

# Earth and Space Sciences Subject Matter Requirements

## Content Domains for Subject Matter Understanding and Skill in Earth and Space Sciences

### Domain 1. Earth's Place in the Universe

#### 1.1 Understand the universe and its stars.

- a. Analyze evidence for the Big Bang model (e.g., light spectra, motion of distant galaxies, spectra of primordial radiation).
- b. Analyze the roles of gravity and nuclear fusion in the formation and life cycle of stars, including the sun.
- c. Apply knowledge of how a star's light spectrum and brightness can be used to identify its temperature, age, and evolution.
- d. Analyze the characteristics of galaxies (e.g., size, origin, shape), including the role of gravity in their structural development.
- e. Analyze the process of the nuclear synthesis of both lighter and heavier chemical elements and of how scientists model these processes (i.e., in stars and supernovas).
- f. Apply knowledge of the use of various instruments to collect data about stars.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS1.A)

#### 1.2 Understand Earth and the solar system.

- a. Analyze the motion of orbiting objects using Newton's laws and Kepler's laws.
- b. Analyze evidence used to explain how and when the solar system was formed, including differences and similarities among the sun, planets, and other objects in the solar system.
- c. Evaluate evidence for the existence of celestial objects and other solar systems.
- d. Analyze the history and evolution of the solar system over time (e.g., orbital migration, Late Heavy Bombardment, solar output).
- e. Analyze the cyclic patterns of the Earth, moon, and sun systems (e.g., lunar phases, eclipses, the seasons, tides, motion of planets in the sky relative to stars).
- f. Apply knowledge of astronomical measurements to determine the scale of the solar system and the universe and the proximity of the planets in the solar system in relation to Earth, stars, and the universe.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS1.B)

#### 1.3 Understand the history of planet Earth.

- a. Analyze plate tectonics theory to explain changes in Earth's surface over time.
- b. Analyze the formation and evolution of Earth's atmosphere over geologic time (e.g., outgassing, carbon dioxide concentration, origin of atmospheric oxygen).
- c. Analyze evidence that Earth and other planets have changed over time, including the role of collisional processes in the formation and shaping of Earth's surface and layers and life on the planet.

- d. Apply knowledge of the development and the major divisions of the geologic timescale.
- e. Analyze evidence from rocks and fossils to interpret Earth's history and the origins and development of life on Earth.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS1.C)

## **Domain 2. Earth's Systems**

### **2.1 Understand Earth's materials and systems.**

- a. Explain how the properties of rocks are due to the physical conditions under which they are formed and their chemical composition.
- b. Analyze the properties of common rock-forming minerals and techniques for identifying minerals.
- c. Analyze the processes of mechanical, chemical, and biological weathering.
- d. Analyze the role of biogeochemical cycles on Earth (e.g., carbon, oxygen, nitrogen).
- e. Analyze the interconnectedness of Earth's systems in their response to changing conditions (e.g., feedback effects, such as El Niño and deforestation).
- f. Analyze how changes in Earth's systems alter the flow of energy into and through the systems (e.g., ocean circulation, volcanic activity, atmospheric conditions).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS2.A)

### **2.2 Understand plate tectonics and large-scale systems.**

- a. Apply knowledge of the thermodynamic process driving the motion of Earth's mantle, tectonic plates, and the effects on the cycling of matter.
- b. Analyze the characteristics (e.g., formation, rock composition) of volcanoes, including volcanoes that are due to hot spots and those due to subduction.
- c. Analyze the causes of and characteristics (e.g., intensity, epicenter) of earthquakes, including basic interpretation of seismograms.
- d. Analyze geologic structures and their relationships to tectonic settings and forces.
- e. Interpret geologic maps as a basis for understanding the tectonic evolution of California.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS2.B)

### **2.3 Understand oceanography and the role of water in Earth's surface processes.**

- a. Apply knowledge of the chemical and physical properties of seawater.
- b. Demonstrate knowledge of the mechanisms that cause wave action and tides.
- c. Analyze how the properties of seawater (e.g., penetration of sunlight, density, salinity) are related to the layered structure of the oceans (e.g., ocean currents, distribution of marine organisms).
- d. Analyze the processes that drive the water cycle.
- e. Relate the abundance of liquid water on Earth's surface and water's physical and chemical properties to the dynamic processes shaping the planet.

- f. Demonstrate knowledge of deposition and transport in aquatic environments, including factors controlling these processes.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS2.C)

## **2.4 Understand the atmosphere, weather, and climate.**

- a. Analyze the properties of different atmospheric layers (e.g., composition, thermal structure, density).
- b. Apply knowledge of the role of the ozone layer in the upper atmosphere and the way in which this layer varies both naturally and in response to human activities.
- c. Analyze the role of water in Earth's atmosphere (e.g., clouds, precipitation, air masses) and the causes and effects of severe weather.
- d. Analyze how insolation contributes to the formation of Earth's global climate systems.
- e. Analyze factors that affect climate (e.g., latitude, elevation, topography).
- f. Identify the bands at specific latitudes where rain forests and deserts are distributed and analyze the causes of these patterns.
- g. Analyze the characteristics of the El Niño/Southern Oscillation (ENSO) cycle in terms of sea-surface and air temperature variations across the Pacific and climatic results of this cycle.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS2.D)

## **Domain 3. Earth and Human Activity**

### **3.1 Understand natural resources.**

- a. Analyze the origin of California's water (e.g., precipitation, California State Water Project, desalination) and the environmental, political, and economic effects resulting from its distribution, conservation, and uses.
- b. Analyze the development, conservation, recycling, and importance of California's major economic resources (e.g., energy, minerals) and how the environmental impacts of their use can be minimized (e.g., in agriculture, mining, and energy extraction).
- c. Recognize how scientific modeling can be used to preserve the long-term availability of resources.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS3.A)

### **3.2 Understand natural hazards.**

- a. Analyze the location of natural hazards in California (e.g., floods, landslides, fires), the factors that increase their frequency and intensity, and their relationship to California's geology.
- b. Demonstrate knowledge of monitoring methods used to reduce the impact of natural hazards.

- c. Analyze published geologic hazard maps of California (e.g., to identify past geologic events, to predict geologic changes).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS3.B)

### **3.3 Understand human impacts on Earth's systems.**

- a. Analyze the effects of human activities and increasing population size on Earth's systems, including feedback from one system to another.
- b. Evaluate strategies for mitigating the effects of human activities on Earth's systems (e.g., recycling, treating sewage, designating marine conservation areas).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS3.C)

### **3.4 Understand global climate change.**

- a. Analyze the potential short-term and long-term impacts of human activities on regional and global climate changes.
- b. Analyze methods used to study past and current climate conditions, including how modeling and simulations are used to study and make predictions about how Earth's systems respond to human activities.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Earth and Space Sciences: ESS3.D)

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