

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

# **INTEGRATED SCIENCE:**

## **Level 3**

**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 10<sup>th</sup> grade and will be assess the high school biology and middle school

life science standards. Schools/districts that are implementing integrated science in both 9<sup>th</sup> and 10<sup>th</sup> 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 7<sup>th</sup> 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.

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## **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  $6.02 \times 10^{23}$  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 conservation 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 random 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 effect 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 response 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.

1C1

**Earth's atmosphere in the past: What is the origin of the Earth's atmospheric oxygen?**

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. (ES2h)

Application of the universal laws of composition, motion, and energy to specific natural phenomena, i.e., Greenhouse effect, ozone layer, photosynthetic-respiratory cycles.

How did outgassing affect the early atmosphere of the Earth?

Earth's atmosphere over time: What are the energy changes that are the result of atmospheric changes over time?

Atmospheres on other planets: How do the atmospheric conditions on Earth, Mars and Venus affect the climates of each planet?

Students know the differing greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each. (ES4d)

Energy enters the Earth system primarily as solar radiation & eventually escapes as heat.

Earth's atmosphere in the present and implications for the future: What effect do greenhouse gases have on the Earth's thermal radiation?

Students know the different atmospheric gases that absorb the Earth's thermal radiation and the mechanism and significance of the greenhouse effect. (ES4c)

What is the nature of the bonds of the greenhouse gases that allows them to absorb the Earth's reflected radiation?

How has the ozone layer been affected over time?

Instruction will include:  
 - Revisit Year 2 Earth Science 6c and 6d

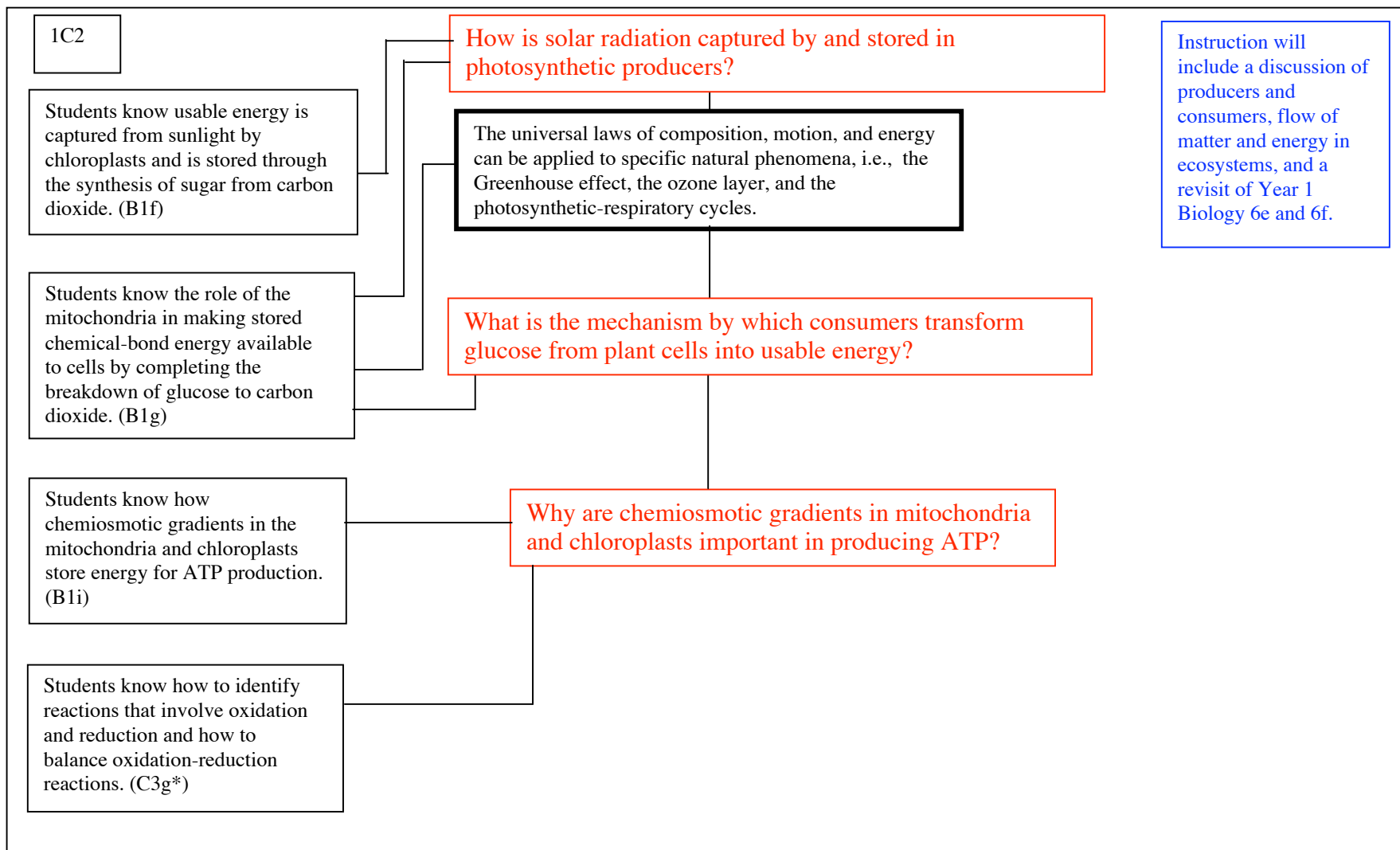
Instruction will include:  
 - Revisit of Year 2 Earth Science 6a

Instruction will include:  
 -Revisit Year 1 Chemistry 2b

Instruction will include where the ozone layer is, what the role of the ozone layer is and how the ozone layer has changed over time. Students can investigate the amount of UV that reaches the Earth by wearing UV goggles

Integrated Science- Year 3  
Sample Flowchart for Concept Instructional Sequence

Some solar radiation is absorbed by the Earth's atmosphere and clouds. Some of the energy reaches the surface and is reflected. Some of the energy is absorbed by abiotic materials. Some of the energy is captured and used by living things.



## Bridge Statements Integrated Science

### 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.

Bridge Statements Integrated Science

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.

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