Grade 6 Science-Technology-Engineering

Introduction: The diocesan Science-Technology-Engineering curriculum guidelines are adapted from the Next Generation Science Standards (NGSS) [http://www.nextgenscience.org/] and are based on the 2016 MA Science & Technology/Engineering Framework (MA STE) [available: http://www.doe.mass.edu/frameworks/current.html] Both of these resources should be explored since they include a wealth of information beyond the standards. As in the MA STE, the content of grades 6-8 is integrated across disciplines. The benefits of this arrangement are summarized in *The Case for an Integrated Approach for Pre-K-8,* Appendix V, of the MA STE [available along with other resources at http://www.doe.mass.edu/stem/review.html] The order of the standards within each grade does not imply a recommended instructional sequence. The diocesan guidelines use the same numbering system for the standards in order to facilitate searches for lessons and other resources. "Assessment boundaries" indicate what may be included on future MCAS tests and are included here since they frequently offer further clarification of the performance expectations at that level. "Not included from NGSS", "Clarification statements" and the set of standards themselves are not intended to be restrictive in any way. A standard followed by an asterisk "*" indicates an engineering design practice.

Grades 6–8: Overview of Science and Engineering Practices

Active engagement of middle school students with the science and engineering practices is critical: students generally make up their minds about whether they identify with science and engineering by the time they leave grade 8, 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 to engage in scientific and technical reasoning so critical to success in civic life, postsecondary education, and careers. Inclusion of science and engineering practices in standards only speaks 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.

Standards for grades 6 through 8 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:

1. Define criteria and constraints 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 through 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.
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 those outlined above should be reflected in curricula and instruction that engage students in an integrated use of the practices.

Grade 6 Focus – Structure and Function

The integration of Earth and space, life, and physical sciences with technology/engineering gives grade 6 students relevant and engaging opportunities with natural phenomena and design problems that highlight the relationship of structure and function in the world around them. Students relate structure and function through analyzing the macro- and microscopic world, such as Earth features and processes, the role of cells and anatomy in supporting living organisms, and properties of materials and waves. Students use models and provide evidence to make claims and explanations about structure-function relationships in different STE domains.

Grade 6: Earth and Space Sciences

ESS1. Earth's Place in the Universe

Students who demonstrate understanding can:

6.MS-ESS1-1a. Develop and use a model of the Earth-Sun-Moon system to explain the causes of lunar phases and eclipses of the Sun and Moon.

Clarification Statement: Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.

6.MS-ESS1-4. Analyze and interpret rock layers and index fossils to determine the relative ages of rock formations that result from processes occurring over long periods of time.

Clarification Statements: Analysis includes laws of superposition and crosscutting relationships limited to minor displacement faults that offset layers. Processes that occur over long periods of time include changes in rock types through weathering, erosion, heat, and pressure.

Assessment Boundary: Strata sequences that have been reordered or overturned, names of specific periods or epochs and events within them, or the identification and naming of minerals or rock types are not expected in state assessment.

6.MS-ESS1-5(MA). Use graphical displays to illustrate that Earth and its solar system are one of many in the Milky Way galaxy, which is one of billions of galaxies in the universe.

Clarification Statement: Graphical displays can include maps, charts, graphs, and data tables.

Found in grade 8: MS-ESS1-1b. Develop and use a model of the Earth-Sun system to explain the cyclical pattern of seasons, which includes Earth's tilt and differential intensity of sunlight on different areas of Earth across the year. 8.MS-ESS1-2. Explain the role of gravity in ocean tides, the orbital motions of planets, their moons, and asteroids in the solar system.

Not included from NGSS: MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.

ESS2. Earth's Systems

6.MS-ESS2-3. Analyze and interpret maps showing the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence that Earth's plates have moved great distances, collided, and spread apart.

Clarification Statement: Maps may show similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches), similar to Wegener's visuals.

Assessment Boundary: Mechanisms for plate motion or paleomagnetic anomalies in oceanic and continental crust are not expected in state assessment.

Found in grade 7: 7.MS-ESS2-2. Construct an explanation based on evidence for how Earth's surface has changed over scales that range from local to global in size. 7.MS-ESS2-4. Develop a model to explain how the energy of the Sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere.

Found in grade 8: MS-ESS2-1. Use a model to illustrate that energy from Earth's interior drives convection that cycles Earth's crust, leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building, and active volcanic chains. MS-ESS2-5. Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to local weather. MS-ESS2-6. Describe how interactions involving the ocean affect weather and climate on a regional scale, including the influence of the ocean temperature as mediated by energy input from the Sun and energy loss due to evaporation or redistribution via ocean currents.

Grade 6: 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).

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 that work together as body systems. Body systems to be included are the circulatory, digestive, respiratory, excretory, muscular/skeletal, and nervous systems. Essential functions of life include obtaining food and other nutrients (water, oxygen, minerals), releasing energy from food, removing wastes, responding to stimuli, maintaining internal conditions, and growing/developing. An example of interacting systems could include the respiratory system taking in oxygen from the environment which the circulatory system delivers to cells for cellular respiration, or the digestive system taking in nutrients which the circulatory system transports to cells around the body.

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.

Found in grade 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.

Found in grade 8: MS-LS1-5. Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms. 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.

Not included from NGSS: MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

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.

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.

Found in grade 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. 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.

Not included from NGSS: MS-LS4-3. 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. MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Grade 6: Physical Science

PS1. Matter and Its Interactions

6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release or absorption of thermal energy.

Clarification Statements: Emphasis is on describing transfer of energy to and from the environment. Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.

6.MS-PS1-7(MA). Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Apply proportional reasoning to describe, calculate, and compare relative densities of different materials.

6.MS-PS1-8(MA). Conduct an experiment to show that many materials are mixtures of pure substances that can be separated by physical means into their component pure substances.

Clarification Statement: Examples of common mixtures include salt water, oil and vinegar, milk, and air.

Found in grade 8: MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances. MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS1-4. Develop a model that describes and predicts changes in particle motion, relative spatial arrangement, temperature, and state of a pure substance when thermal energy is added or removed. MS-PS1-5. Use a model to explain that atoms are rearranged during a chemical reaction to form new substances with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved.

Not included from NGSS: MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

PS2. Motion and Stability: Forces and Interactions

6.MS-PS2-4. Use evidence to support the claim that gravitational forces between objects are attractive and are only noticeable when one or both of the objects have a very large mass.

Clarification Statement: Examples of objects with very large masses include the Sun, Earth, and other planets.

Assessment Boundary: Newton's law of gravitation or Kepler's laws are not expected in state assessment.

Found in grade 7: MS-PS2-3. Analyze data to describe the effect of distance and magnitude of electric charge on the strength of electric forces. MS-PS2-5. Use scientific evidence to argue that fields exist between objects with mass, between magnetic objects, and between electrically charged objects that exert force on each other even though the objects are not in contact.

Found in grade 8: MS-PS2-1. Develop a model that demonstrates Newton's third law involving the motion of two colliding objects. MS-PS2-2. Provide evidence that the change in an object's speed depends on the sum of the forces on the object (the net force) and the mass of the object.

PS4. Waves and Their Applications in Technologies for Information Transfer

6.MS-PS4-1. Use diagrams of a simple wave to explain that (a) a wave has a repeating pattern with a specific amplitude, frequency, and wavelength, and (b) the amplitude of a wave is related to the energy of the wave.

Assessment Boundaries: Electromagnetic waves are not expected in state assessment. State assessment will be limited to standard repeating waves.

6.MS-PS4-2. Use diagrams and other models to show that both light rays and mechanical waves are reflected, absorbed, or transmitted through various materials.

Clarification Statements: Materials may include solids, liquids, and gases. Mechanical waves (including sound) need a material (medium) through which they are transmitted. Examples of models could include drawings, simulations, and written descriptions.

Assessment Boundary: State assessment will be limited to qualitative applications.

6.MS-PS4-3. Present qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses representing 0s and 1s) can be used to encode and transmit information.

Assessment Boundary: Binary counting or the specific mechanism of any given device are not expected in state assessment.

Grade 6: Technology/Engineering

ETS1. Engineering Design

6.MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.*

6.MS-ETS1-5(MA). Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.*

Clarification Statements: Examples of visual representations can include sketches, scaled drawings, and orthographic projections. Examples of scale can include ¼" = 1'0" and 1 cm = 1 m.

6.MS-ETS1-6(MA). Communicate a design solution to an intended user, including design features and limitations of the solution.

Clarification Statement: Examples of intended users can include students, parents, teachers, manufacturing personnel, engineers, and customers.

Found in grade 7: MS-ETS1-2. Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution. MS-ETS1-4. Generate and analyze data from iterative testing and modification of a proposed object, tool, or process to optimize the object, tool, or process for its intended purpose.* MS-ETS1-7(MA). Construct a prototype of a solution to a given design problem.**

Not included from NGSS: MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

ETS2. Materials, Tools, and Manufacturing

6.MS-ETS2-1(MA). Analyze and compare properties of metals, plastics, wood, and ceramics, including flexibility, ductility, hardness, thermal conductivity, electrical conductivity, and melting point.

6.MS-ETS2-2(MA). Given a design task, select appropriate materials based on specific properties needed in the construction of a solution.*

Clarification Statement: Examples of materials can include metals, plastics, wood, and ceramics.

6.MS-ETS2-3(MA). Choose and safely use appropriate measuring tools, hand tools, fasteners, and common hand-held power tools used to construct a prototype.*

Clarification Statements: Examples of measuring tools include a tape measure, a meter stick, and a ruler. Examples of hand tools include a hammer, a screwdriver, a wrench, and pliers. Examples of fasteners include nails, screws, nuts and bolts, staples, glue, and tape. Examples of common power tools include jigsaw, drill, and sander.

Found in grade 8: MS-ETS2-4(MA). Use informational text to illustrate that materials maintain their composition under various kinds of physical processing; however, some material properties may change if a process changes the particulate structure of a material. MS-ETS2-5(MA). Present information that illustrates how a product can be created using basic processes in manufacturing systems, including forming, separating, conditioning, assembling, finishing, quality control, and safety. Compare the advantages and disadvantages of human vs. computer control of these processes.