

Science

Topic: Inquiry & Experimentation

- *Learning Outcome:* Demonstrate appropriate skills for scientific inquiry and experimentation across the science curriculum

Performance Objective(s):

- Pose questions and state hypotheses based on prior scientific observations, experiments, and knowledge.
- Distinguish between hypothesis and theory as scientific terms.
- Either individually or as part of a student team, design and complete a scientific experiment that extends over several days or weeks.
- Use mathematics to analyze and support findings and to model conclusions.
- Simulate physical processes or phenomena using different kinds of representations.
- Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- Revise scientific models.
- Communicate and defend a scientific argument.

Topic: Laboratory Skills

- *Learning Outcome:* Demonstrate effective and appropriate use of laboratory equipment

Performance Objective(s):

- Accurately measure mass, volume and length, and time.
- Make appropriate choice of measuring devices.
- Compile, represent and interpret data.
- Use available technology to accurately represent data.

Topic: Laboratory Safety

- *Learning Outcome:* Demonstrate basic laboratory safety skills

Performance Objective(s):

- Display appropriate and responsible behavior in the laboratory.
- Adhere to all standard rules of laboratory safety.
- Wear appropriate protective coverings.
- Maintain a clean lab area.
- Dispose of materials properly.
- Locate lab safety equipment and explain proper use.
- Report safety issues to instructor.

Biology

Topic: The Chemistry of Life

- *Learning Outcome:* Explain that living things are made of atoms bonded together to form molecules

Performance Objective(s):

- Explain the significance of carbon in organic molecules.
- Recognize the six most common elements in organic molecules (C, H, N, O, P, S).
- Describe the composition and functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- Describe how dehydration synthesis and hydrolysis relate to organic molecules.
- Explain the role of enzymes in biochemical reactions.

Topic: Structure and Function of Cells

- *Learning Outcome:* Demonstrate an understanding that all living things are composed of cells and that life processes in a cell are based on molecular interactions

Performance Objective(s):

- Relate cell parts/organelles to their functions.
- Differentiate between prokaryotic cells and eukaryotic cells, in terms of their general structures and degrees of complexity.
- Distinguish between plant and animal cells.
- Describe how cells function in a narrow range of physical conditions, such as temperature and pH, to perform life functions that help to maintain homeostasis.
- Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, and active transport).
- Identify the reactants and products in the general reaction of photosynthesis. Describe the use of isotopes in this identification.
- Provide evidence that the organic compounds produced by plants are the primary source of energy and nutrients for most living things.
- Identify how cellular respiration is important for the production of ATP.
- Explain the interrelated nature of photosynthesis and cellular respiration.
- Describe and compare the processes of mitosis and meiosis, and their role in the cell cycle.

Topic: Genetics

- *Learning Outcome:* Demonstrate an understanding of the relationship between the genetic code and the phenotypic expression and integrate bioethical implications of applied genetics

Performance Objective(s):

- Describe the structure and function of DNA, and distinguish among replication, transcription, and translation.
- Describe the processes of replication, transcription, and translation and how they relate to each other in molecular biology.
- Describe the general pathway by which ribosomes synthesize proteins by using tRNAs to translate genetic information encoded in mRNAs.
- Explain how mutations in the DNA sequence of a gene may be silent or result in phenotypic change in an organism and in its offspring.
- Differentiate between dominant, recessive, codominant, polygenic, and sex-linked traits.
- State Mendel's laws of segregation and independent assortment.
- Use a Punnett Square to determine the genotype and phenotype of monohybrid crosses.
- Explain how zygotes are produced in the fertilization process.
- Recognize that while viruses lack cellular structure, they have the genetic material to invade living cells.
- Discuss the bioethical implications of cloning, stem cell technology, reproductive technologies and genetic engineering.

Topic: Human Anatomy & Physiology

- *Learning Outcome:* Describe the relationship of structure and function in organ systems of humans and their significance in maintaining homeostasis

Performance Objective(s):

- Explain how major organ systems in humans (e.g., kidney, muscle, lung) have functional units (e.g., nephron, sarcome, alveoli) with specific anatomy that perform the function of that organ system.
- Describe how the function of individual systems within humans are integrated to maintain a homeostatic balance in the body.

Topic: Evolution & Biodiversity

- *Learning Outcome:* Appreciate the diversity and value of living things and their role in the larger picture of life, understanding that evolution and biodiversity are the result of genetic selection that occur in the constantly changing environments

Performance Objective(s):

- Explain how the fossil record, comparative anatomy, and other evidence support the theory of evolution.
- Illustrate how genetic variation is preserved or eliminated from a population through Darwinian natural selection (evolution) resulting in biodiversity.
- Describe how the taxonomic system classifies living things into domains (eubacteria, archaeobacteria, and eukaryotes) and kingdoms (animals, plants, fungi, etc.).

Topic: Ecology

- *Learning Outcome:* Develop a respect for the environment and all its inhabitants, realizing that ecology is the fragile interaction between living organisms and their environment

Performance Objective(s):

- Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen).
- Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels.
- Identify the factors in an ecosystem that influence fluctuations in population size.
- Analyze changes in an ecosystem resulting from natural causes, changes in climate, human activity, or introduction of non-native species.
- Explain how symbiotic behavior produces interactions within ecosystems.

Earth and Space Science

- *This topic is currently addressed in a widespread manner in life and physical science courses and several elective courses. Depth and breadth vary by school. The feasibility of a fully integrated course of study in the earth and space sciences is under discussion.*

Chemistry

Topic: Properties of Matter

- *Learning Outcome:* Use physical and chemical properties to classify and describe matter

Performance Objective(s):

- Identify and explain some of the physical properties that are used to classify matter, e.g., density, melting point, and boiling point.
- Explain the difference between mixtures and pure substances.
- Describe the four states of matter (solid, liquid, gas, plasma) in terms of energy, particle motion, and phase transitions.
- Distinguish between chemical and physical changes.

Topic: Atomic Structure

- *Learning Outcome:* Present the atom as a discrete unit, using the atomic model to help understand the interaction of elements and compounds observed on a macroscopic scale

Performance Objective(s):

- Trace the development of atomic theory and the structure of the atom from the ancient Greeks to the present (Dalton, Thompson, Rutherford, Bohr, and modern theory).
- Interpret Dalton's atomic theory in terms of the Laws of Conservation of Mass, Constant Composition, and Multiple Proportions.
- Identify the major components of the nuclear atom (protons, neutrons, and electrons) and explain how they interact.
- Understand that matter has properties of both particles and waves.
- Using Bohr's model of the atom interpret changes (emission/absorption) in electron energies in the hydrogen atom corresponding to emission transitions between quantum levels.
- Describe the electromagnetic spectrum in terms of wavelength and energy; identify regions of the electromagnetic spectrum.
- Write the electron configurations for elements in the first three rows of the periodic table.
- Describe alpha, beta, and gamma particles; discuss the properties of alpha, beta, and gamma radiation; and write balanced nuclear reactions.
- Compare nuclear fission and nuclear fusion and mass defect.
- Describe the process of radioactive decay as the spontaneous breakdown of certain unstable elements (radioactive) into new elements (radioactive or not) through the spontaneous emission by the nucleus of alpha or beta particles. Explain the difference between stable and unstable isotopes.
- Explain the concept of half-life of a radioactive element, e.g., explain why the half-life of C14 has made carbon dating a powerful tool in determining the age of very old objects.

Topic: Periodicity

- *Learning Outcome:* Relate periodicity of physical and chemical properties to atomic structure and the development and organization of the periodic table

Performance Objective(s):

- Explain the relationship of an element's position on the periodic table to its atomic number and mass.
- Use the periodic table to identify metals, nonmetals, metalloids, families (groups), periods, valence electrons, and reactivity with other elements in the table.
- Relate the position of an element on the periodic table to its electron configuration.

- Identify trends on the periodic table (ionization energy, electronegativity, electron affinity, and relative size of atoms and ions).

Topic: Chemical Bonding

- *Learning Outcome:* Describe the role of atoms in the formation of chemical bonds by the interactions of their valence electrons

Performance Objective(s):

- Explain how atoms combine to form compounds through both ionic and covalent bonding.
- Draw Lewis dot structures for simple molecules.
- Relate electronegativity and ionization energy to the type of bonding an element is likely to undergo.
- Predict the geometry of simple molecules and their polarity (valence shell electron pair repulsion).
- Identify the types of intermolecular forces present based on molecular geometry and polarity.
- Predict chemical formulas based on the number of valence electrons.
- Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain common polyatomic ions.

Topic: Chemical Reactions & Stoichiometry

- *Learning Outcome:* Calculate the number, mass and volume of products and reactants as related to the conservation of atoms in chemical reactions

Performance Objective(s):

- Balance chemical equations by applying the law of conservation of mass.
- Recognize synthesis, decomposition, single displacement, double displacement, and neutralization reactions.
- Understand the mole concept in terms of number of particles, mass, and gaseous volume.
- Determine molar mass, percent compositions, empirical formulas, and molecular formulas.
- Calculate mass-mass, mass-volume, volume-volume, and limiting reactant problems for chemical reactions.
- Calculate percent yield in a chemical reaction.

Topic: Gases & Kinetic Molecular Theory

- *Learning Outcome:* Explain the behavior of gases as a function of the Kinetic Molecular Theory

Performance Objective(s):

- Using the kinetic molecular theory, explain the relationship between pressure and volume (Boyle's law), volume and temperature (Charles' law), and the number of particles in a gas sample (Avogadro's hypothesis).
- Explain the relationship between temperature and average kinetic energy.
- Perform calculations using the ideal gas law.
- Describe the conditions under which a real gas deviates from ideal behavior.
- Interpret Dalton's empirical Law of Partial Pressures and use it to calculate partial pressures and total pressures.
- Use the combined gas law to determine changes in pressure, volume, or temperature.

Topic: Solutions

- *Learning Outcome:* Understand the solids, liquid and gases dissolve to form solutions

Performance Objective(s):

- Describe the process by which solutes dissolve in solvents.
- Identify and explain the factors that affect the rate of dissolving, i.e., temperature, concentration, and mixing.
- Describe the dynamic equilibrium that occurs in saturated solutions.
- Calculate concentration in terms of molarity, molality, and percent by mass.
- Use a solubility curve to determine saturation values at different temperatures.
- Calculate the freezing point depression and boiling point elevation of a solution.
- Write net ionic equations for precipitation reactions in aqueous solutions.

Topic: Acids and Bases

- *Learning Outcome:* Discuss the importance of acids and bases in numerous chemical processes that occur around us, from industrial processes to biological ones, from the laboratory to the environment
Performance Objective(s):
 - Define Arrhenius' theory of acids and bases in terms of the presence of hydronium and hydroxide ions, and Bronsted's theory of acids and bases in terms of proton donor and acceptor, and relate their concentrations to the pH scale.
 - Compare and contrast the nature, behavior, concentration and strength of acids and bases.
 - a. Acid-base neutralization
 - b. Degree of dissociation or ionization
 - c. Electrical conductivity
 - Identify a buffer and explain how it works.
 - Explain how indicators are used in titrations and how they are selected.
 - Describe an acid-base titration. Identify when the equivalence point is reached and its significance.
 - Calculate the pH or pOH of aqueous solutions using the hydronium or hydroxide ion concentration.

Topic: Equilibrium & Kinetics

- *Learning Outcome:* Explain how chemical equilibrium is a dynamic process that is significant in many systems (biological, ecological and geological) and that chemical reactions occur at different rates
Performance Objective(s):
 - Write the equilibrium expression and calculate the equilibrium constant for a reaction.
 - Predict the shift in equilibrium when the system is subjected to a stress (LeChatelier's principle).
 - Identify the factors that affect the rate of a chemical reaction (temperature, concentration) and the factors that can cause a shift in equilibrium (concentration, pressure, volume, temperature).
 - Explain rates of reaction in terms of collision frequency, energy of collisions, and orientation of colliding molecules.
 - Define the role of activation energy in a chemical reaction.

Topic: Thermochemistry (Enthalpy)

- *Learning Outcome:* Emphasize that the driving forces of chemical reactions are energy and entropy and discuss the important implications for many applications
Performance Objective(s):
 - Interpret the law of conservation of energy.
 - Explain the relationship between energy transfer and disorder in the universe.
 - Analyze the energy changes involved in physical and chemical processes using calorimetry.
 - Apply Hess's law to determine the heat of reaction.

Topic: Oxidation-Reduction and Electrochemistry

- *Learning Outcome:* Explain that oxidation-reduction reactions occur by electron transfer and constitute a major class of chemical reactions
Performance Objective(s):
 - Describe the chemical processes known as oxidation and reduction.
 - Assign oxidation numbers.
 - Balance oxidation-reduction equations by using half-reactions.
 - Identify the components, and describe the processes that occur in an electrochemical cell.
 - Explain how a typical battery, such as a lead storage battery or a dry cell, works.
 - Compare and contrast voltaic and electrolytic cells and their uses.
 - Calculate the net voltage of a cell given a table of standard reduction potentials.

Physics

Topic: Motion and Forces

- *Learning Outcome:* Describe and predict the motion of most objects using Newton's Laws of motion and gravitation

Performance Objective(s):

- Distinguish between vector quantities (velocity, acceleration, and force) and scalar quantities (speed and mass).
- Illustrate how to represent vectors graphically and be able to add them graphically.
- Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.
- Create and interpret graphs of motion (position vs. time, speed vs. time, velocity vs. time, constant acceleration vs. time).
- Explain the relationship between mass and inertia.
- Interpret and apply Newton's first law of motion.
- Interpret and apply Newton's second law of motion to show how an object's motion will change only when a net force is applied.
- Use a free body force diagram with only co-linear forces to show forces acting on an object, and determine the net force on it.
- Qualitatively distinguish between static and kinetic friction, what they depend on and their effects on the motion of objects.
- Interpret and apply Newton's third law of motion.
- Understand conceptually Newton's law of universal gravitation.
- Identify appropriate standard international units of measurement for force, mass, distance, speed, acceleration, and time, and explain how they are measured.

Topic: Conservation of Energy and Momentum

- *Learning Outcome:* Explain how the laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects

Performance Objective(s):

- Interpret and provide examples that illustrate the law of conservation of energy.
- Provide examples of how energy can be transformed from kinetic to potential and vice versa.
- Apply quantitatively the law of conservation of mechanical energy to simple systems.
- Describe the relationship among energy, work, and power both conceptually and quantitatively.
- Interpret the law of conservation of momentum and provide examples that illustrate it. Calculate the momentum of an object.
- Identify appropriate standard international units of measurement for energy, work, power, and momentum.

Topic: Heat and Heat Transfer

- *Learning Outcome:* Explain that heat is energy that is transferred between bodies that are at different temperatures by the processes of convection, conduction, and/or radiation

Performance Objective(s):

- Relate thermal energy to molecular motion.
- Differentiate between specific heat and heat capacity.
- Explain the relationship among temperature change in a substance for a given amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.
- Recognize that matter exists in four phases, and explain what happens during a phase change.

Topic: Waves

- *Learning Outcome:* Explain that waves carry energy from place to place without the transfer of matter

Performance Objective(s):

- Relate thermal energy to molecular motion.
- Differentiate between specific heat and heat capacity.
- Explain the relationship among temperature change in a substance for a given amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.
- Recognize that matter exists in four phases, and explain what happens during a phase change.
- Interpret and be able to apply the laws of reflection and refraction (qualitatively) to all waves.
- Recognize the effects of polarization, wave interaction, and the Doppler effect.
- Explain, graph, and interpret graphs of constructive and destructive interference of waves.
- Explain the relationship between the speed of a wave (e.g., sound) and the medium it travels through.
- Recognize the characteristics of a standing wave and explain the conditions under which two waves on a string or in a pipe can interfere to produce a standing wave.

Topic: Electromagnetism

- *Learning Outcome:* Explain that stationary and moving charge particles result in the phenomenon known as electricity and magnetism.

Performance Objective(s):

- Recognize the characteristics of static charge, and explain how a static charge is generated
- Interpret and apply Coulomb's law.
- Explain the difference in concept between electric forces and electric fields
- Develop a qualitative and quantitative understanding of current, voltage, resistance, and the connection between them
- Identify appropriate units of measurement for current, voltage, and resistance, and explain how they are measured
- Analyze circuits (find the current at any point and the potential difference between any two points in the circuit) using Kirchoff's and Ohm's laws

Topic: Electromagnetic Radiation

- *Learning Outcome:* Explain that oscillating electric or magnetic fields can generate electromagnetic waves over a wide spectrum of energies.

Performance Objective(s):

- Describe the electromagnetic spectrum in terms of wavelength and energy, and be able to identify specific regions such as visible light.
- Explain how the various wavelengths in the electromagnetic spectrum have many useful applications such as radio, television, microwave appliances, and cellular telephones.
- Calculate the frequency and energy of an electromagnetic wave from the wavelength.
- Recognize and explain the ways in which the direction of visible light can be changed.