Grade 8 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 8 Focus – Cause and Effect

Grade 8 students use more robust abstract thinking skills to explain causes of complex phenomena and systems. Many causes are not immediately or physically visible to students. An understanding of cause and effect of key natural phenomena and designed processes allows students to explain patterns and make predictions about future events. In grade 8 these include, for example, causes of seasons and tides; causes of plate tectonics and weather or climate; the role of genetics in reproduction, heredity, and artificial selection; and how atoms and molecules interact to explain the substances that make up the world and how materials change. Being able to analyze phenomena for evidence of causes and processes that often cannot be seen, and being able to conceptualize and describe those, is a significant outcome for grade 8 students.

Grade 8: Earth and Space Sciences

ESS1. Earth's Place in the Universe

Students who demonstrate understanding can:

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.

Clarification Statement: Examples of models can be physical or graphical.

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.

Assessment Boundary: Kepler's laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth are not expected in state assessment.

Found in grade 6: 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. 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. 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.

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

8.MS-ESS2-1. Use a model to illustrate that energy from Earth's interior drives convection that cycles Earth's crust, leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building, and active volcanic chains.

Clarification Statement: The emphasis is on large-scale cycling resulting from plate tectonics.

8.MS-ESS2-5. Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to local weather.

Clarification Statements: Data includes temperature, pressure, humidity, precipitation, and wind. Examples of patterns can include air masses flow from regions of high pressure to low pressure, and how sudden changes in weather can result when different air masses collide. Data can be provided to students (such as in weather maps, data tables, diagrams, or visualizations) or obtained through field observations or laboratory experiments.

Assessment Boundary: Specific names of cloud types or weather symbols used on weather maps are not expected in state assessment.

8.MS-ESS2-6. Describe how interactions involving the ocean affect weather and climate on a regional scale, including the influence of the ocean temperature as mediated by energy input from the Sun and energy loss due to evaporation or redistribution via ocean currents.

Clarification Statement: A regional scale includes a state or multi-state perspective.

Assessment Boundary: Koppen Climate Classification names are not expected in state assessment.

Found in grade 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.

Found in grade 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. 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.

ESS3. Earth and Human Activity

8.MS-ESS3-1. Analyze and interpret data to explain that the Earth's mineral and fossil fuel resources are unevenly distributed as a result of geologic processes.

Clarification Statement: Examples of uneven distributions of resources can include where petroleum is generally found (locations of the burial of organic marine sediments and subsequent geologic traps), and where metal ores are generally found (locations of past volcanic and hydrothermal activity).

8.MS-ESS3-5. Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.

Clarification Statements: Examples of human activities include fossil fuel combustion, deforestation, and agricultural activity. Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and the rates of human activities.

Found in grade 7: MS-ESS3-2. Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events. MS-ESS3-4. (Merged with MS-ESS3-3) Construct an argument supported by evidence that human activities and technologies can mitigate the impact of increases in human population and per capita consumption of natural resources on the environment.

Grade 8: Life Science

LS1. From Molecules to Organisms: Structures and Processes

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

Clarification Statements: Examples of environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs, such as Great Danes and Chihuahuas. Examples of environmental factors could include drought decreasing plant growth, fertilizer increasing plant growth, and fish growing larger in large ponds than they do in small ponds. Examples of both genetic and environmental factors could include different varieties of plants growing at different rates in different conditions.

Assessment Boundary: Methods of reproduction, genetic mechanisms, gene regulation, biochemical processes, or natural selection are not expected in state assessment.

8.MS-LS1-7. Use informational text to describe that food molecules, including carbohydrates, proteins, and fats, are broken down and rearranged through chemical reactions forming new molecules that support cell growth and/or release of energy.

Assessment Boundary: Specific details of the chemical reaction for cellular respiration, biochemical steps of breaking down food, or the resulting molecules (e.g., carbohydrates are broken down into monosaccharides) are not expected in state assessment.

Found in grade 6: MS-LS1-1. Provide evidence that all organisms (unicellular and multicellular) are made of cells. 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. MS-LS1-3. Construct an argument supported by evidence that the body systems interact to carry out essential functions of life.

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.

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.

LS3. Heredity: Inheritance and Variation of Traits

8.MS-LS3-1. Develop and use a model to describe that structural changes to genes (mutations) may or may not result in changes to proteins, and if there are changes to proteins there may be harmful, beneficial, or neutral changes to traits.

Clarification Statements: An example of a beneficial change to the organism may be a strain of bacteria becoming resistant to an antibiotic. A harmful change could be the development of cancer; a neutral change may change the hair color of an organism with no direct consequence.

Assessment Boundary: Specific changes at the molecular level (e.g., amino acid sequence change), mechanisms for protein synthesis, or specific types of mutations are not expected in state assessment.

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

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

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

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

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

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

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

LS4. Biological Evolution: Unity and Diversity

8.MS-LS4-4. Use a model to describe the process of natural selection, in which genetic variations of some traits in a population increase some individuals' likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations.

Clarification Statements: The model should include simple probability statements and proportional reasoning. Examples of evidence can include Darwin's finches, necks of giraffes, and peppered moths.

Assessment Boundary: Specific conditions that lead to natural selection are not expected in state assessment.

8.MS-LS4-5. Synthesize and communicate information about artificial selection, or the ways in which humans have changed the inheritance of desired traits in organisms.

Clarification Statement: Emphasis is on the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy).

Found in grade 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. MS-LS4-2. Construct an argument using anatomical structures to support evolutionary relationships among and between fossil organisms and modern 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 8: Physical Science

PS1. Matter and Its Interactions

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.

Clarification Statement: Examples of molecular-level models could include drawings, three-dimensional ball and stick structures, and computer representations showing different molecules with different types of atoms.

Assessment Boundary: Valence electrons and bonding energy, the ionic nature of subunits of complex structures, complete depictions of all individual atoms in a complex molecule or extended structure, or calculations of proportions in mixtures are not expected in state assessment.

8.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.

Clarification Statements: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl. Properties of substances include density, melting point, boiling point, solubility, flammability, and odor.

8.MS-PS1-4. Develop a model that describes and predicts changes in particle motion, relative spatial arrangement, temperature, and state of a pure substance when thermal energy is added or removed.

Clarification Statements: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of pure substances could include water, carbon dioxide, and helium.

8.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.

Clarification Statement: Examples of models can include physical models or drawings, including digital forms, that represent atoms.

Assessment Boundary: Use of atomic masses, molecular weights, balancing symbolic equations, or intermolecular forces is not expected in state assessment.

Found in grade 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. 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. 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.

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

8.MS-PS2-1. Develop a model that demonstrates Newton's third law involving the motion of two colliding objects.

Assessment Boundary: State assessment will be limited to vertical or horizontal interactions in one dimension.

8.MS-PS2-2. Provide evidence that the change in an object's speed depends on the sum of the forces on the object (the net force) and the mass of the object.

Clarification Statement: Emphasis is on balanced (Newton's first law) and unbalanced forces in a system, qualitative comparisons of forces, mass, and changes in speed (Newton's second law) in one dimension.

Assessment Boundaries: State assessment will be limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. The use of trigonometry is not expected in state assessment.

Found in grade 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.

Found in grade 7: 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.

Grade 8: Technology/Engineering

ETS2. Materials, Tools, and Manufacturing

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.

Clarification Statements: Examples of physical processing can include cutting, forming, extruding, and sanding. Examples of changes in material properties can include a non-magnetic iron material becoming magnetic after hammering and a plastic material becoming rigid (less elastic) after heat treatment.

8.MS-ETS2-5(MA). Present information that illustrates how a product can be created using basic processes in manufacturing systems, including forming, separating, conditioning, assembling, finishing, quality control, and safety. Compare the advantages and disadvantages of human vs. computer control of these processes.

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