California Subject Examinations for Teachers®

TEST GUIDE

SCIENCE SUBTEST III: EARTH AND PLANETARY SCIENCE

Subtest Description

This document contains the Earth and Planetary Science subject matter requirements arranged according to the domains covered by Subtest III: Earth and Planetary Science of CSET: Science. In parentheses after each named domain is the CCTC-assigned domain code from the Earth and Planetary Science subject matter requirements.

CS-TG-SD122X-01

California Subject Examinations for Teachers (CSET®)

Science
Subtest III: Earth and Planetary Science

Part I: Content Domains for Subject Matter Understanding and Skill in Earth and Planetary Science

EARTH'S PLACE IN THE UNIVERSE (SMR Domain 1)

Candidates demonstrate an understanding of Earth's place in the universe as contained in the Science Content Standards for California Public Schools (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of the solar system and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time, and how astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. They base this understanding on their knowledge of the characteristics and properties of phenomena such as galaxies, stars, and bodies of the solar system.

0001 Galaxies and Stars (SMR 1.1)

a. Identify and describe characteristics of galaxies
b. Explain the evidence for the "big bang" model
c. Know that the Sun is a typical star and is powered by nuclear reactions, primarily the fusion of hydrogen to form helium
d. Describe the process of the nuclear synthesis of chemical elements and how accelerators simulate the conditions for nuclear synthesis (i.e., in stars and in the early universe)
e. Compare the use of visual, radio, and X-ray telescopes to collect data that reveal that stars differ in their life cycles
f. Describe, in terms of color and brightness, how the evolution of a star is determined by a balance between gravitational collapse and nuclear fusion

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 1e, 2b-g)

0002 Solar Systems (SMR 1.2)

a. Explain how the solar system was formed, including differences and similarities among the sun, terrestrial planets, and the gas planets, and cite the evidence from Earth and moon rocks that indicate that the solar system was formed approximately 4.6 billion years ago

b. Know the current evidence for the existence of planets orbiting other stars
c. Describe changes in the solar system over time

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 1a, 1b, 1g)

0003 Planets and Satellites (SMR 1.3)

a. Cite various forms of evidence that indicate the proximity of the planets in the solar system in relation to Earth and the stars
b. Cite various forms of evidence that Earth and other planets change over time
c. Describe the influence of collisional processes on early Earth and other planetary bodies in terms of shaping planetary surfaces and affecting life on Earth

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 1c, 1d, 1f))

PLANET EARTH (SMR Domain 2)

Candidates demonstrate an understanding of the foundations of Earth contained in the Science Content Standards for California Public Schools (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of Earth and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of the dynamic processes of the solid Earth, oceans, and the atmosphere. Candidates understand how plate tectonics operating over geologic time have changed the patterns of land, sea, and mountains on Earth's surface. Candidates also understand the dynamic processes that operate in and among the atmosphere, oceans and other water bodies, and the biosphere. They understand how life has changed Earth's atmosphere, and how changes in the atmosphere affect conditions for life. Candidates apply their knowledge of dynamic Earth processes to make predictions and form conclusions about surface phenomena such as earthquakes.

0004 Tectonic Processes (SMR 2.1)

a. Diagram the major divisions of the geologic time scale as a basis for understanding changes in the Earth's processes
b. Describe how earthquake intensity, magnitude, epicenter, focal mechanism, and distance are determined from a seismogram
c. Compare major types of volcanoes in terms of shape and chemical and rock composition
d. Describe the location and characteristics of volcanoes that are due to hot spots and those due to subduction
e. Relate geologic structures to tectonic settings and forces

f. Describe the evidence for plate tectonics on the sea floor and on land

(Science Content Standards for California Public Schools, Grade 7: 3c, 4b, 4d, 4g; Grades 9-12, Earth Sciences: 1c, 3a-b, 3d-f)

0005 Oceans (SMR 2.2)

a. Describe the chemical and physical properties of sea water
b. Describe the mechanisms that cause wave action and tides
c. Explain the layered structure of the oceans, including the generation of horizontal and vertical ocean currents and the geographic distribution of marine organisms, and how properties of ocean water, such as temperature and salinity, are related to these phenomena

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 5d)

0006 Atmosphere (SMR 2.3)

a. Compare the layers of the atmosphere in terms of chemical composition and thermal structure
b. Discuss the evolution of Earth's atmosphere over geologic time, including the effects of outgassing, the variations of carbon dioxide concentration, and the origin of atmospheric oxygen
c. Know the location of the ozone layer in the upper atmosphere, explain its role in absorbing ultraviolet radiation, and explain the way in which this layer varies both naturally and in response to human activities
d. Identify the bands at specific latitudes where rainforests and deserts are distributed and the causes of this pattern

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 5e-f, 8a-c)

ENERGY IN THE EARTH SYSTEM (SMR Domain 3)

Candidates demonstrate an understanding of energy in the Earth system contained in the Science Content Standards for California Public Schools (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of energy in the Earth system and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how energy enters, flows through, and leaves the Earth system, and the relationship between energy transfer and the dynamic processes of the Earth system. They base this on knowledge of how energy enters the Earth system primarily as solar radiation and eventually escapes as heat, and how heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. Candidates apply their knowledge of dynamic Earth processes to make predictions and form conclusions about surface phenomena such as climate.

0007 Earth's Energy Budget: Inflow and Outflow (SMR 3.1)

a. Compare the amount of incoming solar energy, the Earth's internal energy, the energy used by society, and the energy reflected back to space
b. Describe what happens to incoming solar radiation as it relates to reflection, absorption, and photosynthesis
c. Explain the mechanism and evaluate the significance of the greenhouse effect
d. Differentiate among greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 4a-d, 6a)

0008 Circulation in the Oceans and Atmosphere (SMR 3.2)

a. Assess the differential effects of heating on circulation patterns in the atmosphere and oceans
b. Relate the rotation of Earth to the circular motions of ocean currents and air in low- and high-pressure centers
c. Compare the causes and structures of various cloud types, precipitation, air masses, and fronts, and the causes and effects of different types of severe weather
d. Know and explain features of the ENSO cycle (El Niño southern oscillation, including La Niña) in terms of sea-surface and air temperature variations across the Pacific, and climatic results of this cycle

(Science Content Standards for California Public Schools, Grade 5: 3b-c, 4c; Grades 9-12, Earth Sciences: 5a-b, 5g)

0009 Climate Variations in Time and Space (SMR 3.3)

a. Analyze weather (short-term) and climate (over time) in relation to the transfer of energy into and out of the atmosphere
b. Discuss and assess factors that affect climate including latitude, elevation, topography, and proximity to large bodies of water and cold or warm ocean currents

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 5e, 6a, 6b)

BIOGEOCHEMICAL CYCLES (SMR Domain 4)

Candidates demonstrate an understanding of the foundations of the biogeochemical cycles contained in the Science Content Standards for California Public Schools (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of biogeochemical cycles and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates

demonstrate an understanding of how each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. Candidates understand how the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.

0010 Rock Cycle (SMR 4.1)

a. Compare and contrast the properties of rocks based on physical and chemical conditions in which rocks are formed, including plate tectonic processes
b. Identify common rock-forming minerals (e.g., feldspars, quartz, biotite, calcite) using a table of diagnostic properties
c. Identify common ore minerals as sources of copper, iron, lead, zinc, cement, halite, gypsum, and uranium

(Science Content Standards for California Public Schools, Grade 4: 4b, 6c; Grades 9-12, Earth Sciences: 3c)

0011 Water, Carbon, and Nitrogen Cycles (SMR 4.2)

a. Illustrate the mechanism that drives the water cycle
b. Compare the processes of photosynthesis and respiration in terms of reservoirs of carbon and oxygen
c. Identify the carbon reservoirs (i.e., physical and chemical forms of carbon in the atmosphere, oceans, biomass, soils, fossil fuels, and solid earth) and describe the movement of carbon among these reservoirs in the global carbon cycle
d. Describe the nitrogen cycle as it relates to the atmosphere, soils as reservoirs, life processes, and pollution

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 7a-d)

CALIFORNIA GEOLOGY (SMR Domain 5)

Candidates demonstrate an understanding of the foundations of the California geology contained in the Science Content Standards for California Public Schools (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of California geology and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that the geology of California underlies the state's scenic diversity and wealth of natural resources as well as its natural hazards. Candidates are familiar with the geology of California, and are aware of the unique opportunities for field experiences in the state. Candidates describe activities using geologic maps that illustrate processes, location, and scale of phenomena. Candidates also describe field experiences that include the basic elements of geologic mapping to record and interpret the history of geological processes portrayed in California.

0012 Tectonic Evolution (SMR 5.1)

a. Interpret geologic maps as a basis for understanding the tectonic evolution of California in terms of plate margins (i.e., Atlantic-type passive margin, Japanese volcanic arc, Andean arc, and faulted margin

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 9d, Investigation and Experimentation: 1h)

0013 Major Economic Earth Resources (SMR 5.2)

a. Understand the importance of water to society, the origins of California's fresh water, statewide water distribution, and the environmental and economic impact of water re-distribution
b. Describe resources of major economic importance in California and their relation to California's geology (e.g., oil, gas, gold, sand, gravel, salts, open space, soil, arable land, clean air)

(Science Content Standards for California Public Schools, Grade 6: 6b; Grades 9-12, Earth Sciences: 9a, 9c)

0014 Surface Processes (SMR 5.3)

a. Assess mechanisms by which tectonics, geologic structures (i.e., folds and faults), and rock properties influence surface properties (e.g., flow of water, differential erosion, uplift, subsidence)
b. Discuss the factors controlling the influence of water in modifying the landscape
c. Interpret the factors controlling erosion, deposition, and transport in surficial processes
d. Appraise desert environments in terms of water resource needs for habitation

(Science Content Standards for California Public Schools, Grade 4: 5b-c; Grade 6: 2a-c)

0015 Natural Hazards (SMR 5.4)

a. Analyze published geologic hazard maps of California and know how to use maps to identify evidence of geologic events of the past and to predict the likelihood of geologic changes in the future

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 9b, 9d, Investigation and Experimentation: 1h)

0016 Geologic Mapping (SMR 5.5)

a. Know how to find position using a topographic map
b. Know how to make a geologic map showing faults, structural data, and contacts between formations
c. Know how to interpret geologic history and processes from a geologic map

(Science Content Standards for California Public Schools, Grades 9-12, Earth Sciences: 9b, 9d, Investigation and Experimentation: 1h)

Part II: Subject Matter Skills and Abilities Applicable to the Content Domains in Science

Domain 1. Investigation and Experimentation

Candidates for Single Subject Teaching Credentials in Science formulate and conduct scientific investigations. They select appropriate scientific tools, make relevant measurements of changes in natural phenomena, and present unbiased findings in logical and meaningful formats using charts, maps, tables, models, graphs, and labeled diagrams. Candidates apply mathematics to scientific investigations and experimentation(s) for the purpose of quantifying results and drawing conclusions. Candidates interpret experimental results and determine whether further information is necessary to formulate accurate conclusions. They communicate results through various methods, and use technology where appropriate.

1.1 Question Formulation

a. Formulate and evaluate a viable hypothesis
b. Recognize the value and role of observation prior to question formulation
c. Recognize the iterative nature of questioning
d. Given an experimental design, identify possible hypotheses that it may test

(Science Content Standards for California Public Schools, Grade 6: 7a)

1.2 Planning a Scientific Investigation (including Experimental Design)

a. Given a hypothesis, formulate an investigation or experimental design to test that hypothesis
b. Evaluate an experimental design for its suitability to test a given hypothesis
c. Distinguish between variable and controlled parameters

(Science Content Standards for California Public Schools, Grade 5: 6c-d; Grade 8: 9a, 9c)

1.3 Observation and Data Collection

a. Identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hill slope)
b. Analyze the locations, sequences, and time intervals that are characteristic of natural phenomena (e.g., locations of planets over time, succession of species in an ecosystem)
c. Select and use appropriate tools and technology (e.g., computer-linked probes, spreadsheets, graphing calculators) to perform tests, collect data, analyze relationships, and display data
d. Evaluate the precision, accuracy, and reproducibility of data
e. Identify and analyze possible reasons for inconsistent results, such as sources of error or uncontrolled conditions
f. Identify and communicate sources of unavoidable experimental error
g. Recognize the issues of statistical variability and explain the need for controlled tests
h. Know and evaluate the safety issues when designing an experiment and implement appropriate solutions to safety problems
i. Appropriately employ a variety of print and electronic resources (e.g., the World Wide Web) to collect information and evidence as part of a research project
j. Assess the accuracy validity and reliability of information gathered from a variety of sources

(Science Content Standards for California Public Schools, Grade 3: 5a; Grade 6: 7a-b, 7g-h; Grade 7: 7a-b; Grade 8: 9b; Grades 9-12, Investigation and Experimentation: 1a-c, 1i-j, 1m)

1.4 Data Analysis/Graphing

a. Construct appropriate graphs from data and develop qualitative and quantitative statements about relationships between variables
b. Recognize the slope of the linear graph as the constant in the relationship y=kx and apply this principle in interpreting graphs constructed from data
c. Apply simple mathematical relationships to determine a missing quantity in an algebraic expression, given the two remaining terms (e.g., speed = distance/time, density = mass/volume, force = pressure x area, volume = area x height)
d. Determine whether a relationship on a given graph is linear or non-linear and determine the appropriateness of extrapolating the data
e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions

(Science Content Standards for California Public Schools, Grade 6: 7c; Grade 8: 9d-g; Grades 9-12, Investigation and Experimentation: 1e)

1.5 Drawing Conclusions and Communicating Explanations

a. Draw appropriate and logical conclusions from data
b. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence
c. Communicate the steps and results of an investigation in written reports and oral presentations

d. Recognize whether evidence is consistent with a proposed explanation
e. Construct appropriate visual representations of scientific phenomenon and processes (e.g., motion of Earth's plates, cell structure)
f. Read topographic and geologic maps for evidence provided on the maps and construct and interpret a simple scale map

(Science Content Standards for California Public Schools, Grade 5: 6g; Grade 6: 7e-f; Grade 7: 7c-e; Grade 8: 9a; Grades 9-12, Investigation and Experimentation: 1d, 1h)

Domain 2. Nature of Science

Candidates recognize that science is an active endeavor in which acquisition of knowledge is based upon the collection and examination of data. Candidates understand that scientists have a responsibility to report fully and openly the methods and results of their observations and experiments, even if those results disagree with their favored hypotheses or are controversial in public opinion. They understand that to hide data, arbitrarily eliminate data, or conceal how an experiment was conducted is to invite errors, make those errors difficult to discover, and risk harm to colleagues and communities. They understand that scientists carefully consider questions and challenges raised by fellow scientists about the assumptions, procedures, and accuracy of their experiments. They understand that a fundamental aspect of scientific inquiry is that it is dynamic and self-correcting by design. Conclusions, hypotheses, and theories are tested in every experiment and revised or rejected when they no longer correctly or accurately predict experimental results. Candidates understand that scientists must consider the safety, ethical concerns, risks, and costs and benefits of experiments to society.

2.1 Scientific Inquiry

a. Distinguish among the terms hypothesis, theory, and prediction as used in scientific investigations
b. Evaluate the usefulness, limitations, and interdisciplinary and cumulative nature of scientific evidence as it relates to the development of models and theories as representations of reality
c. Recognize that when observations do not agree with an accepted scientific theory, either the observations are mistaken or fraudulent, or the accepted theory is erroneous or incorrect
d. Understand that reproducibility of data is critical to the scientific endeavor
e. Recognize that science is a self-correcting process that eventually identifies misconceptions and experimental biases
h. Recognize that an inquiring mind is at the heart of the scientific method and that doing science involves thinking critically about the evidence presented, the usefulness of models, and the limitations of theories
i. Recognize that theories are judged by how well they explain observations and predict results and that when they represent new ideas that are counter to mainstream ideas they often encounter vigorous criticism
j. Recognize that when observations, data, or experimental results do not agree, the unexpected results are not necessarily mistakes; to discard the unusual in order to reach the expected is to guarantee that nothing but what is expected will ever be seen

k. Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out

(Science Content Standards for California Public Schools, Grade 6: 7e; Grades 9-12, Investigation and Experimentation: 1f-g, 1n)

2.2 Scientific Ethics

a. Understand that honesty is at the core of scientific ethics; first and foremost is the honest and accurate reporting of procedures used and data collected
b. Know that all scientists are obligated to evaluate the safety of an investigation and ensure the safety of those performing the experiment
c. Know the procedures for respectful treatment of all living organisms in experimentation and other investigations

2.3 Historical Perspectives

a. Discuss the cumulative nature of scientific evidence as it relates to the development of models and theories
b. Recognize that as knowledge in science evolves, when observations do not support an accepted scientific theory, the observations are reconsidered to determine if they are mistaken or fraudulent, or if the accepted theory is erroneous or incomplete (e.g., an erroneous theory is the Piltdown Man fossil; an incomplete theory is Newton's laws of gravity)
c. Recognize and provide specific examples that scientific advances sometimes result in profound paradigm shifts in scientific theories
d. Discuss the need for clear and understandable communication of scientific endeavors so that they may be reproduced and why reproduction of these endeavors is important

(Science Content Standards for California Public Schools, Grade 6: 7d; Grade 7: 7c, 7e; Grades 9-12, Investigation and Experimentation: 1k, 1n)

Domain 3. Science and Society

Candidates understand that science relies on basic human qualities such as reasoning, insight, curiosity, skill, and creativity – as well as on scientific habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. Candidates recognize their responsibility to increase scientific literacy so that the general population can understand current issues and appreciate their personal roles and responsibilities. Candidates know about possible hazards and take precautions that are the basis for creating a safe learning environment that benefits all students. They are familiar with established rules and guidelines that intend to ensure the safety of students and to protect the subjects and environments studied. Candidates understand that technology is the application of proven scientific knowledge for practical purposes serving human needs; however, science and technology are interrelated—one often propels the other.

3.1 Science Literacy

a. Recognize that science attempts to make sense of how the natural and the designed world function
b. Demonstrate the ability to apply critical and independent thinking to weigh alternative explanations of events
c. Apply evidence, numbers, patterns, and logical arguments to solve problems
d. Understand that, although much has been learned about the objects, events and phenomena in nature, there are many unanswered questions, i.e., science is a work in progress
e. Know that the ability of science and technology to resolve societal problems depends on the scientific literacy of a society

3.2 Diversity

a. Identify examples of women and men of various social and ethnic backgrounds with diverse interests, talents, qualities and motivations who are, or who have been, engaged in activities of science and related fields

3.3 Science, Technology, and Society

a. Identify and evaluate the impact of scientific advances on society
b. Recognize that scientific advances may challenge individuals to reevaluate their personal beliefs

(Science Content Standards for California Public Schools, Grades 9-12, Investigation and Experimentation: 1m, 1n)

3.4 Safety

a. Choose appropriate safety equipment for a given activity (e.g., goggles, apron, vented hood)
b. Discuss the safe use, storage, and disposal of commonly used chemicals and biological specimens
c. Assess the safety conditions needed to maintain a science laboratory (e.g., eye wash, shower, fire extinguisher)
d. Read and decode MSDS/OSHA (Material Safety Data Sheet/Occupational Safety and Health Administration) labels on laboratory supplies and equipment
e. Discuss key issues in the disposal of hazardous materials in either the laboratory or the local community
f. Be familiar with standard safety procedures such as those outlined in the Science Safety Handbook for California Schools (1999)