Conejo Valley Unified School District
9-12 Grade Level Science Standards
Board Approved - 2/27/2007

GRADES 9-12
Physics
Motion and Forces
1. Newton's laws predict the motion of most objects. As a basis for understanding this concept:
1. a. Students know how to solve problems that involve constant speed and average speed.
1. b. Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
1. c. Students know how to apply the law F=ma to solve one-dimensional motion problems that involve constant forces (Newton's second law).
1. d. Students know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).
1. e. Students know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.
1. f. Students know applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (e.g., Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).
1. g. Students know circular motion requires the application of a constant force directed toward the center of the circle.
1. h.* Students know Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.
1. i.* Students know how to solve two-dimensional trajectory problems.
1. j.* Students know how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.
1. k.* Students know how to solve two-dimensional problems involving balanced forces (statics).
1. l.* Students know how to solve problems in circular motion by using the formula for centripetal acceleration in the following form: $a = v^2/r$.
1. m.* Students know how to solve problems involving the forces between two electric charges at a distance (Coulomb's law) or the forces between two masses at a distance (universal gravitation).
Conservation of Energy and Momentum
2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept:
2. a. Students know how to calculate kinetic energy by using the formula $E = \frac{1}{2}mv^2$.
2. b. Students know how to calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) = mgh (h is the change in the elevation).
2. c. Students know how to solve problems involving conservation of energy in simple systems, such as falling objects.
2. d. Students know how to calculate momentum as the product mv.
2. e. Students know momentum is a separately conserved quantity different from energy.
2. f. Students know an unbalanced force on an object produces a change in its momentum.
2. g. Students know how to solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.
2. h.* Students know how to solve problems involving conservation of energy in simple systems with various sources of potential energy, such as capacitors and springs.

Heat and Thermodynamics
3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:
3. a. Students know heat flow and work are two forms of energy transfer between systems.
3. b. Students know that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.
3. c. Students know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.
3. d. Students know that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.
3. e. Students know that entropy is a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system.
3. f.* Students know the statement "Entropy tends to increase" is a law of statistical probability that governs all closed systems (second law of thermodynamics).
3. g.* Students know how to solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings.
Waves
4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:
4. a. Students know waves carry energy from one place to another.
4. b. Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
4. c. Students know how to solve problems involving wavelength, frequency, and wave speed.
4. d. Students know sound is a longitudinal wave whose speed depends on the proper ties of the medium in which it propagates.
4. e. Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second).
4. f. Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

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Electric and Magnetic Phenomena
5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:
5. a. Students know how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
5. b. Students know how to solve problems involving Ohm's law.
5. c. Students know any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = IR (potential difference) x I (current) = I^2 R.
5. d. Students know the properties of transistors and the role of transistors in electric circuits.
5. e. Students know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.
5. f. Students know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
5. g. Students know how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.
5. h. Students know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.
5. i. Students know plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.
5. j.* Students know electric and magnetic fields contain energy and act as vector force fields.
5. k.* Students know the force on a charged particle in an electric field is qE, where E is the electric field at the position of the particle and q is the charge of the particle.
5. l.* Students know how to calculate the electric field resulting from a point charge.
5. m.* Students know static electric fields have as their source some arrangement of electric charges.
5. n.* Students know the magnitude of the force on a moving particle (with charge q) in a magnetic field is qvB sin(a), where *a* is the angle between v and B (v and B are the magnitudes of vectors v and B, respectively), and students use the right-hand rule to find the direction of this force.
5. o.* Students know how to apply the concepts of electrical and gravitational potential energy to solve problems involving conservation of energy.

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Chemistry
Atomic and Molecular Structure
1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:
1. a. Students know how to relate the position of an element in the periodic table to its atomic number and atomic mass.
1. b. Students know how to use the periodic table to identify metals, semi-metals, non-metals, and halogens.
1. c. Students know how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.
1. d. Students know how to use the periodic table to determine the number of electrons available for bonding.
1. e. Students know the nucleus of the atom is much smaller than the atom yet contains most of its mass.
1. f.* Students know how to use the periodic table to identify the lanthanide, actinide, and transactinide elements and know that the transuranium elements were synthesized and identified in laboratory experiments through the use of nuclear accelerators.
1. g.* Students know how to relate the position of an element in the periodic table to its quantum electron configuration and to its reactivity with other elements in the table.
1. h.* Students know the experimental basis for Thomson's discovery of the electron, Rutherford's nuclear atom, Millikan's oil drop experiment, and Einstein's explanation of the photoelectric effect.
1. i.* Students know the experimental basis for the development of the quantum theory of atomic structure and the historical importance of the Bohr model of the atom.
1. j.* Students know that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Planck's relationship ($E = hv$).
Chemical Bonds
2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:
2. a. Students know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.
2. b. Students know chemical bonds between atoms in molecules such as H_2 , CH_4 , NH_3 , H_2CCH_2 , N_2 ,Cl_2 , and many large biological molecules are covalent.
2. c. Students know salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.
2. d. Students know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.
2. e. Students know how to draw Lewis dot structures.
2. f.* Students know how to predict the shape of simple molecules and their polarity from Lewis dot structures.
2. g.* Students know how electronegativity and ionization energy relate to bond formation.
2. h.* Students know how to identify solids and liquids held together by Van der Waals forces or hydrogen bonding and relate these forces to volatility and boiling/melting point temperatures.

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Conservation of Matter and Stoichiometry
3. The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:
3. a. Students know how to describe chemical reactions by writing balanced equations.
3. b. Students know the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.
3. c. Students know one mole equals $6.02x10^{23}$ particles (atoms or molecules).
3. d. Students know how to determine the molar mass of a molecule from its chemical formula and a table of atomic masses and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.
3. e. Students know 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 masses.
3. f.* Students know how to calculate percent yield in a chemical reaction.
3. g.* Students know how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.
Gases and Their Properties
4. The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:
4. a. Students know the random motion of molecules and their collisions with a surface create the observable pressure on that surface.
4. b. Students know the random motion of molecules explains the diffusion of gases.
4. c. Students know 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.
4. d. Students know the values and meanings of standard temperature and pressure (STP).
4. e. Students know how to convert between the Celsius and Kelvin temperature scales.
4. f. Students know there is no temperature lower than 0 Kelvin.
4. g.* Students know the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.
4. h.* Students know how to solve problems by using the ideal gas law in the form $PV = nRT$.
4. i.* Students know how to apply Dalton’s law of partial pressures to describe the composition of gases and Graham’s law to predict diffusion of gases.
Acids and Bases
5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:
5. a. Students know the observable properties of acids, bases, and salt solutions.
5. b. Students know acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
5. c. Students know strong acids and bases fully dissociate and weak acids and bases partially dissociate.
5. d. Students know how to use the pH scale to characterize acid and base solutions.
5. e.* Students know the Arrhenius, Brønsted-Lowry, and Lewis acid–base definitions.
5. f.* Students know how to calculate pH from the hydrogen-ion concentration.
5. g.* Students know buffers stabilize pH in acid–base reactions.

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Solutions
6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:
6. a. Students know the definitions of solute and solvent.
6. b. Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
6. c. Students know temperature, pressure, and surface area affect the dissolving process.
6. d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.
6. e.* Students know the relationship between the molality of a solute in a solution and the solution's depressed freezing point or elevated boiling point.
6. f.* Students know how molecules in a solution are separated or purified by the methods of chromatography and distillation.
Chemical Thermodynamics
7. Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:
7. a. Students know how to describe temperature and heat flow in terms of the motion of molecules (or atoms).
7. b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.
7. c. Students know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.
7. d. Students know how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.
7. e.* Students know how to apply Hess's law to calculate enthalpy change in a reaction.
7. f.* Students know how to use the Gibbs free energy equation to determine whether a reaction would be spontaneous.
Reaction Rates
8. Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules. As a basis for understanding this concept:
8. a. Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
8. b. Students know how reaction rates depend on such factors as concentration, temperature, and pressure.
8. c. Students know the role a catalyst plays in increasing the reaction rate.
8. d.* Students know the definition and role of activation energy in a chemical reaction.
Chemical Equilibrium
9. Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:
9. a. Students know how to use LeChatelier's principle to predict the effect of changes in concentration, temperature, and pressure.
9. b. Students know equilibrium is established when forward and reverse reaction rates are equal.
9. c.* Students know how to write and calculate an equilibrium constant expression for a reaction.

Organic and Biochemistry
10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the bio-chemical basis of life. As a basis for understanding this concept:
10. a. Students know large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.
10. b. Students know the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules.
10. c. Students know amino acids are the building blocks of proteins.
10. d.* Students know the system for naming the ten simplest linear hydrocarbons and isomers that contain single bonds, simple hydrocarbons with double and triple bonds, and simple molecules that contain a benzene ring.
10. e.* Students know how to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.
10. f.* Students know the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins.
Nuclear Processes
11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:
11. a. Students know protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.
11. b. Students know the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by $E = mc^2$) is small but significant in nuclear reactions.
11. c. Students know some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
11. d. Students know the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.
11. e. Students know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.
11. f.* Students know how to calculate the amount of a radioactive substance remaining after an integral number of half lives have passed.
11. g.* Students know protons and neutrons have substructures and consist of particles called *quarks.*

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Biology/Life Sciences
Cell Biology
1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:
1. a. Students know cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.
1. b. Students know 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.
1. c. Students know how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.
1. d. Students know the central dogma of molecular biology outlines the flow of information from transcription of ribonucleic acid (RNA) in the nucleus to translation of proteins on ribosomes in the cytoplasm.
1. e. Students know the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins.
1. f. Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.
1. g. Students know the role of the mitochondria in making stored chemical-bond energy available to cells by completing the breakdown of glucose to carbon dioxide.
1. h. Students know most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors.
1. i.* Students know how chemiosmotic gradients in the mitochondria and chloroplast store energy for ATP production.
1. j* Students know how eukaryotic cells are given shape and internal organization by a cytoskeleton or cell wall or both.
Genetics (Meiosis and Fertilization)
2. Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept:
2. a. Students know 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.
2. b. Students know only certain cells in a multicellular organism undergo meiosis.
2. c. Students know how random chromosome segregation explains the probability that a particular allele will be in a gamete.
2. d. Students know new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).
2. e. Students know why approximately half of an individual's DNA sequence comes from each parent.
2. f. Students know the role of chromosomes in determining an individual's sex.
2. g. Students know how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents.

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Genetics (Mendel's Laws)
3. A multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization. As a basis for understanding this concept:
3. a. Students know how to predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive).
3. b. Students know the genetic basis for Mendel's laws of segregation and independent assortment.
3. c.* Students know how to predict the probable mode of inheritance from a pedigree diagram showing phenotypes.
3. d.* Students know how to use data on frequency of recombination at meiosis to estimate genetic distances between loci and to interpret genetic maps of chromosomes.
Genetics (Molecular Biology)
4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept:
4. a. Students know the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA.
4. b. Students know how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.
4. c. Students know 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.
4. d. Students know specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.
4. e. Students know proteins can differ from one another in the number and sequence of amino acids.
4. f.* Students know why proteins having different amino acid sequences typically have different shapes and chemical properties.
Genetics (Biotechnology)
5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:
5. a. Students know the general structures and functions of DNA, RNA, and protein.
5. b. Students know how to apply base-pairing rules to explain precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA.
5. c. Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.
5. d.* Students know how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules.
5. e.* Students know how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.

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Ecology
6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
6. a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
6. b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
6. c. Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
6. d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
6. e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.
6. f. Students know 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. This dissipation may be represented in an energy pyramid.
6. g.* Students know how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.
Evolution (Population Genetics)
7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:
7. a. Students know why natural selection acts on the phenotype rather than the genotype of an organism.
7. b. Students know why alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool.
7. c. Students know new mutations are constantly being generated in a gene pool.
7. d. Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.
7. e.* Students know the conditions for Hardy-Weinberg equilibrium in a population and why these conditions are not likely to appear in nature.
7. f.* Students know how to solve the Hardy-Weinberg equation to predict the frequency of genotypes in a population, given the frequency of phenotypes.

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Evolution (Speciation)
8. Evolution is the result of genetic changes that occur in constantly changing environments. As a basis for understanding this concept:
8. a. Students know how natural selection determines the differential survival of groups of organisms.
8. b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.
8. c. Students know the effects of genetic drift on the diversity of organisms in a population.
8. d. Students know reproductive or geographic isolation affects speciation.
8. e. Students know how to analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction.
8. f.* Students know how to use comparative embryology, DNA or protein sequence comparisons, and other independent sources of data to create a branching diagram (cladogram) that shows probable evolutionary relationships.
8. g.* Students know how several independent molecular clocks, calibrated against each other and combined with evidence from the fossil record, can help to estimate how long ago various groups of organisms diverged evolutionarily from one another.
Physiology (Homeostasis)
9. As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept:
9. a. Students know how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.
9. b. Students know how the nervous system mediates communication between different parts of the body and the body's interactions with the environment.
9. c. Students know how feedback loops in the nervous and endocrine systems regulate conditions in the body.
9. d. Students know the functions of the nervous system and the role of neurons in transmitting electrochemical impulses.
9. e. Students know the roles of sensory neurons, interneurons, and motor neurons in sensation, thought, and response.
9. f.* Students know the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acid, and bile salts.
9. g.* Students know the homeostatic role of the kidneys in the removal of nitrogenous wastes and the role of the liver in blood detoxification and glucose balance.
9. h.* Students know the cellular and molecular basis of muscle contraction, including the roles of actin, myosin, Ca^{+2} , and ATP.
9. i.* Students know how hormones (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms.

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Physiology (Infection and Immunity)
10. Organisms have a variety of mechanisms to combat disease. As a basis for understanding the human immune response:
10. a. Students know the role of the skin in providing nonspecific defenses against infection.
10. b. Students know the role of antibodies in the body's response to infection.
10. c. Students know how vaccination protects an individual from infectious diseases.
10. d. Students know 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.
10. e. Students know why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign.
10. f.* Students know the roles of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system.

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Earth Sciences
<u>Earth's Place in the Universe (Solar System)</u>
1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:
1. a. Students know how the differences and similarities among the sun, the terrestrial planets, and the gas planets may have been established during the formation of the solar system.
1. b. Students know the evidence from Earth and moon rocks indicates that the solar system was formed from a nebular cloud of dust and gas approximately 4.6 billion years ago.
1. c. Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.
1. d. Students know the evidence indicating that the planets are much closer to Earth than the stars are.
1. e. Students know the Sun is a typical star and is powered by nuclear reactions, primarily the fusion of hydrogen to form helium.
1. f. Students know the evidence for the dramatic effects that asteroid impacts have had in shaping the surface of planets and their moons and in mass extinctions of life on Earth.
1. g.* Students know the evidence for the existence of planets orbiting other stars.
<u>Earth's Place in the Universe (Stars, Galaxies, and the Universe)</u>
2. Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time. As a basis for understanding this concept:
2. a. Students know the solar system is located in an outer edge of the disc-shaped Milky Way galaxy, which spans 100,000 light years.
2. b. Students know galaxies are made of billions of stars and comprise most of the visible mass of the universe.
2. c. Students know the evidence indicating that all elements with an atomic number greater than that of lithium have been formed by nuclear fusion in stars.
2. d. Students know that stars differ in their life cycles and that visual, radio, and X-ray telescopes may be used to collect data that reveal those differences.
2. e.* Students know accelerators boost subatomic particles to energy levels that simulate conditions in the stars and in the early history of the universe before stars formed.
2. f.* Students know the evidence indicating that the color, brightness, and evolution of a star are determined by a balance between gravitational collapse and nuclear fusion.
2. g.* Students know how the red-shift from distant galaxies and the cosmic background radiation provide evidence for the "big bang" model that suggests that the universe has been expanding for 10 to 20 billion years.

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Dynamic Earth Processes
3. Plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on Earth's surface. As the basis for understanding this concept:
3. a. Students know features of the ocean floor (magnetic patterns, age, and sea-floor topography) provide evidence of plate tectonics.
3. b. Students know the principal structures that form at the three different kinds of plate boundaries.
3. c. Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
3. d. Students know why and how earthquakes occur and the scales used to measure their intensity and magnitude.
3. e. Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.
3. f.* Students know the explanation for the location and properties of volcanoes that are due to hot spots and the explanation for those that are due to subduction.
Energy in the Earth System (Solar Energy Enters, Heat Escapes)
4. Energy enters the Earth system primarily as solar radiation and eventually escapes as heat. As a basis for understanding this concept:
4. a. Students know the relative amount of incoming solar energy compared with Earth's internal energy and the energy used by society.
4. b. Students know the fate of incoming solar radiation in terms of reflection, absorption, and photosynthesis.
4. c. Students know the different atmospheric gases that absorb the Earth's thermal radiation and the mechanism and significance of the greenhouse effect.
4. d.* Students know the differing greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each.
Energy in the Earth System (Ocean and Atmospheric Convection)
5. Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. As a basis for understanding this concept:
5. a. Students know how differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.
5. b. Students know the relationship between the rotation of Earth and the circular motions of ocean currents and air in pressure centers.
5. c. Students know the origin and effects of temperature inversions.
5. d. Students know properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.
5. e. Students know rain forests and deserts on Earth are distributed in bands at specific latitudes.
5. f.* Students know the interaction of wind patterns, ocean currents, and mountain ranges results in the global pattern of latitudinal bands of rain forests and deserts.
5. g.* Students know features of the ENSO (El Niño southern oscillation) cycle in terms of sea-surface and air temperature variations across the Pacific and some climatic results of this cycle.

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Energy in the Earth System (Climate and Weather)
6. Climate is the long-term average of a region's weather and depends on many factors. As a basis for understanding this concept:
6. a. Students know weather (in the short run) and climate (in the long run) involve the transfer of energy into and out of the atmosphere.
6. b. Students know the effects on climate of latitude, elevation, topography, and proximity to large bodies of water and cold or warm ocean currents.
6. c. Students know how Earth's climate has changed over time, corresponding to changes in Earth's geography, atmospheric composition, and other factors, such as solar radiation and plate movement.
6. d.* Students know how computer models are used to predict the effects of the increase in greenhouse gases on climate for the planet as a whole and for specific regions.
Biogeochemical Cycles
7. Each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. As a basis for understanding this concept:
7. a. Students know the carbon cycle of photosynthesis and respiration and the nitrogen cycle.
7. b. Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.
7. c. Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.
7. d.* Students know the relative residence times and flow characteristics of carbon in and out of its different reservoirs.
Structure and Composition of the Atmosphere
8. Life has changed Earth's atmosphere, and changes in the atmosphere affect conditions for life. As a basis for understanding this concept:
8. a. Students know the thermal structure and chemical composition of the atmosphere.
8. b. Students know how the composition of Earth's atmosphere has evolved over geologic time and know the effect of outgassing, the variations of carbon dioxide concentration, and the origin of atmospheric oxygen.
8. c. Students know the location of the ozone layer in the upper atmosphere, its role in absorbing ultraviolet radiation, and the way in which this layer varies both naturally and in response to human activities.
California Geology
9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards. As a basis for understanding this concept:
9. a. Students know the resources of major economic importance in California and their relation to California's geology.
9. b. Students know the principal natural hazards in different California regions and the geologic basis of those hazards.
9. c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.
9. d.* Students know how to analyze published geologic hazard maps of California and know how to use the map's information to identify evidence of geologic events of the past and predict geologic changes in the future.

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<u>Investigation and Experimentation</u>
1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations.
Students will:
1. a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
1. b. Identify and communicate sources of unavoidable experimental error.
1. c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
1. d. Formulate explanations by using logic and evidence.
1. e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.
1. f. Distinguish between hypothesis and theory as scientific terms.
1. g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.
1. h. Read and interpret topographic and geologic maps.
1. i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
1. j. Recognize the issues of statistical variability and the need for controlled tests.
1. k. Recognize the cumulative nature of scientific evidence.
1. l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
1. m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.
1. n. Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).