California Subject Examinations for Teachers®

TEST GUIDE

SCIENCE SUBTEST II: GENERAL SCIENCE

Subtest Description

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

CS-TG-SD119X-01

California Subject Examinations for Teachers (CSET®)

General Science
Subtest II: Ecology; Genetics and Evolution; Molecular Biology and Biochemistry; Cell and Organismal Biology; Heat Transfer and Thermodynamics; Structure and Properties of Matter

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

ECOLOGY (SMR Domain 4)

Candidates demonstrate an understanding of the foundations of the ecology 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 ecology and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how organisms in ecosystems exchange energy and nutrients among themselves and with the environment. They can identify factors that affect organisms within an ecosystem, including natural hazards and human activity.

0001 Ecology (SMR 4.1)

a. Explain energy flow and nutrient cycling through ecosystems (e.g., food chain, food web)
b. Explain matter transfer (e.g., biogeochemical cycles) in ecosystems
c. Distinguish between abiotic and biotic factors in an ecosystem
d. Compare the roles of photosynthesis and respiration in an ecosystem
e. Describe interrelationships within and among ecosystems (e.g., predator/prey)
f. Identify and explain factors that affect population types and size (e.g., competition for resources, niche, habitats, species and population interactions, abiotic factors)

(Science Content Standards for California Public Schools, Grade 4: 2a-c, 3a-c; Grade 5: 2f-g; Grade 6: 5a-e)

GENETICS AND EVOLUTION (SMR Domain 5)

Candidates demonstrate an understanding of the foundations of the genetics and evolution 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 genetics and evolution and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that a typical cell of any organism contains genetic instructions that specify its traits. They can explain

how biological evolution accounts for the diversity of species that developed through gradual processes over many generations. Candidates can describe evidence used to explain the evolution of life on Earth.

0002 Genetics and Evolution (SMR 5.1)

a. Explain the inheritance of traits which are determined by one or more genes, including dominance, recessiveness, sex linkage, phenotypes, genotypes, and incomplete dominance
b. Solve problems that illustrate monohybrid and dihybrid crosses
c. Compare sexual and asexual reproduction
d. Explain how the coding of DNA (deoxyribonucleic acid) controls the expression of traits by genes
e. Define mutations and explain their causes
f. Explain the process of DNA replication
g. Describe evidence, past and present, that supports the theory of evolution, including diagramming relationships that demonstrate shared characteristics of fossil and living organisms
h. Explain the theory of natural selection, including adaptation, speciation, and extinction
i. List major events that affected the evolution of life on Earth (e.g., climate changes, asteroid impacts)

(Science Content Standards for California Public Schools, Grade 7: 2a-e, 3a-e; Grades 9-12, Biology/Life Sciences: 4c, 7c, 8a)

MOLECULAR BIOLOGY AND BIOCHEMISTRY (SMR Domain 6)

Candidates demonstrate an understanding of the foundations of the molecular biology and biochemistry 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 molecular biology and biochemistry and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand and apply the principles of chemistry that underlie the functioning of biological systems. They describe the properties of biochemical compounds that make them essential to life.

0003 Molecular Biology and Biochemistry (SMR 6.1)

a. Demonstrate understanding that a small subset of elements (C, H, O, N, P, S) makes up most of the chemical compounds in living organisms by combining in many ways
b. Recognize and differentiate the structure and function of molecules in living organisms, including carbohydrates, lipids, proteins, and nucleic acids

c. Describe the process of protein synthesis, including transcription and translation
d. Compare anaerobic and aerobic respiration
e. Describe the process of photosynthesis

(Science Content Standards for California Public Schools, Grade 5: 2f-g; Grade 6: 5a; Grade 8: 6b-c; Grades 9-12, Biology/Life Sciences: 1d, 1f, 1g, 1h, 4a, Chemistry: 10c)

CELL AND ORGANISMAL BIOLOGY (SMR Domain 7)

Candidates demonstrate an understanding of the foundations of the cell and organismal biology 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 cell and organismal biology and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that all living organisms are composed of cells and explain important cellular processes. They describe and give examples of how the anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Candidates demonstrate understanding of physical principles that underlie biological structures and functions. They apply these principles to important biological systems.

0004 Cell and Organismal Biology (SMR 7.1)

a. Describe organelles and explain their function in the cell
b. Relate the structure of organelles and cells to their functions
c. Identify and contrast animal and plant cells
d. Explain the conversion, flow, and storage of energy of the cell
e. Identify the function and explain the importance of mitosis and meiosis as processes of cellular and organismal reproduction
f. Compare single-celled and multicellular organisms, noting the role of cell differentiation in the development of multicellular organisms
g. Describe the levels of organization (e.g., cells, tissues, organs, systems, organisms) in plants and animals
h. Describe the structures and functions of human body systems, including, but not limited to, the skeletal, reproductive, nervous, and circulatory systems
i. Explain the major structures and their functions in vascular and nonvascular plants
j. Describe the life processes of various plant groups, including, but not limited to, reproduction, photosynthesis, respiration, and transpiration
k. Explain the reproductive processes in flowering plants

(Science Content Standards for California Public Schools, Grade 3: 1b, 1c; Grade 5: 2a, 2e; Grade 7: 1a-f, 5a-g, 6d, 6h-j)

HEAT TRANSFER AND THERMODYNAMICS (SMR Domain 11)

Candidates demonstrate an understanding of the foundations of heat transfer and thermodynamics 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 heat transfer and thermodynamics and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates explain how heat flows in a predictable manner. They understand that energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. Candidates apply their knowledge to explain how many phenomena on Earth's surface are affected by the transfer of energy through radiation and convection currents.

0005 Heat Transfer and Thermodynamics (SMR 11.1)

a. Know the principle of conservation of energy and apply it to energy transfers
b. Discuss how the transfer of energy as heat is related to changes in temperature
c. Diagram the direction of heat flow in a system
d. Describe the methods of heat transfer by conduction, convection, and radiation, and provide examples for each
e. Explain how chemical energy in fuel is transformed to heat
f. Design and explain experiments to induce a physical change such as freezing, melting, or boiling
g. Distinguish between physical and chemical changes and provide examples of each

(Science Content Standards for California Public Schools, Grade 6: 3a-d, 4d; Grade 8: 3b, 3d-e, 5c-d; Grade 9-12, Physics: 3a-c, Chemistry: 7a-c)

STRUCTURE AND PROPERTIES OF MATTER (SMR Domain 12)

Candidates demonstrate an understanding of the structure and properties of matter 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 matter and its underlying structures, candidates have a deep conceptual knowledge of the content area. Candidates know that more than 100 elements of matter exist, each with distinct properties and a distinct atomic structure. They describe both macroscopic and microscopic properties of matter including intermolecular and intramolecular forces. They know that the organization of the periodic table is based on the properties of the elements and reflects the structure of atoms. Candidates understand how the periodic table is constructed and the periodic trends in chemical and physical properties that can be seen in the table. They recognize chemical reactions as processes that involve the rearrangement of electrons to break and form bonds with different atomic partners. Candidates demonstrate understanding of the principles of chemistry that underlie the functioning of biological systems.

0006 Structure and Properties of Matter (SMR 12.1)

a. Identify, describe, and diagram the basic components within an atom (i.e., proton, neutron, and electron)
b. Know that isotopes of any element have different numbers of neutrons but the same number of protons, and that some isotopes are radioactive
c. Differentiate between atoms, molecules, elements, and compounds
d. Compare and contrast states of matter and describe the role energy plays in the conversion from one state to another
e. Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity
f. Recognize that all chemical substances are characterized by a unique set of physical properties
g. Define and calculate density, and predict whether an object will sink or float in a fluid
h. Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules
i. Explain and apply principles of conservation of matter to chemical reactions, including balancing chemical equations
j. Distinguish among acidic, basic, and neutral solutions by their observable properties
k. Describe the construction and organization of the periodic table
l. Based on position in the periodic table, predict which elements have characteristics of metals, semimetals, nonmetals, and inert gases
m. Explain chemical reactivity using position on the periodic table
n. Predict and explain chemical bonding using elements' positions in the periodic table
o. Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems
p. Explain the central role of carbon in living system chemistry

(Science Content Standards for California Public Schools, Grade 8: 3a-c, 5a-e, 6a, 6c, 7a-c, 8a-d; Grades 9-12, Chemistry: 7b, 11c)

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)