Grades 6–8 Overview of Science and Engineering Practices

Active engagement of middle school students with the science and engineering practices is critical as students generally make up their minds about whether they identify with science and engineering by the time they leave eighth grade, and whether they will pursue these fields in high school and beyond. Students must have opportunities to develop the skills necessary for a meaningful progression of development in order for them to engage in scientific and technical reasoning so critical to success in civic life, post-secondary education, and careers. Inclusion of science and engineering practices in standards only speak to the types of performances students should be able to demonstrate at the end of instruction at a particular grade; the standards do not limit what educators and students should or can be engaged in through a well-rounded curriculum.

Grades 6 through 8 standards integrate all eight science and engineering practices. Students' understanding of and ability with each practice gets more detailed and sophisticated through middle school. For example, by the end of middle school, students can identify limitations of a particular model, including limitations of its accuracy, what features are included (or not), and limitations of what phenomena or outcomes it can predict. Students can develop models of varying levels of detail and accuracy and can identify when a situation calls for a conceptual model with little detail or a specific model with attention to accuracy, such as for making predictions of particular events.

Some examples of specific skills students should develop in these grades include:

1. define criteria and constrains of a design problem with precision;
2. develop a model to describe cycling of matter in an ecosystem; develop a model that describes and predicts changes in particle motion and spatial arrangement during phase changes; develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena;
3. conduct an investigation to show relationships among energy transfer, type of matter, and kinetic energy of particles; conduct an experiment to show that many materials are mixtures;
4. examine and interpret data to describe the role human activities have played in the rise of global temperatures over time; construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships; distinguish between causal and correlational relationships in data; consider limitations of data analysis;
5. describe, including the use of probability statements and proportional reasoning, the process of natural selection; use data and graphs to describe relationships among kinetic energy, mass, and speed of an object;
6. construct an explanation using evidence for how Earth's surface has changed over time; apply scientific reasoning to show why the data or evidence is adequate for the explanation;
7. construct an argument based on evidence for how environmental and genetic factors influence organism growth; respectfully provide and receive critiques about one's arguments, procedures, and models by citing relevant evidence with pertinent detail; and
8. synthesize and communicate information about artificial selection; obtain and communicate information on how past geologic events are analyzed to make future predictions.

While presented as distinct skill sets, the eight practices intentionally overlap and interconnect. Skills such as outlined above should be reflected in curriculum and instruction that engage students in an integrated use of the practices. See the Science and Engineering Practices Progression Matrix for more information, including particular skills for students in grades 6-8 (www.doe.mass.edu/stem/resources/SciEngPractices-Matrix.pdf).

Grade 7: 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.

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 which 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.

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 transferring pollen or seeds; and, 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.

State Assessment Boundary:

- Natural selection is not expected in state assessment.

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, biochemical processes, or natural selection 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.

LS2. Ecosystems: Interactions, Energy, and Dynamics

7.MS-LS2-1. Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the size of populations in an ecosystem.

7.MS-LS2-2. Describe how relationships among and between organisms in an ecosystem can be competitive, predatory, parasitic, and mutually beneficial and that these interactions are found across multiple ecosystems.

Clarification Statement:

- Emphasis is on describing consistent patterns of interactions in different ecosystems in terms of relationships among and between organisms.

7.MS-LS2-3. Develop a model to describe that matter and energy cycle among living and nonliving parts of an ecosystem and that both matter and energy are conserved through these processes

Clarification Statements:

- Cycling of matter should include the role of photosynthesis, cellular respiration, and decomposition, and transfer among producers, primary, secondary, and tertiary consumers, and decomposers.
- Models may include food webs and food chains.

State Assessment Boundary:

- Cycling of specific atoms (such as carbon or oxygen), or the biochemical steps of photosynthesis, cellular respiration, and decomposition are not expected in state assessment.

7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Clarification Statement:

- Focus should be on ecosystem characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.

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.

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.

8.MS-LS3-2. Construct an argument based on evidence for how asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Compare and contrast advantages and disadvantages of asexual and sexual reproduction.

Clarification Statements:

- Examples of an advantage of sexual reproduction can include genetic variation when the environment changes or a disease is introduced, while examples of an advantage of asexual reproduction can include not using energy to find a mate and fast reproduction rates.
- Examples of a disadvantage of sexual reproduction can include using resources to find a mate, while a disadvantage in asexual reproduction can be the lack of genetic variation when the environment changes or a disease is introduced.

8.MS-LS3-3(MA). Communicate through writing and in diagrams that chromosomes contain many distinct genes and that each gene holds the instructions for the production of specific proteins, which in turn affects the traits of an individual.

State Assessment Boundary:

- Specific changes at the molecular level or mechanisms for protein synthesis are not expected in state assessment.

8.MS-LS3-4(MA). Develop and use a model to show that sexually reproducing organisms have two of each chromosome in their nucleus, and hence two variants (alleles) of each gene that can be the same or different from each other, with one random assortment of each chromosome passed down to offspring from both parents.

Clarification Statement:

- Examples of models can include Punnett squares, diagrams (e.g., simple pedigrees), and simulations.

State Assessment Boundary:

- State assessment will limit inheritance patterns to dominant-recessive alleles only.

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 extinction or speciation are not expected in state assessment.

6.MS-LS4-2. Construct an argument using anatomical structures to support evolutionary relationships among and between fossil organisms and modern organisms.

Clarification Statement:

- Evolutionary relationships include (a) some organisms have similar traits with similar functions because they were inherited from a common ancestor, (b) some organisms have similar traits that serve similar functions because they live in similar environments, and (c) some organisms have traits inherited from common ancestors that no longer serve their original function because their environments are different than their ancestors' environments.

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).