California Science Teachers Association
In collaboration with the California Department of Education

INTEGRATED SCIENCE:
A Logic and Sequence for Meaningful Instruction

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Forward

In October, 2003, the California State Board of Education established sets of standards for each of four levels of high school integrated science. These standards are identical to the Grade 9-12 content standards in biology, chemistry, earth science, physics, and investigation and experimentation. By "successfully meeting the challenge [of these standards] . . . high school graduates can attain the highest level of science literacy . . ." (2003 Science Framework, Pg.154).

The 2003 Science Framework for California Public Schools states, "that no sequence or emphasis is prescribed" for structuring the high school science program (p.154) but leaves each high school and district the flexibility to design their own course structure. This document, developed collaboratively by the California Science Teachers Association and the California Department of Education, recognizes the autonomy of schools and districts and offers an instructional organization of standards that supports student learning in a four year integrated science program. The instructional models for the four levels of integrated science, as contained in this document, are provided as *examples* of how high school instruction in integrated science might be organized. There are alternative ways in which an integrated science curriculum might be organized and, therefore, this document does not represent a mandate for instruction.

The four models provide for the integration of each of the disciplines of science, as well as the process of science, contained in the investigation and experimentation standards. They include narrative information that describes the overarching concepts for each level. Each level, excluding level IV, is developed into two semesters. Each semester is then developed into possible units. Specific standards are listed for each unit, and narrative is provided to facilitate the reader's understanding of why specific standards are clustered together. The narrative also gives teachers a design for scaffolding the standards to enhance student understanding of the science concepts contained in the standards. Additionally, flowcharts are presented for one or two concepts in each level to graphically illustrate both the instructional sequence and the "integrated relationships" between the standards clustered in a particular unit of instruction. These visual tools provide teachers with a quick overview of the connections and probable sequences in their curriculum. Teachers are encouraged to review each level and make appropriate modifications to best match their students' needs and their school context. The reader will also find the investigation and experimentation topics placed at the beginning of each course, as these standards should be embedded and covered throughout the entire course.

It is important to note that the standards sets for the four levels of integrated science are aligned to the blueprints for the California Standards Tests (CSTs). Schools are advised not to rearrange standards from one level to another for this reason. Each high school standard appears once in the four levels of integrated science. However, some standards may be introduced and not tested or may need to be reintroduced to facilitate complete understanding at a particular level.

In January, 2004, the State Board of Education approved a set of blueprints that will be used to design a high school assessment mandated by the No Child Left Behind (NCLB) act. This exam will be administered in 10th grade and will be assess the high school biology and middle school

life science standards. Schools/districts that are implementing integrated science in both 9th and 10th grade should recognize that 57 percent of the standards defined on the blueprint are covered in years one and two of the integrated science blueprints. Districts are encouraged to offer a comprehensive 7th grade standards-based science course so that students entering high school will have mastery of the life science standards which form the foundation for the high school biology standards.

This document is designed primary for science teachers who are responsible for implementing the science standards. The document is also useful for designers of science materials and professional development, who will be able to familiarize themselves with what is expected from our California students in the integrated/coordinated sequence. Parents, guardians, and students will find this document useful to see the overall coverage of the Science Content Standards for California Public Schools grade 9-12.

Table of Contents

INTEGRATED SCIENCE- LEVEL 1
PROPOSED INSTRUCTIONAL SEQUENCE

COURSE CONCEPT—The science curriculum in the first year of integrated science emphasizes how Earth is a unique system that supports life. Earth's biotic and abiotic systems are defined by the interaction of matter and energy through dynamic processes. These processes impact the biosphere over time. The standards in Integrated Science 1 present the foundations of physics, chemistry, biology, and earth science. These standards build the knowledge base that prepares the student for the next three years of integrated science where the rest of the California Science Standards will be addressed. The Integrated Science 1 concepts will be further enhanced by having students perform careful scientific investigations.

I. **Semester 1—The interaction of matter and energy define the Earth's systems**
The periodicity of elements is a method of organizing the components of matter. This periodicity allows scientists to predict and/or demonstrate how chemicals will react when combined together with the absorption or release of energy. Following from an understanding of atomic structure and interaction, the ideas of electromagnetism and wave mechanics are introduced. The vibration of electrons gives rise to the entire electromagnetic spectrum. The movement of the electrons is the foundation of electricity and magnetism. The same principles of wave mechanics in electromagnetic waves hold true for those waves that are mechanical in nature. The earthquakes in California are a result of the motion of large plates of land and emit waves and energy that are responsible for natural hazards. A knowledge of atomic and molecular structure will provide understanding of the chemical and physical characteristics of rocks that comprise the lithosphere.

A. **Unit Concept #1—**The characteristics of matter are defined by its composition and structure. A key component to earth's systems is the structure and composition of matter. The investigation of atomic behavior through the study of the Periodic Table will provide the foundation to understand various topics in earth science. The physical and chemical properties of rocks is determined by the atomic make up of the matter. The formation and composition of molecules determines the characteristics of matter. With this knowledge, the study of California geology and how it is shaped by plates, in the earth, will be investigated.

1. Chemistry1- 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.
    a. Chemistry 1a- Students know how to relate the position of an element in the Periodic Table to its atomic number and atomic mass.
    b. Chemistry 1b- Students know how to use the Periodic Table to identify metals, semimetals, non-metals, and halogens.

c. Chemistry 1c- 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.
d. Chemistry 1d- Students know how to use the Periodic Table to determine the number of electrons available for bonding.
e. Chemistry 1e- Students know the nucleus of the atom is much smaller than the atom yet contains most of its mass.
f. Chemistry 1f*- 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.
f. Chemistry 2a – 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. Earth 3c- Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
   a. Earth 3b- Students know the principal structures that form at the three different kinds of plate boundaries. (types of boundaries only)
   b. Earth 9b- Students know the principal natural hazards in different California regions and the geologic basis of those hazards. (introductory exposure only)

B. **Unit Concept #2—**The characteristics of energy transmission explain electricity, magnetism and wave phenomena. Transmission of energy has an important role in earth's processes. Waves and electricity occur as a result of energy transmission. The dynamics of how waves are produced and propagated will be investigated. This provides an understanding of the principles of sound and seismic wave transmission. Electric and magnetic fields are examples of energy transmission. Electricity is the result of a moving electric field caused by the movement of electrons. A moving electric field causes a change in the magnetic field. The relationship between an electric field and magnetic field shall be investigated. Natural and applied examples of these fields will be explained.

1. Physics 4- Waves have characteristic properties that do not depend on the type of wave.
   a. Physics 4a- Students know waves carry energy from one place to another.
   b. Physics 4b- Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).

(i) Earth 3d- Students know why and how earthquakes occur and the scales used to measure their intensity and magnitude.

c. Physics 4d- Students know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.

c. Physics 4e- 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 x 108 m/s (186,000 miles/second).

c. Physics 4f- Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

2. Physics 5- Electric and magnetic phenomena are related and have many practical applications.

a. Physics 5a- Students know how to predict the voltage or current in simple direct (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.

(i) Physics 5d- Students know the properties of transistors and the role of transistors in electric circuits.

b. Physics 5e- Students know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

b. Physics 5i- Students know plasmas, the fourth state of matter, contains ions or free electrons or both and conduct electricity.

b. Physics 5h- Students know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

(i) Earth 3a- Students know features of the ocean floor (magnetic patterns, age, and sea-floor topography) provide evidence of plate tectonics.

(a) Earth 3e- 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.

(b) Earth 3f*- 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.

e. Physics 5j*- Students know electric and magnetic fields contain energy and act as vector force fields.

f. Physics 5m*- Students know static electric fields have as their source some arrangement of electric charges.

f. Earth 3b- Students know the principal structures that form at the three different kinds of plate boundaries. (more detail)

f. Earth 9d- 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.

f. Earth 9b- Students know the principal natural hazards in different California regions and the geologic basis of those hazards. (more detail)

II. **Semester 2—Systems of the Earth impact the biosphere**

Biogeochemical cycles impact life on Earth. To understand these impacts, an examination of the biological, physical, and chemical properties of matter in the biogeochemical cycles needs to be established. The stability of life on earth is closely linked to the water, oxygen, carbon, and nitrogen cycles. Knowledge of these chemical cycles will assist in assessing changes that can affect the dynamic equilibrium of the Earth's biotic community. Organic evolution and shifts in biotic communities occur in the context of the Earth's constantly changing environments.

A. **Unit Concept #1—**Biogeochemical cycles support the Earth's biotic systems, and important abiotic influences help to govern these biogeochemical cycles. Understanding how chemical bonds form supports the study of these influences. Water, the universal solvent, can produce acidic and alkaline environments within its cycles. Further study will examine how specific molecules affect the water, carbon, and nitrogen cycles. Examples of these molecules are those of oxygen as it forms bonds with either carbon or nitrogen as it flows through the ecosystem.

1. Chemistry 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.
   a. Chemistry 2a- Students know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds. (Review)
   b. Chemistry 2b- 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.
   b. Chemistry 2c- Students know salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.

2. Biology 6d- 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.
   a. Chemistry 7c- Students know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.

a. Physics 4e- 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 x 108 m/s (186,000 miles/second). (Focus here is on infrared and visible light spectra.)
a. Earth 7a- Students know the carbon cycle of photosynthesis and respiration and the nitrogen cycle.
a. Earth 7b- 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.
a. Earth 7c- Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.
a. Earth 7d*- Students know the relative residence times and flow characteristics of carbon in and out of its different reservoirs.
a. Earth 9c- Students know the importance of water to society; the origins of California's fresh water, and the relationship between supply and need.

a. Biology 6d (water cycle only)- 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.

3. Chemistry 5- Acids, bases and salts are three classes of compounds that form ions in water solutions.
   a. Chemistry 5a- Students know the observable properties of acids, bases, and salt solutions.
   b. Chemistry 5c- Students know strong acids and bases fully dissociate and weak acids and bases partially dissociate.

B. **Unit Concept #2—**-The biotic systems of the Earth exist in a dynamic equilibrium. The biotic composition of the Earth has changed over time. The evolution of species and the ecosystems to which they belong occurs as a result of the Earth's constantly changing environments. The composition and stability of the Earth's ecosystems are affected by the dynamic interactions among many factors, including changes in climate and human activity. Over time, the species composition of ecosystems evolves as a result of genetic changes that occur in changing environments. A large diversity of species within an ecosystem increases the probability that at least some members will survive major environmental changes.

1. Biology 6- Stability in an ecosystem is a balance between competing effects.
   a. Biology 6a- Students know biodiversity is the sum total of different kinds of organism and is affected by alterations of habitats.

b. Biology 6b- 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.
c. Biology 6c- Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
d. Biology 6e- Students know a vital part of an ecosystem is the stability of its producers and decomposers.
e. Biology 6g*- 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.
f. Biology 6f- 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.
    (i.) Biology 6d- 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. (review nitrogen cycle)
    (i.) Chemistry 7b- Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.
    (iii) Physics 3f*- Students know the statement "Entropy tends to increase" is a law of statistical probability that governs all closed systems (second law of thermodynamics).

2. Biology 8- Evolution is the result of genetic changes that occur in constantly changing environments.
    a. Biology 8a- Students know how natural selection determines the differential survival of groups of organisms.
    a. Biology 8b- Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.
        i. Earth 3c- Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes. (review of sedimentary rocks)
        i. Biology 8e- Students know how to analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction.

ESSENTIAL QUESTIONS:

Year question: In what ways does the Earth support life?

Semester 1: What interactions occur within matter and energy that are found in earth systems?

Semester 2: How do different earth systems affect the biosphere?

Integrated Science- Year 1
Sample Flowchart for Concept Instructional Sequence

The Earth is a unique system that supports life within an ever-changing and complex universe.

The interaction of matter and energy determine the characteristics of our Earth's system.

The interaction of matter and energy results in a dynamic Earth system.

The interaction of matter and energy determine the characteristics of life.

The chemical structure of inorganic and organic matter forms the basis of life on Earth.

The chemical structure of inorganic and organic determine the structures and functions of cells.

The unique properties of carbon and water contribute to the fundamental structures and functions of cells.

The structure and function of cells rely on the self-replicating properties of DNA.

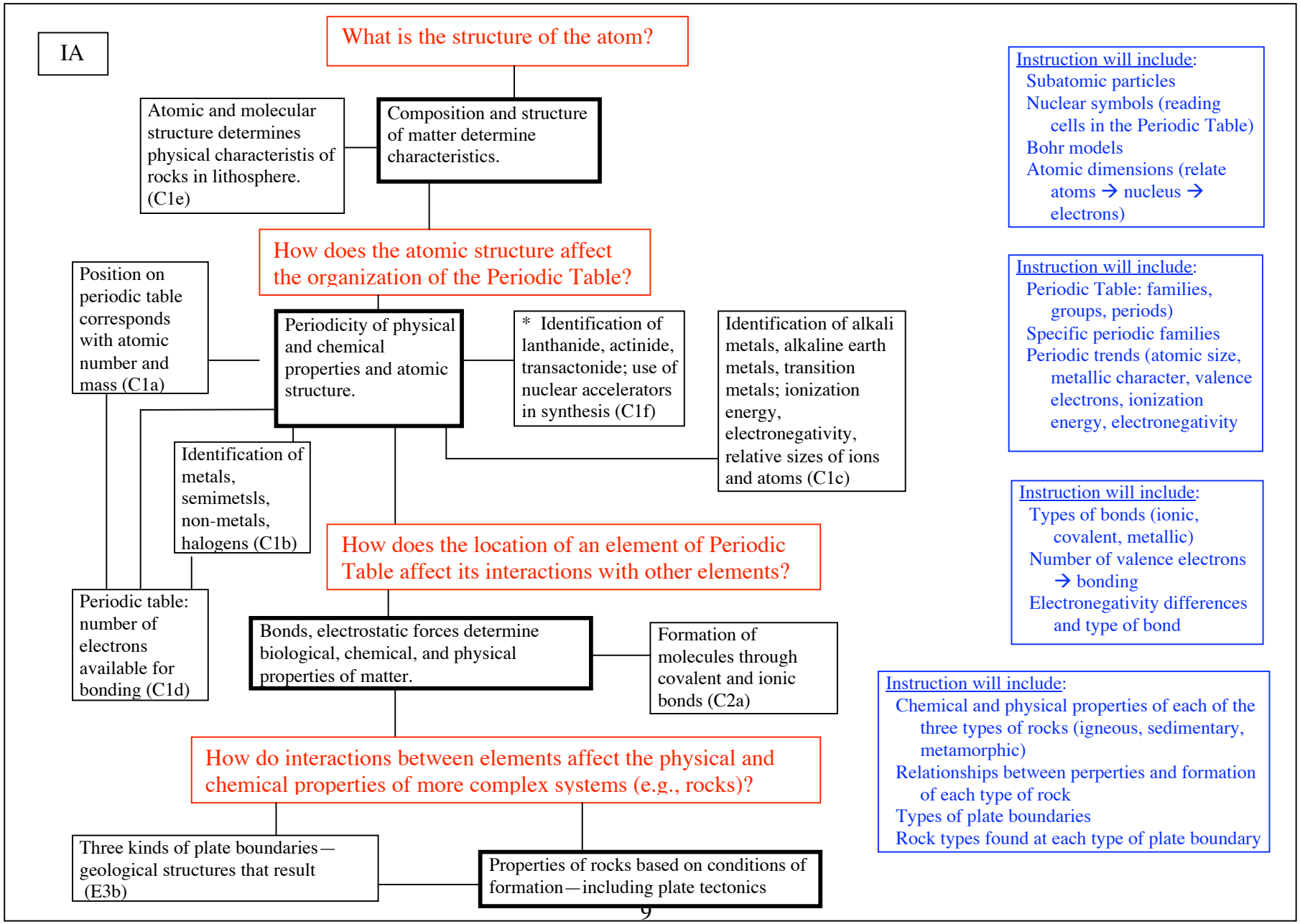
The self-replication property of DNA forms the basis for continuity and change in the reproduction of cells.

Continuity and change in the reproduction of cells rely on inherited genotype.

The inherited genotype determines an organism's phenotype.

Integrated Science- Year 1
Sample Flowchart for Concept Instructional Sequence

The Earth is a unique system that supports life.



Integrated Science- Year 1
Sample Flowchart for Concept Instructional Sequence

Abiotic factors that affect the biosphere are based on geochemical Earth

IIA

How do electrostatic forces affect bonding behaviors of simple and complex molecules?

Biogeochemical cycles support biotic systems.

Covalent and ionic bonding (C2a)

Crystals as repeating patterns of positive and negative ions (C2c)

Covalent bonds of hydrogen, methane, etc. (C2b)

How do bonding behaviors of complex molecules affect biogeochemical

Electromagnetic waves: radio waves, light, and X-rays (P4e, review)

Interchangability of elements, energy in abiotic, biotic environments

Energy release, absorption; condensation and freezing, evaporation and melting (C7c)

Water, carbon, nitrogen cycle in the ecosystem; oxygen cycles in photosynthesis, respiration. (B6d)

Carbon cycle of photosynthesis, respiration; nitrogen cycle (E7a)

Global carbon cycle: atmosphere, oceans, biomass, fossil fuels (E7b)

Importance of water; origins of California's fresh water; supply and need (E9c)

Movement of matter among reservoirs is driven by Earth's internal and external sources of energy (E7c)

* Relative residence times and flow characteristics of carbon (E7d)

Stability in an ecosystem is a balance between competing effects.

How does human impact affect the water cycle?

Water cycles between abiotic resources and organic matter (B6d)

Acids, bases and salts are three classes of compounds that form ions in water solutions.

Observable properties of acids, bases, and salt solutions (C5a)

Strong, weak acids & bases: full & partial dissociation (C5c)

Instruction will include:
- Types of bonds (rev.)
- Effect of electronegativity on bond type (rev.)
- Lewis Dot models and structural formulas of covalent molecules
- Biological molecules (details to follow in Year 2); relationship of crystals and rock structure, formation

Instruction will include:
- States/phases of matter, phase changes
- Water, nitrogen, carbon cycles
- Balanced equations, photosynthesis & respiration
- Carbon reservoirs (carbon in biotic &abiotic Earth systems, heat
  - CO_2 emissions, climate and water cycle
  - Internal, external sources of heat; effect on movement of matter (plate techtonics)
- Freshwater locations in California; relate to geological hazard map (Sem. I review).

Instruction will include:
- Water cycle (review)
- Pollution & sulfur emissions (relate to C cycle and C reservoirs, including fossil fuels)
- Properties of acids, bases, and salt solutions
  - testing acidity, alkalinity, pH
  - strong versus weak acieds & bases—dissociation
  - acid rain

Bridge Statements Integrated Science 1

Semester 1

The periodicity of elements is a method of organizing the components of matter.

IA The characteristics of matter are defined by composition and structure.

Movement of tectonic plates and actions at plate boundaries are determined by and can be characterized by wave phenomena.

IB The characteristics of energy transmission explain electricity, matnetism and wave phenomena.

Geochemical Earth systems discussed in Semester I form the basis of the abiotic factors affecting the biosphere.

Semester 2

Biogeochemical cycles impact life on Earth.

IIA Biogeochemical cycles support biotic system.

Acid rain and pollution provide examples of human impact on all biogeochemical cycles and the subsequent effects on ecosystem stability.

IIB The biotic systems of Earth exist in a dynamic equilibrium.

INTEGRATED SCIENCE- LEVEL 2
PROPOSED INSTRUCTIONAL SEQUENCE

COURSE CONCEPT—The overarching concept for Integrated Science 2 is that the Earth is a unique system that supports life within an ever-changing and complex universe. Building upon the standards covered in Integrated Science 1, this theme includes standards taken from physics, chemistry, biology, and Earth science. Included among the standards from physics are those pertaining to energy and Newton's Laws. In chemistry, the standards pertain to solutions, chemical reactions, and organic chemistry. The biology standards include considerations of molecules, cells, protein synthesis, cell reproduction, and Mendelian genetics. Earth science standards pertain to planetary motion, solar radiation, energy transformations at the Earth's surface, and geological and climatic changes. The Integrated Science 2 concepts will be further enhanced by having students perform careful scientific investigations.

I. <u>Semester 1—The formation and motion of planets.</u>

A. Unit Concept #1—The interaction of matter and energy result in a dynamic solar system that can be explained by the universal laws of physics. Forces affect planetary systems, and universal laws of energy and motion explain the movement of planets and all other objects. Universal laws can be observed by studying simple systems, and Newton's laws of motion help to explain simple and universal systems. Inherent in any useful study of motion is the concept of force, and Newton's laws provide a solid foundation upon which to analyze forces. There is an important relationship between the universal law of gravitation and the effect of gravity on an object at the surface of the Earth. Celestial and earth systems are affected by the same forces as explained by Newton's Laws.

1. Earth Science 1- Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time.
    a. Earth Science 1a- 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.
    b. Earth Science 1g*- Students know the evidence for the existence of planets orbiting other stars.
2. Physics 2a - Students know how to calculate kinetic energy by using the formula $E = (1/2)mv^2$
3. Physics 2b- 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)l.
4. Physics 2c- Students know how to solve problems involving conservation of energy in simple systems, such as falling objects.
5. Physics 2d- Students known how to calculate momentum as the product mv.

6. Physics 1- Newton's laws predict the motion of most objects.
    a. Physics 1a- Students know how to solve problems that involve constant speed and average speed.
    b. Physics 1b- 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).
    c. Physics 1c- Students know how to apply the law F = ma to solve one-dimensional motion problems that involve constant forces (Newton's second law).
    d. Physics 1d- 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).
    e. Physics 1e- Students know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of the Earth.
    f. Physics 1g - 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).
    g. Physics 1h*- Students know Newton's laws are not exact but provide good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.
    h. Physics 1i*- Students know how to solve problems in circular motion by using the formula for centripetal acceleration in the following form: $a=v^2/r$.
    i. Physics 1f- 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 extinction of life on Earth.

B. Unit Concept #2—The interaction of matter and energy results in a dynamic earth system. Energy affects Earth as a system; the uneven heating of Earth causes air movements, and oceans and the water cycle influence weather. Heat energy is transferred by radiation, conduction, and convection, and radiation from the sun is responsible for winds and ocean currents, which in turn influence weather and climate. Geologic and climatic changes are part of an evolving earth system.

1. Earth 4- Energy enters the earth system primarily as solar radiation and eventually escapes as heat.
    a. Earth 4b- Students know the fate of incoming solar radiation in terms of reflection, absorption, and photosynthesis.
2. Earth 5- Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

a. Earth 5a- Students know how differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.
b. Earth 5b- Students know the relationship between the rotation of Earth and the circular motions of ocean currents and air in pressure centers.
c. Earth 5c- Students know the origin and effects of temperature inversions.
d. Earth 5e- Students know rain forests and deserts on Earth are distributed in bands at specific latitudes.
e. Earth 5f*- 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.
f. Earth 5g*- Students know features of the ENSO (El Nino southern oscillation) cycle in terms of sea-surface and air temperature variations across the Pacific and some climatic results of this cycle.

3. Earth 6- Climate is the long-term average of a region's weather and depends on many factors.
   a. Earth 6a- Students know weather (in the short run) and climate (in the long run) involve the transfer of energy into and out of the atmosphere.
   b. Earth 6b- Students know the effects on climate of latitude, elevation, topography, and proximity to large bodies of water and cold or warm ocean currents.
   c. Earth 6c- 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.
   d. Earth 1c- Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.

II. SEMESTER 2—The dynamic Earth supports life.

A. **Unit Concept #1—**The chemical structure of inorganic and organic matter forms the basis of life on Earth, and the laws of chemistry apply to both non-living and living systems. The cell can be viewed as a package of chemicals that interact according to basic laws of chemistry. The cell is composed of a major solvent (water) into which are dissolved a variety of solutes. The chemicals contained within a cell are subject to kinetic molecular theory and the law of the conservation of matter. Methods of chemistry, including those of chromatography and distillation, inform our understanding of the biochemical systems within the cell.

1. 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.
2. Chemistry 6- Solutions are homogenous mixtures of two or more substances.
    a. Chemistry 6a- Students know the definitions of solute and solvent.
    b. Chemistry 6f*- Students know how molecules in a solution are separated or purified by the methods of chromatography and distillation.
    c. Chemistry 6b- Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
    d. Chemistry 6c- Students know temperature, pressure, and surface area affect the dissolving process.
3. Chemistry 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.
    a. Chemistry 3a- Students know how to describe chemical reactions by writing balanced equations.

B. **Unit Concept #2—**The unique properties of carbon and water contribute to the fundamental structure and functions of cells. There are many organic molecules essential to the structure and function of a cell. The four major groups of macromolecules that form the basis of life are carbohydrates, proteins, lipids, and nucleic acids. These macromolecules are the structural and functional building blocks of cell membranes and organelles**.**

1. Chemistry 10- The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life.
    a. Chemistry 10b- 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.
    b. Chemistry 10d*- 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.
    c. Chemistry 10a- Students know large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.
    d. Chemistry 10c- Students know amino acids are the building blocks of proteins.
    e. Chemistry 10f*- Students know the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins.

f. Chemistry 10e*- Students know how to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, aldehydes, and organic acids.
    i. Biology 1h- Students know most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors.
        (a) Biology 1a- Students know cells are enclosed within semi-permeable membranes that regulate their interaction with their surroundings.
        (b) Biology 1e- Students know the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins.
        (c) Biology 1j*- Students know how eukaryotic cells are given shape and internal organization by a cytoskeleton or cell wall or both.

C. **Unit Concept #3—**The self-replicating property of DNA forms the bases for continuity and change in the reproduction of cells. Changes in DNA result in structural and functional alterations in cells, organisms and populations. DNA also serves as a template for the production of other molecules that are responsible for the structure and function of the cell. The processes of meiosis and fertilization determine the genotypes and diversity of offspring.

1. 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.
    a. Biology 4a- Students know the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA.
    b. Biology 4b- Students know how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.
    c. Biology 4d- 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.
2. Biology 2- Mutation and sexual reproduction lead to genetic variation in a population.
    a. Biology 2a- 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.
    b. Biology 2b- Students know only certain cells in a multicellular organism undergo meiosis.

c. Biology 2c- Students know how random chromosome segregation explains the probability that a particular allele will be in a gamete.
d. Biology 2e-Students know why approximately half of an individual's DNA sequence comes from each parent.
e.

D. Unit Concept #4—The inherited genotype contributes to an organism's phenotype. Mendel's laws of segregation and independent assortment form the basis for understanding patterns of inheritance. Using Mendel's laws, we can predict the probable outcome of phenotypes based upon the genotypes of the parents.

1. Biology 3- A multi-cellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization.
   a. Biology 3b- Students know the genetic basis for Mendel's laws of segregation and independent assortment.
   b. Biology 3f- Students know the role of chromosomes in determining an individual's sex.
   c. Biology 3a- 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).
   d. Biology 3c*- Students know how to predict the probable mode of inheritance from a pedigree diagram showing phenotypes.
   e. Biology 2g- Students know how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents.
   f. Biology 3d*- 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.

ESSENTIAL QUESTIONS:

Year question: What are the universal laws that govern relationships of matter and energy and make possible the existence of life?

Semester One question: What are the forces that interact to form and sustain the dynamic universe?

Semester Two question: What exchanges of energy are necessary for life?

Integrated Science- Year 2
Sample Flowchart for Concept Instructional Sequence

Bridge Statements

IA

The Earth is a unique system that supports life within an ever-changing and complex

The interaction of matter and energy determine the characteristics of our Earth's system.

IB

The interaction of matter and energy results in a dynamic Earth

The interaction of matter and energy determine the characteristics of life.

IIA

The chemical structure of inorganic and organic matter forms the basis of life on Earth

The chemical structure of inorganic and organic determine the structures and functions of cells.

IIB

The unique properties of carbon and water contribute to the fundamental structures and functions of cells.

The structure and function of cells rely on the self-replicating properties of DNA.

IIC

The self-replication property of DNA forms the basis for continuity and change in the reproduction of cells.

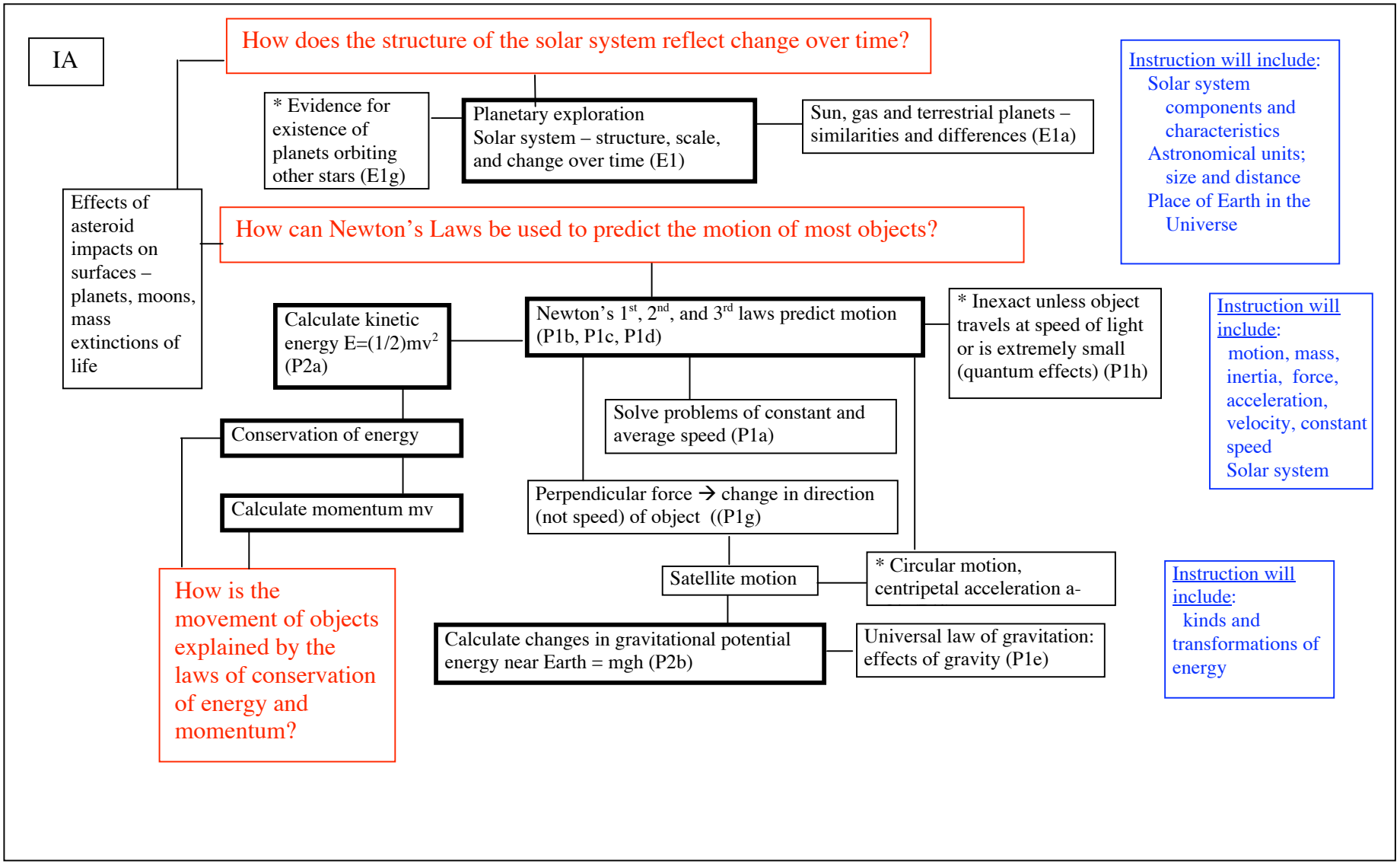
Continuity and change in the reproduction of cells rely on inherited genotype.

IIC

The inherited genotype determines an organism's phenotype.

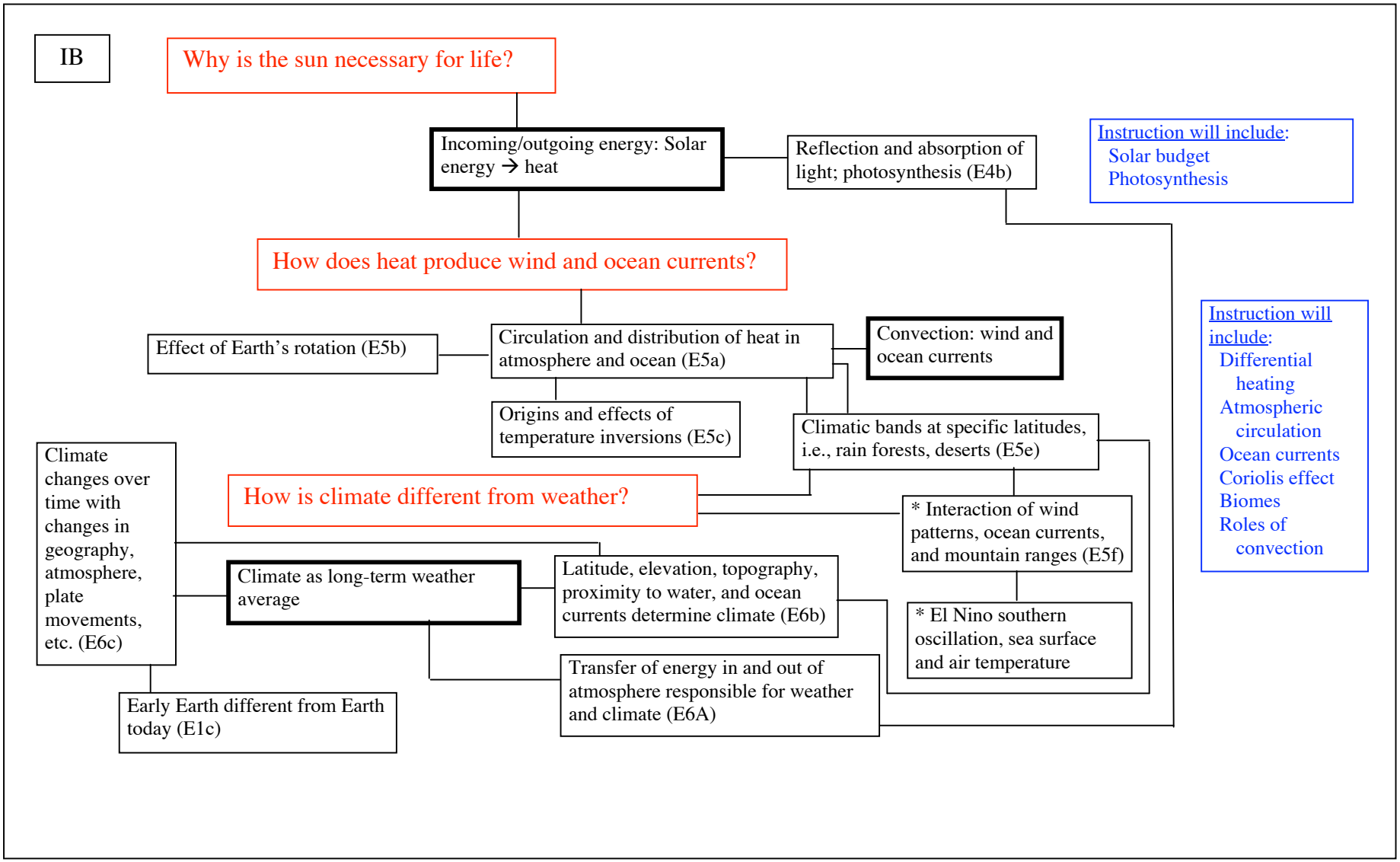
Integrated Science- Year 2
Sample Flowchart for Concept Instructional Sequence

The Earth is a unique system that supports life within an ever-changing and complex universe.



Integrated Science- Year 2
Sample Flowchart for Concept Instructional Sequence

The interaction of matter and energy results in a dynamic Earth system.



Integrated Science- Year 2
Sample Flowchart for Concept Instructional Sequence

The chemical structure of inorganic and organic matter forms the basis of life on Earth

IIB

How do simple subunits combine to form large molecules that make up all living things?

Shape, internal organization of eukaryotic cells due to cytoskeleton, cell wall, or both

Biochemical basis of life: bonding characteristics of carbon determine size and shape of molecules and their chemical properties

Simple hydrocarbons to complex polymers and biological molecules (C10b)

Simple subunits form large molecules such as proteins, nucleic acids, and starch. (C10a)

* simplest linear hydrocarbons and isomers; single, double, triple bonds; nomenclature (C10d)

Macromolecules: polysaccharides, nucleic acids, proteins, lipids (B1h)

* bonding of amino acids, R-groups (C10f)

Building blocks of protein are amino acids. (C10c).

Role of endoplasmic reticulum and Golgi apparatus in secretion of proteins (B1e)

Cells enclosed within semipermeable membranes regulating interaction with surroundings (B1a)

* functional groups: alcohols, ketones, ethers, amines, aldehydes, and organic acids (C10e)

Instruction will include:
- Carbon bonding
- Simple hydrocarbons
- Functional groups
- Formation and structure of macromolecules
- Membranous cell structures, cytoskeleton, cell wall

Bridge Statements Integrated Science 2

Semester 1

Formation and motion of planets.

IA The interaction of matter and energy result in a dynamic solar system that can be explained by the universal laws of physics.

The interaction of matter and energy determine the characteristics of our Earth's system.

IB The interaction of matter and energy results in a dynamic Earth system.

The interaction of matter and energy make life possible.

Semester 2

The dynamic Earth supports life.

IIA The chemical structure of inorganic and organic matter forms the basis of life on Earth.

The chemical structure of inorganic and organic matter determine the structures and functions of cells.

IIB The unique properties of carbon and water contribute to the fundamental structures and functions of cells.

The structure and function of cells rely on the self-replicating properties of DNA.

The self-replication property of DNA forms the basis for continuity and change in the reproduction of cells.

Continuity and change in the reproduction of cells rely on inherited genotype.

IIC The inherited genotype contributes to an organism's phenotype.

INTEGRATED SCIENCE -- LEVEL 3
PROPOSED INSTRUCTIONAL SEQUENCE

COURSE CONCEPT—The overarching theme of the third year is that the Earth changes over time. These changes are inherently interrelated in a cause-and-effect fashion with changes in both abiotic and biotic systems. Year three continues to build upon the standards studied in Integrated Science 1 and 2, including standards from physics, chemistry, biology, and earth science. The physics standards studied in the third year pertain to motion and forces, conservation of energy and momentum, and electric and magnetic phenomena. The chemistry standards include conservation of matter and stoichiometry, gases and their properties, acids and bases, solutions and reaction rates, and chemical equilibrium. The biology standards include cell biology, genetics, and evolution. The earth science standards, which relate to the study of the Earth's atmosphere, provide the foundations upon which each of the foregoing scientific disciplines will be taught. The Integrated Science 3 concepts will be further enhanced by having students perform careful scientific investigations.

I. **Semester 1—Universal laws of nature**

Semester one focuses on certain universal laws of matter and energy as they apply to the changes in the physical structure and chemical composition of the Earth and its atmosphere.

A. **Unit Concept #1—**Certain universal laws of nature govern the composition of matter. These include the theory and application of the law of conservation of matter, in terms of both number and mass, the kinetic molecular theory particularly as applied to the study of gases, and the concept of the mole.

1. Earth 8a- Students know the thermal structure and chemical composition of the atmosphere.
    a. Chemistry 4d- Students know the values and meanings of standard temperature and pressure (STP).
        (i) Chemistry 4e- Students know how to convert between the Celsius and Kelvin temperature scales.
        (ii) Chemistry 4f- Students know there is no temperature lower than 0 Kelvin.
    b. Chemistry 3d- 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.
        (i) Chemistry 3c- Students know one mole equals 6.02×10^{23} particles (atoms or molecules).
        (ii) Chemistry 3b- Students know the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.

2. Chemistry 6d- Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.
    a. Chemistry 6e*- Students know the relationship between the molality of a solute in a solution and the solution's depressed freezing point or elevated boiling point.

3. Chemistry 3e- 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.
    a. Chemistry 3f*- Students know how to calculate percent yield in a chemical reaction.

B. **Unit Concept #2—**Certain universal laws of nature govern the motion and energy of particles of matter. These universalities include the theory and application of the laws of conservation of momentum and energy, two-dimensional motion, laws of electricity and magnetism, and further amplification of the kinetic molecular theory.

1. Physics 2e- Students know momentum is a separately conserved quantity different from energy.
    a. Physics 2f- Students know an unbalanced force on an object produces a change in its momentum.
    b. Physics 2g- Students know how to solve problems involving elastic and inelastic collisions in one dimension by using the principles of conversation of momentum and energy.
        (i) Physics 1k*- Students know how to solve two-dimensional problems involving balanced forces (statics).
        (ii) Physics 1j*- Students know how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.
            (a) Physics 1i*- Students know how to solve two-dimensional trajectory problems.
        (iii) Physics 2h*- Students know how to solve problems involving conservation of energy in simple systems with various sources of potential energy such as capacitors and springs.
    c. Physics 1g- Students know circular motion requires the application of a constant force directed toward the center of the circle.

2. Physics 5f- Students know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from magnetic fields of other sources.
    a. Physics 5g- Students know how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.

b. Physics 1m*- 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).

3. Chemistry 4b- Students know the ransom motion of molecules explains the diffusion of gases.
   a. Chemistry 4a– Students know the random motion of molecules and their collisions with a surface create the observable pressure on that surface.
   b. Chemistry 4c- Students know how to apply the gas laws to relations between the pressure, temperature, and volume of an ideal gas or any mixture of ideal gases.

C. **Unit Concept #3—**The universal laws of composition, motion, and energy can be applied to specific natural phenomena. These phenomena include the greenhouse effect, the ozone layer, and the photosynthetic-respiratory cycles.

1. Earth 8b- Students know how the composition of Earth's atmosphere has evolved over geologic time and know the effectd of outgassing, the variations of carbon dioxide concentration, and the origin of atmospheric oxygen.
   a. Earth 4c- Students know the different atmospheric gases that absorb the Earth's thermal radiation and the mechanism and significance of the greenhouse effect.
      (i) Earth 4d*- Students know the differing greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each.
   b. Earth 8c- 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 resonse to human activities.

2. Biology 1f- Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.
   a. Biology 1g- 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.
   b. Biology 1i*- Students know how chemiosmotic gradients in the mitochondria and chloroplasts store energy for ATP production.

3. Chemistry 3g*- Students know how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.

II. **Semester 2—Understanding universal laws will allow us to analyze processes of and changes in living systems**.

Semester two focuses on the relationship of the processes and changes found among living systems and the impact they make upon the Earth.

A. **Unit Concept #1—**Living systems must maintain homeostatic equilibrium and do so through the delicate balance of chemical processes.

1. Chemistry 9b- Students know equilibrium is established when forward and reverse reaction rates are equal.
    a. Chemistry 9c*- Students know how to write and calculate an equilibrium constant expression for a reaction.
    b. Chemistry 9a- Students know how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature and pressure.
    c. Chemistry 8d*- Students know the definition and role of activation energy in a chemical reaction.
    d. Chemistry 5e*- Students know the Arrhenius, Bronsted-Lowery, and Lewis acid-base definitions.
        (i) Chemistry 5f*- Students know how to calculate pH from the hydrogen –ion concentrations.
        (ii) Chemistry 5g*- Students know buffers stabilize pH in acid-base reactions.

2. Biology 1b- 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.
    a. Biology 4e- Students know proteins can differ from one another in the number and sequence of amino acids.
    b. Biology 4f*- Students know why proteins having different amino acid sequences typically have different shapes and chemical properties.
    c. Biology 4c- 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.

3. Chemistry 8b- Students know how reaction rates depend on such factors as concentration, temperature, and pressure.
    a. Chemistry 8a- Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
    b. Chemistry 8c- Students know the role a catalyst plays in increasing the reaction rate.

B. **Unit Concept #2—**Adaptations can be traced to cellular processes and to the genetic level. The study of genetics helps us to understand both micro and macroevolution.

1. Biology 7d- Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.
    a. Biology 4d- 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.
        (i) Biology 7b- Students know why alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool.
    b. Biology 7c- Students know new mutations are constantly being generated in a gene pool.
    c. Biology 7a- Students know why natural selection acts on the phenotype rather than the genotype of an organism.

2. Biology 8c- Students know the effects of genetic drift on the diversity of organisms in a population.
    a. Biology 7f*- Students know how to solve the Hardy-Weinberg equation to predict the frequency of genotypes in a population, given the frequency of phenotypes.
    b. Biology 7e*- Students know the condition for Hardy-Weinberg equilibrium in a population and why these conditions are not likely to appear in nature.

3. Biology 8d- Students know reproductive or geographic isolation affects speciation.

4. Biology 8f*- 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.

5. Biology 8g*- 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.

C. **Unit Concept #3—**Genetic engineering is a method of artificially inducing change among living organisms.

1. Biology 5c- Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.

a. Biology 5d*- Students know how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules.
b. Biology 5e*- Students know how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.

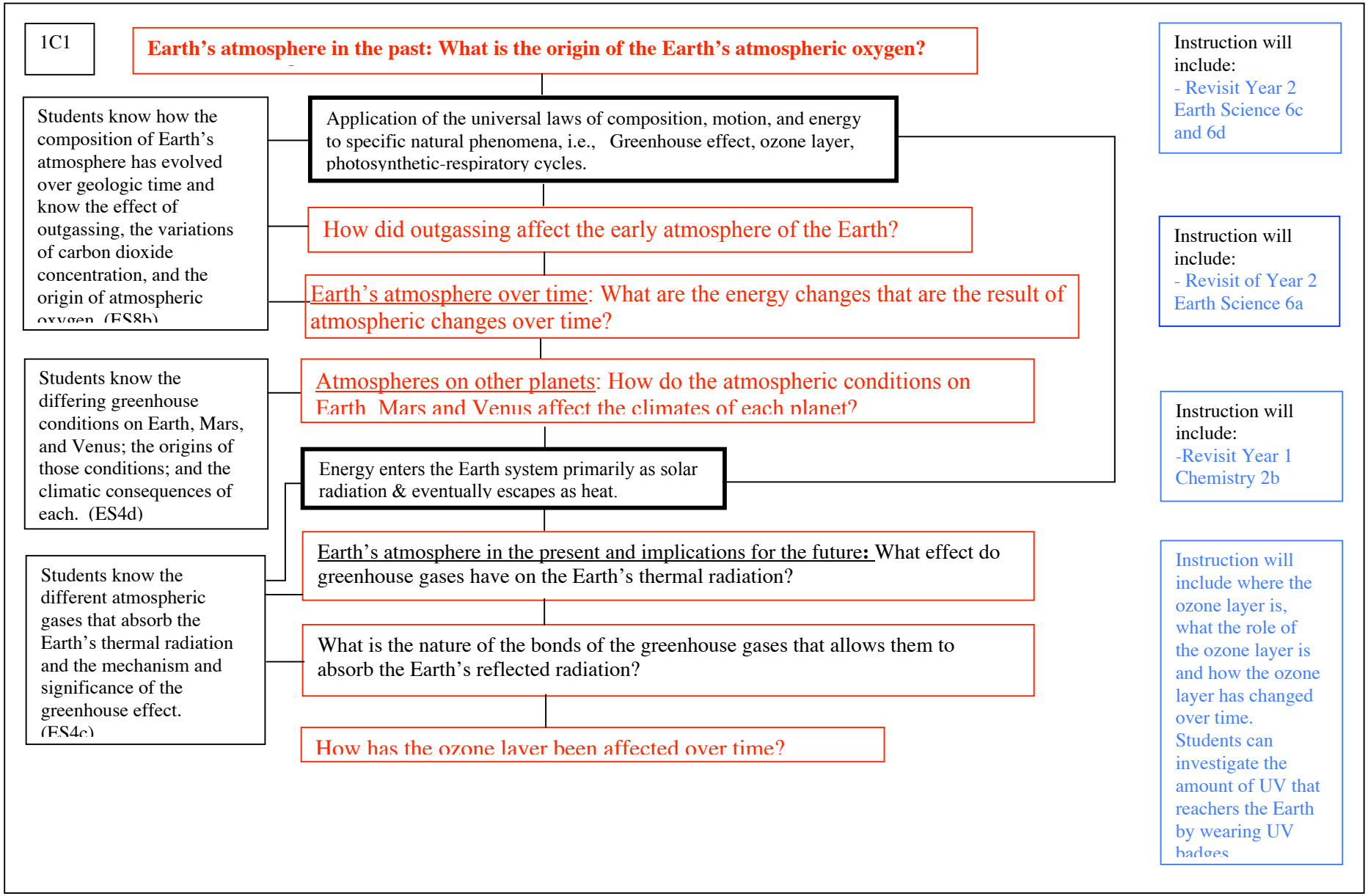
Questions:
Year question: How can changes in the Earth and its systems over time be explained through universal laws?

Semester 1: In what ways do the composition and characteristics of the Earth's atmosphere affect basic energy systems in living organisms?

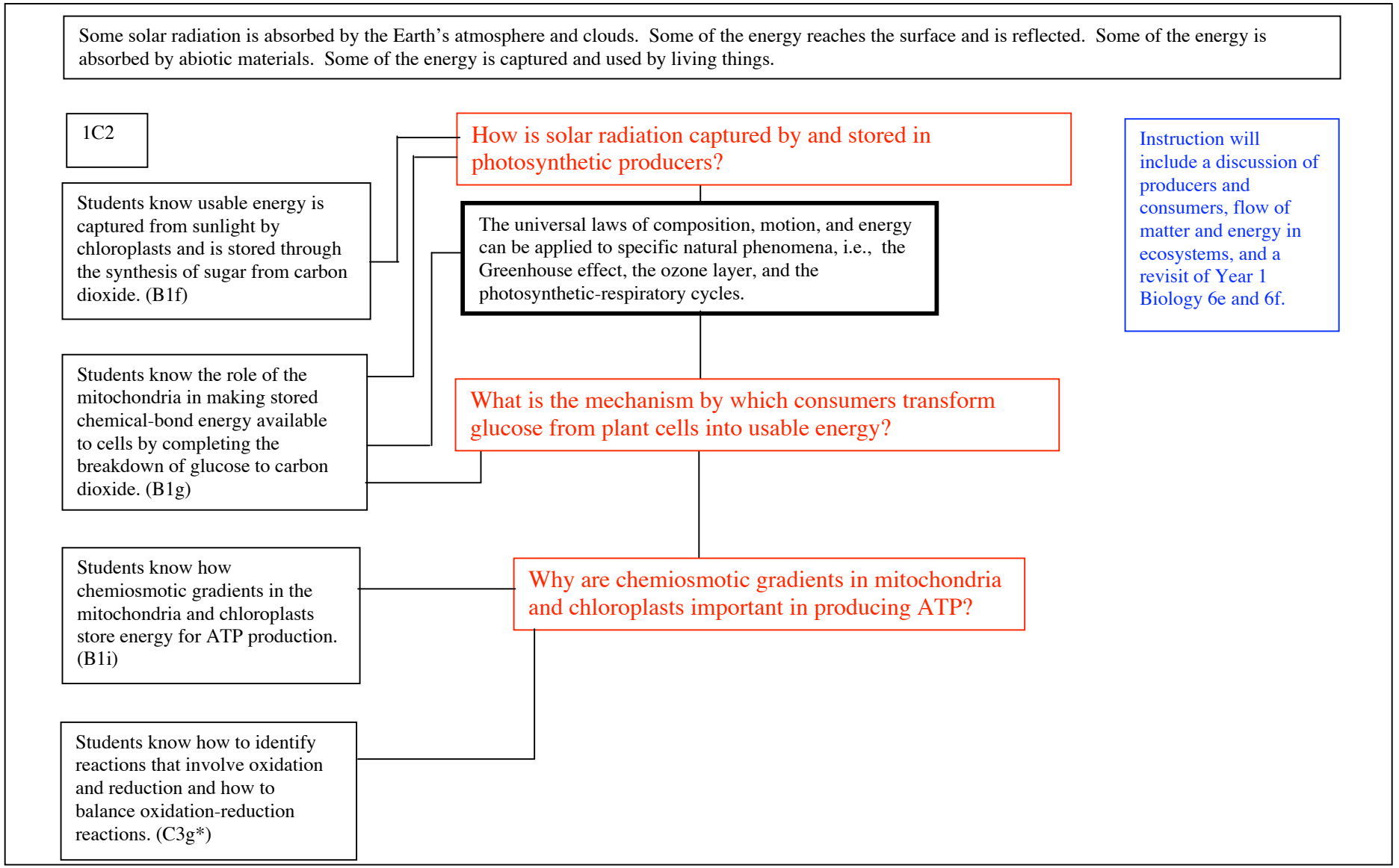
Semester 2: How are molecular and genetic changes involved in the evolution of living organisms?

Integrated Science- Year 3
Sample Flowchart for Concept Instructional Sequence

The Earth changes over time. These changes are inherently interrelated in a cause and effect fashion with changes in both abiotic and biotic systems.



Integrated Science- Year 3
Sample Flowchart for Concept Instructional Sequence



Semester 1

Universal laws of matter and energy establish the physical and chemical characteristics of the Earth and its atmosphere.

Interactions of matter and energy at the atomic level form a base for planetary phenomena.

IA Law of conservation of matter: number and mass; kinetic molecular theory

Observable processes and events on Earth are explained by laws of physics and chemistry.

IB Laws of conservation of momentum and energy, two-dimensional motion, laws of electricity and magnetism, kinetic molecular theory.

The Earth's ecosystems are affected by changes in kinds and directions changes.

IC Greenhouse effect, ozone layer, and photosynthetic-respiratory cycles

Disruptions of biological and ecological systems result when the Earth's dynamic equilibrium shifts.

Semester 2

Impact of processes and changes in living systems on the Earth

Individuals, species populations, and communities are affected by environmental changes.

IIA Living systems maintain homeostatic equilibrium through chemical processes.

Individuals, species populations and communities have adaptive mechanisms.

IIB

Adaptations at the genetic level: Short- and long-term changes in individuals and in species.

Knowledge of the physical and chemical foundations of life enables humans to purposely apply them for their benefit.

IIC

Genetic engineering is a method of artificially inducing change among living organisms.

INTEGRATED SCIENCE –- LEVEL 4
PROPOSED INSTRUCTIONAL SEQUENCE

COURSE CONCEPT— Integrated Science 4 focuses on the collection of evidence that underlies the development of scientific ideas and how science supports the development of various technologies. The sequence emphasizes literature-based research, hands-on investigations, and problem-solving to support student understanding of scientific knowledge and process. Students should discover through reading, research, and problem-solving the underlying concepts supporting technology and how technology can be used to help provide for a sustainable future. Student research should include two essential questions: How is it that scientists know what they know about a particular topic, and how does this knowledge help to develop technology that extends our ability to change the world?

The instructional environment for Integrated Science 4 is intended to be student centered. Students explore each* of the eleven topics through a series of required investigations and other labs as needed. The investigations are guided by key questions that focus on the science and technological implications of each topic. The explorations allow them to examine key ideas through hands-on activities and to participate in the scientific process by designing their own experiments and building their own equipment. Each topic lends itself to directed instruction so that students become aware of major scientific issues and social implications in each topic. Students are expected to choose a project** based on one or more of the standards, to research the science embedded in the task, and to present their findings to the class at the end of each semester.

Semester 1—Human body systems

The human body is studied from a systems perspective spanning molecular interactions within the cell to the relationships among organs. Students examine the molecular machinery common to living organisms and apply this understanding to improving the quality of life. At the macro level the complexity of the human body is investigated with a particular focus on vision. Internal feedback loops that help our bodies survive stressful and changing environmental conditions are examined at the cellular and organ levels.

Topic	Standards	Key Questions	Required Investigation
Replication	B5a, C2h*, B5b	How can we design a machine to efficiently and accurately make DNA?	Students replicate a short nucleotide sequence and insert it into bacteria and test for its presence.
Immunity	B10a, B10b, B10c, B10d, B10e, B10f*	What is the process of making a vaccine?	Students investigate the process of perfecting an antibiotic.
Human Body Systems	B9c, B9h*	What is the relationship between the nervous, endocrine and muscular systems?	Students will investigate the factors influencing the activity of enzymes such as catalase and diastase.

Topic	Standards	Key Questions	Required Investigation
Vision	B9b, B9d, B9e, C1g*, C1j*, P4c	How do we see in color?	Students investigate the nature of vision and perception.
Homeostasis	B9a, B9f*, B9g*, B9i*, C2d, C5b, C5d	How do our bodies survive extreme conditions? How do our bodies keep us toxin free?	Students explore osmosis as passive transport and the characteristics of cellular equilibrium.

Semester 2—Understanding the past to create a sustainable future

Students and teacher explore the history of the solar system. They examine the evidence that pinpoints the formation of the solar system and its evolution through time. Students and teacher study the Earth's energy budget and the effects of the sun on the Earth's surface. They examine the law of conservation of energy and the second law of thermodynamics to better understand how to craft a sustainable future.

Topic	Standards	Key Questions	Required Investigation
Space Exploration	E1b, E1d	How can we use knowledge of the universe and use this information to predict future explorations of the solar system?	Students investigate the nature of parallax and its implications for measuring distances of some astronomical objects.
Origin of the Universe	E1e, E2a, E2b, E2c, E2d, E2e*, E2f*, E2g*, P4c	How do we know the origin of the universe and how can we use this information to predict the future of the universe?	Students study wavelengths of EM waves by measuring microwaves and the Doppler effect.
Earth's Energy Budget	E4a, E5d, E9a	Can ocean currents be used to generate usable energy?	Students design an instrument to measure the sun's intensity using a solar cell and multimeter.
Transportation in the Future	C7a, C7d, C7e*, C7f*, C2e, C2f*, C2g*, C1h*,E4c, P5a, P5b, P5c, P5k*, P5l*, P5n*, P5o*, P3g	How do we build a fuel cell car? How can fuel cell technology be used to move people and products in our society?	Students make a fuel cell and use it to do mechanical work.
Nuclear Energy	C11a, C11b, C11c, C11d, C11e, C11f*, C11g*	Is nuclear energy old technology or the wave of the future?	Students use radon gas detectors to monitor presence of radon in designated structures.

Topic	Standards	Key Questions	Required Investigation
Conservation of Energy	P3a, P3b, P3c, P3d, P3e	How do we know that energy cannot be created or destroyed? What does the conservation of energy mean for developing and using energy sources in the future?	Students compete to build the most efficient machine or engine that will raise the temperature of water by a specified number of joules.

10th GRADE NCLB TEST
COMPARISON OF STANDARDS ADDRESSED IN BIOLOGY WITH INTEGRATED SCIENCE I AND II

	% of Test	Number of Items	Integrated I	Integrated II
CELL BIOLOGY	**17**	**10**		
CALIFORNIA CONTENT STANDARDS: Grade 7 **1. All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope. As a basis for understanding this concept:** c. Students *know* the nucleus is the repository for genetic information in plant and animal cells. d. Students *know* that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis. e. Students *know* cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes. **CALIFORNIA CONTENT STANDARDS: Grade 8** **6. Principles of chemistry underlie the functioning of biological systems. As a basis for understanding this concept:** b. Students *know* that living organisms are made of molecules consisting largely of carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. c. Students *know* that living organisms have many different kinds of molecules, including small ones, such as water and salt, and very large ones, such as carbohydrates, fats, proteins, and DNA.	**X = a match between the Biology Standard and Biology/Life Science Standard in either the Integrated I or II Blueprint**			
CALIFORNIA CONTENT STANDARDS: 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:				
a. Students *know* cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.				**X**
c. Students *know* how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.				**X**
f. Students *know* usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.				

	% of Test	Number of Items	Integrated I	Integrated II
GENETICS	**20**	**12**		
CALIFORNIA CONTENT STANDARDS: Grade 7 **2. A typical cell of any organism contains genetic instructions that specify itstraits. Those traits may be modified by environmental influences. As a basis for understanding this concept:** a. Students *know* the differences between the life cycles and reproduction methods of sexual and asexual organisms. c. Students *know* an inherited trait can be determined by one or more genes. d. Students *know* plant and animal cells contain many thousands of different genes and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive. e. Students *know* DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell				
CALIFORNIA CONTENT STANDARDS: Biology				
2. Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept:				
b. Students *know* only certain cells in a multicellular organism undergo meiosis.				**X**
d. Students *know* new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).				
e. Students *know* why approximately half of an individual's DNA sequence comes from each parent.				**X**
f. Students *know* the role of chromosomes in determining an individual's sex.				**X**
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:				
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 Xlinked, dominant or recessive).				**X**
5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:				
a. Students *know* the general structures and functions of DNA, RNA, and protein.				

	% of Test	Number of Items	Integrated I	Integrated II
PHYSIOLOGY	**17**	**10**		
CALIFORNIA CONTENT STANDARDS: Grade 7 **5. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. As a basis for understanding this concept:** a. Students *know* plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism. c. Students *know* how bones and muscles work together to provide a structural framework for movement. **6. Physical principles underlie biological structures and functions. As a basis for understanding this concept:** j. Students *know* that contractions of the heart generate blood pressure and that heart valves prevent backflow of blood in the circulatory system.				
CALIFORNIA CONTENT STANDARDS: Biology				
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:				
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.				
b. Students *know* how the nervous system mediates communication between different parts of the body and the body's interactions with the environment.				
10. Organisms have a variety of mechanisms to combat disease. As a basis for understanding the human immune response:				
b. Students *know* the role of antibodies in the body's response to infection.				
c. Students *know* how vaccination protects an individual from infectious diseases.				
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.				

	% of Test	Number of Items	Integrated I	Integrated II
ECOLOGY	**18**	**11**		
CALIFORNIA CONTENT STANDARDS: Grade 6 **5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:** b. Students *know* matter is transferred over time from one organism to others in the food web and between organisms and the physical environment. c. Students *know* populations of organisms can be categorized by the functions they serve in an ecosystem. e. Students *know* the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.				
CALIFORNIA CONTENT STANDARDS: Biology				
6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:				
a. Students *know* biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.			**X**	
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.			**X**	
c. Students *know* how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.			**X**	
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.			**X**	
e. Students *know* a vital part of an ecosystem is the stability of its producers and decomposers.			**X**	
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.			**X**	

	% of Test	Number of Items	Integrated I	Integrated II
EVOLUTION	**18**	**11**		
Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept: a. Students *know* both genetic variation and environmental factors are causes of evolution and diversity of organisms. b. Students *know* the reasoning used by Charles Darwin in reaching his conclusion that natural selection is the mechanism of evolution. c. Students *know* how independent lines of evidence from geology, fossils, and comparative anatomy provide the bases for the theory of evolution.				
CALIFORNIA CONTENT STANDARDS: Biology				
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:**				
a. Students *know* why natural selection acts on the phenotype rather than the genotype of an organism.				
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.				
c. Students *know* new mutations are constantly being generated in a gene pool.				
d. Students *know* 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 in constantly changing environments. As a basis for understanding this concept:				
a. Students *know* how natural selection determines the differential survival of groups of organisms.			**X**	
b. Students *know* a great diversity of species increases the chance that at least some organisms survive major changes in the environment.			**X**	
e. Students *know* how to analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction.			**X**	

	% of Test	Number of Items	Integrated I	Integrated II
INVESTIGATION AND EXPERIMENTATION	**10**	**6**		
CALIFORNIA CONTENT STANDARDS: Grade 6 **7. 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:** c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables. e. Recognize whether evidence is consistent with a proposed explanation. **CALIFORNIA CONTENT STANDARDS: Grade 7** **7. Scientific progress is made by asking meaningful questions …** c. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence. **CALIFORNIA CONTENT STANDARDS: Grade 8** **9. Scientific progress is made by asking meaningful questions …** b. Evaluate the accuracy and reproducibility of data. c. Distinguish between variable and controlled parameters in a test.				
CALIFORNIA CONTENT STANDARDS: Grades 9-12				
1. Scientific progress is made by asking meaningful questions and conducting careful investigations. …				
c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.			X	X
f. Distinguish between hypothesis and theory as scientific terms.			X	X
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).			X	X
j. Recognize the issues of statistical variability and the need for controlled tests.			X	X
TOTALS	**100**	**60**		

Comments:

- 61% coverage of Integrated I and II Biology/Life Sciences Standards with Biology Standards in 10th grade NCLB Blueprint. [There is a match of 19 of 31 Biology Standards.]*
- Because Biology Standards in 10th grade NCLB test make up 57% of the test, 78% of the total standards for the 10th Grade NCLB test are addressed in Integrated Science I and II and 6th, 7th and 8th grade Standards.
- Integrated Science I and II do not address any of the area of Physiology in the Biology portion of the 10th grade NCLB test.
- Some Biology standards not addressed in Integrated Science I and II can be incorporated into a review of 7th and 8th grade standards. For example, Biology Standard 1f that is not addressed in either Integrated I or II, can be taught as part of Biology Standard 6d which is addressed in Integrated I. There are numerous other places where Biology Standards that are not components of the Integrated Science I or II Blueprint can be taught in a Chemistry or Earth Science unit or as part of a review of 7th and 8th grade Standards.

*There are 31 Biology Standards in the NCLB 10th grade Blueprint, not 30 as stated by CDE.

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