Biology/Physics/Chemistry (High School)

Essential Standards

Science

Based on State Key Content Standards compiled by the Pulliam Group

Biology	Physics	Chemistry
Cell Biology- *1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of organism's cells. Students should know:* a. that cells are enclosed within semi permeable membranes that regulate their interaction with their surrounding. b. that enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium, and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings. c. how prokaryotic and eukaryotic cells, and viruses differ in complexity and structure. d. that the central dogma of molecular biology outlines the flow of information from transcription of RNA in the nucleus to translation of proteins on ribosomes in the cytoplasm. e. the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins. f. that usable energy is captured from sunlight by chloroplasts and is stored through synthesis of sugar from carbon dioxide. g. the role of the mitochondria in making stored chemical-bond energy available to cells by completing the breakdown of glucose to carbon dioxide. h. that most macro-molecules in cells and organisms are synthesized from a small collection of simple precursors. **Genetics-** *2. Mutation and reproduction lead to variation in a population. Students should know:* a. that meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type. b. that only certain cells in a multi-cellular organism undergo meiosis. c. how random chromosome segregation explains the probability that a particular allele will be in a gamete. d. that new combinations of alleles may be generated in a zygote through the fusion of male and female gametes. e. why approximately half of an individual's DNA sequence come from each parent. f. the role of chromosomes in determining an individual's sex. g. how to predict possible combinations of alleles in a	**1. Motion and Forces** – *Newton's laws predict the motion of most objects. To understand this concept, students should know:* a. how to solve problems that involve constant speed and average speed. b. that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's second law). c. how to apply the law $F = ma$ to solve one-dimensional motion problems that involve constant forces (Newton's second law). d. that when one object exerts a force on a second object, the second object exerts a force of equal magnitude **in** the opposite direction (Newton's third law). e. the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth. f. that applying a force to an object perpendicular to the direction of its motion cause the object to change direction but not speed. g. that circular motion requires constant force directed toward the center of the circle. **2. *Conservation of Energy & Momentum*** - The *laws of conservation of energy and* momentum *predict and describe the movement* of *objects. Students should know:* a. how to calculate kinetic energy by using the formula E = *(l/2) mV2.* b. how to calculate changes in gravitational potential energy near Earth.* c. how to solve problems involving conservation of energy in simple systems. d. how to calculate momentum as the product *mv.* e. that momentum is a separately conserved quantity different from energy. f. that an unbalanced force on an object produces a change in its momentum. g. how to solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy. **3. *Heat and Thermodynamics*** - *Energy cannot be created or destroyed, but may be transferred as heat. To understand this concept, students should know that:* a. heat flow and work are two forms of energy transfer	**Atomic and Molecular Structure** - *To understand the nature of the periodic table, students should know:* a. how to relate the position of an element in the periodic table to its atomic number and atomic mass. b. how to use the periodic table to identify metals, semimetals, nonmetals, and halogens. c- how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electro negativity, and the relative sizes of ions and atoms. d. how to use the periodic table to determine the number of electrons available for bonding. e. that the nucleus of the atom is much smaller than the atom yet contains most of its mass. **Chemical Bonds -** *The properties of matter result from the ability of atoms to form bonds from electrostatic forces. To understand this concept, students should know:* a. that atoms combine to *form* molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds. b. that chemical bonds between atoms in molecules such as H_2, CH_4, NH_3, H_2CCH_2, N_2, CI_2, and many large biological molecules are covalent. c. salt crystals are repeating patterns of positive and negative ions held together by electrostatic attraction. d. that atoms and molecules in liquids move in a random pattern relative to one another because intermolecular forces are too weak to hold atoms or molecules in a solid form. e. how to draw Lewis dot structures. **Conservation of Matter and Stoichiometry** *Students should know:* a. how to describe chemical reactions by writing balanced equations. b. that the quantity *one mole* is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams. c. that one mole equals 6.02×10^{23} particles (atoms or molecules). d. how to determine the molar mass of a molecule and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas. e. how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic

zygote from the genetic makeup of the parents.
3. Multi-cellular organisms develop from a single zygote and phenotype depends on genotype. Students should know that:
a. how to predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance.
b. the genetic basis for Mendel's laws of segregation and independent assortment.
4. Genes are a set of instructions encoded in DNA. Students should know that:
a. the general pathway by which ribosomes synthesize proteins, using RNA's to translate genetic information in mRNA.
b. how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.
c. how mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.
d. that specialization of cells in multi-cellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.
e. that proteins can differ from one another in the number and sequence of amino acids.
5. Cell can be altered by exogenous DNA. Students should know:
a. the general structures and functions of DNA, RNA, and protein.
b. how to apply base-pairing rules to explain precise copying of DNA during semi-conservative replication and transcription of information from DNA into mRNA.
c. how genetic engineering produces novel biomedical and agricultural products.

Ecology
6. Stability in an ecosystem is a balance between competing effects. To understand this concept, students should know:
a. that biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
b. how to analyze changes in an ecosystem resulting from changes in climate, human, activity, introduction of non-native species, or changes in population size.
c. how fluctuations in population size in an ecosystem are determined b y the relative rates of birth, immigration, emigration, and death.
d. how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
e. that a vital part of an ecosystem is the stability of its producers and decomposers.
f. that at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat.

between systems.
b. (he work done by a heat engine that is working in a cycle is the difference between the heat How into the engine at high temperature and the heat flow out at a lower temperature and that this is an example of the law of conservation of energy.
c. the greater the temperature of (tie object, me greater the energy of motion of the atoms and molecules that make up the object-
d. most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.
e. entropy is a quantity that measures the order or disorder of a system.

4. *Waves-* *Waves have properties that do not depend of the type of wave. To understand this concept, students should know:*
a. that waves carry energy from one place to another.
b. how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves) *!*
c. how to solve problems involving wavelength, frequency, and wave speed.
d. that sound is a longitudinal wave whose speed depends on the medium in which it propagates.
f. how to identify the characteristic properties of waves: interference, diffraction, refraction, Doppler effect, and polarization.

5*. Electric and Magnetic* *Phenomena - Electric and magnetic phenomena are related and have many practical applications. To understand this concept, students should know:*
a. how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
b. how to solve problems involving Ohm's law.
c. that any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power in any resistive circuit element by using the formula Power = IR (potential difference) x I (current) = I^2R.
d. the properties of transistors and the role of transistors in electric circuits.
e. that charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.
f. that magnetic materials and electric currents are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
g. how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.
h. that changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

masses.

Gases and their Properties
4. Kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. Students should know:
a- that the random motion of molecules and their collisions with a surface create the observable pressure on that surface.
b. that the random motion of molecules explains the diffusion of gases.
c. how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.
d. the values and meanings of standard temperature and pressure (STP).
e. how to convert between the Celsius and Kelvin temperature scales.
f. that there is no temperature lower than 0 Kelvin.

Acids and Bases
5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. Students should know:
a. the observable properties of acids, bases, and salt solutions.
b. that acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
c. that strong acids and bases fully dissociate and weak acids and bases partially dissociate.
d. how to use the pH scale to characterize acid and base solutions.

Solutions
6. Solutions are homogenous mixtures of two or more substances. Students should know:
a. the definitions *of solute* and *solvent.*
b. how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
c. that temperature, pressure, and surface area affect the dissolving process.
d. how to calculate the concentration of a solute in terms of gram per liter, molarity, parts per million, and percent composition.

Chemical Thermo- Dynamics
7. Energy is exchanged or transformed in all chemical *reactions. Students should know:*
a. how to describe temperature and heat flow in terms of the motion of molecules.
b. that chemical processes can either release or absorb thermal energy.
c that energy is released when a material condenses or freezes and is absorbed when a material evaporates **or** melts.

Evolution- *7. The frequency of an allele in a gene pool may be stable or unstable. To understand this, students should know:* a. why natural selection acts on the phenotype rather than the genotype of an organism. b. why alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool. c. that new mutations are constantly being generated in a gene pool. d. that variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions. *8. Evolution is the result of genetic changes that occur constantly. To understand this, students should know:* a. how natural selection determines the differential survival of groups of organisms. c. the effects of genetic drift on the diversity of organisms in a population. d. that reproductive or geographic isolation affects speciation. e. how to analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction. **Physiology-** *9. The internal environment of the human body remains relatively stable. Students should know:* a. how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide. b. how the nervous system mediates communication between different parts of the body and the body's interactions with the environment. c. how feedback loops in the nervous and endocrine systems regulates conditions in the body. d. the functions of the nervous system and the role of neurons in transmitting electrochemical impulses. *10. Organisms have a variety of mechanisms to combat disease. Students should know:* a. the role of the skin in providing nonspecific defenses against infection. b. the role of antibodies in the body's response to infection. c. how vaccination protects an individual from infectious diseases. d. there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections. e. why an individual with a compromised immune system may be unable to fight off and survive infection by microorganisms that are usually benign.	i. that plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.	d. how to solve problems involving heat flow and temperature changes using known values of specific heat and latent heat of phase change. **Reaction Rates** *8. Students should know:* a. that the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time. b. how the reaction rates depend on concentration, temperature and pressure. c. the role a catalyst plays in increasing the reaction rate. ' **Chemical Equilibrium** ***9.*** *Students should know;* a. how to use LeChatelier's principle to predict the effect of changes in concentration, temperature, and pressure. b. that equilibrium is established when forward and reverse reaction rates are equal. **Organic Chemistry and Biochemistry** *10. Students should know:* a. that large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combination of simple subunits. b. the bonding characteristics of carbon that results in the formation of structures ranging from simple hydrocarbons to complex polymer, and biological molecules. c. that ammo acids are the building blocks of proteins. **Nuclear Processes** *11. Students should know:* a. protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons. b. the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. c. some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.

Investigation and Experimentation – *To ask meaningful questions and conduct careful investigations, Students will:* a. select and use appropriate tools and technology to perform tests, collect, and display data. b. identify and communicate sources of unavoidable experimental error. c. identify possible reasons of inconsistent results. d. formulate explanations using logic and evidence. f. distinguish between hypothesis and theory as scientific terms. h. read and interpret topographic and geologic maps. i. analyze the locations, sequences or time intervals that are characteristic of the succession of species in an ecosystem.	**7. *Investigation and Experimentation*** - Scientific *progress is* made *by asking meaningful questions and conducting careful* investigations*. To understand this students .should be able to:* a. select and use appropriate tools and technology to perform test, collect data, analyze relationships and display data. b. identify and communicate sources of unavoidable experimental error. c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. d. formulate explanations by using logic and evidence. e. solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions. f. distinguish between hypothesis and theory as scientific terms. g. recognize the usefulness and limitations of models and theories as scientific representations of reality.	**Investigation and Experimentation** *Scientific progress is made by asking meaningful questions and conducting careful investigations. To understand this students should be able to:* a. select and use appropriate tools and technology to perform tests, collect data, analyze relationships and display data. b. identify and communicate sources of unavoidable experimental error. c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. d. formulate explanations by using logic and evidence. e. solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions. f. distinguish between hypothesis and theory as scientific terms. g. recognize the usefulness and limitations of models and theories as scientific representations of reality. n. know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent and that the theory is sometimes wrong.