TITLE 210. STATE DEPARTMENT OF EDUCATION
CHAPTER 15. CURRICULUM AND INSTRUCTION

SUBCHAPTER 3. ~~PRIORITY ACADEMIC STUDENT SKILLS~~ OKLAHOMA ACADEMIC STANDARDS

PART 3. PRE-KINDERGARTEN AND KINDERGARTEN

210:15-3-5.6 Science

(a) **Pre-Kindergarten**. Science knowledge is developed through experiences with real animals, plants and objects in the classroom and the environment.

(1) **Science Processes and Inquiry**. The child will investigate and experiment with objects to discover information.

(A) Develops increasing abilities to classify, compare, and contrast objects, events and experiences.

(B) Explores and becomes familiar with simple scientific tools (e.g., magnifying glass, magnet).

(C) Participate in simple experiments to discover information (e.g., bottles of water or homemade telephone to explore vibration and sound, simple scale to determine heavy and light).

(D) Ask questions, make predictions, and communicates observations orally and/or in drawings.

(E) Explores cause and effect (e.g., temperature determines clothing choices).

(2) **Physical Science performance expectation. ~~Standard.~~** The child will investigate and describe objects that can be sorted in terms of their physical properties.

(A) Develops an awareness of the sensory attributes of objects according to taste, smell, hearing, touch, and sight.

(B) Develops an awareness of the properties of some objects (e.g., float-sink, heavy-light, rough-smooth, hard-soft, magnetic-nonmagnetic, solid-liquid, wet-dry).

(C) Observes and describes how objects move (e.g., slide, turn, twirl, roll).

(3) **Life Science performance expectation. ~~Standard.~~** The child will observe and investigate plants and animals.

(A) Develops an awareness of what various plants and animals need for growth.

(B) Demonstrates a beginning awareness of the changes that plants and animals go through during their life (e.g., seed/plant, egg/chicken).

(C) Demonstrates a beginning awareness for the care of the plant and animal life around them.

(4) **Earth Science performance expectation. ~~Standard.~~** The child will investigate and observe the basic concepts of the Earth.

(A) Develops an awareness of the properties of common earth materials (e.g., soil, rocks, water).

(B) Develops an awareness of daily weather (e.g., sunny, cloudy, rainy, snowy, windy, hot, warm, cold).

(C) Develops an awareness of the four seasons (e.g., temperature, weather, appropriate clothing, changing leaves).

(D) Observes and participates in a variety of activities related to preserving the environment.

(b) **Kindergarten**. The Kindergarten Oklahoma Academic Standards for Science include the following domains:

(1) **Physical Science**. Standards for Kindergarten students from the domain of Physical Science include all of the following topics:

(A) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(i) **Performance expectation one (1).** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

(ii) **Performance expectation one (1) – Clarification statement.** Examples of pushes or pulls may include pulling a string attached to an object being pulled; a person pushing an object; a person stopping a rolling ball; and two objects colliding and pushing on each other (e.g. ramps such as blocks or wooden moldings with cars and balls; paper towel threaded on rope or string across the classroom).

(iii) **Performance expectation Two (2).** Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

(iv) **Performance expectation Two (2) – Clarification statement.** Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn and using a rope or string to pull an object.

(B) **Energy**. Standards for students include all of the following performance expectations:

(i) **Performance expectation one (1).** Make observations to determine the effect of sunlight on Earth's surface.

(ii) **Performance expectation one (1) – Clarification statement.** Examples of Earth’s surface could include sand, soil, rocks, and water. Examples can extend beyond natural objects on Earth’s surface to include man-made objects such as plastics, asphalt, or concrete.

(iii) **Performance expectation two (2).** Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.

(iv) **Performance expectation two (2) - Clarification statement**. Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.

(2) **Life Science**. Standards for Kindergarten students from the domain of Life Science shall be in the topic of "From molecules to organisms: Structures and processes." Standards for students include all of the following performance expectations:

(1) **Performance expectation one (1).** Use observations to describe patterns of what plants and animals (including humans) need to survive.

(2) **Performance expectation one (1) – Clarification statement.** Examples of patterns could include observations that plants make their own food while animals do not; the

different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.

(3) **Earth and Space Science.** Standards for Kindergarten students from the domain of Earth and Space Science include all of the following topics:

(A) **Earth's systems**. Standards for students include all of the following performance expectations:

(i) **Performance expectation one (1).** Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

(ii) **Performance expectation one (1) – Clarification statement**. Examples of plants and animals changing their environment could include a squirrel digs a hole in the ground to hide its food and tree roots can break concrete, or a dandelion spreading seeds to generate more dandelions.

(B) **Earth and human activity**. Standards for students include all of the following performance expectations:

(i) **Performance expectation one (1)**. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.

(ii) **Performance expectation one (1) – Clarification statement**. Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.

(iii) **Performance expectation two (2)**. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.

(iv) **Performance expectation two (2) – Clarification statement**. Emphasis is on local forms of severe weather and safety precautions associated with that severe weather.

~~Science knowledge is developed through experiences with real animals, plants, and objects in the classroom and the environment.~~

~~(1) **Process Standards**. The student will investigate and experiment with objects to discover information.~~

~~(A) Observes, describes, sorts, and classifies objects according to their common properties (e.g., animals, plants, shells, rocks, buttons).~~

~~(B) Participate in simple experiments to discover information (e.g., bottles of water or homemade telephone to explore vibration and sound, simple scale to determine heavy light).~~

~~(C) Asks questions, makes predictions, and communicates observations orally and/or in drawings.~~

~~(D) Selects and describes simple science tools (e.g., simple magnet, magnifying glass, thermometer.~~

~~(E) Explores cause and effect (e.g., temperature determines clothing choices).~~

~~(2) **Physical Science Standard**. The student will investigate and describe objects that can be sorted in terms of physical properties.~~

~~(A) Observes, describes, sorts, and classifies the sensory attributes of objects according to taste, smell, hearing, touch, and light.~~

~~(B) Describes and compares the properties of some objects (e.g., magnetic-nonmagnetic, float-sink, heavy-light, rough-smooth, hard-soft, solid-liquid, wet-dry).~~

~~(C) Observes and describes how objects move (e.g., slide, turn, twirl, roll).~~

~~(3) **Life Science Standard**. The student will observe and investigate plants and animals.~~

~~(A) Observes and describes what various plants and animals need for growth.~~

~~(B) Observes and describes the changes that plants and animals go through during their life (e.g., seed/plant, egg/chicken).~~

~~(4) **Earth Science Standard**. The student will investigate and observe the basic concepts of the Earth and sky.~~

~~(A) Explores and describes the properties of common earth materials (e.g., soil, rocks, water).~~

~~(B) Observes and describes daily weather (e.g., sunny, cloudy, rainy, snowy, windy, hot, warm, cold).~~

~~(C) Observes and describes characteristics of the four seasons (e.g., temperature, weather, appropriate clothing, changing leaves).~~

~~(D) Describes simple conservation measures used to protect the environment (e.g., recycling, careful use of water).~~

~~(E) Observes and describes characteristics of shadows (e.g, shadow at different times of day).~~

PART 9. SCIENCE

210:15-3-70. Overview and organization of standards

(a) **Introduction.** Science uses observation and experimentation to explain natural phenomena. Science refers to an organized body of knowledge that includes core ideas to the disciplines of science and common themes that bridge the disciplines. The Oklahoma Academic Standards for Science include performance expectations for Kindergarten through grade twelve (12). The performance expectations are arranged by grade levels at grades Kindergarten (K) through grade eight (8), and by course subject at the high school level (grades nine (9) through twelve (12)). The Oklahoma Academic Standards include the integration of scientific and engineering practices with core content from Physical Science, Life Science, and Earth/Space Science. This integrated approach will provide students with a coordinated, coherent understanding of the necessary skills and knowledge to be sufficiently literate citizens.

(b) **Use of the standards.** The standards in this Part and in 210:15-3-5.6 describe the specific areas of student learning that are considered the most important for proficiency in the discipline of science at the particular level and provide a basis for the development of local curricula and statewide assessments. The standards in this Part are not sequenced for instruction and do not prescribe classroom activities, materials, or instructional strategies, approaches, or practices. The standards in this Part are not a curriculum and they do not represent a scope, sequence, or curriculum guide. They provide a framework for schools and teachers to develop an aligned science curriculum. Such curriculum includes instructional units, lessons, and tasks; formative and summative assessments; opportunities for remediation and acceleration; and other selected activities, interventions, and strategies deemed appropriate and meaningful for the academic success of students. Because each of the standards subsumes the knowledge and skills of the other standards, they are designed to be used as a whole. Although material can be added to the standards, using only a portion of the standards will leave gaps in the scientific understanding and practice of students. Standards in this Part are organized into the following components:

(1) **Performance expectations.** Performance expectations represent the things students should know, understand, and be able to do to be proficient in science. Performance expectations are the standards.

(2) **Clarification statements.** Where needed, a clarification statement accompanies a performance expectation. The aim of a clarification statement is to provide further explanation or examples to better support educators in understanding the aim of the performance expectation.

~~(a) The Priority Academic Student Skills (PASS) are organized by Science Process and Inquiry Standards and Content Standards which include Physical Science, Life Science, and Earth/Space Science. They are arranged by grade level at Grades 1-8, and by course subject area at the high school level. Each standard is followed by two or more objectives to accomplish each standard. Students should be provided with science experiences at each grade level from all areas of the content standards. This integrated approach will provide students with a coordinated, coherent understanding of the necessary skills and knowledge of scientifically literate citizens.~~

~~(b) The Oklahoma State Testing Program assesses the Science Priority Academic Student Skills (PASS) with a 5th and 8th grade criterion-referenced test and a Biology I End-of-Instruction Test. All of these state level assessments are based on the standards in this document.~~

~~(c) The objectives presented in the "Science Processes and Inquiry" standards are included at all grade levels, because the understandings and abilities associated with these concepts need to be developed throughout a student's educational experience.~~

~~(d) The content standard areas (physical, life, earth/space) are designed to facilitate conceptual development by building on the content knowledge introduced at the Kindergarten level. Because each of the content standards subsumes the knowledge and skills of the other standards, they are designed to be used as a whole. Although material can be added to the content standards, using only a portion of the standards will leave gaps in the scientific understanding expected of students.~~

210:15-3-70.1 Science standards for grades 1 through 12

~~(a) The science framework presented in this outline is what students should know, understand, and be able to do in the natural sciences. Students combine process and knowledge as they use scientific reasoning and critical thinking to develop their understanding of science. Inquiry builds conceptual bridges between process and scientific knowledge. Relevant use of developmentally appropriate technology facilitates the inquiry process.~~

~~(b) The attainment of scientific literacy is the result of a sequential curriculum that is dependent on quality science teaching at each grade level beginning in prekindergarten. Quality science teaching requires direct, inquiry-oriented learning experiences that emphasize the processes of science and major science concepts. Consistent with national standards, fewer concepts in physical, life and earth/space sciences are explored while more emphasis is placed on in-depth understanding. The following standards provide a framework to achieve the above goals.~~

~~(c) The science standards are not a scope and sequence or a district curriculum guide. They provide a framework for schools to develop an aligned science curriculum and for teachers to develop their own classroom lessons. The science standards in this document were developed based on the National Science Education Standards by the National Research Council (NRC), the Benchmarks for Scientific Literacy by the American Association for the Advancement of Science (AAAS), and the SCIENCE FRAMEWORKS by the National Association for Educational Progress (NAEP). The United States has established a goal for all students to~~

~~achieve scientific literacy. These national publications, developed by science and education experts, will enable the nation and the State of Oklahoma to meet this goal.~~

210:15-3-70.2 Definitions

The following words and terms, when used in this Subchapter, shall have the following meaning, unless the context clearly indicates otherwise:

~~"**Classifying**" classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships.~~

"**Communicating**" ~~communicating is~~ means the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations.

~~"**Experimenting**" experimenting is a method of discovering information. It requires making observations and measurements to test ideas.~~

~~"**Inquiry**" inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to ask a question, formulate a procedure, and observe phenomena.~~

"**Interpreting**" ~~interpreting is~~ means the process of recognizing patterns in collected data by making inferences, predictions, or conclusions.

"**Modeling**" ~~modeling is~~ means the active process of forming a mental or physical representation from data, patterns, or relationships to facilitate understanding and enhance prediction.

"**Observing and measuring**" ~~observing is~~ means the first action taken by the learner to acquire new information about an object or event. Opportunities for observations are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified.

"**Qualitative changes**" ~~qualitative changes refer~~ means changes to any characteristics of, relating to, or involving quality or kind. Examples include texture, color, or odor.

"**Qualitative observations**" ~~qualitative observations describe~~ a description of property such as color, texture, odor, and taste (as appropriate). Qualitative observations utilize descriptive language.

"**Quantitative changes**" ~~quantitative changes can be measured~~ means changes in measurement by quantity or amount. Examples include mass, volume, and temperature.

"**Quantitative observations**" ~~quantitative observations describe~~ means observation and description of the amount of mass, weight, temperature, length, and time. Quantitative observations require the use of numbers.

~~"**Safety**" safety is an essential part of any science activity. Safety in the classroom and care of the environment are individual and group responsibilities.~~

~~"**Serial order**" serial order refers to the task of ordering objects from least to greatest and greatest to least.~~

210:15-3-71. Standards for inquiry, physical, life, and earth/space science for grade 1

(a) **Physical Science.** Standards for first (1st) grade students from the domain of Physical Science shall be in the topic of "Waves and their applications in technology for information transfer." Standards for students include all of the following performance expectations:

(1) **Performance expectation one (1).** Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

(2) **Performance expectation one (1) – Clarification statement**. Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.

(3) **Performance expectation two (2)**. Make observations to construct an evidence-based account that objects can be seen only when illuminated.

(4) **Performance expectation two (2) – Clarification statement**. Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light. This can be explored with light tables, 3-way mirrors, overhead projectors and flashlights.

(5) **Performance expectation three (3)**. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

(6) **Performance expectation three (3) - Clarification statement**. Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).

(7) **Performance expectation four (4)**. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance

(8) **Performance expectation four (4) - Clarification statement**. Examples of devices could include a light source to send signals, paper cup and string "telephones", and a pattern of drumbeats.

(b) **Life Science**. Standards for first (1st) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

(B) **Performance expectation one (1) - Clarification statement**. Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and, detecting intruders by mimicking eyes and ears.

(C) **Performance expectation two (2)**. Read text and use media to determine patterns in behavior of parents and offspring that help offspring survive.

(D) **Performance expectation two (2) – Clarification statement**. Examples of patterns of behaviors could include the signals that offspring make (such as crying, chirping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring). Information may be obtained through observations, media, or text.

(2) **Heredity: Inheritance and variation of traits.** Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

(B) **Performance expectation one (1) - Clarification statement**. Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.

(c) **Earth and Space Science**. Performance expectations for first (1st) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe.** Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use observations of the sun, moon, and stars to describe patterns that can be predicted.

(B) **Performance expectation one (1) - Clarification statement**. Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.

(C) **Performance expectation two (2)**. Make observations at different times of year to relate the amount of daylight and relative temperature to the time of year.

(D) **Performance expectation two (2) – Clarification statement**. Emphasis is on relative comparisons of the amount of daylight and temperature in the winter to the amount in the spring, fall or summer.

(2) **Earth and human activity.** Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

(B) **Performance expectation one (1) - Clarification statement**. Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Observe and measure objects, organisms, and/or events using developmentally appropriate nonstandard units of measurement (e.g., hand, paper clip, book, etc.) and International System of Units (SI) (i.e., meters, centimeters, and degrees Celsius).~~

~~(2) Compare and contrast similar and/or different characteristics in a given set of simple objects, familiar organisms, and/or observable events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Classify a set of simple objects, familiar organisms, and/or observable events by observable properties.~~

~~(2) Arrange simple objects, familiar organisms, and/or observable events in a serial order (e.g., least to greatest, tallest to shortest, etc.).~~

(c) **Process standard - experiment and inquiry**. Experimenting is a method of discovering information. It requires making observations and measurements to test ideas. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to ask a question, formulate a procedure, and observe phenomena. The student will accomplish these objectives to meet this process standard.

(1) Ask a question about objects, organisms, or events in the environment.

(2) Plan and conduct a simple investigation.

(3) Employ simple equipment and tools; such as magnifiers, thermometers, rulers, etc.; to gather data.

(4) Recognize potential hazards and practice safety procedures in all science activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, and other visual representations. The student will accomplish these objectives to meet this process standard.

(1) Interpret pictures, simple bar graphs, and/or tables.

(2) Recognize and describe patterns, then make predictions based on patterns.

(3) Communicate the results of a simple investigation using drawings, tables, graphs, and/or written and oral language.

(e) **Standard - properties of objects and materials**. Characteristics of objects can be described using physical properties such as size, shape, color, or texture. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Objects have properties that can be observed, described, and measured.

(2) Using the five senses, objects can be grouped or ordered by physical properties.

(3) Water can be a liquid or a solid, and can be made to go back and forth from one form to the other.

(f) **Standard - characteristics and basic needs of organisms**. All living things have structures that enable them to function in unique and specific ways to obtain food, reproduce, and survive. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Plants and animals need to take in air, water, and food. In addition, plants need light.

(2) Scientists use the five senses and tools (e.g., magnifiers and rulers) to gather information, such as size and shape about living things.

(g) **Standard - changes of earth and sky**. Observing natural changes of all kinds such as the movement of the sun and variable changes like the weather. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) The sun warms the land, air, and water.

(2) Weather changes from day to day and over the seasons. Weather can be observed by measuring temperature and describing cloud formations.

210:15-3-72. Standards for inquiry, physical, life, and earth/space science for grade 2

(a) **Physical Science.** Performance expectations for second (2nd) grade students from the domain of Physical Science shall be in the topic of "Matter and its interactions." Standards for students include all of the following performance expectations:

(1) **Performance expectation one (1)**. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

(2) **Performance expectation one (1) - Clarification statement**. Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share. Investigations could include ice and snow melting or frozen objects thawing.

(3) **Performance expectation two (2)**. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

(4) **Performance expectation two (2) - Clarification statement**. Examples of properties could include, strength, flexibility, hardness, texture, and absorbency (e.g. paper towels could be utilized to measure absorbency and strength).

(5) **Performance expectation three (3)**. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.

(6) **Performance expectation three (3) - Clarification statement**. Examples of pieces could include blocks, building bricks, or other assorted small objects. Provide students with the same number of objects to create a different object.

(7) **Performance expectation four (4)**. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

(8) **Performance expectation four (4) - Clarification statement**. Demonstrations of reversible changes could include materials such as water, butter or crayons at different temperatures. Demonstrations of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.

(b) **Life Science.** Standards for second (2nd) grade students from the domain of Life Science include all of the following topics:

(1) **Ecosystems: Interactions, energy and dynamics**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Plan and conduct an investigation to determine if plants need sunlight and water to grow.

(B) **Performance expectation one (1) - Clarification statement**. Investigations should be limited to testing one variable at a time.

(C) **Performance expectation two (2)**. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

(D) **Performance expectation two (2) - Clarification statement**. Examples include: placing socks on the outside of students' shoes and walking outside allows socks to gather seeds; plant sock(s) to see what grows; using an eyedropper to move liquids from one container to another emulating hummingbirds or bees pollinating plants.

(2) **Biological unity and diversity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Make observations of plants and animals to compare the diversity of life in different habitats.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the diversity of living things in each of a variety of different habitats. Students could explore different habitats around their school, aquariums, neighborhoods.

(c) **Earth and Space Science**. Standards for first (1st) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

(B) **Performance expectation one (1) - Clarification statement**. Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly.

(2) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

(B) **Performance expectation one (1) - Clarification statement**. Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land. Students could explore these ideas with sand tables or soil and water in large containers.

(C) **Performance expectation two (2)**. Develop a model to represent the shapes and kind of land and bodies of water in an area.

(D) **Performance expectation two (2) - Clarification statement**. E.g., Maps show where things are located. One can map the shapes and kinds of land and water in any area.

(E) **Performance expectation three (3)**. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

(F) **Performance expectation three (3) - Clarification statement**. E.g., Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and liquid form.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Observe and measure objects, organisms, and/or events using developmentally appropriate nonstandard units of measurement (e.g., inches, feet, year, degrees Fahrenheit) and International System of Units (SI) (i.e., meters, centimeters, grams, and degrees Celsius).~~

~~(2) Compare and contrast similar and/or different characteristics in a given set of simple objects, familiar organisms and/or observable events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Classify a set of simple objects, familiar organisms, and/or observable events by observable properties (e.g., graphic organizers, t-charts, tables, Venn diagrams).~~

~~(2) Arrange simple objects, familiar organisms, and/or observable events in a serial order (e.g., least to greatest, tallest to shortest,).~~

(c) **Process standard - experiment and inquiry**. Experimenting is a method of discovering information. It requires making observations and measurements to test ideas. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to ask a question, formulate a procedure, and observe phenomena. The student will accomplish these objectives to meet this process standard.

(1) Ask a question about objects, organisms, or events in the environment.

(2) Plan and conduct a simple investigation.

(3) Employ simple equipment and tools (e.g., magnifiers, thermometers, rulers) to gather data.

(4) Recognize potential hazards and practice safety procedures in all science activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, and other visual representations. The student will accomplish these objectives to meet this process standard.

(1) Interpret pictures, simple bar graphs, and/or tables.

(2) Recognize and describe patterns, then make predictions based on patterns.

(3) Communicate the results of a simple investigation using drawings, tables, graphs, and/or written and oral language.

(e) **Standard - properties and interactions of objects and materials**. Characteristics of objects can be described using physical properties such as size, shape, color, texture, or magnetism. Interactions change the position and motion of objects. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Objects can be described in terms of the materials of which they are made. Physical properties of materials can be changed by tearing, sifting, sanding, or pounding.

(2) Motion and interaction of objects can be observed in toys and playground activities.

(3) Magnets attract and repel each other and certain other materials. Magnetic force passes through materials such as paper, glass, and water.

(f) **Standard - life cycles and organisms**. Life cycles represent the stages an organism passes through from its own birth to the birth of the next generation. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Plants and animals have life cycles that include developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.

(2) Plants and animals often have characteristics similar to their parents.

(g) **Standard - properties and changes of earth and sky**. Earth materials consist of rocks, soils, water, and air. The sun appears to move across sky in the same way every day. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Earth materials have different properties and serve as natural resources that sustain plant and animal life.

(2) The size and shape of shadows change at different times of the day.

210:15-3-73. Standards for inquiry, physical, life, and earth/space science for grade 3

(a) **Physical Science**. Standards for third (3rd) grade students from the domain of Physical Science include all of the following topics:

(1) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Plan and conduct investigations on the effects of balanced and unbalanced forces on the motion of an object.

(B) **Performance expectation one (1) - Clarification statement**. Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.

(C) **Performance expectation two (2)**. Make observations and/or measurements of the object's motion to provide evidence that a pattern can be used to predict future motion.

(D) **Performance expectation two (2) - Clarification statement**. Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.

(E) **Performance expectation three (3)**. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

(F) **Performance expectation three (3) - Clarification statement**. Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.

(G) **Performance expectation four (4)**. Define a simple design problem that can be solved by applying scientific ideas about magnets.

(H) **Performance expectation four (4) - Clarification statement**. Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.

(b) **Life Science.** Standards for third (3rd) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

(B) **Performance expectation one (1) - Clarification statement**. Changes different organisms go through during their life form a pattern.

(2) **Ecosystems: Interactions, energy and dynamics**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct an argument that some animals form groups that help members survive.

(B) **Performance expectation one (1) - Clarification statement**. Arguments could include examples of group behavior such as division of labor in a bee colony, flocks of

birds staying together to confuse or intimidate predators, or wolves hunting in packs to more efficiently catch and kill prey.

(3) **Heredity: Inheritance and variation of traits**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

(B) **Performance expectation one (1) - Clarification statement**. Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.

(C) **Performance expectation two (2)**. Use evidence to support the explanation that traits can be influenced by the environment.

(D) **Performance expectation two (2) - Clarification statement**. Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; a pet dog that is given too much food and little exercise may become overweight; and animals who teach their offspring skills like hunting.

(4) **Biological: Unity and diversity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.

(C) **Performance expectation two (2)**. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving and reproducing.

(D) **Performance expectation two (2) - Clarification statement**. Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.

(E) **Performance expectation three (3)**. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

(F) **Performance expectation three (3) - Clarification statement**. Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.

(G) **Performance expectation four (4)**. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change

(H) **Performance expectation four (4) - Clarification statement**. Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.

(c) **Earth and Space Science**. Standards for third (3rd) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data at this grade level could include average temperature, precipitation, and wind direction.

(C) **Performance expectation two (2)**. Obtain and combine information to describe climates in different regions of the world.

(D) **Performance expectation two (2) – Clarification statement**. N/A

(2) **Earth and human activity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

(B) **Performance expectation one (1) - Clarification statement**. Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, tornado shelters and lighting rods.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Observe and measure objects, organisms, and/or events using developmentally appropriate International System of Units (SI) (i.e., meters, centimeters, grams, and degrees Celsius).~~

~~(2) Compare and contrast similar and/or different characteristics in a given set of simple objects, familiar organisms, and/or observable events.~~

~~(b) **Process standard - classify. Classifying establishes order**. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Classify a set of simple objects, familiar organisms, and/or observable events by observable properties (e.g., graphic organizers, t charts, tables, Venn diagrams).~~

~~(2) Arrange simple objects, familiar organisms, and/or observable events in a serial order (e.g., least to greatest, order of steps, smallest to largest).~~

~~(c) **Process standard - experiment and inquiry**. Experimenting is a method of discovering information. It requires making observations and measurements to test ideas. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to ask a question, formulate a procedure, and observe phenomena. The student will accomplish these objectives to meet this process standard.~~

~~(1) Ask a question about objects, organisms, or events in the environment.~~

~~(2) Plan and conduct a simple investigation.~~

~~(3) Employ simple equipment and tools (e.g., magnifiers, thermometer, rulers) to gather data.~~

~~(4) Recognize potential hazards and practice safety procedures in all science activities.~~

~~(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.~~

~~(1) Interpret tables, pictorial, and/or simple bar graphs.~~

~~(2) Recognize and describe patterns, then make predictions based on patterns.~~

~~(3) Communicate the results of a simple investigation using drawings, tables, graphs, and/or written and oral language.~~

~~(e) **Standard - properties of objects and materials**. Characteristics of objects that describe physical properties such as size, shape, color, or texture. Vibration of materials causes sound. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Objects can be described in terms of the materials of which they are made. Mixtures and solutions can be separated (i.e., sand and marbles, salt and water).~~

~~(2) Sound is produced by vibrations (i.e., pitch, a loudness).~~

~~(3) Sound travels through air, water, and/or solids.~~

~~(f) **Standard - characteristics and basic needs of organisms and environments**. All living things have structures that enable them to function in unique and specific ways to obtain food, reproduce, and survive. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Plants and animals have features (i.e., breathing structures, limbs, skin covering, seed dispersal, roots, stems, leaves) that help them live in different environments such as air, water, or land.~~

~~(2) Each plant or animal has different structures that serve different functions in growth and survival (i.e., the way it moves, type of food it needs, where it lives).~~

~~(3) All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.~~

~~(A) The primary source of energy in a food chain is the sun.~~

~~(B) Animals can be classified by the type of food that they eat.~~

~~(g) **Standard - properties of earth materials**. Earth materials consist of rocks, soils, water, and air. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Rocks and minerals have similarities and differences (i.e., size of particles, color pattern, layering).~~

~~(2) Soils have properties of color and texture, capacity to retain water, and ability to support the growth on many kinds of plants and animals, including those in our food supply.~~

~~(3) Earth exerts a force called gravity which attracts objects, pulling them toward Earth's center.~~

210:15-3-74. Standards for inquiry, physical, life, and earth/space science for grade 4

(a) **Physical Science**. Standards for fourth (4th) grade students from the domain of Physical Science include all of the following topics:

(1) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

(B) **Performance expectation one (1) - Clarification statement**. Energy can be moved from place to place by moving objects or through sound, light, or electric currents. At this grade level, no attempt is made to give a precise or complete definition of energy.

(C) **Performance expectation two (2)**. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

(D) **Performance expectation two (2) - Clarification statement**. When energy is transferred it can stay in the same form, change forms, or both. Examples of this can include a moving arm throwing a baseball, the light from the sun warming a windowpane, and two moving objects colliding and changing their motion.

(E) **Performance expectation three (3)**. Ask questions and predict outcomes about the changes in energy that occur when objects collide.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.

(G) **Performance expectation four (4)**. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

(H) **Performance expectation four (4) - Clarification statement**. Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat, mousetrap cars, rubber band-powered vehicles. Examples of constraints could include the materials, cost, or time to design the device.

(1) **Waves and their applications in technologies for information transfer**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model of waves to describe patterns in terms of amplitude and wavelength and to show that waves can cause objects to move.

(B) **Performance expectation one (1) - Clarification statement**. Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves. Examples of wave patterns could include the vibrating patterns associated with sound; the vibrating patterns of seismic waves produced by earthquakes.

(C) **Performance expectation two (2)**. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

(D) **Performance expectation two (2) – Clarification statement**. N/A

(E) **Performance expectation three (3)**. Generate and compare multiple solutions that use patterns to transfer information.

(F) **Performance expectation three (3) - Clarification statement**. Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, QR codes, barcodes, and using Morse code to send text.

(b) **Life Science.** Standards for fourth (4th) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

(B) **Performance expectation one (1) - Clarification statement**. Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.

(C) **Performance expectation two (2)**. Use a model to describe that animals' receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on systems of information transfer. Examples of response to stimuli include animals running from predators and plant leaves turning toward the sun.

(c) **Earth and Space Science**. Standards for fourth (4th) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

(B) **Performance expectation one (1) - Clarification statement**. Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.

(2) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Plan and conduct investigations on the effects of water, ice, wind, and vegetation on the relative rate of weathering and erosion.

(B) **Performance expectation one (1) - Clarification statement**. Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.

(C) **Performance expectation two (2)**. Analyze and interpret data from maps to describe patterns of Earth’s features.

(D) **Performance expectation two (2) - Clarification statement**. Maps can include topographic maps of Earth’s land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.

(3) **Earth and human activity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Obtain and combine information to describe that energy and fuels are derived from renewable and non-renewable resources and how their uses affect the environment.

(B) **Performance expectation one (1) - Clarification statement**. Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of

environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.

(C) **Performance expectation two (2)**. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

(D) **Performance expectation two (2) - Clarification statement**. Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Observe and measure objects, organisms, and/or events (e.g., mass, length, time, volume, temperature) using International System of Units (SI) (i.e., grams, milligrams, meters, millimeters, centimeters, kilometers, liters, milliliters, and degrees Celsius).~~

~~(2) Compare and/or contrast similar and/or different characteristics (e.g., color, shape, size, texture, sound, position, change) in a given set of objects organisms or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Classify a set of objects, organisms, and/or events using two or more observable properties (e.g., simple dichotomous keys).~~

~~(2) Arrange objects, organisms, and/or events in serial order (e.g., least to greatest, fastest to slowest).~~

~~(c) **Process standard - experiment**. Experimenting is a method of discovering information. It requires making observations and measurements to test ideas. The student will accomplish these objectives to meet this process standard.~~

~~(1) Ask questions about the world and formulate an orderly plan to investigate a question.~~

~~(2) Evaluate the design of a scientific investigation.~~

~~(3) Design and conduct a scientific investigation.~~

~~(4) Recognize potential hazards and practice safety procedures in all science investigations.~~

~~(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.~~

~~(1) Report data using tables, line, bar, trend, and/or simple circle graphs.~~

~~(2) Interpret data tables, line, bar, trend and/or simple circle graphs.~~

~~(3) Make predictions based on patterns in experimental data.~~

~~(4) Communicate the results of investigations and/or give explanations based on data.~~

~~(e) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to ask a question, formulate a procedure, and observe phenomena. The student will accomplish these objectives to meet this process standard.~~

~~(1) Use different ways to investigate questions and evaluate the fairness of the test.~~

(2) Use a variety of measurement tools and technology.

(3) Formulate a general statement to represent the data.

(4) Share results of an investigation in sufficient detail so that data may be combined with data from other students and analyzed further.

(f) **Standard - position and motion of objects**. The position of a moving object can be described relative to a stationary object or background. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

(2) The motion of an object can be described by tracing and measuring its position over time.

(g) **Standard - electricity**. Energy - Energy is the ability to do work or to cause a change in matter. Forms of energy include electricity, heat (thermal), light and sound. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Electricity is the flow of electrical power or charge.

(A) The flow of electricity is controlled by open and closed circuits.

(B) Some materials are conductors of electricity while others are insulators.

(2) Heat results when substances burn, when certain kinds of materials rub against each other, and when electricity flows through wires.

(A) Metals are good conductors of heat and electricity.

(B) Increasing the temperature of any substance requires the addition of heat energy.

(3) Light is a form of energy made of electromagnetic waves.

(A) Light waves travel in a straight line.

(B) Substances may cause light waves to change direction of travel (e.g., reflection, refraction).

(4) Sound is a form of energy caused by waves of vibrations that spread from the energy source.

(h) **Standard - characteristics of organisms**. Each type of organism has structures that enable it to function in unique and specific ways to obtain food, reproduce and survive. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Organisms can survive only in environments in which their needs can be met (e.g., food, shelter, air, reproduction, and water).

(2) Living organisms may be grouped by various characteristics or by the environment in which they live (e.g., habitats, anatomy, behaviors).

(3) Many observable characteristics of an organism are inherited from the parents of the organisms (e.g., color of flowers, number of limbs on an animal).

(4) Energy from the sun is passed to organisms through food chains.

(i) **Standard - properties of earth and moon**. The earth and its moon have specific properties. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Earth materials consist of rocks, soils, water, and air.

(2) The processes of erosion, weathering, and sedimentation affect earth materials (e.g., earthquakes, floods, landslides, volcanic eruptions).

~~(3) Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time (e.g., simulating the fromation of fossils).~~
~~(4) The observable shape of the moon changes from day to day in a cycle that lasts about a month.~~

210:15-3-75. Standards for inquiry, physical, life, and earth/space science for grade 5

(a) **Physical Science**. Standards for fifth (5th) grade students from the domain of Physical Science include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to describe that matter is made of particles too small to be seen.

(B) **Performance expectation one (1) - Clarification statement**. Examples of evidence that could be utilized in building models include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.

(C) **Performance expectation two (2)**. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

(D) **Performance expectation two (2) - Clarification statement**. Examples of reactions or changes could include phase changes, dissolving, and mixing that forms new substances.

(E) **Performance expectation three (3)**. Make observations and measurements to identify materials based on their properties.

(F) **Performance expectation three (3) - Clarification statement**. Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.

(G) **Performance expectation four (4)**. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

(H) **Performance expectation four (4) - Clarification statement**. Examples of interactions forming new substances can include mixing baking soda and vinegar. Examples of interactions not forming new substances can include mixing baking soda and water.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Support an argument that the gravitational force exerted by the Earth is directed down.

(B) **Performance expectation one (1) - Clarification statement**. "Down" is a local description of the direction that points toward the center of the spherical earth. Earth causes objects to have a force on them that point toward the center of the Earth, “down”. Support for arguments can be drawn from diagrams, evidence, and data that are provided.

(3) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

(B) **Performance expectation one (1) - Clarification statement**. Examples of models could include diagrams, and flow charts.

(b) **Life Science.** Performance expectations for fifth (5th) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Support an argument that plants get the materials they need for growth chiefly from air and water.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.

(2) **Ecosystems: Interactions, energy, and dynamics**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.

(C) **Performance expectation two (2)**. Use models to explain factors that upset the stability of local ecosystems.

(D) **Performance expectation two (2) - Clarification statement**. Factors that upset an ecosystem's stability includes: invasive species, drought, human development, and removal of predators. Models could include simulations, and representations, etc.

(c) **Earth and Space Science**. Performance expectations for fifth (5th) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.

(B**) Performance expectation one (1) - Clarification statement**. N/A

(C) **Performance expectation two (2)**. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

(D) **Performance expectation two (2) - Clarification statement**. Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.

(2) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

(B) **Performance expectation one (1) - Clarification statement**. Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.

(C) **Performance expectation two (2).** Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

(D) **Performance expectation two (2) - Clarification statement**. N/A

(3) **Earth and human activity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1).** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

(B) **Performance expectation one (1) - Clarification statement**. Examples of information might include the use of natural fertilizers or biological pest control by farmers, replanting trees after cutting them by the logging industry, and the institution of recycling programs in cities.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Observe and measure objects, organisms, and/or events (e.g., mass, length, time, volume, temperature) using International System of Units (SI) (i.e., grams, milligrams, meters, millimeters, centimeters, kilometers, liters, milliliters, and degrees Celsius). Measure using tools (e.g., simple microscopes or magnifier, graduated cylinders, gram spring scales, metric rulers, metric balances, and Celsius thermometers).~~

~~(2) Compare and/or contrast similar and/or different characteristics (e.g., color, shape, size, texture, sound, position, change, etc.) in a given set of objects, organisms, or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Classify a set of objects, organisms, and/or events using no more than three observable properties (e.g., dichotomous keys).~~

~~(2) Arrange objects, organisms, and/or events in serial order (e.g., least to greatest, fastest to slowest).~~

~~(c) **Process standard - experiment**. Experimenting is a method of discovering information. It requires making observations and measurements to test ideas. The student will accomplish these objectives to meet this process standard.~~

~~(1) Ask questions about the world and formulate an orderly plan to investigate a question.~~

~~(2) Evaluate the design of a scientific investigation (e.g., order of investigation procedures, number of tested variables).~~

~~(3) Design and conduct a scientific investigation.~~

~~(4) Recognize potential hazards and practice safety procedures in all science investigations.~~

~~(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.~~

(1) Report data using tables, line, bar, trend, and/or simple circle graphs.

(2) Interpret data tables, line, bar, trend, and/or simple circle graphs.

(3) Make predictions based on patterns in experimental data.

(4) Communicate the results of investigations and/or give explanations based on data.

(e) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to ask a question, formulate a procedure, and observe phenomena. The student will accomplish these objectives to meet this process standard.

(1) Use different ways to investigate questions and evaluate the fairness of the test.

(2) Use a variety of measurement tools and technology.

(3) Formulate a general statement to represent the data.

(4) Share results of an investigation in sufficient detail so that data may be combined with data from other students and analyzed further.

(f) **Standard - properties of matter and energy**. Characteristics of objects that describe physical qualities such as size, shape, color, mass, temperature, and texture. Energy can produce changes in properties of objects such as changes in temperature. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Matter has physical properties that can be used for identification (e.g., color, texture, shape).

(2) Physical properties of objects can be observed, described, and measured using tools (e.g., simple microscopes, gram spring scales, metric rulers, metric balances, Celsius thermometers).

(3) Energy can be transferred in many ways (e.g., energy from the Sun to air, water, metal).

(4) Energy can be classified as either potential or kinetic.

(g) **Standard - organisms and environments**. Organisms within a community are dependent on one another and the environment. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Organisms in an ecosystemdepend on each other for food, shelter, and reproduction.

(A) Ecosystems include food chains and food webs.

(B) Relationships exist between consumers, producers, and decomposers within an ecosystem.

(C) Predator and prey relationships affect populations in an ecosystem.

(2) Changes in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species.

(A) Earth's resources can be natural (non-renewable) or man-made (renewable).

(B) The practices of recycling, reusing, and reducing help to conserve Earth's limited resources.

(h) **Standard - structure of earth and the solar system**. Interactions exist between air, water, rocks/soil, and all living things. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers.

(2) Weather exhibits daily and seasonal patterns (i.e., air temperature, basic cloud types - cumulus, cirrus, stratus, and nimbus, wind direction, wind speed, precipitation).

~~(A) Weather measurement tools include the thermometer, barometer, anemometer, and rain gauge.~~

~~(B) Weather maps are used to display current weather and weather predictions.~~

~~(3) Earth is the third planet from the Sun in a system that includes the moon, the Sun, and seven other planets. Pluto is identified as a dwarf planet.~~

~~(A) Most objects in the solar system are in regular and predictable motion (e.g., phases of the moon).~~

~~(B) Objects in the solar system have individual characteristics (e.g., distance from the sun, number of moons, temperature of the object).~~

~~(C) The earth rotates on its axis while making revolutions around the sun.~~

210:15-3-76. Standards for inquiry, physical, life, and earth/space science for grade 6

(a) **Physical Science**. Standards for sixth (6th) grade students from the domain of Physical Science include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. 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.

(B) **Performance expectation one (1) - 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 drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

(B) **Performance expectation one (1) - Clarification statement**. Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.

(C) **Performance expectation two (2)**. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

(D) **Performance expectation two (2) - Clarification statement**. Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.

(3) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.

(C) **Performance expectation two (2)**. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

(E) **Performance expectation three (3)**. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

(F) **Performance expectation three (3) - Clarification statement**. Examples of devices could include an insulated box, a solar cooker, and a styrofoam cup. Care should be taken with devices that concentrate significant amounts of energy (e.g. conduction, convection, and/or radiation).

(G) **Performance expectation four (4)**. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

(H) **Performance expectation four (4) - Clarification statement**. Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.

(b) **Life Science.** Standards for sixth (6th) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living cells, and understanding that living things may be made of one cell or many varied cells.

(C) **Performance expectation two (2)**. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell,

specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall. Other organelles should be introduced while covering this concept.

(E) **Performance expectation three (3)**. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.

(G) **Performance expectation four (4)**. 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.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on tracing movement of matter and flow of energy.

(2) **Ecosystems: Interactions, energy, and dynamics**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.

(C) **Performance expectation two (2)**. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial (e.g., competition, predation, parasitism, commensalism, mutualism).

(E) **Performance expectation three (3)**. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

(G) **Performance expectation four (4)**. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.

(I) **Performance expectation five (5)**. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

(J) **Performance expectation five (5) – Clarification statement**. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

(c) **Earth and Space Science**. Standards for sixth (6th) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

(2) **Earth and human activity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

(B) **Performance expectation one (1) - Clarification statement**. Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative and/or quantitative changes given conditions (e.g., temperature, mass, volume, time, position, length,) before, during, and after an event.~~

~~(2) Use appropriate tools (e.g., metric ruler, graduated cylinder, thermometer, balances, spring scales, stopwatches, computers, handheld data collection devices) to measure objects, organisms, and/or events.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds), and SI prefixes (i.e. milli , centi , and kilo) when measuring objects, organisms and/or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Using observable properties, place an object, organism, and/or event into a classification system (e.g., dichotomous keys, periodic table, biological hierarchy).~~

~~(2) Identify properties by which a set of objects, organisms, or events could be ordered.~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

~~(1) Ask questions about the world and design investigations that lead to scientific inquiry. Identify testable questions based on prior knowledge, background research, or observations.~~

~~(2) Evaluate the design of a scientific investigation.~~

~~(3) Identify variables and/or controls in an experimental setup: independent variable and dependent variable.~~

(4) Identify a testable hypothesis for an experiment.

(5) Follow a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

(6) Recognize potential hazards and practice safety procedures in all science activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.

(1) Report and record both quantitative/qualitative data in an appropriate method when given an experimental procedure or data.

(2) Interpret data tables, line, bar, trend, and/or circle graphs.

(3) Evaluate data to develop reasonable explanations and/or predictions.

(4) Determine if results of investigations support or do not support hypotheses.

(5) Communicate scientific processes, procedures, and conclusions (e.g., model, poster, diagram, journal entry, lab report, scientific paper, oral presentation, digital presentation).

(e) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific thinking. In order for inquiry to occur students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conclusions based on evidence.The student will accomplish these objectives to meet this process standard.

(1) Ask questions that can be answered through scientific investigation.

(2) Design and conduct experiments utilizing scientific processes.

(3) Use the engineering design process to address a problem or need (e.g., identify a need, conduct background research, prepare preliminary designs, build and test a prototype, test and revise design, communicate results).

(4) Understand the value of technology and use technology to gather data and analyze results of investigations (e.g., probes, handheld digital devices, digital cameras, software, computers, calculators, digital balances, GPS).

(5) Develop a logical relationship between evidence and explanation to form and communicate a valid conclusion and then suggest alternative explanations.

(f) **Standard - physical properties in matter**. Physical characteristics of objects can be described using shape, size, and mass whereas the materials from which objects are made can be described using color and texture. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, and texture). Changes in physical properties of objects can be observed, described, and measured using tools such as simple microscopes, gram spring scales, metric rulers, metric balances, and Celsius thermometers.

(2) The mass of an object is not altered due to changes in shape.

(g) **Standard - transfer of energy**. Change from one form of energy to another. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Energy exists in many forms (e.g., heat, light, electricity, mechanical motion, and sound). Energy can be transferred in various ways (e.g., potential to kinetic, electrical to light, chemical to electrical, mechanical to electrical).

(2) Electrical circuits provide a means of transferring electrical energy when heat, light, and sound are produced (e.g., open and closed circuits, parallel and series circuits).

(3) Electric currents and magnets can exert a force on each other (e.g., direct and alternating currents).

(h) **Standard 3 - structure and function in living systems**. Living systems at all levels of organization demonstrate the complementary nature of structure and function. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Cells are the building blocks of all organisms (both plants and animals). Plant and animal cells have similarities and differences (i.e., nucleus, mitochondria, cell wall, plasma memberane, chloroplast, vacuole).

(2) Living systems are organized by levels of complexity (i.e., cells, organisms, ecosystems).

(i) **Standard - populations and ecosystems**. Populations consist of individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Some source of energy is needed for all organisms to stay alive and grow. Energy transfer can be followed in food chains and webs.

(2) In all environments, organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. Other relationships may be beneficial (e.g., producers/autotrophs, consumers/heterotrophs, symbiosis).

(j) **Standard - structures of the earth and the solar system**. The earth is mostly rock, three-fourths of its surface is covered by a relatively thin layer of water, and the entire planet is surrounded by a relatively thin blanket of air, and is able to support life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Earth has four main systems that interact: the geosphere, the hydrosphere, the atmosphere, and the biosphere.

(A) The geosphere is the portion of the earth system that includes the earth's interior, rocks and minerals, landforms, and the processes that shape the earth's surface.

(B) The hydrosphere is the liquid water component of the earth. Water covers the majority of the earth's surface and circulates through the crust, oceans, and atmosphere in what is known as the water cycle.

(C) The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has a different physical and chemical composition at different elevations.

(D) The biosphere is made up of all that is living on the Earth. It is a life-supporting global ecosystem where living things depend on other organisms and the environment.

(2) The sun provides the light and heat necessary to maintain life on earth and is the ultimate source of energy (i.e., producers receive their energy from the sun).

210:15-3-77. Standards for inquiry, physical, life, and earth/space science for grade 7

(a) **Physical Science**. Standards for seventh (7th) grade students from the domain of Physical Science include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop models to describe the atomic composition of simple molecules and extended structures.

(B) **Performance expectation one (1) - 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.

(C) **Performance expectation two (2).** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

(D) **Performance expectation two (2) – Clarification statement**. Analyze characteristic chemical and physical properties of pure substances. Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

(B) **Performance expectation one (1) - Clarification statement**. Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.

(3) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

(B) **Performance expectation one (1) - Clarification statement**. Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.

(b) **Life Science.** Standards for seventh (7th) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use arguments 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.

(B) **Performance expectation one (1) - 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.

(C) **Performance expectation two (2)**. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

(D) **Performance expectation two (2) - 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.

(E) **Performance expectation three (3)**. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

(F) **Performance expectation three (3) - Clarification statement**. N/A

(2) **Heredity: Inheritance and variation of traits**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. 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.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. Examples: Radiation treated plants, genetically modified organisms (e.g. roundup resistant crops, bioluminescence), mutations both harmful and beneficial.

(C) **Performance expectation two (2)**. 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.

(D) **Performance expectation two (2) - 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.

(3) **Biological unity and diversity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. 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.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.

(C) **Performance expectation two (2)**. 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.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on using simple probability statements and proportional reasoning to construct explanations.

(E) **Performance expectation three (3)**. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

(F) **Performance expectation three (3) - 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.

(G) **Performance expectation four (4)**. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

(H) **Performance expectation four (4) – Clarification statement**. Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

(c) **Earth and Space Science**. Standards for seventh (7th) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

(B) **Performance expectation one (1) - Clarification statement**. Earth's rotation relative to the positions of the moon and sun describes the occurrence of tides; the revolution of Earth around the sun explains the annual cycle of the apparent movement of the constellations in the night sky; the moon's revolution around Earth explains the cycle of spring/neap tides and the occurrence of eclipses; the moon's elliptical orbit mostly explains the occurrence of total and annular eclipses. Examples of models can be physical, graphical, or conceptual.

(C) **Performance expectation two (2)**. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as their school or state).

(E) **Performance expectation three (3)**. Analyze and interpret data to determine scale properties of objects in the solar system.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale

properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.

(2) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).

(C) **Performance expectation two (2)**. Develop and use a model to describe how unequal heating and rotation of the Earth causes patterns of atmospheric and oceanic circulation that determine regional climates.

(D) **Performance expectation two (2) – Clarification statement**. Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation (e.g. el niño/la niña) is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative and/or quantitative changes given conditions (e.g., temperature, mass, volume, time, position, length) before, during, and after an event.~~

~~(2) Use appropriate tools (e.g., metric ruler, graduated cylinder, thermometer, balances, spring scales, stopwatches, computers, handheld data collection devices) when measuring objects, organisms, and/or events.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds), and SI prefixes (i.e., milli , centi , and kilo) when measuring objects, organisms, and/or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Use observable properties to place an object, organism, and/or event into a classification system (e.g., dichotomous keys, periodic table, biological hierarchy).~~

~~(2) Identify properties by which a set of objects, organisms, and/or events could be ordered.~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

(1) Ask questions about the world and design investigations that lead to scientific inquiry. Identify testable questions based on prior knowledge, background research, or observations.

(2) Evaluate the design of a scientific investigation.

(3) Identify variables and/or controls in an experimental setup: independent variable and dependent variable.

(4) Identify a testable hypothesis for an experiment.

(5) Follow a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

(6) Recognize potential hazards and practice safety procedures in all science activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.

(1) Report and record both quantitative/qualitative data in an appropriate method when given an experimental procedure or data.

(2) Interpret data tables, line, bar, trend, and/or circle graphs.

(3) Evaluate data to develop reasonable explanations, and/or predictions.

(4) Determine if results of investigations support or do not support hypotheses.

(5) Communicate scientific processes, procedures, and conclusions (e.g., model, poster, diagram, journal entry, lab report, scientific paper, oral presentation, digital presentation).

(e) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific thinking. In order for inquiry to occur students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conclusions based on evidence. The student will accomplish these objectives to meet this process standard.

(1) Ask questions that can be answered through scientific investigation.

(2) Design and conduct experiments utilizing scientific processes.

(3) Use the engineering design process to address a problem or need (e.g., identify a need, conduct background research, prepare preliminary designs, build and test a prototype, test and revise design, communicate results).

(4) Understand the value of technology and use technology to gather data and analyze results of investigations (e.g., probes, handheld digital devices, digital cameras, software, computers, calculators, digital balances, GPS).

(5) Develop a logical relationship between evidence and explanation to form and communicate a valid conclusion and then suggest alternative explanations.

(f) **Standard - properties and physical changes in matter**. Physical characteristics of objects can be described using shape, size, and mass whereas the materials from which objects are made can be described using color and texture. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, and density). Physical changes of a substance do not alter the chemical nature of a substance (e.g., phase changes of water, sanding wood).

(2) Mixtures can be classified as homogeneous or heterogeneous and can be separated by physical means.

(g) **Standard - structure and function in living systems**. Living systems at all levels of organization demonstrate the complementary nature of structure and function. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Living systems are organized by levels of complexity (i.e., cells, tissues, organs, systems).

(2) Specialized structures perform specific functions at all levels of complexity (e.g., leaves on trees, wings on bird, organelles in cells).

(h) **Standard - reproduction and heredity**. Reproduction is the process by which organisms give rise to offspring. Heredity is the passing of traits to offspring. All organisms must be able to grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Characteristics of an organism result from inheritance and from interactions with the environment (e.g., genes, chromosomes, DNA, inherited traits, cell division).

(2) Similarities among organisms are found in anatomical features, which can be used to infer the degree of relatedness among organisms.

(i) **Standard - behavior and regulations**. All organisms must be able to grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. Behavioral response is a set of actions determined in part by heredity and in part by experience. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Living organisms strive to maintain a constant internal environment (i.e., homeostasis).

(2) Living organisms have physical and/or behavioral responses to external stimuli (e.g., hibernation, migration, geotropism).

(j) **Standard - structures of the earth system**. The earth is mostly rock, three-fourths of its surface is covered by a relatively thin layer of water, and the entire planet is surrounded by a relatively thin blanket of air, and is able to support life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Global patterns of atmospheric movement influence weather and climate (e.g., sea breezes, land breezes, and ocean currents, ocean's effect on climate).

(2) Clouds, formed by the condensation of water vapor, affect local weather and climate.

(3) The solid crust of the earth consists of separate plates that move very slowly, pressing against one another in some places and pulling apart in other places (i.e., volcanoes, earthquakes, and creation of mountains).

(k) **Standard - earth and the solar system**. The earth is the third planet from the sun in a system that includes the earth's moon, the sun, seven other planets and their moons, and smaller objects (e.g., asteroids, comets, dwarf planets). The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.

(2) Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day. The motion relationship of the sun, earth, and earth's moon is a result of the force of gravity.

210:15-3-78. Standards for inquiry, physical, life, and earth/space science for grade 8

(a) **Physical Science**. Standards for eighth (8th) grade students from the domain of Physical Science include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

(B) **Performance expectation one (1) - 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.

(C) **Performance expectation two (2)**. 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.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.

(E) **Performance expectation three (3)**. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

(F) **Performance expectation three (3) - 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.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

(B) **Performance expectation one (1) - Clarification statement**. Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

(C) **Performance expectation two (2)**. Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.

(3) **Waves and their applications in technologies for information**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on describing waves with both qualitative and quantitative thinking.

(C) **Performance expectation two (2)**. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.

(E) **Performance expectation three (3)**. Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversion of stored binary patterns to make sound or text on a computer screen.

(b) **Life Science.** Performance expectations for eighth (8th) grade students from the domain of Life Science include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.

(C) **Performance expectation two (2).** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer ancestral relationships.

(D) **Performance expectation two (2) - Clarification statement.** Emphasis is on explanations of the ancestral relationships among organisms in terms of similarities or differences in the gross appearance of anatomical structures.

(2) **Biological unity and diversity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. 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.

(B) **Performance expectation one (1) - 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.

(c) **Earth and Space Science**. Performance expectations for seventh (7th) grade students from the domain of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's geologic history.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on analyses of rock formations and fossils they contain to establish relative ages of major events in Earth’s history. Major events could include the formation of mountain chains

and ocean basins, adaptation and extinction of particular living organisms, volcanic eruptions, periods of massive glaciation, and the development of watersheds and rivers through glaciation and water erosion. The events in Earth's history happened in the past continue today. Scientific explanations can include models.

(2) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.

(C) **Performance expectation two (2)**. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes usually behave gradually but are punctuated by catastrophic events such as earthquakes, volcanoes, and meteor impacts. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.

(E) **Performance expectation three (3)**. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

(F) **Performance expectation three (3) - Clarification statement**. Examples of data include 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).

(3) **Earth and human activity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

(C) **Performance expectation two (2)**. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by

phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

(E) **Performance expectation three (3)**. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

(F) **Performance expectation three (3) - 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.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object, organism, or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative and/or quantitative changes given conditions (e.g., temperature, mass, volume, time, position, length) before, during, and after an event.~~

~~(2) Use appropriate tools (e.g., metric ruler, graduated cylinder, thermometer, balances, spring scales, stopwatches, computers, and handheld data collection devices) when measuring objects, organisms, and/or events.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds), and SI prefixes (i.e., milli , centi , and kilo) when measuring objects, organisms and/or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects, organisms, and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Using observable properties, place an object, organism, and/or event into a classification system (e.g., dichotomous keys, periodic table, biological hierarchy).~~

~~(2) Identify properties by which a set of objects, organisms, and/or events could be ordered.~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

~~(1) Ask questions about the world design investigations that lead to scientific inquiry.~~

~~(2) Evaluate the design of a scientific investigation.~~

~~(3) Identify variables and/or controls in an experimental setup: independent variable and dependent variable.~~

~~(4) Identify a testable hypothesis for an experiment.~~

~~(5) Follow a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.~~

(6) Recognize potential hazards and practice safety procedures in all biology activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.

(1) Report and record both quantitative/qualitative data in an appropriate method when given an experimental procedure or data.

(2) Interpret data tables, line, bar, trend, and/or circle graphs.

(3) Evaluate data to develop reasonable explanations, and/or predictions.

(4) Determine if results of investigations support or do not support hypotheses.

(5) Communicate scientific processes, procedures, and conclusions (e.g., model, poster, diagram, journal entry, lab report, scientific paper, oral presentation, digital presentation).

(e) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific thinking. In order for inquiry to occur students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conclusions based on evidence. The student will accomplish these objectives to meet this process standard.

(1) Ask questions that can be answered through scientific investigation.

(2) Design and conduct experiments utilizing scientific processes.

(3) Use the engineering design process to address a problem or need (e.g., identify a need, conduct background research, prepare preliminary designs, build and test a prototype, test and revise design, communicate results).

(4) Understand the value of technology and use technology to gather data and analyze results of investigations (e.g., probes, handheld digital devices, digital cameras, software, computers, calculators, digital balances, GPS).

(5) Develop a logical relationship between evidence and explanation to form and communicate a valid conclusion and then suggest alternative explanations.

(f) **Standard - properties and chemical changes in matter**. Physical characteristics of objects can be described using shape, size, and mass. The materials from which objects are made can be described using color, texture, and hardness. These properties can be used to distinguish and separate one substance from another. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Substances react chemically with other substances to form new substances with different characteristics (e.g., oxidation, combustion, acid/base reactions).

(2) Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, density, and hardness) and chemical properties. In chemical reactions and physical changes, matter is conserved (e.g., compare and contrast physical and chemical changes).

(g) **Standard - motions and forces**. The motion of an object can be described by its position, direction of motion, and speed as prescribed by Newton's Laws of Motion. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) The motion of an object can be measured. The position of an object, its speed, and direction can be represented on a graph.

~~(2) An object that is not being subjected to a net force will continue to move at a constant velocity (i.e., inertia, balanced and unbalanced forces).~~

~~(h) **Standard 3 - diversity and adaptations of organisms**. Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal and external structures. Adaptation involves the selection of naturally occurring variations in populations. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) By classifying organisms, biologists consider details of internal and external structure to infer the degree of relatedness among organisms(i.e., kingdom, phylum, class, order family, genus, species).~~

~~(2) Organisms have a great variety of internal and external structures that enable them to survive in a specific habitat (e.g., echolocation, seed dispersal).~~

~~(i) **Standard - structures and forces of the earth and solar system**. The earth is mostly rock, three-fourths of its surface is covered by a relatively thin layer of water, and the entire planet is surrounded by a relatively thin blanket of air, and is able to support life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Landforms result from constructive forces such as crustal deformation, volcanic eruption, and deposition of sediment and destructive forces such as weathering and erosion.~~

~~(2) The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its form changes.~~

~~(3) Atmospheric and ocean circulation patterns affect weather on a global scale (e.g., El Nino~, La Nina~, Gulf Stream).~~

~~(j) **Standard - earth's history**. The earth's history involves periodic changes in the structures of the earth over time. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Earth's history has been punctuated by occasional catastrophic events, such as the impact of asteroids or comets, enormous volcanic eruptions, periods of continental glaciation, and the rise and fall of sea level.~~

~~(2) Fossils provide important evidence of how life and environmental conditions have changed (e.g., Law of Superposition, index fossil, geologic time period, extinction).~~

210:15-3-79. Physical Science - standards for inquiry and the physical sciences for high school

Physical Science. Standards for high school students from the domain of Physical Science include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

(B) **Performance expectation one (1) - Clarification statement**. Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.

(C) **Performance expectation two (2)**. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, knowledge of the patterns of chemical properties, and formation of compounds.

(D) **Performance expectation two (2) - Clarification statement**. Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. Reaction classification aids in the prediction of products (e.g., synthesis/combustion, decomposition, single displacement, double displacement).

(E) **Performance expectation three (3)**. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.

(G) **Performance expectation four (4)**. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale (e.g. Law of Conservation of Mass). Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Analyze data and use it to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.

(C) **Performance expectation two (2)**. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

(E) **Performance expectation three (3)**. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

(F) **Performance expectation three (3) - Clarification statement**. Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.

(G) **Performance expectation four (4).** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

(H) **Performance expectation four (4) - Clarification statement**. N/A

(3) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on explaining the meaning of mathematical expressions used in the model.

(C) **Performance expectation two (2)**. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

(D) **Performance expectation two (2) - Clarification statement**. Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

(E) **Performance expectation three (3)**. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

(G) **Performance expectation four (4)**. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

(4) **Waves and their applications in technologies for information**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

(C) **Performance expectation two (2)**. Evaluate questions about the advantages and disadvantages of using a digital transmission and storage of information.

(D) **Performance expectation two (2) - Clarification statement**. Examples of advantages could include that digital information is stable because it can be stored

reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.

(E) **Performance expectation three (3)**. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative and quantitative changes given conditions (e.g., temperature, mass, volume, time, position, length, etc.) before, during, and after an event.~~

~~(2) Use appropriate tools with accuracy and precision (e.g., metric ruler, graduated cylinder, thermometer, balance, spring scale, stopwatch) when measuring objects and/or events.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds) and SI prefixes (i.e. micro , milli , centi , and kilo) when measuring objects and/or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Using observable properties, place an object or event into a classification system.~~

~~(2) Identify the properties by which a classification system is based.~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

~~(1) Evaluate the design of a physical science experiment.~~

~~(2) Identify the independent variables, dependent variables, controlled variables, and control set-up in an experiment.~~

~~(3) Use mathematics to show relationships within a given set of observations.~~

~~(4) Identify a hypothesis for a given problem in physical science investigations.~~

~~(5) Recognize potential hazards and practice safety procedures in all physical science activities.~~

~~(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.~~

~~(1) Select appropriate predictions based on previously observed patterns of evidence.~~

~~(2) Report and display data using appropriate technology and other media.~~

(3) Interpret data tables, line, bar, trend, and/or circle graphs from existing science research or student experiments.

(4) Determine if results of physical science investigations support or do not support hypotheses.

(5) Evaluate experimental data to draw the most logical conclusion.

(6) Routinely prepare a written report describing the sequence, results, and interpretation of a physical science investigation or event.

(A) Establish and maintain a formal style and objective tone.

(B) When appropropriate or possible, utilize technology to produce, publish, or revise writing products.

(C) Gather relevant information from multiple authoritative print and digital sources and follow a standard format for citation avoiding plagiarism.

(7) Communicate or defend scientific thinking that resulted in conclusions.

(A) Read, comprehend, and present evidence from a range of sources (e.g., texts, experiments, or simulations) to support conclusions.

(B) Recognize bias in observation/research.

(8) Identify and/or create an appropriate graph or chart from collected data, tables, or written description.

(A) Translate quantitative information expressed in words into visual form (e.g., a table, chart).

(B) Translate information expressed visually or mathematically (e.g., a table, chart, equation) into words.

(e) **Process standard - model**. Modeling is the active process of forming a mental or physical representation from data, patterns, or relationships to facilitate understanding and enhance prediction. The student will accomplish these objectives to meet this process standard.

(1) Interpret a model which explains a given set of observations.

(2) Select predictions based on models and when appropriate, apply mathematical reasoning to make accurate predictions.

(3) Compare a given model to the physical world.

(f) **Process standard - inquiry**. In order for inquiry to occur, students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conlusions based on evidence. The student will accomplish these objectives to meet this process standard.

(1) Ask a scientific question, formulate a testable hypothesis, and design an appropriate experiment relating to the physical world.

(2) Design and conduct physical science investigations in which variables are identified and controlled.

(3) Use a variety of technologies, (e.g., probes, handheld digital devices, digital cameras, software, calculators, digital balances, microscopes, measuring instruments, computers) to collect, analyze, and display data.

(4) Inquiries should lead to the formulation of explanations or models (physical, conceptual, and mathematical). In answering questions, students should engage in discussions (based on scientific knowledge, the use of logic, and evidence from the investigation) and arguments that encourage the revision of their explanations, leading to further inquiry.

(g) **Process standard - engineering design**. Engineering design can be defined as the creative process of turning abstract ideas into a physical prototype (laboratory apparatus, trial product, or

model) that addresses a need or solves a problem. In order for engineering design to occur, students must have the opportunity to identify a need or problem, establish design criteria, prepare preliminary designs, build and then test a prototype, and test and redesign as necessary. The student will accomplish these objectives to meet this process standard:

(1) Identify a need or problem or improve an existing design.

(2) Identify design criteria and constraints (e.g., materials used, product limitations, time limits).

(3) Use a variety of resources (e.g., Internet, databases, text) to conduct research in order to develop a preliminary design.

(4) Build and test a prototype. Document the strengths and weaknesses of the prototype in writing.

(5) Analyze and redesign to determine which solutions best meet the criteria and constraints.

(6) Communicate results in a variety of ways (e.g., orally, written, Internet publications, videos, posters, product demonstrations.

(h) **Standard - structure and properties of matter**. All matter is made up of atoms. Its structure is made up of repeating patterns and has characteristic properties. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Matter is made up of minute particles called atoms, and atoms are composed of even smaller components (i.e., protons, neutrons, and electrons).

(2) An element is identified by the number of protons (atomic number) in the nucleus. with.

(A) When elements are listed in order of increasing number of protons, repeating patterns of physical and chemical properties identify families of elements with similar properties.

(B) Elements found on the earth are also found throughout the universe.

(3) Matter has characteristic properties that are unique for pure substances and can be used to separate one substance from another (e.g., boiling points, melting points, density).

(4) A compound is formed when two or more kinds of atoms bind together chemically. Each compound has unique chemical and physical properties.

(i) **Standard - conservation of matter**. Matter is neither created nor destroyed in physical and chemicalinteractions. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Chemical changes are identified by one or more events (i.e., precipitate, color change, gas production, heat gain or loss).

(2) Chemical equations are used to represent chemical changes in which reactant(s) form product(s).

(3) Chemical reactions can be classified (e.g., synthesis/combination, decomposition, single displacement, double displacement).

(j) **Standard - motion and forces**. The motion of an object can be described by its position, direction of motion, and speed. A change in motion occurs as a result of a net force. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Objects change their motion only due to a net force. Laws of motion are used to determine the effects of forces on the motion of objects. Gravitation is a universal force that each object exerts on any other object.

~~(2) Moving electric charges produce magnetic forces, and moving magnets produce electric forces. Electricity and magnetism are two aspects of a single electromagnetic force (e.g., voltage, current, resistance, induction).~~

~~(k) **Standard - interactions of energy and matter**. Energy can be transferred or transformed, but never destroyed. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Energy can be classified as kinetic energy (energy of motion) or potential energy (e.g., positional, elastic,chemical, nuclear).~~

~~(2) Waves radiate energy and interact with matter.~~

~~(A) Propagation of mechanical waves (e.g., sound, seismic, water) requires a medium.~~

~~(B) Electromagnetic waves (radio waves to gamma rays) do not require a medium.~~

210:15-3-80. Biology I - standards for inquiry and the biological sciences for high school

Biology. Standards for high school students in the subject of Biology include all of the following topics:

(1) **From molecules to organisms: Structures and processes**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the conceptual understanding that DNA sequences determine the amino acid sequence, and thus, protein structure. Students can produce scientific writings, oral presentations and or physical models that communicate constructed explanations.

(C) **Performance expectation two (2)**. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on the levels of organization including cells, tissues, organs, and systems of an organism.

(E) **Performance expectation three (3)**. Plan and conduct an investigation to provide evidence of the importance of maintaining homeostasis in living organisms.

(F) **Performance expectation three (3) - Clarification statement**. A state of homeostasis must be maintained for organisms to remain alive and functional even as external conditions change within some range. Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, root development in response to water levels, and cell response to hyper and hypotonic environments.

(G) **Performance expectation four (4)**. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on conceptual understanding that mitosis passes on genetically identical materials via replication, not on the details of each phase in mitosis.

(I) **Performance expectation five (5)**. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

(J) **Performance expectation five (5) - Clarification statement**. Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in

photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, conceptual models, and/or laboratory investigations.

(K) **Performance expectation six (6)**. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

(L) **Performance expectation six (6) - Clarification statement**. Emphasis is on students constructing explanations for how sugar molecules are formed through photosynthesis and the components of the reaction (i.e., carbon, hydrogen, oxygen). This hydrocarbon backbone is used to make amino acids and other carbon-based molecules that can be assembled (anabolism) into larger molecules (such as proteins or DNA).

(M) **Performance expectation seven (7)**. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

(N) **Performance expectation seven (7) - Clarification statement**. Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. Examples of models could include diagrams, chemical equations, conceptual models, and/or laboratory investigations.

(2) **Ecosystems: Interactions, energy, and dynamics**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.

(C) **Performance expectation two (2)**. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

(D) **Performance expectation two (2) - Clarification statement**. Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

(E) **Performance expectation three (3)**. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments (e.g., chemosynthetic bacteria, yeast, and muscle cells).

(G) **Performance expectation four (4)**. Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter

cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

(I) **Performance expectation five (5)**. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

(J) **Performance expectation five (5) - Clarification statement**. Examples of models could include simulations and mathematical models (e.g., chemical equations that demonstrate the relationship between photosynthesis and cellular respiration.

(K) **Performance expectation six (6)**. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

(L) **Performance expectation six (6) - Clarification statement**. Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

(M) **Performance expectation seven (7)**. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

(N) **Performance expectation seven (7) - Clarification statement**. Emphasis is on advantages of grouping behaviors (e.g., flocking, schooling, herding) and cooperative behaviors (e.g., hunting, migrating, swarming) on survival and reproduction.

(3) **Heredity: Inheritance and variation of traits**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis should be on asking questions and making predictions to obtain reliable information about the role of DNA and chromosomes in coding the instructions for traits (e.g., pedigrees, karyotypes, genetic disorders, Punnett squares). In addition, students should recognize that DNA serves in functions beyond coding for proteins.

(C) **Performance expectation two (2)**. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on using data to support arguments for the way variation occurs.

(E) **Performance expectation three (3)**. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on distribution and variation of traits in a population and the use of mathematics (e.g., calculations of frequencies in Punnett squares, graphical representations) to describe the distribution.

(4) **Biological diversity and unity**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Analyze and evaluate how evidence such as similarities in DNA sequences, anatomical structures, and order of appearance of structures during embryological development contribute to the scientific explanation of biological diversity.
(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on identifying sources of scientific evidence.
(C) **Performance expectation two (2)**. Construct an explanation based on evidence that biological diversity is influenced by (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.
(E) **Performance expectation three (3)**. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations for adaptations.
(G) **Performance expectation four (4)**. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or adaptation of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. One example could be that as climate became more arid, grasses replaced forests, which led to adaptation in mammals over time (e.g. Increase tooth enamel and size of teeth in herbivores).
(I) **Performance expectation five (5)**. Synthesize, communicate, and evaluate the information that describes how changes in environmental conditions can affect the distribution of traits in a population causing: 1) increases in the number of individuals of some species, 2) the emergence of new species over time, and 3) the extinction of other species.
(J) **Performance expectation five (5) - Clarification statement**. Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an organism or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

(1) Identify qualitative and quantitative changes in cells, organisms, populations, and ecosystems given conditions (e.g., temperature, mass, volume, time, position, length, quantity) before, during, and after an event.

(2) Use appropriate tools with accuracy and precision (e.g., microscope, pipette, metric ruler, graduated cylinder, thermometer, balance, stopwatch,) when measuring cells, organisms, populations, and ecosystems.

(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds) and SI prefixes (i.e., micro , milli , centi , and kilo) when measuring cells, organisms, populations, and ecosystems.

(b) **Process standard - classify**. Classifying establishes order. Organisms and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.

(1) Using observable properties, place cells, organisms, and/or events into a biological classification system (e.g., dichotomous keys, taxonomy charts, cladograms).

(2) Identify the properties by which a biological classification system is based.

(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.

(1) Evaluate the design of a biology laboratory experiments.

(2) Identify the independent variables, dependent variables, controlled variables, and control set-up in an experiment.

(3) Use mathematics to show relationships within a given set of observations (e.g., population studies, biomass, probability, etc.).

(4) Identify a hypothesis for a given problem in biology investigations.

(5) Recognize potential hazards and practice safety procedures in all biology activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.

(1) Select appropriate predictions based on previously observed patterns of evidence.

(2) Report and display data using appropriate technology and other media.

(3) Interpret data tables, line, bar, trend, and/or circle graphs from existing science research or student experiments.

(4) Determine if results of biological investigations support or do not support hypotheses.

(5) Evaluate experimental data to draw the conclusion that is best supported by the evidence.

(6) Routinely prepare a written report describing the sequence, results, and interpretation of a biological investigation or event.

(A) Establish and maintain a formal style and objective tone.

(B) When appropriate or possible, utilize technology to produce, publish, or revise writing products.

(C) Gather relevant information from multiple authoritative print and digital sources and follow a standard format for citation avoiding plagiarism.

(7) Communicate or defend scientific thinking that results in conclusions.

(A) Read, comprehend, and present evidence from a range of sources (e.g., texts, experiments, simulations) to support conclusions.

(B) Recognize bias in observation/research.

(8) Identify and/or create an appropriate graph or chart from collected data, tables, or written description (e.g., population studies, plant growth, heart rate).

(A) Translate quantitative information expressed in words into visual form (e.g. a table, chart, equation) .

(B) Translate information expressed visually or mathematically (e.g., a table, chart, equation) into words.

(e) **Process standard - model**. Modeling is the active process of forming a mental or physical representation from data, patterns, or relationships to facilitate understanding and enhance prediction. The student will accomplish these objectives to meet this process standard.

(1) Interpret a biological model which explains a given set of observations.

(2) Select predictions based on models (e.g., pedigrees, life cycles, energy pyramids,) and when appropriate, apply mathematical reasoning to make accurate predictions.

(3) Compare a given model to the living world.

(f) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conlusions based on evidence. The student will accomplish these objectives to meet this process standard.

(1) Ask a scientific question, formulate a testable hypothesis and design an appropriate experiment relating to the living world.

(2) Design and conduct biological investigations in which variables are identified and controlled.

(3) Use a variety of technologies, such as (e.g., probes, handheld digital devices, electrophoresis equipment, digital cameras, software, calculators, digital balances, microscopes, measuring instruments, and computers) to collect, analyze, and display data.

(4) Inquiries should lead to the formulation of explanations or models (physical, conceptual, and mathematical). In answering questions, students should engage in discussions (based on scientific knowledge, the use of logic, and evidence from the investigation) and arguments that encourage the revision of their explanations, leading to further inquiry.

(g) **Standard - The cell**. Cells are the fundamental unit of life, comprised of a variety of structures that perform functions necessary to maintain life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Cells are composed of a variety of structures such as the nucleus, cell/plasma membrane, cell wall, cytoplasm, ribosomes, mitochondria, and chloroplasts.

(A) The cell/plasma membrane functions (i.e., active transport, passive transport, diffusion, osmosis, and surface area to volume ratio) to maintain homeostasis.

(B) Differentiate among hypotonic, hypertonic, and isotonic conditions.

(C) Compare and contrast prokaryotic and eukaryotic cells.

(2) In multicellular organisms, cell have levels of organization (i.e., cells, tissues, organs, organ systems, organisms).

(3) Specialized cells enable organisms to monitor what is going on in the world around them (e.g., detect light, sound, specific chemicals, gravity, plant tropism, sense organs, homeostasis).

(h) **Standard - the molecular basis of heredity**. DNA determines the characteristics of organisms. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Cells function according to the information contained in the master code of DNA (i.e., cell cycle, DNA replication and transcription). Transfer RNA and protein synthesis will be taught in life science courses with rigor greater than Biology I.

(2) A sorting and recombination of genes during sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents (i.e., Punnett squares and pedigrees). Students will understand concepts in a single trait cross (e.g., alleles, dominant trait, recessive trait, phenotype, genotype, homozygous, heterozygous, incomplete dominance, sex-linked traits.

(i) **Standard - biological diversity**. Diversity of species is developed through gradual processes over many generations. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Different species might look dissimilar, but the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry (e.g., homologous and analogous structures, embryology, fossl record, genetic data).

(2) Characteristics of populations change through the mechanism of natural selection. These biological adaptations, including changes in structures, behaviors, and/or physiology, may enhance or limit survival and reproductive success within a particular environment.

(3) Broad patterns of behavior exhibited by animals have changed over time to ensure reproductive success. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses can be either innate or learned.

(j) **Standard - The interdependence of organisms**. Interdependence of organisms in an environment includes the interrelationships and interactions between and among organisms.The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Organisms both cooperate and compete in ecosystems (i.e., parasitism and symbiosis) (e.g., symbiotic relationships).

(2) Living organisms have the capacity to produce populations of infinite size, but environments and resources limit population size (e.g., carrying capacity, limiting factors, ecological succession).

(k) **Standard - matter, energy, and organization in living systems**. Living systems require a continuous input of energy to maintain their chemical and physical organizations. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism (i.e., photosynthesis and cellular respiration).

(2) As matter and energy flow through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in

~~different ways by different structures. Matter and energy are conserved in each change (i.e., water cycle, carbon cycle, nitrogen cycle, food webs, and energy pyramids).~~

~~(3) Matter on earth cycles among the living (biotic) and nonliving (abiotic) components of the biosphere.~~

210:15-3-81. Chemistry - standards for inquiry and chemistry for high school

Chemistry. Standards for high school students in the subject of Chemistry include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

(B) **Performance expectation one (1) - Clarification statement**. Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.

(C) **Performance expectation two (2)**. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, knowledge of the patterns of chemical properties, and formation of compounds.

(D) **Performance expectation two (2) - Clarification statement**. Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. Reaction classification aids in the prediction of products (e.g., synthesis/combustion, decomposition, single displacement, double displacement, oxidation/reduction, acid/base.

(E) **Performance expectation three (3)**. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. The intent of the performance expectation is limited to evaluation of bulk scale properties and not micro scale properties.

(G) **Performance expectation four (4)**. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.

(I) **Performance expectation five (5)**. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

(J) **Performance expectation five (5) - Clarification statement**. Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.

(K) **Performance expectation six (6)**. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

(L) **Performance expectation six (6) - Clarification statement**. Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

(M) **Performance expectation seven (7)**. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

(N) **Performance expectation seven (7) - Clarification statement**. Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale (i.e., Conservation of Matter and Stoichiometry). Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

(O) **Performance expectation eight (8)**. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

(P) **Performance expectation eight (8) - Clarification statement**. Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

(3) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

(C) **Performance expectation two (2)**. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different

temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

(4) **Waves and their applications in technologies for information**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use mathematical representations to describe relationships among the frequency, wavelength, and speed of waves.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data could include relationship to the electromagnetic spectrum.

(C) **Performance expectation two (2)**. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative changes in reactions and quantitative changes in chemical reactions given conditions (e.g., temperature, mass, volume, time, position, length) before, during, and after an event.~~

~~(2) Use appropriate tools with accuracy and precision (e.g., metric ruler, graduated cylinder, thermometer, balance, spring scale, stopwatch) when measuring objects and/or events.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds) and SI prefixes (i.e., micro , milli , centi , and kilo) when measuring mass volume and temperature.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Using observable properties, place an object or event (i.e., chemical versus physical, charge, electron levels, and reaction types) into a classification system.~~

~~(2) Identify properties by which a classification system is based.~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

~~(1) Evaluate the design of a chemistry laboratory (experiment).~~

~~(2) Identify the independent variables, dependent variables, controlled variables, and control set-up in an experiment.~~

~~(3) Use mathematics to show relationships within a given set of observations (i.e., conservation of mass and stoichiometry).~~

(4) Identify a hypothesis for a given problem in chemistry investigations.

(5) Recognize potential hazards and practice safety procedures in all chemistry laboratory activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.

(1) Select appropriate predictions based on previously observed patterns of evidence.

(2) Report and display data using appropriate technology and other media.

(3) Interpret data tables, line, bar, trend, and/or circle graphs from existing science research or student experiments.

(4) Determine if results of chemistry investigations support or do not support hypotheses.

(5) Evaluate experimental data to draw the most logical conclusion.

(6) Routinely prepare a written report describing the sequence, results, and interpretation of a chemistry investigation or event.

(A) Establish and maintain a formal style and objective tone.

(B) When appropropriate or possible, utilize technology to produce, publish, or revise writing products.

(C) Gather relevant information from multiple authoritative print and digital sources and follow a standard format for citation avoiding plagiarism.

(7) Communicate or defend scientific thinking that resulted in conclusions.

(A) Read, comprehend, and present evidence from a range of sources (e.g. texts, experiments simulations) to support conclusions.

(B) Recognize bias in observation/research.

(8) Identify and/or create an appropriate graph or chart from collected data, tables, or written description.

(A) Translate quantitative information expressed in words into visual form (e.g. a table, chart, equation).

(B) Translate information expressed visually or mathematically (e.g., a table, chart, equation) into words.

(e) **Process standard - model**. Modeling is the active process of forming a mental or physical representation from data, patterns, or relationships to facilitate understanding and enhance prediction. The student will accomplish these objectives to meet this process standard.

(1) Interpret an atomic model which explains a given set of observations.

(2) Select predictions based on models (e.g., electron configuration, bonding, compound formation), and when appropriate, apply mathematical reasoning to make accurate predictions.

(3) Compare a given model to the physical world.

(f) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conlusions based on evidence. The student will accomplish these objectives to meet this process standard.

(1) Ask a scientific question, formulate a testable hypothesis and design an appropriate experiment to identify an unknown substance.

(2) Design and conduct scientific investigations in which variables are identified and controlled.

(3) Use a variety of technologies, (e.g., hand tools, balances, conductivity apparatus, thermometers, graduated cylinders, volumetric flasks, computers, probeware, graphing calculators, digital cameras, digital balances, computer simulations) to collect, analyze, and display data.

(4) Inquiries should lead to the formulation of explanations or models (physical, conceptual, and mathematical). In answering questions, students should engage in discussions (based on scientific knowledge, the use of logic, and evidence from the investigation) and arguments that encourage the revision of their explanations, leading to further inquiry.

(g) **Process standard - engineering design**. Engineering design can be defined as the creative process of turning abstract ideas into a physical prototype (laboratory apparatus, trial product, or model) that addresses a need or solves a problem. In order for engineering design to occur, students must have the opportunity to identify a need or problem, establish design criteria, prepare preliminary designs, build and then test a prototype, and test and redesign as necessary. The student will accomplish these objectives to meet this process standard:

(1) Identify a need or problem or improve an existing design.

(2) Identify design criteria and constraints (e.g., materials used, product limitations, time limits).

(3) Use a variety of resources (e.g., Internet, databases, text) to conduct research in order to develop a preliminary design.

(4) Build and test a prototype. Document the strengths and weaknesses of the prototype in writing.

(5) Analyze and redesign to determine which solutions best meet the criteria and constraints.

(6) Communicate results in a variety of ways (e.g., orally, written, Internet publications, videos, posters, product demonstrations.

(h) **Standard - structure and properties of matter**. All matter is made up of atoms. Its structure is made up of repeating patterns and has characteristic properties. The student will engage in investigations that integrate the process and inquiry standards and lead to the discovery of the following objectives:

(1) Matter is made of atoms which are in constant motion. Atoms are composed of subatomic particles (e.g., protons, neutrons, electrons, quarks).

(2) Atoms interact with one another by transferring or sharing outer electrons that are farthest from the nucleus. These outer electrons govern the chemical properties of the element.

(3) When elements are listed in order by increasing numbers of protons, repeating patterns of physical and chemical properties identify families of elements with similar properties.

(4) A compound is formed when two or more kinds of atoms bind together chemically.

(A) Atoms interact with one another by transferring (ionic) or sharing (covalent) valence electrons.

(B) Valence electrons govern the chemical properties and reactivity of the element.

(C) Each compound has unique chemical and physical properties

(i) **Standard - chemical reactions**. A reaction in which one or more substances are changed into different substances. A chemical change cannot be reversed by physical means. The student

~~will engage in investigations that integrate the process and inquiry standards and lead to the discovery of the following objectives:~~

~~(1) Chemical substances react in definite molar weight proportions and mass is conserved. Balanced chemical equations are used to determine molar ratios.~~

~~(2) Chemical reactions can be classified (e.g., synthesis/combination), decomposition, single displacement, double displacement, combustion, oxidation/reduction, acid/base). Reaction classification aids in the prediction of products.~~

~~(3) The rate of a chemical reaction is affected by the concentration, temperature, and presence of a catalyst.~~

~~(j) **Standard - interactions of energy and matter**. Total energy is conserved in a closed system. The student will engage in investigations that integrate the process and inquiry standards and lead to the discovery of the following objectives:~~

~~(1) Matter can be found in four phases (i.e., solid, liquid, gas, plasma). Phase change occurs when heat energy is absorbed or released from the system.~~

~~(2) Chemical reactions in a system either release energy to the surroundings (exothermic) or absorb energy from the surroundings (endothermic) as a result of breaking or forming bonds between atoms.~~

~~(3) The amount of heat gained or released during interactions (e.g., phase changes, chemical reactions, specific heat) can be quantified using calorimetric methods.~~

~~(4) As energy varies in a closed system containing a gas, the parameter (i.e., volume temperature pressure) are governed by specific laws (i.e., Avogadro's Law, Boyle's Law, Charles' Law, Dalton's Law, Ideal Gas Law).~~

~~(k) **Standard - solution chemistry**. Solutions are homogenous mixtures of solutes dissolved in solvents. Most chemical reactions occur in solutions. The student will engage in investigations that integrate the process and inquiry standards and lead to the discovery of the following objectives:~~

~~(1) Dissolving rates can be influenced by conditions (e.g., temperature, surface area of solute, particle collisions, pressure concentration).~~

~~(2) Solutions can be classified by the amount of solute dissolved by a solvent (i.e., unsaturated, saturated supersaturated). Solution concentration can be quantified.~~

210:15-3-82. Physics - standards for inquiry and physics for high school

Physics. Standards for high school students in the subject of Physics include all of the following topics:

(1) **Matter and its interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.

(2) **Motion and stability: Forces and interactions**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.

(C) **Performance expectation two (2)**. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

(E) **Performance expectation three (3)**. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

(F) **Performance expectation three (3) - Clarification statement**. Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.

(G) **Performance expectation four (4)**. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.

(I) **Performance expectation five (5)**. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

(J) **Performance expectation five (5) - Clarification statement**. N/A

(3) **Energy**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on explaining the meaning of mathematical expressions used in the model.

(C) **Performance expectation two (2)**. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

(D) **Performance expectation two (2) - Clarification statement**. Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

(E) **Performance expectation three (3)**. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

(G) **Performance expectation four (4)**. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

(I) **Performance expectation five (5)**. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

(J) **Performance expectation five (5) - Clarification statement**. Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other, including an explanation of how the change in energy of the objects is related to the change in energy of the field.

(4) **Waves and their applications in technologies for information**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

(B) **Performance expectation one (1) - Clarification statement**. Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

(C) **Performance expectation two (2)**. Evaluate questions about the advantages and disadvantages of using a digital transmission and storage of information.

(D) **Performance expectation two (2) - Clarification statement**. Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.

(E) **Performance expectation three (3)**. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.

(G) **Performance expectation four (4)**. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on the idea that different frequencies of light have different energies, and the damage to living

tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

(I) **Performance expectation five (5)**. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

(J) **Performance expectation five (5) – Clarification statement**. Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an object or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative and quantitative changes given conditions (e.g., temperature, mass, volume, time, position, length) before, during, and after an event.~~

~~(2) Use appropriate tools with accuracy and precision (e.g., metric ruler, graduated cylinder, thermometer, balance, spring scale, stopwatch) when measuring objects and/or events.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, and seconds) and SI prefixes (i.e., micro , milli , centi , and kilo) when measuring objects and/or events.~~

~~(b) **Process standard - classify**. Classifying establishes order. Objects and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Using observable properties, place an object or event into a classification system.~~

~~(2) Identify the properties by which a classification system is based.~~

~~(3) Graphically classify physical relationships (e.g., linear, parabolic, inverse).~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

~~(1) Evaluate the design of a physics experiment.~~

~~(2) Identify the independent variables, dependent variables, controlled variables, and control set-up in an experiment.~~

~~(3) Use mathematics to show relationships within a given set of observations.~~

~~(4) Identify a hypothesis for a given problem in physics investigations.~~

~~(5) Recognize potential hazards and practice safety procedures in all physics activities.~~

~~(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.~~

~~(1) Select appropriate predictions based on previously observed patterns of evidence.~~

~~(2) Report and display data using appropriate technology and other media.~~

~~(3) Interpret data tables, line, bar, trend, and/or circle graphs from existing science research or student experiments.~~

~~(4) Determine if results of physics investigations support or do not support hypotheses.~~

(5) Evaluate experimental data to draw the most logical conclusion.

(6) Routinely prepare a written report describing the sequence, results, and interpretation of a physics investigation or event.

(A) Establish and maintain a formal style and objective tone.

(B) When appropropriate or possible, utilize technology to produce, publish, or revise writing products.

(C) Gather relevant information from multiple wuthoritative print and digital sources and follow a standard format for citation avoiding plagiarism.

(7) Communicate or defend scientific thinking that resulted in conclusions.

(A) Read, comprehend, and present evidence from a range of sources (e.g. texts, experiments, or simulations) to support conclusions.

(B) Recognize bias in observation/research.

(8) Identify and/or create an appropriate graph or chart from collected data, tables, or written description.

(A) Translate quatitative information expressed in words into visual form (e.g. a table, chart, or equation).

(B) Translate information expressed visually or mathematically (e.g., a table, chart or equation) into words.

(e) **Process standard - model**. Modeling is the active process of forming a mental or physical representation from data, patterns, or relationships to facilitate understanding and enhance prediction. The student will accomplish these objectives to meet this process standard.

(1) Interpret a model which explains a given set of observations.

(2) Select predictions based on models and when appropriate, apply mathematical reasoning to make accurate predictions.

(3) Compare a given model to the physical world.

(f) **Process standard - inquiry**. In order for inquiry to occur, students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out experiments, and make conlusions based on evidence. The student will accomplish these objectives to meet this process standard.

(1) Ask a scientific question, formulate a testable hypothesis and design an appropriate experiment relating to the physical world.

(2) Design and conduct physics investigations in which variables are identified and controlled.

(3) Use a variety of technologies, (e.g., hand tools, balances, conductivity apparatus, thermometers, graduated cylinders, volumetric flasks, probeware, graphing calculators, digital cameras, digital balances, computer simulations) to collect, analyze, and display data.

(4) Inquiries should lead to the formulation of explanations or models (physical, conceptual, and mathematical). In answering questions, students should engage in discussions (based on scientific knowledge, the use of logic, and evidence from the investigation) and arguments that encourage the revision of their explanations, leading to further inquiry.

(g) **Process standard - engineering design**. Engineering design can be defined as the creative process of turning abstract ideas into a physical prototype (laboratory apparatus, trial product, or model) that addresses a need or solves a problem. In order for engineering design to occur, students must have the opportunity to identify a need or problem, establish design criteria, prepare preliminary designs, build and then test a prototype, and test and redesign as necessary. The student will accomplish these objectives to meet this process standard:

(1) Identify a need or problem or improve an existing design.

(2) Identify design criteria and constraints (e.g., materials used, product limitations, time limits).

(3) Use a variety of resources (e.g., Internet, databases, text) to conduct research in order to develop a preliminary design.

(4) Build and test a prototype. Document the strengths and weaknesses of the prototype in writing.

(5) Analyze and redesign to determine which solutions best meet the criteria and constraints.

(6) Communicate results in a variety of ways (e.g., orally, written, Internet publications, videos, posters, product demonstrations).

(h) **Standard - motion**. The change in position of an object is motion. The student will engage in investigations that integrate the process and inquiry standards and lead to the discovery of the following objectives:

(1) The motion of an object can be described by its position, direction, and speed.

(2) Motion can be modeled in terms of 1- or 2-dimensions relative to a system's defined reference point (e.g., particle model, vector model, graphical model).

(3) Objects undergoing acceleration can be mathematically modeled using time, displacement, velocity, and acceleration equations.

(i) **Standard - force**. A change in motion occurs as a result of a net force.The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Objects change their motion due to a net force. Newton's Laws of Motion are used to calculate the effects of forces on the motion of objects (e.g., balanced vs. unbalanced forces, momentum, inertia, impulse, action vs. reaction, friction, torque).

(2) Gravitation is a universal force that each object exerts on any other object. The strength of the gravitational attractive force between two objects is proportional to the masses and inversely proportional to the square of the distance between them (e.g., Law of Universal Gravitation, Kepler's Law).

(3) The electric force is a universal force that exists between any two charged objects. The strength of the force is proportional to the charges and inversely proportional to the square of the distance between them (e.g., Coulomb's Law).

(4) Electricity and magnetism are two aspects of a single electromagnetic force (e.g., series/parallel/complex circuits, electromagnets, induction, Ohm's Law, generators, motors, capacitors).

(j) **Standard - energy**. The total energy of the universe is constant. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) Energy in a system is never created nor destroyed but may be transferred or transformed (e.g., Law of Conservation of Energy, Laws of Thermodynamics).

(A) As changes occur, energy becomes less ordered.

(B) Conservation of energy can be modeled (e.g., pendulum motion, spring system).

(2) Energy can be classified as kinetic (energy of motion), potential, elastic, chemical, or nuclear).

(k) **Standard - interactions of energy and matter**. Energy interacts with matter and is transferred during these interactions. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

~~(1) Heat is energy transferred due to temperature differences within a system. The amount of heat is also dependent on the mass and type of substances.~~
~~(2) Transfer of energy and changes in wave properties (e.g., speed, amplitude, wavelength, frequency) may occur as waves and matter interact (e.g., reflection, refraction, diffraction, interference).~~
~~(3) When work is done on an object, energy is transferred.~~
~~(4) Machines change the force/distance ratios involved in doing work.~~

210:15-3-83. Earth and Space Science and Environmental Science - Earth and Space Science and Environmental Science – standards for inquiry, Earth and Space Science and Environmental Science ~~and environmental science~~ for high school

(a) **Earth and Space Science.** Standards for high school students in the subject of Earth and Space Science include all of the following topics:

(1) **Earth's place in the universe**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.

(C) **Performance expectation two (2)**. Develop models to describe the sun's place in relation to the Milky Way galaxy and the distribution of galaxies and galaxy clusters in the Universe.

(D) **Performance expectation two (2) - Clarification statement**. Mathematical models can focus on the logarithmic powers-of-ten relationship among the sun, its solar system, the Milky Way galaxy, the local cluster of galaxies, and the universe, these relationships can also be investigated graphically, using 2D or 3D scaled models, or through computer programs, either pre-made or student-written.

(E) **Performance expectation three (3)**. Communicate scientific ideas about the way stars, over their life cycle, produce elements.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on the way nucleosynthesis, and therefore the different elements created, depend on the mass of a star and the stage of its lifetime.

(G) **Performance expectation four (4)**. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

(H) **Performance expectation four (4) - Clarification statement**. Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. (e.g. graphical representations of orbits)

(I) **Performance expectation five (5)**. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

(J) **Performance expectation five (5) - Clarification statement**. Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust decreasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).

(K) **Performance expectation six (6)**. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

(L) **Performance expectation six (6) - Clarification statement**. Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth. Examples of evidence include materials obtained through space exploration, radiometric dating of meteorites and Earth's oldest minerals, the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

(2) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, erosion, and mass wasting).

(C) **Performance expectation two (2)**. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks and interactions that cause changes to other Earth's systems.

(D) **Performance expectation two (2) - Clarification statement**. Examples could be taken from system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion, which limits additional vegetation patterns; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent. Examples could also include climate feedbacks that increase surface temperatures through geologic time.

(E) **Performance expectation three (3)**. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of the Earth's surface features as well as three-dimensional structure in the subsurface, obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and predictions of the composition of Earth's layers from high-pressure laboratory experiments.

(G) **Performance expectation four (4)**. Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate.

(H) **Performance expectation four (4) - Clarification statement**. Changes differ by timescale, from sudden (large volcanic eruption, ocean circulation); to intermediate (ocean circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, maps of global and regional temperatures, and atmospheric levels of gases.

(I) **Performance expectation five (5)**. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

(J) **Performance expectation five (5) - Clarification statement**. Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

(K) **Performance expectation six (6)**. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

(L) **Performance expectation six (6) - Clarification statement**. Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

(M) **Performance expectation seven (7)**. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth.

(N) **Performance expectation seven (7) - Clarification statement**. Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors influence conditions for life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and affected animal life; how microbial life on land increased the formation of soil, which in turn allowed for the development of land plant species; or how the changes in coral species created reefs that altered patterns of erosion and deposition along coastlines and provided habitats to support biodiversity. Geologic timescale should be considered with the emphases above.

(3) **Earth and human activities**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

(B) **Performance expectation one (1) - Clarification statement**. Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic

eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

(C) **Performance expectation two (2)**. Evaluate competing design solutions for developing, managing, and utilizing natural resources based on cost-benefit ratios.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural, soil use, forestry, and mining.

(E) **Performance expectation three (3)**. Construct a scientific explanation from evidence for how geological processes lead to uneven distribution of natural resources.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on how geological processes have led to geological sedimentary basins that provide significant accumulations of crude oil and natural gas in some areas and not others and how geological processes lead to diverse soil profiles that support a diversity and range of agricultural crops and how plate tectonics leads to concentrations of mineral deposits.

(b) **Environmental Science**. Performance expectations for high school students in the subject of Environmental Science include all of the following topics:

(1) **Earth's systems**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).

(C) **Performance expectation two (2)**. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks and interactions that cause changes to other Earth's systems.

(D) **Performance expectation two (2) - Clarification statement**. Examples could be taken from system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion, which limits additional vegetation patterns; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent. Examples could also include climate feedbacks that increase surface temperatures through geologic time.

(E) **Performance expectation three (3)**. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate

tectonics. Examples of evidence include maps of the Earth's surface features as well as three-dimensional structure in the subsurface, obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.

(G) **Performance expectation four (4)**. Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate.

(H) **Performance expectation four (4) - Clarification statement**. Changes differ by timescale, from sudden (large volcanic eruption, ocean circulation) to intermediate (ocean circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, and maps of global and regional temperatures, and atmospheric levels of gases.

(I) **Performance expectation five (5)**. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

(J) **Performance expectation five (5) - Clarification statement**. Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

(K) **Performance expectation six (6)**. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

(L) **Performance expectation six (6) - Clarification statement**. Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

(M) **Performance expectation seven (7)**. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth.

(N) **Performance expectation seven (7) - Clarification statement**. Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors influence conditions for life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and affected animal life; how microbial life on land increased the formation of soil, which in turn allowed for the development of land plant species; or how the changes in coral species created reefs that altered patterns of erosion and deposition along coastlines and provided habitats to support biodiversity. Geologic timescale should be considered with the emphases above.

(2) **Earth and human activities**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

(B) **Performance expectation one (1) - Clarification statement**. Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

(C) **Performance expectation two (2)**. Evaluate competing design solutions for developing, managing, and utilizing natural resources based on cost-benefit ratios.

(D) **Performance expectation two (2) - Clarification statement**. Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas).

(E) **Performance expectation three (3)**. Create a computational simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.

(F) **Performance expectation three (3) - Clarification statement**. Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of consumption, and urban planning.

(G) **Performance expectation four (4)**. Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems.

(H) **Performance expectation four (4) - Clarification statement**. Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use. Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions.

(3) **Ecosystems: Interaction, energy, and dynamics**. Standards for students include all of the following performance expectations:

(A) **Performance expectation one (1)**. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

(B) **Performance expectation one (1) - Clarification statement**. Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical

comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.

(C) **Performance expectation two (2)**. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

(D) **Performance expectation two (2) - Clarification statement**. Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

(E) **Performance expectation three (3)**. Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

(F) **Performance expectation three (3) - Clarification statement**. Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

(G) **Performance expectation four (4)**. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

(H) **Performance expectation four (4) - Clarification statement**. Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

~~(a) **Process standard - observe and measure**. Observing is the first action taken by the learner to acquire new information about an organism or event. Opportunities for observation are developed through the use of a variety of scientific tools. Measurement allows observations to be quantified. The student will accomplish these objectives to meet this process standard.~~

~~(1) Identify qualitative and quantitative changes in cells, organisms, populations, and ecosystems given conditions (e.g., temperature, mass, volume, time, position, length, quantity) before, during, and after an event.~~

~~(2) Use appropriate tools with accuracy and precision (e.g., microscope, pipette, metric ruler, graduated cylinder, thermometer, balances, stopwatches, etc.) when measuring cells, organisms, populations, and ecosystems.~~

~~(3) Use appropriate International System of Units (SI) (i.e., grams, meters, liters, degrees Celsius, seconds) and SI prefixes (i.e., micro , milli , centi , and kilo) when measuring cells, organisms, populations, and ecosystems.~~

~~(b) **Process standard - classify**. Classifying establishes order. Organisms and events are classified based on similarities, differences, and interrelationships. The student will accomplish these objectives to meet this process standard.~~

~~(1) Using observable properties, place cells, organisms, and/or events into a classification system.~~

~~(2) Identify the properties by which a classification system is based.~~

~~(c) **Process standard - experimental design**. Understanding experimental design requires that students recognize the components of a valid experiment. The student will accomplish these objectives to meet this process standard.~~

(1) Evaluate the design of laboratory experiments.

(2) Identify the independent variables, dependent variables, controlled variables, and control set-up in an experiment.

(3) Use mathematics to show relationships within a given set of observations.

(4) Identify a hypothesis for a given problem in environmental investigations.

(5) Recognize potential hazards and practice safety procedures in all activities.

(d) **Process standard - interpret and communicate**. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others. Communication may be oral, written, or mathematical and includes: organizing ideas, using appropriate vocabulary, graphs, other visual representations, and mathematical equations. The student will accomplish these objectives to meet this process standard.

(1) Select appropriate predictions based on previously observed patterns of evidence.

(2) Report and display data using appropriate technology and other media.

(3) Interpret data tables, line, bar, trend, and/or circle graphs from existing science research or student experiments.

(4) Determine if results of environmental investigations support or do not support hypotheses.

(5) Evaluate experimental data to draw the conclusion that is best supported by the evidence.

(6) Routinely prepare a written report describing the sequence, results, and interpretation of a biological investigation or event.

(A) Establish and maintain a formal style and objective tone.

(B) When appropropriate or possible, utilize technology to produce, publish, or revise writing products.

(C) Gather relevant information from multiple wuthoritative print and digital sources and follow a standard format for citation avoiding plagiarism.

(7) Communicate or defend scientific thinking that results in conclusions.

(A) Read, comprehend, and present evidence from a range of sources (e.g. texts, experiments, simulations) to support conclusions.

(B) Recognize bias in observation/research.

(8) Identify and/or create an appropriate graph or chart from collected data, tables, or written description (e.g., population studies, plant growth).

(A) Translate quatitative information expressed in words into visual form (e.g. a table, chart, equation).

(B) Translate information expressed visually or mathematically (e.g., a table, chart or equation) into words.

(e) **Process standard - model**. Modeling is the active process of forming a mental or physical representation from data, patterns, or relationships to facilitate understanding and enhance prediction. The student will accomplish these objectives to meet this process standard.

(1) Interpret a model which explains a given set of observations.

(2) Select predictions based on models, and when appropriate, apply mathematical reasoning to make accurate predictions.

(3) Compare a given model to the living world.

(f) **Process standard - inquiry**. Inquiry can be defined as the skills necessary to carry out the process of scientific or systemic thinking. In order for inquiry to occur, students must have the opportunity to make observations, pose questions, formulate testable hypotheses, carry out

~~experiments, and make conlusions based on evidence. The student will accomplish these objectives to meet this process standard.~~

~~(1) Ask a scientific question, formulate a testable hypothesis and design an appropriate experiment relating to the living world.~~

~~(2) Design and conduct biological investigations in which variables are identified and controlled.~~

~~(3) Use a variety of technologies, (e.g., probes, handheld digital devices, digital cameras, software, calculators, digital balances, microscopes, measuring instruments, computers) to collect, analyze, and display data.~~

~~(4) Inquiries should lead to the formulation of explanations or models (physical, conceptual, and mathematical). In answering questions, students should engage in discussions (based on scientific knowledge, the use of logic, and evidence from the investigation) and arguments that encourage the revision of their explanations, leading to further inquiry.~~

~~(g) **Standard - the physical earth system**. The physical earth system is determined by dynamic and static processes revealed through investigations of the geosphere, atmosphere, and hydrosphere. These interrelated processes are large-scale and long-term characteristics of the Earth that require knowledge of energy and matter. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Composition and structure of the Earth is affected by an interaction of processes and events.~~

~~(A) Geologic processes affect the Earth over time (e.g., plate tectonics, erosion).~~

~~(B) Atmospheric processes affect the Earth over time (e.g., changes in daily weather conditions, convection/conduction/radiation, greenhouse effect, climate trends).~~

~~(C) Hydrologic processes affect the Earth over time (e.g., water cycle, ocean currents, ground water transport).~~

~~(D) Earth's current structure has been influenced by both sporadic and gradual events.~~

~~(2) Natural systems require a certain amount of energy input to maintain their organization.~~

~~(h) **Standard - the living earth system**. The living environment is comprised of interrelated, dynamic systems of the biosphere. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) The biosphere can be examined at several levels (e.g., biome, ecosystem, community, population, species, organism.~~

~~(2) Ecosystems are composed of biotic and abiotic factors. Matter and energy move between these factors.~~

~~(3) Energy flows through ecosystems in one direction, from the sun to producers to consumers (e.g., photosynthesizers, chemoautotrophs).~~

~~(4) Matter flows through biogeochemical cycles (i.e., carbon, nitrogen, phosphorus, water).~~

~~(5) Cycling of matter and the flow of energy are governed by the Laws of Conservation of Matter and Energy.~~

~~(i) **Standard - populations**. A population is a group of naturally interbreeding individuals of one species, living in a defined area and usually isolated to some degree from similar groups. Populations are dynamic: they increase, decrease, or stabilize depending on their interactions with other populations and with their environment. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:~~

~~(1) Organisms and populations both cooperate and compete in ecosystems and/or habitats for resources (e.g., symbiotic relationships, limiting factors).~~

(2) Mutation and environmental selective pressures may result in adaptations which may enhance or limit the survival and reproductive success in a particular environment (e.g., changes in structures, behaviors, diversity).

(3) Each population has specific properties including size, density, and pattern of dispersion (e.g., carrying capacity, exponential growth).

(j) **Standard - natural resources**. Natural resources are raw materials and energy obtained or derived from the environment. The student will engage in investigations that integrate the process and inquiry standards and lead to the discovery of the following objectives:

(1) Natural resources are classified as renewable or nonrenewable.

(A) Only a small fraction of Earth's water supply is available for human use.

(B) Soil conservation methods are important for protecting and managing topsoil and reducing erosion.

(C) Fossil fuels (coal, oil, natural gas) are carbon containing molecules that take millions of years to form. Reserves are being depleted much faster than new ones are being made.

(2) Pollution is an undesired change in air, water, or soil that adversely affects the health, survival, or activities of organism (e.g., temperature inversion, pH changes, organic and inorganic substances).

(3) Alternative energy sources include wind power, active and passive solar power, geothermal power, and biomass power.

(k) **Standard - environment and society**. Environmental perspective encompasses how one thinks society works in relation to environmental issues, what one believes the environmental world should be, and what is ethical environmental behavior. Sustainability is a long-term process to maintain a quality environment for future generations. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

(1) As human populations and their consumption levels increase, it becomes more difficult to sustain environmental quality.

(2) Environmental issues can be described in terms of qualitative and quantitative costs and benefits for different groups of people and specific species or ecosystems (e.g., oil spills, energy consumption, invasive species, natural disasters).

(3) People are capable of reducing and reversing their impact on the environment because they can think, plan, and educate.

(A) Governments develop policies to address environmental problems and establish agencies to implement those policies.

(B) Individuals and groups have the ability and responsibility to help maintain environmental quality and resolve environmental problems and issues.

(C) A variety of methods are used to analyze the sustainability of current trends in world population growth and natural resource consumption (e.g., carrying capacity, ecological footprints).