Science Standard-Specific Supports

Grade 8

Revised October 2022

Contents

Science Standard-Specific Supports

Overview

The West Virginia College- and Career-Readiness Standards for Science[1] identify what students should know and be able to do at the end of science instruction. Each standard represents the integration of three "dimensions" of science education: practices of scientists and engineers, core science content, and science connecting concepts. As such, both student learning and assessment around the standards should be "three dimensional." The Science Standard-Specific Supports in this document are intended to show what it looks like for students to fully satisfy the intent of the standard.

The Science Standard-Specific Supports are adapted from the Evidence Statements of the Next Generation Science Standards (NGSS)[2], created when West Virginia was a lead state during the NGSS writing process, and the Framework for K-12 Science Instruction[3], created prior to the development of the NGSS. For more information on the Evidence Statements, please refer to them in their original form.

Purpose

The Science Standard-Specific Supports were designed to articulate how students can use the practices of scientists and engineers to demonstrate their understanding of the core science content through the lens of the science connecting concepts, and thus, demonstrate proficiency on each standard. The Science Standard-Specific Supports do this by clarifying:

- how the three dimensions could be assessed together, rather than in independent units;
- the underlying knowledge required for each core science content;
- the detailed approaches to the practices of scientists and engineers; and
- how science connecting concepts might be used to deepen content- and practice-driven learning.

The Science Standard-Specific Supports are not intended to be used as curriculum or limit or dictate instruction.

Structure

The practices of scientists and engineers are used as the organizing structure for the Science Standard-Specific Supports. However, this does not mean that the practices are more important than the other dimensions. The practices of scientists and engineers form the activities through which students demonstrate understanding of the science content. The proper integration of the practices makes students' thinking visible.

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[1] *West Virginia College- and Career-Readiness Standards for Science* (Policy 2520.3C) https://apps.sos.wv.gov/adlaw/csr/readfile.aspx?DocId=54673&Format=PDF

[2] NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

[3] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press.

How to Use the Science Standard-Specific Supports

- For instruction:
    - The Science Standard-Specific Supports can be used to aid instructional design, but it is crucial to recognize there are numerous pathways educators may use throughout the sequence of lessons and units to allow students to ultimately be prepared to demonstrate mastery of the standards.
- For assessment:
    - The Science Standard-Specific Supports can be used to inform the development of formative and summative assessments by the classroom educator.

Although supports are listed individually for each standard, this does not indicate that they should be measured individually, or that standards should be taught or assessed individually. Best practices in classroom instruction should be focused on helping students build towards several standards at one time because many concepts and practices are interrelated.

Limitations of the Science Standard-Specific Supports

The science standard supports cannot do the following:

- Provide or prescribe the contexts through which the standards may be taught or assessed.
- Be the rubrics on which levels of student success would be measured.
- Identify the sequence of instruction or assessment.
- Put limits on student learning or student coursework.
- Replace lesson plans or assessment items.
- Serve as complete scoring rubrics.

Science - Grade 8 Introduction

Eighth Grade Science standards build upon students' science understanding from earlier grades and provide deeper understandings in six major content topics: Structure and Properties of Matter; Chemical Reactions; Growth, Development, and Reproduction of Organisms; Natural Selection and Adaptations; and Human Impacts, and Engineering Design. The standards blend central ideas with the practices of scientists and engineers and science connecting concepts to support students in developing useable knowledge across the science disciplines. There is a focus on multiple indicators including planning and carrying out investigations; developing and using models; analyzing and interpreting data; using mathematical and computational thinking; obtaining, evaluating, and communicating information; and engaging in argument from evidence. Engineering, Technology, and the Application of Science are integrated throughout instruction as students define problems and design solutions related to the course topics. Students will engage in active inquiries, investigations, and hands-on activities at least 50% of instructional time as they develop and demonstrate conceptual understandings along with research and laboratory skills described in the standards and indicators for science. Safety instruction is integrated into all activities, and students will implement safe procedures and practices when manipulating equipment, materials, organisms, and models. Standards followed by an asterisk (*) denote the integration of traditional science content with an engineering practice.

Within the evidence statements, the words "description" or "describe" followed by an asterisk indicate those descriptions given by students could include but are not limited to written, oral, pictorial, and kinesthetic descriptions unless otherwise specified.

College- and Career-Readiness Indicators for Science Grades 6-8

Nature of Science
• Scientific knowledge is simultaneously reliable and subject to change based on empirical evidence and interpretation. • Scientific knowledge is obtained through a combination of observations of the natural world and inferences based on those observations. • Science is a creative human endeavor which is influenced by social and cultural biases. • A primary goal of science is the formation of theories and laws. Theories are inferred explanations of some aspect of the natural world based on successfully tested information from evidence and evaluated phenomena. Laws describe relationships among what has been observed in the natural world. • Scientific investigations use a variety of methods to address questions about the natural and material world.

Practices of Scientists and Engineers	Science Connecting Concepts
• Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematical and computational thinking • Constructing explanations and designing solutions • Engaging in argument from evidence • Obtaining, evaluating, and communicating information	• Observing patterns • Investigating and explaining cause and effect • Recognizing scale, proportion, and quantity • Defining systems and system models • Tracking energy and matter flows, into, out of, and within systems to understand system behavior • Determining the relationships between structure and function • Studying stability and change

Science Literacy	Science Lab Safety
• Producing clear and coherent technical writing in which the development, organization and style are appropriate for the science topic • Correctly utilizing and explaining visually expressed information (e.g., flowchart, diagram, model, graph, table, or digital mapping technology) in a science narrative. • Appropriately using technical terminology or scientific concepts and processes to create visually expressed information • Reading with understanding articles about science in the popular press and engaging in social conversation about the validity of the conclusions • Identifying scientific issues underlying national and local decisions and expressing positions that are scientifically and technologically informed • Evaluating the quality and validity of scientific information on the basis of its source and the methods used to generate it	• Requiring student lab safety training and demonstrating appropriate proficiency before participating in lab activities • Archiving signed student safety contracts documenting lab safety training and medical contraindications (e.g., allergies, contact lenses, medical conditions) • Wearing proper protective gear as needed (e.g., goggles, apron, and gloves) • Requiring grade appropriate lab equipment operation and safety training • Using and following SDS protocols • Storing and disposing of chemical/biological materials properly • Following ethical classroom uses of living materials/organisms • Displaying proper safety signage and laboratory rules in the classroom and lab

Life Science

Topic: Growth, Development, and Reproduction of Organisms

S.8.1. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

Practices of Scientists and Engineers	Core Science Content
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Students will use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	Growth and Development of Organisms Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.
Science Connecting Concepts	
Cause and Effect Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	

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

1) Supported claims
   a) Students make a claim to support a given explanation of a phenomenon. In their claim, students include the idea that characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
2) Identifying scientific evidence
   a) Students identify the given evidence that supports the claim (e.g., evidence from data and scientific literature), including:
      i) Characteristic animal behaviors that increase the probability of reproduction.
      ii) Specialized plant and animal structures that increase the probability of reproduction.
      iii) Cause-and-effect relationships between:
         (1) Specialized plant structures and the probability of successful reproduction of plants that have those structures.
         (2) Animal behaviors and the probability of successful reproduction of animals that exhibit those behaviors.
         (3) Plant reproduction and the animal behaviors related to plant reproduction.
3) Evaluating and critiquing the evidence
   a) Students evaluate the evidence and identify the strengths and weaknesses of the evidence used to support the claim, including:
      i) Validity and reliability of sources.
      ii) Sufficiency — including relevance, validity, and reliability — of the evidence to make and defend the claim.

        iii) Alternative interpretations of the evidence and why the evidence supports the student's claim, as opposed to any other claims.
4) Reasoning and synthesis
    a) Students use reasoning to connect the appropriate evidence to the claim, using oral or written arguments. Students describe the following chain of reasoning in their argumentation:
        i) Many characteristic animal behaviors affect the likelihood of successful reproduction.
        ii) Many specialized plant structures affect the likelihood of successful reproduction.
        iii) Sometimes, animal behavior plays a role in the likelihood of successful reproduction in plants.
        iv) Because successful reproduction has several causes and contributing factors, the cause and-effect relationships between any of these characteristics, separately or together, and reproductive likelihood can be accurately reflected only in terms of probability.

S.8.2. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]

Practices of Scientists and Engineers	Core Science Content
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. Students will construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**Growth and Development of Organisms** Genetic factors as well as local conditions affect the growth of the adult plant.
Science Connecting Concepts	
Growth and Development of Organisms Genetic factors as well as local conditions affect the growth of the adult plant.	

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

1) Articulating the explanation of phenomena
    a) Students articulate a statement that relates the given phenomenon to a scientific idea, including the idea that both environmental and genetic factors influence the growth of organisms.
    b) Students use evidence and reasoning to construct a scientific explanation for the given phenomenon.
2) Evidence
    a) Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including:
        i) Environmental factors (e.g., availability of light, space, water; size of habitat) and that they can influence growth.

ii) Genetic factors (e.g., specific breeds of plants and animals and their typical sizes) and that they can influence growth.
iii) Changes in the growth of organisms as specific environmental and genetic factors change.

b) Students use multiple valid and reliable sources of evidence to construct the explanation.

3) Reasoning

a) Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for a phenomenon involving genetic and environmental influences on organism growth. Students describe their chain of reasoning that includes:

i) Organism growth is influenced by multiple environmental (e.g., drought, changes in food availability) and genetic (e.g., specific breed) factors.
ii) Because both environmental and genetic factors can influence organisms simultaneously, organism growth is the result of environmental and genetic factors working together (e.g., water availability influences how tall dwarf fruit trees will grow).
iii) Because organism growth can have several genetic and environmental causes, the contributions of specific causes or factors to organism growth can be described only using probability (e.g., not every fish in a large pond grows to the same size).

S.8.3. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop and use a model to describe phenomena.</td><td rowspan="3">Inheritance of Traits
Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.

Variation of Traits
In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Structure and Function
Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.</td></tr>
</table>

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

1) Components of the model
   a) Students develop a model in which they identify the relevant components for making sense of a given phenomenon involving the relationship between mutations and the effects on the organism, including:
      i) Genes, located on chromosomes.
      ii) Proteins.
      iii) Traits of organisms.
2) Relationships
   a) In their model, students describe the relationships between components, including:
      i) Every gene has a certain structure, which determines the structure of a specific set of proteins.
      ii) Protein structure influences protein function (e.g., the structure of some blood proteins allows them to attach to oxygen, the structure of a normal digestive protein allows it break down particular food molecules).
      iii) Observable organism traits (e.g., structural, functional, behavioral) result from the activity of proteins.
3) Connections
   a) Students use the model to describe that structural changes to genes (i.e., mutations) may result in observable effects at the level of the organism, including why structural changes to genes:
      i) May affect protein structure and function.
      ii) May affect how proteins contribute to observable structures and functions in organisms.
      iii) May result in trait changes that are beneficial, harmful, or neutral for the organism.
   b) Students use the model to describe that beneficial, neutral, or harmful changes to protein function can cause beneficial, neutral, or harmful changes in the structure and function of organisms.

S.8.4. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

Practices of Scientists and Engineers	Core Science Content
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop and use a model to describe phenomena.	**Growth and Development of Organisms** Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary) **Inheritance of Traits** Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **Variation of Traits** In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.
Science Connecting Concepts	
Cause and Effect Cause and effect relationships may be used to predict phenomena in natural systems.	

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

1) Components of the model
   a) Students develop a model (e.g., Punnett squares, diagrams, simulations) for a given phenomenon involving the differences in genetic variation that arise from sexual and asexual reproduction. In the model, students identify and describe the relevant components, including:
      i) Chromosome pairs, including genetic variants, in asexual reproduction:
         (1) Parents.
         (2) Offspring.
      ii) Chromosome pairs, including genetic variants, in sexual reproduction:
         (1) Parents.
         (2) Offspring.
2) Relationships
   a) In their model, students describe the relationships between components, including:
      i) During reproduction (both sexual and asexual), parents transfer genetic information in the form of genes to their offspring.
      ii) Under normal conditions, offspring have the same number of chromosomes, and therefore genes, as their parents.
      iii) During asexual reproduction, a single parent's chromosomes (one set) are the source of genetic material in the offspring.
      iv) During sexual reproduction, two parents (two sets of chromosomes) contribute genetic material to the offspring.
3) Connections
   a) Students use the model to describe a causal account for why sexual and asexual reproduction result in different amounts of genetic variation in offspring relative to their parents, including that:
      i) In asexual reproduction:
         (1) Offspring have a single source of genetic information, and their chromosomes are complete copies of each single parent pair of chromosomes.
         (2) Offspring chromosomes are identical to parent chromosomes.
      ii) In sexual reproduction:
         (1) Offspring have two sources of genetic information (i.e., two sets of chromosomes) that contribute to each final pair of chromosomes in the offspring.
         (2) Because both parents are likely to contribute different genetic information, offspring chromosomes reflect a combination of genetic material from two sources and therefore contain new combinations of genes (genetic variation) that make offspring chromosomes distinct from those of either parent.
   b) Students use cause-and-effect relationships found in the model between the type of reproduction and the resulting genetic variation to predict that more genetic variation occurs in organisms that reproduce sexually compared to organisms that reproduce asexually.

S.8.5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods. Students will gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.</td><td rowspan="3">Natural Selection
In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Cause and Effect
Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Interdependence of Science, Engineering, and Technology
Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Science Addresses Questions About the Natural and Material World
Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.</td></tr>
</table>

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

1) Obtaining information
   a) Students gather information about at least two technologies that have changed the way humans influence the inheritance of desired traits in plants and animals through artificial selection by choosing desired parental traits determined by genes, which are then often passed on to offspring. Examples could include gene therapy, genetic modification, and selective breeding of plants and animals.
   b) Students use at least two appropriate and reliable sources of information for investigating each technology.
2) Evaluating information
   a) Students assess the credibility, accuracy, and possible bias of each publication and method used in the information they gather.
   b) Students use their knowledge of artificial selection and additional sources to describe how the information they gather is or is not supported by evidence.
   c) Students synthesize the information from multiple sources to provide examples of how technologies have changed the ways that humans are able to influence the inheritance of desired traits in organisms.
   d) Students use the information to identify and describe how a better understanding of cause-and-effect relationships in how traits occur in organisms has led to advances in technology that provide a higher probability of being able to influence the inheritance of desired traits in organisms.

Topic: Natural Selection and Adaptation

S.8.6. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Students will analyze and interpret data to determine similarities and differences in findings.

Scientific Knowledge is Based on Empirical Evidence
Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td rowspan="3">Evidence of Common Ancestry and Diversity
The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Patterns
Graphs, charts, and images can be used to identify patterns in data.

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.</td></tr>
</table>

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

1) Organizing data
   a) Students organize the given data (e.g., using tables, graphs, charts, images), including the appearance of specific types of fossilized organisms in the fossil record as a function of time, as determined by their locations in the sedimentary layers or the ages of rocks.
   b) Students organize the data in a way that allows for the identification, analysis, and interpretation of similarities and differences in the data.
2) Identifying relationships
   a) Students identify:
      i) Patterns between any given set of sedimentary layers and the relative ages of those layers.
      ii) The time period(s) during which a given fossil organism is present in the fossil record.
      iii) Periods of time for which changes in the presence or absence of large numbers of organisms or specific types of organisms can be observed in the fossil record (e.g., a fossil layer with very few organisms immediately next to a fossil layer with many types of organisms).
      iv) Patterns of changes in the level of complexity of anatomical structures in organisms in the fossil record, as a function of time.
3) Interpreting data
   a) Students analyze and interpret the data to determine evidence for the existence, diversity, extinction, and change in life forms throughout the history of Earth, using the assumption that natural laws operate today as they would have in the past. Students use similarities and differences in the observed patterns to provide evidence for:
      i) When mass extinctions occurred.

ii) When organisms or types of organisms emerged, went extinct, or evolved.
iii) The long-term increase in the diversity and complexity of organisms on Earth.

S.8.7. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Students will apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.</td><td rowspan="3">Evidence of Common Ancestry and Diversity
Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Patterns
Patterns can be used to identify cause and effect relationships.

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.</td></tr>
</table>

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

1) Articulating the explanation of phenomena
    a) Students articulate a statement that relates a given phenomenon to scientific ideas, including the following ideas about similarities and differences in organisms and their evolutionary relationships:
        i) Anatomical similarities and differences among organisms can be used to infer evolutionary relationships, including:
            (1) Among modern organisms.
            (2) Between modern and fossil organisms.
    b) Students use evidence and reasoning to construct an explanation for the given phenomenon.
2) Evidence
    a) Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data, simulations) necessary for constructing the explanation, including similarities and differences in anatomical patterns in and between:
        i) Modern, living organisms (e.g., skulls of modern crocodiles, skeletons of birds; features of modern whales and elephants).
        ii) Fossilized organisms (e.g., skulls of fossilized crocodiles, fossilized dinosaurs).
3) Reasoning
    a) Students use reasoning to connect the evidence to support an explanation. Students describe the following chain of reasoning for the explanation:
        i) Organisms that share a pattern of anatomical features are likely to be more closely related than are organisms that do not share a pattern of anatomical features, due to the cause-and effect relationship between genetic makeup and anatomy (e.g., although birds and

insects both have wings, the organisms are structurally very different and not very closely related; the wings of birds and bats are structurally similar, and the organisms are more closely related; the limbs of horses and zebras are structurally very similar, and they are more closely related than are birds and bats or birds and insects).
    ii) Changes over time in the anatomical features observable in the fossil record can be used to infer lines of evolutionary descent by linking extinct organisms to living organisms through a series of fossilized organisms that share a basic set of anatomical features.

S.8.8. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]

Practices of Scientists and Engineers	Core Science Content
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Students will analyze displays of data to identify linear and nonlinear relationships.	Evidence of Common Ancestry and Diversity Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.
Science Connecting Concepts	
Patterns Graphs, charts, and images can be used to identify patterns in data.	

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

1) Organizing data
    a) Students organize the given displays of pictorial data of embryos by developmental stage and by organism (e.g., early, middle, just prior to birth) to allow for the identification, analysis, and interpretation of relationships in the data.
2) Identifying relationships
    a) Students analyze their organized pictorial displays to identify linear and nonlinear relationships, including:
        i) Patterns of similarities in embryos across species (e.g., early mammal embryos and early fish embryos both contain gill slits, whale embryos and the embryos of land animals — even some snakes — have hind limbs).
        ii) Patterns of changes as embryos develop (e.g., mammal embryos lose their gill slits, but the gill slits develop into gills in fish).
3) Interpreting data
    a) Students use patterns of similarities and changes in embryo development to describe evidence for relatedness among apparently diverse species, including similarities that are not evident in the fully formed anatomy (e.g., mammals and fish are more closely related than they appear to be based on their adult features, whales are related to land animals).

S.8.9. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]

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

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

1) Articulating the explanation for phenomena
   a) Students articulate a statement that relates the given phenomenon to scientific ideas about the cause-and-effect relationship between the inheritance of traits increasing the chances of successful reproduction and natural selection.
   b) Students use evidence and reasoning to construct an explanation for the given phenomenon.
2) Evidence
   a) Students identify and describe given evidence (e.g., from students' own investigations, observations, reading materials, archived data) necessary for constructing the explanation, including:
      i) Individuals in a species have genetic variation that can be passed on to their offspring.
      ii) The probability of a specific organism surviving and reproducing in a specific environment.
      iii) The traits (i.e., specific variations of a characteristic) and the cause-and-effect relationships between those traits and the probability of survival and reproduction of a given organism in a specific environment.
      iv) The particular genetic variations (associated with those traits) that are carried by that organism.
3) Reasoning
   a) Students use reasoning to connect the evidence and support an explanation that describes the relationship between genetic variation and the success of organisms in a specific environment.
   b) Students describe a chain of reasoning that includes:
      i) Any population in a given environment contains a variety of available, inheritable genetic traits.
      ii) For a specific environment (e.g., different environments may have limited food availability, predators, nesting site availability, light availability), some traits confer advantages that make it more probable that an organism will be able to survive and reproduce there.
      iii) In a population, there is a cause-and-effect relationship between the variation of traits and the probability that specific organisms will be able to survive and reproduce.
      iv) Variation of traits is a result of genetic variations occurring in the population.
      v) The proportion of individual organisms that have genetic variations and traits that are advantageous in a particular environment will increase from generation to generation due to natural selection because the probability that those individuals will survive and reproduce is greater.).

S.8.10. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Using Mathematics and Computational Thinking
Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Students use mathematical representations to support scientific conclusions and design solutions.</td><td rowspan="3">Adaptation
Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Cause and Effect
Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.</td></tr>
</table>

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

1) Representation
   a) Students identify the explanations for phenomena that they will support, which include:
      i) Characteristics of a species change over time (i.e., over generations) through adaptation by natural selection in response to changes in environmental conditions.
      ii) Traits that better support survival and reproduction in a new environment become more common within a population within that environment.
      iii) Traits that do not support survival and reproduction as well become less common within a population in that environment.
      iv) When environmental shifts are too extreme, populations do not have time to adapt and may become extinct.
   b) From given mathematical and/or computational representations of phenomena, students identify the relevant components, including:
      i) Population changes (e.g., trends, averages, histograms, graphs, spreadsheets) gathered from historical data or simulations.
      ii) The distribution of specific traits over time from data and/or simulations.
   c) Environmental conditions (e.g., climate, resource availability) over time from data and/or simulations.
2) Mathematical Modeling
   a) Students use the given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of the phenomenon to identify relationships in the data and/or simulations, including:
      i) Changes and trends over time in the distribution of traits within a population.
      ii) Multiple cause-and-effect relationships between environmental conditions and natural selection in a population.
      iii) The increases or decreases of some traits within a population can have more than one environmental cause.
3) Analysis
   a) Students analyze the mathematical and/or computational representations to provide and describe evidence that distributions of traits in populations change over time in response to changes in environmental conditions. Students synthesize their analysis together with scientific information about natural selection to describe that species adapt through natural selection.

This results in changes in the distribution of traits within a population and in the probability that any given organism will carry a particular trait.

b) Students use the analysis of the mathematical and/or computational representations (including proportional reasoning) as evidence to support the explanations that:
   i) Through natural selection, traits that better support survival and reproduction are more common in a population than those traits that are less effective.
   ii) Populations are not always able to adapt and survive because adaptation by natural selection occurs over generations.

c) Based on their analysis, students describe that because there are multiple cause-and-effect relationships contributing to the phenomenon, for each different cause it is not possible to predict with 100% certainty what will happen.

Physical Science

Topic: Structure and Properties of Matter

S.8.11. Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.]

Practices of Scientists and Engineers	Core Science Content
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop a model to predict and/or describe phenomena.	Structure and Properties of Matter Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
Science Connecting Concepts	
Scale, Proportion, and Quantity Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.	

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

1) Components of the model
   a) Students develop models of atomic composition of simple molecules and extended structures that vary in complexity. In the models, students identify the relevant components, including:
      i) Individual atoms.
      ii) Molecules.
      iii) Extended structures with repeating subunits.
      iv) Substances (e.g., solids, liquids, and gases at the macro level).
2) Relationships
   a) In the model, students describe relationships between components, including:
      i) Individual atoms, from two to thousands, combine to form molecules, which can be made up of the same type or different types of atom.
      ii) Some molecules can connect to each other.
      iii) In some molecules, the same atoms of different elements repeat; in other molecules, the same atom of a single element repeats.
3) Connections
   a) Students use models to describe that:
      (i) Pure substances are made up of a bulk quantity of individual atoms or molecules. Each pure substance is made up of one of the following:
         1. Individual atoms of the same type that are connected to form extended structures.
         2. Individual atoms of different types that repeat to form extended structures (e.g., sodium chloride).
         3. Individual atoms that are not attracted to each other (e.g., helium).
         4. Molecules of different types of atoms that are not attracted to each other (e.g., carbon dioxide).

5. Molecules of different types of atoms that are attracted to each other to form extended structures (e.g., sugar, nylon).
6. Molecules of the same type of atom that are not attracted to each other (e.g., oxygen).

(ii) Students use the models to describe how the behavior of bulk substances depends on their structures at atomic and molecular levels, which are too small to see.

S.8.12. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods. Students will gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence.</td><td rowspan="3">Structure and Properties of Matter
Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

Chemical Reactions
Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</td></tr>
<tr><th>Science Connecting Concepts</th></tr>
<tr><td>Structure and Function
Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Interdependence of Science, Engineering, and Technology
Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Influence of Science, Engineering and Technology on Society and the Natural World
The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.</td></tr>
</table>

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

1) Obtaining information
   a) Students obtain information from published, grade-level appropriate material from at least two sources (e.g., text, media, visual displays, data) about:
      i) Synthetic materials and the natural resources from which they are derived.
      ii) Chemical processes used to create synthetic materials from natural resources (e.g., burning of limestone for the production of concrete).

        iii) The societal need for synthetic materials (e.g., the need for concrete as building material).
2) Evaluating information
    a) Students determine and describe whether the gathered information is relevant for determining:
        i) That synthetic materials, via chemical reactions, come from natural resources.
        ii) The effects of the production and use of synthetic resources on society.
    b) Students determine the credibility, accuracy, and possible bias of each source of information, including the ideas included and methods described.
    c) Students synthesize information that is presented in various modes (e.g., graphs, diagrams, photographs, text, mathematical, verbal) to describe:
        i) How synthetic materials are formed, including the natural resources and chemical processes used.
        ii) The properties of the synthetic material(s) that make it different from the natural resource(s) from which it was derived.
        iii) How those physical and chemical properties contribute to the function of the synthetic material.
        iv) How the synthetic material satisfies a societal need or desire through the properties of its structure and function.
        v) The effects of making and using synthetic materials on natural resources and society.

S.8.13. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

Practices of Scientists and Engineers	Core Science Content
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop a model to predict and/or describe phenomena.	Structure and Properties of Matter Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. Definitions of Energy The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary). The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary)
Science Connecting Concepts	
Cause and Effect Cause and effect relationships may be used to predict phenomena in natural or designed systems.	

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

1) Components of the model
    a) To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
        i) Particles, including their motion.
        ii) The system within which the particles are contained.
        iii) The average kinetic energy of particles in the system.
        iv) Thermal energy of the system.
        v) Temperature of the system.
        vi) A pure substance in one of the states of matter (e.g., solid, liquid, gas at the macro scale).
2) Relationships
    a) In the model, students describe relationships between components, including:
        i) The relationships between:
            (1) The motion of molecules in a system and the kinetic energy of the particles in the system.
            (2) The average kinetic energy of the particles and the temperature of the system.
            (3) The transfer of thermal energy from one system to another and:
                (a) A change in kinetic energy of the particles in that new system, or
                (b) A change in state of matter of the pure substance.
            (4) The state of matter of the pure substance (gas, liquid, solid) and the particle motion (freely moving and not in contact with other particles, freely moving and in loose contact with other particles, vibrating in fixed positions relative to other particles).
3) Connections
    a) Students use their model to provide a causal account of the relationship between the addition or removal of thermal energy from a substance and the change in the average kinetic energy of the particles in the substance.
    b) Students use their model to provide a causal account of the relationship between:
        i) The temperature of the system.
        ii) Motions of molecules in the gaseous phase.
        iii) The collisions of those molecules with other materials, which exerts a force called pressure.
    c) Students use their model to provide a causal account of what happens when thermal energy is transferred into a system, including that:
        i) An increase in kinetic energy of the particles can cause:
            (1) An increase in the temperature of the system as the motion of the particles relative to each other increases, or
            (2) A substance to change state from a solid to a liquid or from a liquid to a gas.
        ii) The motion of molecules in a gaseous state increases, causing the moving molecules in the gas to have greater kinetic energy, thereby colliding with molecules in surrounding materials with greater force (i.e., the pressure of the system increases).
    d) Students use their model to provide a causal account of what happens when thermal energy is transferred from a substance, including that:
        i) Decreased kinetic energy of the particles can cause:
            (1) A decrease in the temperature of the system as the motion of the particles relative to each other decreases, or
            (2) A substance to change state from a gas to a liquid or from a liquid to a solid.
        ii) The pressure that a gas exerts decreases because the kinetic energy of the gas molecules decreases, and the slower molecules exert less force in collisions with other molecules in surrounding materials.
    e) Students use their model to provide a causal account for the relationship between changes in pressure of a system and changes of the states of materials in the system.
        i) With a decrease in pressure, a smaller addition of thermal energy is required for particles of a liquid to change to gas because particles in the gaseous state are colliding with the surface of the liquid less frequently and exerting less force on the particles in the liquid,

thereby allowing the particles in the liquid to break away and move into the gaseous state with the addition of less energy.

ii) With an increase in pressure, a greater addition of thermal energy is required for particles of a liquid to change to gas because particles in the gaseous state are colliding with the surface of the liquid more frequently and exerting greater force on the particles in the liquid, thereby limiting the movement of particles from the liquid to gaseous state.

Topic: Chemical Reactions

S.8.14. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Students will analyze and interpret data to determine similarities and differences in findings.

Scientific Knowledge is Based on Empirical Evidence
Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td rowspan="3">Structure and Properties of Matter
Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

Chemical Reactions
Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</td></tr>
<tr><th>Science Connecting Concepts</th></tr>
<tr><td>Patterns
Macroscopic patterns are related to the nature of microscopic and atomic level structure.</td></tr>
</table>

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

1) Organizing data
   a) Students organize given data about the characteristic physical and chemical properties (e.g., density, melting point, boiling point, solubility, flammability, odor) of pure substances before and after they interact.
   b) Students organize the given data in a way that facilitates analysis and interpretation.
2) Identifying relationships
   a) Students analyze the data to identify patterns (i.e., similarities and differences), including the changes in physical and chemical properties of each substance before and after the interaction (e.g., before the interaction, a substance burns, while after the interaction, the resulting substance does not burn).
3) Interpreting data
   a) Students use the analyzed data to determine whether a chemical reaction has occurred.
   b) Students support their interpretation of the data by describing that the change in properties of substances is related to the rearrangement of atoms in the reactants and products in a chemical reaction (e.g., when a reaction has occurred, atoms from the substances present before the interaction must have been rearranged into new configurations, resulting in the properties of new substances).

S.8.15. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop a model to describe unobservable mechanisms.

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
Laws are regularities or mathematical descriptions of natural phenomena.</td><td rowspan="3">Chemical Reactions
Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Energy and Matter
Matter is conserved because atoms are conserved in physical and chemical processes.</td></tr>
</table>

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

1) Components of the model
   a) To make sense of a given phenomenon, students develop a model in which they identify the relevant components for a given chemical reaction, including:
      i) The types and number of molecules that make up the reactants.
      ii) The types and number of molecules that make up the products.
2) Relationships
   a) In the model, students describe relationships between the components, including:
      i) Each molecule in each of the reactants is made up of the same type(s) and number of atoms.
      ii) When a chemical reaction occurs, the atoms that make up the molecules of reactants rearrange and form new molecules (i.e., products).
      iii) The number and types of atoms that make up the products are equal to the number and types of atoms that make up the reactants.
      iv) Each type of atom has a specific mass, which is the same for all atoms of that type.
3) Connections
   a) Students use the model to describe that the atoms that make up the reactants rearrange and come together in different arrangements to form the products of a reaction.
   b) Students use the model to provide a causal account that mass is conserved during chemical reactions because the number and types of atoms that are in the reactants equal the number and types of atoms that are in the products, and all atoms of the same type have the same mass regardless of the molecule in which they are found.

S.8.16. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. * [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

Practices of Scientists and Engineers	Core Science Content
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. Students will undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. **Science Connecting Concepts** **Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system.	**Chemical Reactions** Some chemical reactions release energy, others store energy. **Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary) **Optimizing the Design Solution** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design (secondary). The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary)

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

1) Using scientific knowledge to generate design solutions
   a) Given a problem to solve that requires either heating or cooling, students design and construct a solution (i.e., a device). In their designs, students:
      i) Identify the components within the system related to the design solution, including:
         (1) The components within the system to or from which energy will be transferred to solve the problem.
         (2) The chemical reaction(s) and the substances that will be used to either release or absorb thermal energy via the device.
      ii) Describe how the transfer of thermal energy between the device and other components within the system will be tracked and used to solve the given problem.
2) Describing criteria and constraints, including quantification when appropriate
   a) Students describe the given criteria, including:
      i) Features of the given problem that are to be solved by the device.
      ii) The absorption or release of thermal energy by the device via a chemical reaction.
   b) Students describe the given constraints, which may include:
      i) Amount and cost of materials.
      ii) Safety.
      iii) Amount of time during which the device must function.

3) Evaluating potential solutions
   a) Students test the solution for its ability to solve the problem via the release or absorption of thermal energy to or from the system.
   b) Students use the results of their tests to systematically determine how well the design solution meets the criteria and constraints, and which characteristics of the design solution performed the best.
4) Modifying the design solution
   a) Students modify the design of the device based on the results of iterative testing and improve the design relative to the criteria and constraints.

Earth and Space Science

Topic: Human Impact

S.8.17. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth’s systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Practices of Scientists and Engineers	Core Science Content
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Students will construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	Human Impacts on Earth Systems Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
Science Connecting Concepts	
Cause and Effect Cause and effect relationships may be used to predict phenomena in natural or designed systems. Influence of Science, Engineering, and Technology on Society and the Natural World All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. Science Addresses Questions About the Natural and Material World Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.	

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

1) Supported claims
   a) Students make a claim, to be supported by evidence, to support or refute an explanation or model for a given phenomenon. Students include the following idea in their claim: that increases in the size of the human population and per-capita consumption of natural resources affect Earth systems.
2) Identifying scientific evidence
   a) Students identify evidence to support the claim from the given materials, including:
      i. Changes in the size of human population(s) in a given region or ecosystem over a given timespan.
      ii. Per-capita consumption of resources by humans in a given region or ecosystem over a given timespan.
      iii. Changes in Earth systems in a given region or ecosystem over a given timespan.

    iv. The ways engineered solutions have altered the effects of human activities on Earth's systems.

3) Evaluating and critiquing evidence
   a) Students evaluate the evidence for its necessity and sufficiency for supporting the claim.
   b) Students determine whether the evidence is sufficient to determine causal relationships between consumption of natural resources and the impact on Earth systems.
   c) Students consider alternative interpretations of the evidence and describe why the evidence supports the claim they are making, as opposed to any alternative claims.
4) Reasoning and synthesis
   a) Students use reasoning to connect the evidence and evaluation to the claim. In their arguments, students describe a chain of reasoning that includes:
      i) Increases in the size of the human population or in the per-capita consumption of a given population cause increases in the consumption of natural resources.
      ii) Natural resource consumption causes changes in Earth systems.
      iii) Because human population growth affects natural resource consumption and natural resource consumption has an effect on Earth systems, changes in human populations have a causal role in changing Earth systems.
      iv) Engineered solutions alter the effects of human populations on Earth systems by changing the rate of natural resource consumption or mitigating the effects of changes in Earth systems.

Engineering, Technology, and Applications of Science

Topic: Engineering Design

S.8.18. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. Students will evaluate competing design solutions based on jointly developed and agreed-upon design criteria.</td><td rowspan="3">Developing Possible Solutions
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td></td></tr>
</table>

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

1) Identifying the given design solution and associated claims and evidence
   a) Students identify the given supported design solution.
   b) Students identify scientific knowledge related to the problem and each proposed solution.
   c) Students identify how each solution would solve the problem.
2) Identifying additional evidence
   a) Students identify and describe additional evidence necessary for their evaluation, including:
      i) Knowledge of how similar problems have been solved in the past.
      ii) Evidence of possible societal and environmental impacts of each proposed solution.
   b) Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.
3) Evaluating and critiquing evidence
   a) Students use a systematic method (e.g., a decision matrix) to identify the strengths and weaknesses of each solution. In their evaluation, students:
      i) Evaluate each solution against each criterion and constraint.
      ii) Compare solutions based on the results of their performance against the defined criteria and constraints.
   b) Students use the evidence and reasoning to make a claim about the relative effectiveness of each proposed solution based on the strengths and weaknesses of each.

S.8.19. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Practices of Scientists and Engineers	Core Science Content
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.	Developing Possible Solutions A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. Models of all kinds are important for testing solutions. Optimizing the Design Solution The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.
Science Connecting Concepts	

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

1) Components of the model
   a) Students develop a model in which they identify the components relevant to testing ideas about the designed system, including:
      i) The given problem being solved, including criteria and constraints.
      ii) The components of the given proposed solution (e.g., object, tools, or process), including inputs and outputs of the designed system.
2) Relationships
   a) Students identify and describe the relationships between components, including:
      i) The relationships between each component of the proposed solution and the functionality of the solution.
      ii) The relationship between the problem being solved and the proposed solution.
      iii) The relationship between each of the components of the given proposed solution and the problem being solved.
      iv) The relationship between the data generated by the model and the functioning of the proposed solution.
3) Connections
   a) Students use the model to generate data representing the functioning of the given proposed solution and each of its iterations as components of the model are modified.
   b) Students identify the limitations of the model with regards to representing the proposed solution.
   c) Students describe how the data generated by the model, along with criteria and constraints that the proposed solution must meet, can be used to optimize the design solution through iterative testing and modification.

David L. Roach
West Virginia Superintendent of Schools