Texas Science

Earth Systems Science (2021)

Adopted 2021

The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to explain phenomena or design solutions using appropriate tools and models. The student is expected to: ES.1

- **A.** ask questions and define problems based on observations or information from text, phenomena, models, or investigations; ES.1.A
- **B.** apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems; ES.1.B
- **C.** use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards; ES.1.C
- **D.** use appropriate tools such as a drawing compass, magnetic compass, bar magnets, topographical and geological maps, satellite imagery and other remote sensing data, Geographic Information Systems (GIS), Global Positioning System (GPS), hand lenses, and fossil and rock sample kits; ES.1.D
- **E.** collect quantitative data using the International System of Units (SI) and qualitative data as evidence; ES.1.E
- **F.** organize quantitative and qualitative data using scatter plots, line graphs, bar graphs, charts, data tables, digital tools, diagrams, scientific drawings, and student-prepared models; ES.1.F
- **G.** develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and ES.1.G
- **H.** distinguish between scientific hypotheses, theories, and laws. ES.1.H

The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to: ES.2

- **A.** identify advantages and limitations of models such as their size, scale, properties, and materials; ES.2.A
- **B.** analyze data by identifying significant statistical features, patterns, sources of error, and limitations; ES.2.B
- **C.** use mathematical calculations to assess quantitative relationships in data; and ES.2.C
- **D.** evaluate experimental and engineering designs. ES.2.D

The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to: ES.3	**A.** develop explanations and propose solutions supported by data and models consistent with scientific ideas, principles, and theories; ES.3.A
	B. communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and ES.3.B
	C. engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence. ES.3.C
The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to: ES.4	**A.** analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student; ES.4.A
	B. relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and ES.4.B
	C. research and explore resources such as museums, planetariums, observatories, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers. ES.4.C
The student understands the formation of the Earth and how objects in the solar system affect Earth's systems. The student is expected to: ES.5	**A.** analyze how gravitational condensation of solar nebular gas and dust can lead to the accretion of planetesimals and protoplanets; ES.5.A
	B. identify comets, asteroids, meteoroids, and planets in the solar system and describe how they affect the Earth and Earth's systems; and ES.5.B
	C. explore the historical and current hypotheses for the origin of the Moon, including the collision of Earth with a Mars-sized planetesimal. ES.5.C
The student knows the evidence for the formation and composition of Earth's atmosphere, hydrosphere, biosphere, and geosphere. The student is expected to: ES.6	**A.** describe how impact accretion, gravitational compression, radioactive decay, and cooling differentiated proto-Earth into layers; ES.6.A
	B. evaluate the roles of volcanic outgassing and water-bearing comets in developing Earth's atmosphere and hydrosphere; ES.6.B
	C. evaluate the evidence for changes to the chemical composition of Earth's atmosphere prior to the introduction of oxygen; ES.6.C
	D. evaluate scientific hypotheses for the origin of life through abiotic chemical processes; and ES.6.D
	E. describe how the production of oxygen by photosynthesis affected the development of the atmosphere, hydrosphere, geosphere, and biosphere. ES.6.E

The student knows that rocks and fossils provide evidence for geologic chronology, biological evolution, and environmental changes. The student is expected to: ES.7	**A.** describe the development of multiple radiometric dating methods and analyze their precision, reliability, and limitations in calculating the ages of igneous rocks from Earth, the Moon, and meteorites; ES.7.A
	B. apply relative dating methods, principles of stratigraphy, and index fossils to determine the chronological order of rock layers; ES.7.B
	C. construct a model of the geological time scale using relative and absolute dating methods to represent Earth's approximate 4.6-billion-year history; ES.7.C
	D. explain how sedimentation, fossilization, and speciation affect the degree of completeness of the fossil record; ES.7.D
	E. describe how evidence of biozones and faunal succession in rock layers reveal information about the environment at the time those rocks were deposited and the dynamic nature of the Earth; and ES.7.E
	F. analyze data from rock and fossil succession to evaluate the evidence for and significance of mass extinctions, major climatic changes, and tectonic events. ES.7.F
The student knows how the Earth's interior dynamics and energy flow drive geological processes on Earth's surface. The student is expected to: ES.8	**A.** evaluate heat transfer through Earth's systems by convection and conduction and include its role in plate tectonics and volcanism; ES.8.A
	B. develop a model of the physical, mechanical, and chemical composition of Earth's layers using evidence from Earth's magnetic field, the composition of meteorites, and seismic waves; ES.8.B
	C. investigate how new conceptual interpretations of data and innovative geophysical technologies led to the current theory of plate tectonics; ES.8.C
	D. describe how heat and rock composition affect density within Earth's interior and how density influences the development and motion of Earth's tectonic plates; ES.8.D
	E. explain how plate tectonics accounts for geologic processes, including sea floor spreading and subduction, and features, including ocean ridges, rift valleys, earthquakes, volcanoes, mountain ranges, hot spots, and hydrothermal vents; ES.8.E
	F. calculate the motion history of tectonic plates using equations relating rate, time, and distance to predict future motions, locations, and resulting geologic features; ES.8.F
	G. distinguish the location, type, and relative motion of convergent, divergent, and transform plate boundaries using evidence from the distribution of earthquakes and volcanoes; and ES.8.G

	H. evaluate the role of plate tectonics with respect to long-term global changes in Earth's subsystems such as continental buildup, glaciation, sea level fluctuations, mass extinctions, and climate change. ES.8.H
The student knows that the lithosphere continuously changes as a result of dynamic and complex interactions among Earth's systems. The student is expected to: ES.9	**A.** interpret Earth surface features using a variety of methods such as satellite imagery, aerial photography, and topographic and geologic maps using appropriate technologies; ES.9.A
	B. investigate and model how surface water and ground water change the lithosphere through chemical and physical weathering and how they serve as valuable natural resources; ES.9.B
	C. model the processes of mass wasting, erosion, and deposition by water, wind, ice, glaciation, gravity, and volcanism in constantly reshaping Earth's surface; and ES.9.C
	D. evaluate how weather and human activity affect the location, quality, and supply of available freshwater resources. ES.9.D
The student knows how the physical and chemical properties of the ocean affect its structure and flow of energy. The student is expected to: ES.10	**A.** describe how the composition and structure of the oceans leads to thermohaline circulation and its periodicity; ES.10.A
	B. model and explain how changes to the composition, structure, and circulation of deep oceans affect thermohaline circulation using data on energy flow, ocean basin structure, and changes in polar ice caps and glaciers; and ES.10.B
	C. analyze how global surface ocean circulation is the result of wind, tides, the Coriolis effect, water density differences, and the shape of the ocean basins. ES.10.C
The student knows that dynamic and complex interactions among Earth's systems produce climate and weather. The student is expected to: ES.11	**A.** analyze how energy transfer through Milankovitch cycles, albedo, and differences in atmospheric and surface absorption are mechanisms of climate; ES.11.A
	B. describe how Earth's atmosphere is chemically and thermally stratified and how solar radiation interacts with the layers to cause the ozone layer, the jet stream, Hadley and Ferrel cells, and other atmospheric phenomena; ES.11.B
	C. model how greenhouse gases trap thermal energy near Earth's surface; ES.11.C
	D. evaluate how the combination of multiple feedback loops alter global climate; ES.11.D
	E. investigate and analyze evidence for climate changes over Earth's history using paleoclimate data, historical records, and measured greenhouse gas levels; ES.11.E
	F. explain how the transfer of thermal energy among the hydrosphere, lithosphere, and atmosphere influences weather; and ES.11.F

	G. describe how changing surface-ocean conditions, including El Niño-Southern Oscillation, affect global weather and climate patterns. ES.11.G
The student understands how Earth's systems affect and are affected by human activities, including resource use and management. The student is expected to: ES.12	**A.** evaluate the impact on humans of natural changes in Earth's systems such as earthquakes, tsunamis, and volcanic eruptions; ES.12.A
	B. analyze the impact on humans of naturally occurring extreme weather events such as flooding, hurricanes, tornadoes, and thunderstorms; ES.12.B
	C. analyze the natural and anthropogenic factors that affect the severity and frequency of extreme weather events and the hazards associated with these events; ES.12.C
	D. analyze recent global ocean temperature data to predict the consequences of changing ocean temperature on evaporation, sea level, algal growth, coral bleaching, and biodiversity; ES.12.D
	E. predict how human use of Texas's naturally occurring resources such as fossil fuels, minerals, soil, solar energy, and wind energy directly and indirectly changes the cycling of matter and energy through Earth's systems; and ES.12.E
	F. explain the cycling of carbon through different forms among Earth's systems and how biological processes have caused major changes to the carbon cycle in those systems over Earth's history. ES.12.F
The student explores global policies and careers related to the life cycles of Earth's resources. The student is expected to: ES.13	**A.** analyze the policies related to resources from discovery to disposal, including economics, health, technological advances, resource type, concentration and location, waste disposal and recycling, mitigation efforts, and environmental impacts; and ES.13.A
	B. explore global and Texas-based careers that involve the exploration, extraction, production, use, disposal, regulation, and protection of Earth's resources. ES.13.B