cycles should focus on comparisons of the general stages of each, not specifics. State Assessment Boundary: Detailed descriptions of any one organism's cycle, the differences of "complete metamorphosis" and "incomplete metamorphosis," or details of human reproduction are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Develop or revise models showing the life cycles of animals and flowering plants.
- Describe the importance of each life cycle stage.
- Compare the life cycles of different organisms and describe similarities between them.
- Use evidence to support a claim that some animals go through metamorphosis during their life cycle.

LS1. From Molecules to Organisms: Structures and Processes
4-LS1-1. Construct an argument that animals and plants have internal and external structures that support their survival, growth, behavior, and reproduction. *Clarification Statements: Animal structures can include legs, wings, fins, feathers, trunks, claws, horns, antennae, eyes, ears, nose, heart, stomach, lung, brain, and skin. Plant structures can include leaves, roots, stems, bark, branches, flowers, fruit, and seeds. State Assessment Boundary: State assessment will be limited to macroscopic structures.*

Additional Guidelines

Students should be able to:

- Support a claim using evidence (observations, data, informational texts, and media) from an organism about how its structures help it to survive, grow, or reproduce. Examples include:
  - Feathers may keep a bird warm, may allow it to fly to find food or fly away from a predator, or may attract mates for reproduction.
  - A flowering plant may attract a certain type of insect or bird so that the insect or bird can spread pollen and the flowering plant can reproduce.
- Use evidence to explain how different structures work to support survival, growth, behavior, and reproduction of an organism. Examples include:
  - the mouth and nose breathe air in and exhale waste air.
  - the lungs exchange fresh air and waste air.
  - the heart pumps blood through the body and delivers nutrients.
  - the roots of a plant take in water, which is used to make sugars.
  - the leaves of a plant take in air and sunlight, which are used to make sugars.

Science and Technology/Engineering (STE)

LS1. From Molecules to Organisms: Structures and Processes
5-LS1-1. Ask testable questions about the process by which plants use air, water, and energy from sunlight to produce sugars and plant materials needed for growth and reproduction. *State Assessment Boundary: The chemical formula or molecular details about the process of photosynthesis are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Use evidence to support a claim about how changing the amount of sunlight, water, or air will affect the process of photosynthesis.
- Revise, analyze, or complete a model of the structures that help plants obtain air, sunlight, and water to produce sugars.
- Use evidence from an investigation such as plant growth, to support a claim about the relative amount of photosynthesis taking place in plants.

LS2. Ecosystems: Interactions, Energy, and Dynamics PS3. Energy
5-LS2-1. Develop a model to describe the movement of matter among producers, consumers, decomposers, and the air, water, and soil in the environment to (a) show that plants produce sugars and plant materials, (b) show that animals can eat plants and/or other animals for food, and (c) show that some organisms, including fungi and bacteria, break down dead organisms and recycle some materials back to the air and soil. *Clarification Statement: Emphasis is on matter moving throughout the ecosystem. State Assessment Boundary: Molecular explanations, or distinctions among primary, secondary, and tertiary consumers are not expected in state assessment.* **5-PS3-1. Use a model to describe that the food animals digest (a) contains energy that was once energy from the Sun, and (b) provides energy and nutrients for life processes, including body repair, growth, motion, body warmth, and reproduction.** *Clarification Statement: Examples of models could include diagrams and flow charts. State Assessment Boundary: Details of cellular respiration, ATP, or molecular details of the process of photosynthesis or respiration are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Analyze, interpret, and modify models, including food webs, to describe how changes to the size of one population may affect the other populations in the food web.
- Describe how organic material is recycled throughout an ecosystem.
- Construct an explanation about the roles of sunlight and soil nutrients in an ecosystem.
- Construct an an explanation that food provides both energy and matter animals need to survive.
- Complete and interpret a model describing how energy is transferred from the Sun to producers and then to consumers.

Science and Technology/Engineering (STE)

LS2. Ecosystems: Interactions, Energy, and Dynamics
5-LS2-2(MA). Compare at least two designs for a composter to determine which is most likely to encourage decomposition of materials.* *Clarification Statement: Measures or evidence of decomposition should be on qualitative descriptions or comparisons.*

Additional Guidelines

Students should be able to:

- Describe the function of a composter and how compost is used in a garden or on a farm.
- Describe the role of air, temperature, moisture, and decomposers in a composter.
- Construct an explanation for why one composter design will work better than another design. Factors that affect decomposition of compost include:
    - the amount of air available inside a composter, either due to the compost design or stirring the compost,
    - the number of bacteria (decomposers),
    - the temperature and moisture level,
    - the types of materials that can and cannot be added to a composter (for example, food and yard waste but not plastic), and
    - the size of the materials that are added to a composter.

LS3. Heredity: Inheritance and Variation of Traits
3-LS3-1. Provide evidence, including through the analysis of data, that plants and animals have traits inherited from parents and that variation of these traits exist in a group of similar organisms. *Clarification Statements: Examples of inherited traits that vary can include the color of fur, shape of leaves, length of legs, and size of flowers. Focus should be on non-human examples. State Assessment Boundary: Genetic mechanisms of inheritance or prediction of traits are not expected in state assessment.* **3-LS3-2. Distinguish between inherited characteristics and those characteristics that result from a direct interaction with the environment. Give examples of characteristics of living organisms that are influenced by both inheritance and the environment.** *Clarification Statements: Examples of the environment affecting a characteristic could include normally tall plants grown with insufficient water or light are stunted; a lizard missing a tail due to a predator; and a pet dog that is given too much food and little exercise may become overweight. Focus should be on non-human examples.*

Additional Guidelines

Students should be able to:

- Analyze data to support a claim that a certain characteristic is inherited, influenced by the environment, or both.
- Describe how offspring inherit some traits from their mother and some traits from their father, so that the offspring have a variety of traits from both parents.
- Construct and explanation for why some groups of organisms in the same species have more similar traits than other groups of organisms because of their environment.

Science and Technology/Engineering (STE)

LS4. Biological Evolution: Unity and Diversity
3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction. *Clarification Statements: Examples can include rose bushes of the same species, one with slightly longer thorns than the other which may prevent its predation by deer, and color variation within a species that may provide advantages so one organism may be more likely to survive and therefore more likely to produce offspring. Examples of evidence could include needs and characteristics of the organisms and habitats involved.* **3-LS4-3. Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive.** *Clarification Statement: Examples of evidence could include needs and characteristics of the different organisms (species) and habitats involved.* **3-LS4-4. Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.** *Clarification Statements: Changes should include changes to landforms, distribution of water, climate, and availability of resources. Changes in the habitat could range in time from a season to a decade. While it is understood that ecological changes are complex, the focus should be on a single change to the habitat.* **3-LS4-5(MA). Provide evidence to support a claim that the survival of a population is dependent upon reproduction.** *State Assessment Boundary: Details of reproduction are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Describe how seasonal behaviors such as leaf loss, migration, hibernation, or storing food help plants and animals survive changing environmental conditions.
- Use information about an organism to determine whether the organism has a characteristic that provides a survival or reproductive advantage over another organism of the same species such as, brighter feathers or larger body.
- Analyze and interpret data showing how a change in the environment can create a survival advantage for a certain population of plants or animals.
- Construct an explanation for how a species can become extinct if organisms of that species do not survive to adulthood. For example, if all organisms of a species do not survive to adulthood, then the organisms cannot reproduce (produce offspring), and the species will become extinct.
- Use evidence to support an explanation that populations of plants and animals adapted to live in a certain environment may decrease if the environment changes.
- Analyze data or a model to determine whether a population will change in size based on the availability of food sources.

Science and Technology/Engineering (STE)

Physical Science

PS1. Matter and Its Interactions
5-PS1-1. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. *Clarification Statement: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution. State Assessment Boundary: Atomic-scale mechanisms of evaporation and condensation or defining unseen particles are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Construct or compare models of a substance as a solid, liquid, and gas. The models should represent the spacing and movement of particles in the solid, liquid, or gas state of matter.
- Use evidence to communicate that all matter takes up space.
- Construct an explanation for how phase changes can occur when heat is added to or removed from a substance.

PS1. Matter and Its Interactions
5-PS1-4. Conduct an experiment to determine whether the mixing of two or more substances results in new substances with new properties (a chemical reaction) or not (a mixture).

Additional Guidelines

Students should be able to:

- Analyze observations made before and after combining two substances to determine if a chemical reaction occurred. Evidence of a chemical reaction could include presence of bubbles, a temperature change, a new substance forming, a change in color, etc.
- Use evidence from an investigation to explain that dissolving a solid in a liquid forms a mixture. For example, students may dissolve sugar in water and then separate the sugar from the water through evaporation.

Science and Technology/Engineering (STE)

PS2. Motion and Stability: Forces and Interactions
3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object. *Clarification Statements: Descriptions of force magnitude should be qualitative and relative. Force due to gravity is appropriate but only as a force that pulls objects down. State Assessment Boundaries: Quantitative force magnitude is not expected in state assessment. State assessment will be limited to one variable at a time: number, size, or direction of forces.*

Additional Guidelines

Students should be able to:

- Construct or revise a model that uses arrows to represent the relative size and direction of each force acting on an object.
- Interpret models of the forces acting on an object to determine whether the forces acting on the object are balanced or unbalanced, including models with different-sized forces that are acting in the same or opposite directions.
- Construct an explanation about how the speed or direction of an object changes when unbalanced forces act on the object.
- Communicate that the forces acting on an object must be balanced if the object is at rest or moving in a straight line at a constant speed.
- Construct or revise a model that uses arrows to show friction is a force that acts opposite to the direction of motion and may cause moving objects to slow down.

Science and Technology/Engineering (STE)

PS3. Energy

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. *State Assessment Boundaries: State assessment will be limited to analysis of kinetic energy. Accounting for mass, quantitative measures of changes in the speed of an object, or any precise or quantitative definition of energy are not expected in state assessment.*

4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents. *Clarification Statement: Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb. State Assessment Boundary: Quantitative measurements of energy are not expected in state assessment.*

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide. *Clarification Statement: Changes in energy can include a change in the object's motion, position, and the generation of heat and/or sound. State Assessment Boundary: Analysis of forces or quantitative measurements of energy are not expected in state assessment.*

4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts kinetic energy to electrical energy or uses stored energy to cause motion or produce light or sound.* *Clarification Statement: Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.*

Note: 5-PS3-1 is included with 5-LS2-1 on page 14.

Additional Guidelines

Students should be able to:

- Explain that an object's kinetic energy changes as the object speeds up or slows down.
- Analyze and interpret a graph of an object's kinetic energy at different moments in time and make a claim about what is happening to the speed of the object.
- Explain that an object's stored energy changes as the height of the object changes.
- Describe how stored energy is converted to kinetic energy when an object speeds up as it falls or moves down an incline. Notes: An object's stored energy decreases as the height of the object decreases and the object does not lose all of its stored energy until it reaches the ground (a height of zero). An object does not gain stored energy because it stops moving.
- Interpret a model to show that stored energy can be converted to thermal energy, light energy, or sound energy.
- Use evidence to support a claim that kinetic energy is converted to thermal energy and sound energy during a collision.
- Analyze bar graphs that demonstrate energy being converted from one form to another or transferred from one object to another.
- Interpret data, including graphs, to show that energy can be transferred from place to place by sound, light, heat, and electric currents.

Science and Technology/Engineering (STE)

PS4. Waves and Their Applications in Technologies for Information Transfer
4-PS4-1. Develop a model of a simple mechanical wave (including sound) to communicate that waves (a) are regular patterns of motion along which energy travels and (b) can cause objects to move. *Clarification Statement: Examples of models could include diagrams, analogies, and physical models. State Assessment Boundary: Interference effects, electromagnetic waves, or non-periodic waves are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Construct an explanation with evidence that waves carry energy from one place to another and can interact with matter to cause motion.
- Analyze and interpret results from an investigation that show mechanical waves have regular patterns that transfer energy through a medium, such as water or a spring, without transferring matter.
- Describe that when a mechanical wave moves through matter, such as air or a rope, the matter vibrates and energy is transferred.

PS4. Waves and Their Applications in Technologies for Information Transfer
4-PS4-2. Develop a model to describe that light must reflect off an object and enter the eye for the object to be seen. *State Assessment Boundary: Specific colors reflected and seen, the cellular mechanisms of vision, angles of incidence and reflection, or how the retina works is not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Describe how light travels in a straight line and that light changes direction when it is reflected off a surface.
- Revise and complete models showing the source of light, arrows representing a light ray, the object, arrows showing light being reflected, and the eye.

PS4. Waves and Their Applications in Technologies for Information Transfer
4-PS4-3. Develop and compare multiple ways to transfer information through encoding, sending, receiving, and decoding a pattern.* *Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1s and 0s representing black and white to send information about a picture, and using Morse code to send text.*

Additional Guidelines

Students should be able to:

- Construct a model showing encoding as changing information into a different form to make it transferrable, sending as transmitting information, receiving as obtaining information, and decoding as changing information into a different form so it can be interpreted.
- Describe that information, such as sound waves or text, can be converted into a digital format and transferred over long distances.
- Compare multiple ways information is transferred. Comparisons may include how far the information can be transferred, how quickly the information can be transferred, what type of information can be transferred (words, pictures, etc.).

Technology/Engineering

ETS1. Engineering Design
3.3-5-ETS1-2. Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.* *Clarification Statement: Examples of design problems can include adapting a switch on a toy for children who have a motor coordination disability, designing a way to clear or collect debris or trash from a storm drain, or creating safe moveable playground equipment for a new recess game.*

Additional Guidelines

Students should be able to:

- Analyze a simple design problem to determine tradeoffs and benefits of using certain materials in the design solution. Tradeoffs and benefits should describe how appropriate the material is for the design solution based on the material's properties, such as hardness, flexibility, strength, reflectivity, thermal conductivity, durability, water resistance, and magnetism.
- Given a list of criteria[10] and a possible solution, determine which criteria are met and which are unmet.

ETS1. Engineering Design
4.3-5-ETS1-3. Plan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype.* *Clarification Statement: Examples of design features can include materials, size, shape, and weight.*

Additional Guidelines

Students should be able to:

- Describe the purpose of a prototype,[11] including testing to identify failure points.
- Analyze results of a prototype test and explain why and how certain features should be improved.
- Given the criteria[10] of a design problem, determine which design features should be tested to determine if the design meets the criteria.
- Evaluate a description of how one design feature of a prototype was tested to determine if variables were controlled in the test.

ETS3. Technological Systems
5.3-5-ETS3-2(MA). Use sketches or drawings to show how each part of a product or device relates to other parts in the product or device.*

Additional Guidelines

Students should be able to:

- Analyze different representations of a design solution, prototype,[11] product, or device to determine the best representation for a given purpose. Representations can include sketches, diagrams, simple drawings with a few dimensions labeled, models, and drawings with different views.
- Determine which type of representation best shows how each part of a product or device relates to other parts in the product or device.

[10] See page 3 in the section on Practice Category A for more information about criteria and constraints.
[11] See page 4 in the section on Practice Category A for more information about prototypes.