SCIENCE
OVERVIEW
ORGANIZATION

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.

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.

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.

The content standard areas (physical, life, earth/space) are designed to facilitate conceptual development by building on the content knowledge introduced at the PreKindergarten 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.

SCIENCE STANDARDS
Grades 1-12

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.

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.

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) and the *Benchmarks for Scientific Literacy* by the American Association for the Advancement of Science (AAAS), and the *Science Frameworks* by the National Association for Education 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.

NOTE:

Asterisks (*) have been used to identify standards and objectives that must be assessed by the local school district. All other skills may be assessed by the Oklahoma School Testing Program (OSTP).

Book icons (🕮) identify Information Literacy skills. Students are best served when these are taught in collaboration and cooperation between the classroom teacher and the library media specialist.

Use of the term i.e. means “in exactness”; use of the term e.g. means “example given”.

OAC 210:15-3-70—210:15-3-82

PHYSICAL SCIENCE

High School

Standards for Inquiry and the Physical Sciences

The *Priority Academic Student Skills (PASS)* should be taught by investigating broad, integrated content, concepts, and principles of major themes in the physical sciences.

SCIENCE PROCESSES AND INQUIRY

Process Standard 1: 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, balances, spring scales, stopwatches) 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.

Process Standard 2: 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.

Process Standard 3: 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.

Process Standard 4: 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 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 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., table, chart).

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

Process Standard 5: 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.

Process Standard 6: 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 conclusions based on evidence. The student will accomplish these objectives to meet this process standard.

*1. 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.

Process Standard 7: 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 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, texts) 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 solution best meets the criteria and constraints.

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

PHYSICAL SCIENCE

High School

Standard 1: 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.

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

Standard 2: Conservation of Matter – Matter is neither created nor destroyed in physical and chemical interactions. 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).

Standard 3: 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).

Standard 4: 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.

BIOLOGY I

HIGH SCHOOL

Standards for Inquiry and the Biological Sciences

The Priority Academic Student Skills (PASS) should be taught by investigating content, concepts, and principles of major themes in the Biological Sciences.

SCIENCE PROCESSES AND INQUIRY

High School

Process Standard 1: 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, allowing the student to distinguish between observation and inference. 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 objects and/or events.

Process Standard 2: 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.

Process Standard 3: 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 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 (e.g., population studies, biomass, probability).

4. Identify a hypothesis for a given problem in biology investigations.

5. Recognize potential hazards and practice safety procedures in all biology activities.

Process Standard 4: 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 science 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, 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 (e.g., population studies, plant growth, heart rate).

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

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

Process Standard 5: 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), and when appropriate, apply mathematical reasoning to make accurate predictions.

*3. Compare a given model to the living world.

Process Standard 6: 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 observation, 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 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, 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 research and 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.

BIOLOGY I

High School

Standard 1: The Cell – Cells are the fundamental unit of life, composed 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, cells 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).

Standard 2: 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, and sex-linked traits).

Standard 3: 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, fossil 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.

Standard 4: 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 (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).

Standard 5: 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.

CHEMISTRY

HIGH SCHOOL

The Priority Academic Student Skills (PASS) should be taught by investigating content, concepts, and principles of major themes in chemistry.

SCIENCE PROCESSES AND INQUIRY

Process Standard 1: 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, probeware, graphing calculators, digital cameras, computer simulations) when measuring objects and/or events.

3. Use appropriate International Systems of Units (SI) (i.e., meters, liters, degrees Celsius, and seconds) and SI prefixes (i.e., micro-, milli-, centi-, and kilo-) when measuring mass volume and temperature.

Process Standard 2: 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 level, and reaction types) into a classification system

2. Identify properties by which a classification system is based.

Process Standard 3: 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 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.

Process Standard 4: 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, bard, trend, and/or circle graphs from existing science research or student experiments.

4. Determine if results of chemical 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 chemistry 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 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 or chart).

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

Process Standard 5: 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.

Process Standard 6: 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 conclusions 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, 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.

Process Standard 7: Engineering Design - Engineering design can be defined as the creative process of turning abstract ideas into a physical prototype (laboratory apparatus, trial product, 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 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, or product demonstrations).

CHEMISTRY

High School

Standard 1: 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 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.

Standard 2: Chemical Reactions - A chemical reaction is 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 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 and temperature of reactants and presence of a catalyst.

Standard 3: 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 parameters (i.e., volume, temperature, and pressure) are governed by specific laws (i.e., Avogadro's Law, Boyle's Law, Charles' Law, Dalton's Law, Ideal Gas Law).

Standard 4: 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.

PHYSICS

High School

Standards for Inquiry and Physics

The *Priority Academic Student Skills (PASS)* should be taught by investigating content, concepts, and principles of major themes in Physics.

SCIENCE PROCESSES AND INQUIRY

Process Standard 1: 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, probeware, graphing calculators, digital cameras, computer simulations) 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.

Process Standard 2: 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).

Process Standard 3: 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 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.

Process Standard 4: 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 using 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 chemistry 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 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 or chart).

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

Process Standard 5: 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.

Process Standard 6: 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. 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, measuring instruments, 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.

Process Standard 7: Engineering Design - Engineering design can be defined as the creative process of turning abstract ideas into a physical prototype (laboratory apparatus, trial product, 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 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).

PHYSICS

High School

Standard 1: Motion – The change in position of an object is 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 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.

Standard 2: 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).

Standard 3: 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 (energy of motion) or potential energy (e.g., positional, elastic, chemical, nuclear).

Standard 4: 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.
5. Power is the rate at which work is done.

Environmental Science

High School

Standards for Environmental Science

The *Priority Academic Student Skills (PASS)* should be taught by investigating content, concepts, and principles of major themes in Environmental Science.

SCIENCE PROCESSES AND INQUIRY

Process Standard 1: 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 (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.

Process Standard 2: 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.

Process Standard 3: 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 an environmental experiment.

2. Identify the independent variables, dependent variables, controlled variables, and controls 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 environmental activities.

Process Standard 4: 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 research or student experiments.

4. Determine if results of environmental 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 an environmental 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 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 or chart).

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Process Standard 6: 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. Ask a scientific question, formulate a testable hypothesis and design an appropriate experiment relating to the physical world.

*2. Design and conduct environmental investigations in which variables are identified and controlled.

*3. Use a variety of technologies, (e.g., hand tools, measuring instruments, computers, handheld digital devices, 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.

Environmental Science

High School

Standard 1: 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 (i.e., Laws of Thermodynamics).

Standard 2: 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 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.

Standard 3: 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 and exponential growth).

Standard 4: 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.

Standard 5: 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).