Student Assessment Services

MASSACHUSETTS DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION

CURRICULUM & INSTRUCTION

Science and Technology/Engineering (STE)

Instructional Guidelines 6th-8th Grade

Purpose

This document provides additional guidance around the instruction and assessment of the 6th–8th 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 8th grade MCAS test. This document will be updated as necessary. Contact STEM@mass.gov with questions about this document.

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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.

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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 that arise from careful observation of phenomena, models, or unexpected results to clarify or seek additional information.
    - Ask questions about the factors that affect the strength of electric forces after observing a demonstration. (7-MS-PS2-3)
    - Ask questions, after reviewing global temperature data over the last century, about the role human activities have played in causing global temperatures to increase. (8-MS-ESS3-5)
    - Ask questions about what causes hail to occur after observing video clips of hail falling in different areas of the United States. (8-MS-ESS2-5)

- Develop a hypothesis based on observations and scientific principles. A hypothesis is a proposed explanation that is based on observations, scientific principles, or models, and it can be used for further investigation.
    - Develop a hypothesis about whether an object will float or sink in various liquids after approximating the density of the object using measurements and mathematical reasoning. (6-MS-PS1-7-MA)
    - Develop a hypothesis about how a change to a population of one type of organism will affect the population of another type of organism in the same ecosystem using information from a food web. (7-MS-LS2-3)

- Define a design problem with mutiple criteria and constraints that can be solved by developing an object, tool, process, or system. 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.
    - Determine which criteria a material must meet in order to be successfully used in a design solution, such as the materials for a cell phone case must be flexible and strong. (6-MS-ETS2-2-MA)
    - Define a design problem, including listing criteria for success and constraints, for protecting the ocean ecosystem by reducing plastic pollution. For example, students could develop criteria and constraints for making disposable water bottles out of a material other than plastic. (7-MS-LS2-5)

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- Plan an investigation by determining the independent and dependent variables and controls, the types of materials and tools that will be needed, and how data or observations will be collected. Investigations are setup to determine how changing an independent variable affects a dependent variable. Other variables should be controlled to make the relationship between the independent variable and the dependent variable clear. The tools students should use to make measurements and observations during investigations include a thermometer, a scale, a ruler, a tape measure, a meter stick, a graduated cylinder, a stop watch, magnifying lenses, a microscope, a camera (for example, use a camera to record and view a slow motion video), etc.
    - Plan an investigation to provide evidence that the amount of water (independent variable) moving through a canyon affects the amount of material (dependent variable) that is eroded. Decide which tools should be used to measure the amount of water and the amount of material. (7-MS-ESS2-2)
    - Plan an investigation to provide evidence that the change in speed of an object's motion (dependent variable) depends on the size of the net force (independent variable) on the object. Control other variables, such as the mass of the object and the amount of time there is a net force on the object. (8-MS-PS2-2)

- Collect data to answer scientific questions or test design solutions under a range of conditions.
    - Conduct an investigation to answer a scientific question about how the characteristics of a material affect the way light interacts with the material. Make observations of light interacting with various materials. Organize the observations into a table to show whether light was reflected, absorbed, and/or transmitted through each material. (6-MS-PS4-2)
    - Test a model of a solar powered car to determine how a changing environmental condition, such as different amounts of light due to time of day or cloud coverage, affects the speed of the car. Record the observations in a data table. (7-MS-ETS1-4)

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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:

- Construct, analyze, or interpret data sets using graphical displays (e.g., maps, charts, graphs, and tables) to identify relationships.
    - Interpret a tide chart or a line graph of the height of tides over a month to determine when different moon phases (new moon, first quarter, full moon, third quarter) occurred. Determine the relative position of the Sun, Earth, and the Moon when the highest tide of the month occurred. (8-MS-ESS1-2, supported by 6-MS-ESS1-1a)
    - Graph the mass vs. volume of a material from data in a table. Determine that the relationship between mass and volume is linear and explain the reasoning. Compare the density of two materials by comparing different graphs of mass vs. volume. (6-MS-PS1-7-MA)

- Evaluate data to determine patterns and trends.
    - Analyze data about the fuel economy over time of different vehicles (e.g., cars, SUVs, minivan, pickup trucks) that consume gasoline and determine how human activities could reduce the consumption of gasoline. (7-MS-ESS3-4)
    - Analyze a graph to determine the relationship between the intensity of sunlight and the time of year for a specific latitude. Then explain how Earth's tilt results in the pattern in the graph. (8-ESS1-1b)
    - Graph the average height of sunflowers grown with varying environmental factors, such as the amount of light or fertilizer. Interpret the graph(s) to determine the relationship betweeen plant height and each environmental factor. (8-MS-LS1-5)

- Analyze data using concepts of statistics and probability (including mean, median, and mode), using digital tools when feasible. A digital tool is an application that produces, manipulates, or stores data in a digital format (e.g., spreadsheet, graphing program, simulation, drawing/image/video program, 3D-design sketcher).
    - Compare temperature data from a town near the ocean with a town that is farther inland using a spreadsheet to find the average high and low temperatures over a month. Explain why the average temperature data is different for the towns. (8-MS-ESS2-6)
    - Average multiple trials of water temperature data to determine which prototype of a solar water heater best solves a design problem. For example, the design problem could be heating 100 L of water to 40°C to be used for washing. Prototypes are working models that can be tested and are made to scale. (7-MS-ETS1-4)

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- Consider limitations of measurements or seek to improve precision and accuracy of data with better tools and methods (e.g., multiple trials).
    - Consider the limitations of using a 12 inch ruler to measure a bookcase as part of planning a new layout for the school library. Suggest ways to improve the accuracy of the measurement, e.g. choosing a more appropriate measurment tool and measuring each dimension of the bookcase three times. (6-MS-ETS2-3-MA)
    - Explain how the methods used in an investigation about exothermic and endothermic chemical reactions could be improved to produce data sets that are more accurate. For example, students could measure the temperature more consistently, change the position of the thermometer, insulate the container, or use a temperature probe instead of a thermometer. (6-MS-PS1-6)

- Analyze data to determine under what conditions a proposed object, tool, or system works best.
    - Analyze temperature data of model houses to compare how well designs with different insulating materials minimize thermal energy transfer over time. For example, a light could be shone on each house and temperature could be measured inside and outside the houses for 30 minutes. The data could then be used to determine which insulating material is best suited for the climate zone. (7-MS-PS3-3)
    - Analyze data from an investigation to determine at which slope a garden design best limits soil erosion. The data could include the volume of water and the volume of soil in the runoff. (7-MS-LS2-5-MA)

- Apply mathematical reasoning or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.
    - Apply the concept of ratios and basic mathematical operations to create a two-dimensional scaled drawing of a refrigerator. For example, a scale of ½ in. = 1 ft. could be used. (6-MS-ETS1-5-MA)
    - Use simple algebra and ratios to create a scaled model of a solution to a design problem. For example, a scale of 1/8 in. = 1 ft. could be used. (7-MS-ETS1-7-MA)
    - Use mathematical reasoning and a Punnett square to determine the probability that an offspring will inherit a specific trait. (8-MS-LS3-4-MA)
    - Use basic operations to determine the net force, including size and direction, on an object that is changing speed on the floor. For example, students could subtract the frictional force from the applied force to determine the net force. (8-MS-PS2-2)

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 to show the relationship among variables within a phenomena or investigation.
    - Complete a model of a roller coaster track by adding circle graphs at different heights to show the relative amounts of kinetic and potential energy of the roller coaster car. (7-MS-PS3-7-MA)
    - Complete a model of a two-way radio (walky talkie) system to show that sound waves are encoded into radio waves, transmitted by an antenna, received by another antenna, and decoded back into sound waves. (7-MS-ETS3-1-MA)
    - Complete a model showing how body systems interact to allow an animal to move as a result of stimuli. The model should show that body movement occurs when the nervous system detects stimuli and sends signals to the muscular system to move the body's bones. (6-MS-LS1-3)

- Evaluate the limitations of a model.
    - Describe the limitations of an ecological simulation that shows changes to a population size over time. For example, the simulation may not have included factors such as seasons, disease, or competition for resources by other species. (7-MS-LS2-1)
    - Use data from testing a model of a bridge to determine the limitations of that design. For example, the maximum live load or maximum wind speed the model of the bridge can withstand could be determined. (7-MS-ETS3-4-MA)

- Construct an explanation that is based on both evidence obtained from investigations and currently accepted theories and laws. An explanation describes the cause of a phenomenon.
    - Use evidence of changes in atmospheric carbon dioxide, fossil fuel use, and large scale deforestation to construct an explanation of how human activities have resulted in the rise in global temperatures over the past century. (8-MS-ESS3-5)
    - Use observations of the motion of two marbles after a collision to support an explanation that the collision forces that acted on the marbles were in opposite directions. Develop an explanation about how the collision force on each marble was equal in magnitude and opposite in direction. (8-MS-PS2-1)
    - Analyze a diagram of rock layers with a displacement fault and use the laws of superposition and crosscutting relationships to construct an explanation of the order of geologic events, i.e., deposition of specific rock layers and faulting. (6-MS-ESS1-4)

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- Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, or system.
    - Select the best materials for different parts of a pool toy based on the materials' density and whether each part should float or sink in the pool water. (6-MS-PS1-7-MA)
    - Design solutions to the problem of stormwater runoff causing street flooding in a downtown area. Solutions might include increasing absorption of rainwater by changing some pavement to a permeable surface or decreasing runoff by capturing rainwater in holding tanks. (7-MS-ESS2-4 and 7-MS-ESS3-4)

- Compare and critique arguments on the same topic and analyze whether they emphasize similar or different evidence. 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.
    - Analyze the evidence supporting the most common arguments for dinosaur extinction. Determine what evidence supports each argument. (6-MS-LS4-1)
    - Critique the evidence for using different energy resources to produce electricity. Develop an argument about which energy resource(s) a given community should use to produce electricity. (7-MS-ESS3-4)

- Integrate information from written text, media sources, and visual displays to explain scientific or technical information about a phenomena.
    - Use information from multiple sources to describe the manufacturing processes used to make reusable plastic bottles, including how the properties of the plastic change during manufacturing. (8-MS-ETS2-4-MA & 8-MS-ETS2-5-MA)
    - Develop an explanation for what a person sees during a lunar eclipse by using a model of the Sun-Earth-Moon system and information from media reports about a recent lunar eclipse. (6-MS-ESS1-1a)

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Disciplinary Core Ideas (DCIs)

Earth and Space Science

ESS1. Earth's Place in the Universe
6.MS-ESS1-4. Analyze and interpret rock layers and index fossils to determine the relative ages of rock formations that result from processes occurring over long periods of time. *Clarification Statements: Analysis includes laws of superposition and crosscutting relationships limited to minor displacement faults that offset layers. Processes that occur over long periods of time include changes in rock types through weathering, erosion, heat, and pressure. State Assessment Boundary: Strata sequences that have been reordered or overturned, names of specific periods or epochs and events within them, or the identification and naming of minerals or rock types are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Analyze models to describe the relative age of fossils preserved in sedimentary rock and describe how those fossils can be exposed by the processes of weathering and erosion.
- Construct an explanation about how the record of sedimentary rock layers can be incomplete due to weathering and erosion.
- Construct an explanation about how rocks can change type under intense heat and pressure.
- Use index fossils to support a claim about the ages of rock layers in different locations.

ESS1. Earth's Place in the Universe
8.MS-ESS1-2 Explain the role of gravity in ocean tides, the orbital motions of planets, their moons, and asteroids in the solar system. *State Assessment Boundary: Kepler's laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Construct an explanation about how gravity causes a pattern of less massive objects to orbit more massive objects, such as moons orbiting planets and planets orbiting stars.
- Analyze mass and distance data of planets and moons to determine which have the greatest gravitational forces between them.
- Revise, complete, and compare models of the Earth, Moon, Sun, and gravitational forces that show the high and low tides.

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ESS2. Earth's Systems
7.MS-ESS2-2. Construct an explanation based on evidence for how Earth's surface has changed over scales that range from local to global in size. *Clarification Statements: Examples of processes occurring over large, global spatial scales include plate motion, formation of mountains and ocean basins, and ice ages. Examples of changes occurring over small, local spatial scales include earthquakes and seasonal weathering and erosion.* **8.MS-ESS2-1. Use a model to illustrate that energy from Earth's interior drives convection that cycles Earth's crust leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building, and active volcanic chains.** *Clarification Statement: The emphasis is on large-scale cycling resulting from plate tectonics.*

Additional Guidelines

Students should be able to:

- Construct an explanation for how landforms change due to weathering, erosion, and deposition.
- Describe evidence used by scientists to show that glaciers were once present in an area.
- Analyze, revise, and complete models showing that Earth's crust is broken into plates that are moved by convection currents in the mantle, and that lava is magma that reached Earth's surface through a volcano.
- Construct an explanation about how thermal energy from Earth's interior causes rocks to cycle through melting, crystallization, and deformation and how new rock and geologic structures are formed by these processes.
- Use models to show how Earth's plates form convergent and divergent boundaries and explain how different geologic structures form at these boundaries.
- Construct an explanation for how rocks that were formed underground can be found atop mountains due to uplifting and folding of rocks.

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ESS2. Earth's Systems

7.MS-ESS2-4. Develop a model to explain how the energy of the Sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere. *Clarification Statement: Examples of models can be conceptual or physical. State Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not expected in state assessment.*

8.MS-ESS2-5. Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to weather. *Clarification Statements: Data includes temperature, pressure, humidity, precipitation, and wind. Examples of patterns can include air masses flow from regions of high pressure to low pressure, and how sudden changes in weather can result when different air masses collide. Data can be provided to students (such as in weather maps, data tables, diagrams, or visualizations) or obtained through field observations or laboratory experiments. State Assessment Boundary: Specific names of cloud types or weather symbols used on weather maps are not expected in state assessment.*

8.MS-ESS2-6. Describe how interactions involving the ocean affect weather and climate on a regional scale, including the influence of the ocean temperature as mediated by energy input from the sun and energy loss due to evaporation or redistribution via ocean currents. *Clarification Statement: A regional scale includes a state or multi-state perspective. State Assessment Boundary: Koppen Climate Classification names are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Create and revise models showing how energy from the Sun and gravity cycle water through Earth's hydrosphere. Models may include different types of precipitation; water sources, such as streams, oceans, lakes, rivers, groundwater, water tables; water in the atmosphere including water vapor and clouds; organisms; and different phases of water.
- Describe how the amount of water on Earth is generally constant, but the location of water, the phase of water, and whether the water is freshwater or saltwater changes.
- Analyze, revise, and complete models showing how air masses move and how this movement affects weather patterns.
- Describe weather conditions often found at a front, or boundary between two air masses.
- Analyze a map showing areas of high and low atmospheric pressure to determine wind direction.
- Construct an explanation for why temperatures near large bodies of water tend to be milder than temperatures inland.

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ESS3. Earth and Human Activity
7.MS-ESS3-4. Construct an argument supported by evidence that activities and technologies can mitigate the impact of increases in human population and per capita consumption of natural resources on the environment. *Clarification Statements: Arguments should be based on examining historical data such as population graphs, natural resource distribution maps, and water quality studies over time. Examples of negative impacts can include changes to the amount and quality of natural resources such as water, mineral, and energy supplies.* **8.MS-ESS3-1. Analyze and interpret data to explain that the Earth's mineral and fossil fuel resources are unevenly distributed as a result of geologic processes.** *Clarification Statement: Examples of uneven distributions of resources can include where petroleum is generally found (locations of the burial of organic marine sediments and subsequent geologic traps), and where metal ores are generally found (locations of past volcanic and hydrothermal activity).* **8.MS-ESS3-5. Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.** *Clarification Statements: Examples of human activities include fossil fuel combustion, deforestation, and agricultural activity. Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and the rates of human activities.*

Additional Guidelines

Students should be able to:

- Construct an explanation about how fossil fuels and minerals were formed on a geological time scale, making them non-renewable resources.
- Construct an explanation for how extracting, refining, and using fossil fuels or minerals can have a negative impact on the environment and human health.
    - causing more carbon dioxide in the air, which is a primary cause of climate change
    - causing more particulates in the air which contributes to asthma and other respiratory conditions.
    - causing more toxic chemicals to enter water sources.
- Analyze situations to identify ways to decrease human impact on the environment, such as using renewable energy resources, carpooling or taking public transportation, reducing storm water runoff, and recycling.
- Construct an argument based on evidence that human activities, such as deforestation and the use of fossil fuels, cause environmental changes including a global rise in temperatures and increased flooding.

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Life Science

LS1. From Molecules to Organisms: Structures and Processes
6.MS-LS1-1. Provide evidence that all organisms (unicellular and multicellular) are made of cells. *Clarification Statement: Evidence can be drawn from multiple types of organisms, such as plants, animals, and bacteria.* **6.MS-LS1-2. Develop and use a model to describe how parts of cells contribute to the cellular functions of obtaining food, water, and other nutrients from its environment, disposing of wastes, and providing energy for cellular processes.** *Clarification Statement: Parts of plant and animal cells include (a) the nucleus, which contains a cell's genetic material and regulates its activities; (b) chloroplasts, which produce necessary food (sugar) and oxygen through photosynthesis (in plants); (c) mitochondria, which release energy from food through cellular respiration; (d) vacuoles, which store materials, including water, nutrients, and waste; (e) the cell membrane, which is a selective barrier that enables nutrients to enter the cell and wastes to be expelled; and (f) the cell wall, which provides structural support (in plants). State Assessment Boundary: Specific biochemical steps or chemical processes, the role of ATP, active transport processes involving the cell membrane, or identifying or comparing different types of cells are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Describe how bacteria, although simpler, carry out many of the same processes as plant and animal cells.
- Explain, using evidence, that multicellular organisms have specialized cells that carry out specific functions.
- Create, compare, or complete models of plant, animal, bacterial, and fungal cells to show different cell parts and their functions.

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LS1. From Molecules to Organisms: Structures and Processes

6.MS-LS1-3. Construct an argument supported by evidence that the body systems interact to carry out essential functions of life. *Clarification Statements: Emphasis is on the functions and interactions of the body systems, not specific body parts or organs. An argument should convey that different types of cells can join together to form specialized tissues, which in turn may form organs that work together as body systems. Body systems to be included are the circulatory, digestive, respiratory, excretory, muscular/skeletal, and nervous systems. Essential functions of life include obtaining food and other nutrients (water, oxygen, minerals), releasing energy from food, removing wastes, responding to stimuli, maintaining internal conditions, and growing/developing. An example of interacting systems could include the respiratory system taking in oxygen from the environment which the circulatory system delivers to cells for cellular respiration, or the digestive system taking in nutrients which the circulatory system transports to cells around the body. State Assessment Boundaries: The mechanism of one body system independent of others or the biochemical processes involved in body systems are not expected in state assessment. Describing the function or comparing different types of cells, tissues, or organs are not expected in state assessment.*

8.MS-LS1-7. Use informational text to describe that food molecules, including carbohydrates, proteins, and fats, are broken down and rearranged through chemical reactions forming new molecules that support cell growth and/or release of energy. *State Assessment Boundary: Specific details of the chemical reaction for cellular respiration, biochemical steps of breaking down food, or the resulting molecules (e.g., carbohydrates are broken down into monosaccharides) are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Use a model to describe how food is broken down by the digestive system into small molecules that are transported to cells by the circulatory system where they can be broken down for energy through cellular respiration or combined with other small molecules to build and repair cells.
- Use a model to describe how the respiratory system and circulatory system interact, including how oxygen and carbon dioxide are moved in and out of the body.
- Use a model to describe how the nervous system and muscular/skeletal system interact to react to stimuli in an environment.
- Communicate the essential functions of each body system (circulatory, digestive, respiratory, excretory, muscular/skeletal, and nervous systems).
- Construct an explanation that chemical reactions can either break down larger molecules into smaller molecules or combine smaller molecules to build larger molecules.
- Communicate that oxygen and glucose/sugar are needed for cellular respiration to take place, resulting in usable energy for cells.

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LS1. From Molecules to Organisms: Structures and Processes

7.MS-LS1-4. Construct an explanation based on evidence for how characteristic animal behaviors and specialized plant structures increase the probability of successful reproduction of animals and plants. *Clarification Statements: Examples of animal 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 vocalizations and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include (a) transferring pollen or seeds, and (b) creating conditions for seed germination and growth. Examples of plant structures that affect the probability of plant reproduction 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.*

8.MS-LS1-5. Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms. *Clarification Statements: Examples of environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs, such as Great Danes and Chihuahuas. Examples of environmental factors could include drought decreasing plant growth, fertilizer increasing plant growth, and fish growing larger in large ponds than they do in small ponds. Examples of both genetic and environmental factors could include different varieties of plants growing at different rates in different conditions. State Assessment Boundary: Methods of reproduction, genetic mechanisms, gene regulation, or biochemical processes are not expected in state assessment.*

Additional Guidelines

- Note: Natural selection can be expected in the Grade 8 assessment under the standard 8.MS-LS4-4.

LS2. Ecosystems: Interactions, Energy, and Dynamics

7.MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.* *Clarification Statements: Examples of design solutions could include water, land, and species protection and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.*

7.MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. *Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.*

Additional Guidelines

Students should be able to:

- Construct an explanation to show how environmental variables, such as moisture and temperature, or human impacts, such as overharvesting of resources and pollution, affect the availability of resources produced by an ecosystem.
- Use a model, such as a food web, to explain how the parts of an ecosystem are interconnected therefore and a change to one part of the ecosystem can produce changes to other parts of the ecosystem.
- Describe how a natural or human-made change to an ecosystem, such as preservation or deforestation, affects the diversity of organisms within the ecosystem.

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LS3. Heredity: Inheritance and Variation of Traits
8.MS-LS3-1. Develop and use a model to describe that structural changes to genes (mutations) may or may not result in changes to proteins, and if there are changes to proteins there may be harmful, beneficial, or neutral changes to traits. *Clarification Statements: An example of a beneficial change to the organism may be a strain of bacteria becoming resistant to an antibiotic. A harmful change could be the development of cancer; a neutral change may change the hair color of an organism with no direct consequence. State Assessment Boundary: Specific changes at the molecular level (e.g., amino acid sequence change), mechanisms for protein synthesis, or specific types of mutations are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Describe that inside every cell are genes that code for inherited traits and contain the instructions for building the proteins necessary for the structure of a cell and the regulation of cell functions.
- Construct an explanation using evidence to show that a mutation can result in a change in the structure of a protein which may change the function or structure of a part of an organism.
- Describe the effect of a mutation as harmful (e.g., organism dies, is unable to reproduce, or reproduces less), beneficial (e.g., organism is able to better adapt to its environment and therefore survive longer and/or reproduce more), or neutral (e.g., organism's survival and ability to reproduce are not affected).

LS4. Biological Evolution: Unity and Diversity
6.MS-LS4-1. Analyze and interpret evidence from the fossil record to describe organisms and their environment, extinctions, and changes to life forms throughout the history of Earth. *Clarification Statement: Examples of evidence include sets of fossils that indicate a specific type of environment, anatomical structures that indicate the function of an organism in the environment, and fossilized tracks that indicate behavior of organisms. State Assessment Boundary: Names of individual species, geological eras in the fossil record, or mechanisms for speciation are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Construct an explanation using fossil evidence for how the environment of a particular area has changed over time, such as from a sea to a forest.
- Analyze rock layer diagrams and graphs to describe parts of the fossil record, including the extinction and emergence of species and changes in the characteristics of organisms over time.

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LS4. Biological Evolution: Unity and Diversity
8.MS-LS4-4. Use a model to describe the process of natural selection, in which genetic variations of some traits in a population increase some individuals' likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations. *Clarification Statements: The model should include simple probability statements and proportional reasoning. Examples of evidence can include Darwin's finches, necks of giraffes, and peppered moths. State Assessment Boundary: Specific conditions that lead to natural selection are not expected in state assessment.* **8.MS-LS4-5. Synthesize and communicate information about artificial selection, or the ways in which humans have changed the inheritance of desired traits in organisms.** *Clarification Statement: Emphasis is on the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy).*

Additional Guidelines

Students should be able to:

- Construct an explanation based on evidence that individuals with certain inherited traits have a higher probability of surviving and reproducing, which increases the frequency of those traits within a population over time.
- Use a model to describe that in artificial selection humans choose to breed certain plants or animals based on desired characteristics that they want to be passed to offspring.
- Compare and contrast natural selection and artificial selection.
- Describe benefits of artificial selection, such as desired traits appearing more frequently in a population, and compare those benefits to drawbacks, such as increasing the likelihood of genetic diseases, structural abnormities, and a decrease in a population's genetic variation.

Science and Technology/Engineering (STE)

Physical Science

PS1. Matter and Its Interactions
6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release or absorption of thermal energy. *Clarification Statements: Emphasis is on describing transfer of energy to and from the environment. Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.*

Additional Guidelines

Students should be able to:

- Analyze data (e.g., changes in temperature), to support a claim that an exothermic or endothermic reaction has occurred.
- Explain how an experiment could be set up to determine if an exothermic or endothermic reaction occurs between two substances. This should include the equipment to be used, such as beakers, graduated cylinders, and thermometers, the dependent and independent variables for an experiment, and the number of trials necessary for the experiment.
- Create or use a model to show the direction of thermal energy transfer in exothermic and endothermic reactions.

PS1. Matter and Its Interactions
8.MS-PS1-4. Develop a model that describes and predicts changes in particle motion, relative spatial arrangement, temperature, and state of a pure substance when thermal energy is added or removed. *Clarification Statements: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of pure substances could include water, carbon dioxide, and helium.*

Additional Guidelines

Students should be able to:

- Analyze data from an investigation to determine that adding or removing thermal energy to a substance could:
    - change the average kinetic energy of the particles in the substance and the temperature of the system or
    - change the state of matter of the pure substance.
- Analyze a temperature graph of a sample of a pure substance to determine when phase changes, such as melting, freezing, boiling, or condensing, occur.
- Communicate how kinetic energy (movement of particles) and temperature relate to one another.
- Complete or analyze a particle model before and after thermal energy is added or removed. Models could show:
    - particles in a solid vibrate faster in fixed positions when thermal energy is added.
    - particles in a liquid slow down when thermal energy is removed.
    - particles in a gas increase speed when thermal energy is added.

Science and Technology/Engineering (STE)

PS2. Motion and Stability: Forces and Interactions

7.MS-PS2-3. Analyze data to describe the effect of distance and magnitude of electric charge on the strength of electric forces. *Clarification Statement: Includes both attractive and repulsive forces. State Assessment Boundaries: State assessment will be limited to proportional reasoning. Calculations using Coulomb's law or interactions of sub-atomic particles are not expected in state assessment.*

7.MS-PS2-5. Use scientific evidence to argue that fields exist between objects with mass, between magnetic objects, and between electrically charged objects that exert force on each other even though the objects are not in contact. *Clarification Statement: Emphasis is on evidence that demonstrates the existence of fields, limited to gravitational, electric, and magnetic fields. State Assessment Boundary: Calculations of force are not expected in state assessment.*

8.MS-PS2-1. Develop a model that demonstrates Newton's third law involving the motion of two colliding objects. *State Assessment Boundary: State assessment will be limited to vertical or horizontal interactions in one dimension.*

8.MS-PS2-2. Provide evidence that the change in an object's speed depends on the sum of the forces on the object (the net force) 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 speed (Newton's second law) in one dimension. State Assessment Boundaries: State assessment will be limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. The use of trigonometry is not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Construct an explanation about how larger masses have stronger gravitational fields and therefore exert larger gravitational forces on each other.
- Complete or revise a model showing the direction and magnitude of the forces between pairs of electric charges that are either different distances or have different magnitude of charges.
- Analyze data from an investigation to determine the factors that affect the direction and strength of forces between two magnets, including changing the orientation of one magnet, the strength of one magnetic field, or the distance between the magnets.
- Create or revise a model that shows the magnitude and direction of a pair of forces created by a collision between two objects. The model should show that each force acts on one of the objects and that the forces are equal in magnitude and opposite in direction.
- Analyze a model of forces acting on an object to determine the direction of the net force acting on the object.
- Calculate the net force, including size and direction, on an object when given two forces acting in the same or opposite direction.
- Determine how the motion of an object will change or remain constant when given the forces acting on the object.
- Compare the change in speeds of objects over time, when:
    - the objects have the same mass, but different net forces acting on them.
    - the objects have the same net force acting on them, but different masses.

Science and Technology/Engineering (STE)

PS3. Energy

7.MS-PS3-1. Construct and interpret data and graphs to describe the relationships among kinetic energy, mass, and speed of an object. *Clarification Statements: Examples could include riding a bicycle at different speeds and rolling different-sized rocks downhill. Consider relationships between kinetic energy vs. mass and kinetic energy vs. speed separate from each other; emphasis is on the difference between the linear and exponential relationships. State Assessment Boundary: Calculation or manipulation of the formula for kinetic energy is not expected in state assessment.*

7.MS-PS3-2. Develop a model to describe the relationship between the relative positions of objects interacting at a distance and their relative potential energy in the system. *Clarification Statements: Examples of objects within systems interacting at varying distances could include Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a stream of water. Examples of models could include representations, diagrams, pictures, and written descriptions of systems. State Assessment Boundaries: State assessment will be limited to electric, magnetic, and gravitational interactions and to interactions of two objects at a time. Calculations of potential energy are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Compare the kinetic energies of objects with different masses that are traveling at the same speed.
- Construct an explanation about how changing the speed of an object affects the kinetic energy of the object, including the exponential relationship between speed and kinetic energy.
- Construct or revise a model to show how potential energy is affected by the distance between two masses, charges, or magnets and by the strength of the gravitational, electrical, and magnetic fields of each object.
- Use a model to explain that as the height of an object decreases, the objects' potential energy decreases.
- Analyze data from an investigation to show that a force must be applied to move two attracting objects farther apart or two repelling objects closer together.

Science and Technology/Engineering (STE)

PS4. Waves and Their Applications in Technologies for Information Transfer
6.MS-PS4-1. Use diagrams of a simple wave to explain that (a) a wave has a repeating pattern with a specific amplitude, frequency, and wavelength, and (b) the amplitude of a wave is related to the energy of the wave. *State Assessment Boundaries: Electromagnetic waves are not expected in state assessment. State assessment will be limited to standard repeating waves.*
6.MS-PS4-2. Use diagrams and other models to show that both light rays and mechanical waves are reflected, absorbed, or transmitted through various materials. *Clarification Statements: Materials may include solids, liquids, and gases. Mechanical waves (including sound) need a material (medium) through which they are transmitted. Examples of models could include drawings, simulations, and written descriptions. State Assessment Boundary: State assessment will be limited to qualitative applications.*

Additional Guidelines

Students should be able to:

- Complete a model to show the frequency, amplitude, and wavelength of a wave and describe these wave characteristics.
- Describe how the amount of energy transferred by a wave in a given time period is proportional to the frequency of the wave.
- Construct or revise a model to show that a light ray travels through a medium in a straight line, and how the path of a light ray bends (refracts) as it travels from one medium to another, such as from air to water.
- Describe how mechanical waves require a medium to move, while light waves do not.
- Using evidence from an investigation of different-colored materials, determine if light is mostly reflected or absorbed.

Science and Technology/Engineering (STE)

Technology/Engineering

ETS1. Engineering Design
7.MS-ETS1-2. Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution.*

Additional Guidelines

Students should be able to:

- Use a decision matrix to evaluate the strengths and weaknesses of different design solutions systematically
  - Rate each design solution based on its performance against the defined criteria and constraints[1] and calculate a total score for each design solution.
  - Support a claim that one design solution is more effective using evidence from the decision matrix.
- Create or modify a model to explain changes in a design solution and use data from testing to explain the results of these changes. Data may include material properties as listed in the Frameworks (p. 26).

ETS2. Materials, Tools, & Manufacturing
8.MS-ETS2-4(MA). Use informational texts to illustrate that materials maintain their composition under various kinds of physical processing; however, some material properties may change if a process changes the particulate structure of a material. *Clarification Statements: Examples of physical processing can include cutting, forming, extruding, and sanding. Examples of changes in material properties can include a non-magnetic iron material becoming magnetic after hammering or a plastic material becoming rigid (less elastic) after heat treatment.* **8.MS-ETS2-5(MA) Present information that illustrates how a product can be created using basic processes in manufacturing systems, including forming, separating, conditioning, assembling, finishing, quality control, and safety. Compare the advantages and disadvantages of human vs. computer control of these processes.**

Additional Guidelines

Students should be able to:

- Given a description or model of an object or product, explain how that object or product could be manufactured using one or more of the following processes:
  - Forming: squeezing or stretching materials into a desired shape.
  - Separating: removing parts of a material to attain a desired shape.
  - Conditioning: applying heat, force, or a chemical to change one or more properties of the material.
  - Assembling: the act of putting parts together.
  - Finishing: protecting or improving the surface of a material.
  - Quality control: making sure the product is manufactured properly.
  - Safety: ensuring human workers are not injured or in danger of being injured.

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

Science and Technology/Engineering (STE)

ETS3. Technological Systems
7.MS-ETS3-4(MA). Show how the components of a structural system work together to serve a structural function. Provide examples of physical structures and relate their design to their intended use. *Clarification Statements: Examples of components of a structural system could include foundation, decking, wall, and roofing. Explanations of function should include identification of live vs. dead loads and forces of tension, torsion, compression, and shear. Examples of uses include carrying loads and forces across a span (such as a bridge), providing livable space (such as a house or office building), and providing specific environmental conditions (such as a greenhouse or cold storage). State Assessment Boundary: Calculations of magnitude or direction of loads or forces are not expected in state assessment.*

Additional Guidelines

Students should be able to:

- Identify the live loads and dead loads acting on a structure.
- Use or revise a model to show where forces (compression, tension, torsion, or shear) act on a bridge or other structure when a load is applied.
- Analyze and interpret data about the properties of materials to determine which material is best to use for resisting tension, compression, torsion, or shear.