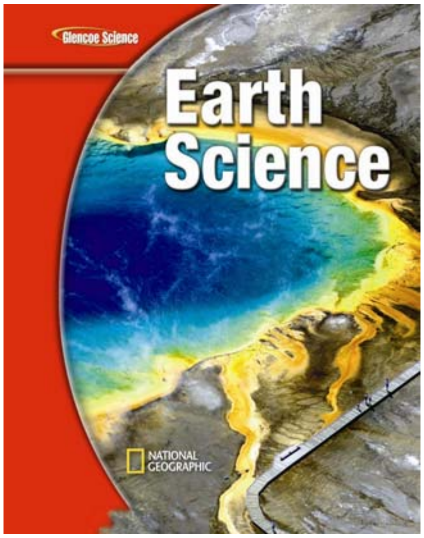
High School Science Content Expectations
Earth Science
Essential Skills



Earth Science

STANDARDS		PAGE REFERENCES
	EARTH SCIENCE	
	STANDARD E1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS *Students will understand the nature of science and demonstrate an ability to practice scientific reasoning by applying it to the design, execution, and evaluation of scientific investigations. Students will demonstrate their understanding that scientific knowledge is gathered through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. They will be able to distinguish between types of scientific knowledge (e.g., hypotheses, laws, theories) and become aware of areas of active research in contrast to conclusions that are part of established scientific consensus. They will use their scientific knowledge to assess the costs, risks, and benefits of technological systems as they make personal choices and participate in public policy decisions. These insights will help them analyze the role science plays in society, technology, and potential career opportunities.*	
	E1.1 Scientific Inquiry Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.	
E1.1A	Generate new questions that can be investigated in the laboratory or field.	**Student Edition:** 265 #29, 295 #22, 449 #23 *Lab* 24-25, 52-53, 260-261, 634

Codes used for Teacher Wraparound Edition pages are the initial caps of headings on that page.

STANDARDS		PAGE REFERENCES
E1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	**Student Edition:** 29 #27 *Applying Science* 21 *Lab* 45, 52-53, 142-143, 172-173, 200-201, 290-291, 350-351, 382-383, 414-415, 444-445, 474-475, 650-651 *Communicating Your Data* 98
E1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).	**Student Edition:** *Lab* 24-25, 52-53, 67, 80-81, 136, 200-201, 221, 228-229, 260-261, 350-351, 444-445, 503, 504-505, 608, 616-617
E1.1D	Identify patterns in data and relate them to theoretical models.	**Student Edition:** *MiniLAB* 19 *Lab* 98, 136, 195, 200-201, 221, 228-229, 260-261, 290-291, 320-321, 344, 376, 407, 504-505 *Applying Science* 223
E1.1E	Describe a reason for a given conclusion using evidence from an investigation.	**Student Edition:** *Lab* 24-25, 52-53, 67, 80-81, 98, 136, 195, 200-201, 221, 228-229, 260-261, 350-351, 414-415, 444-445, 531
	E1.2 Scientific Reflection and Social Implications The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.	
E1.2A	Critique whether or not specific questions can be answered through scientific investigations.	**Student Edition:** 8, 20
E1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence.	**Student Edition:** *Integrate Career* 20 *Science and Society* 112, 262, 476, 592, 652 *Science Online* 197

STANDARDS		PAGE REFERENCES
E1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	**Student Edition:** *Lab* 23, 434 *Research* 82, 174, 592, 716 *Write* 112 *Debate* 262 *Science Online* 273 *Make Posters* 618 *Science Skill Handbook* 756
E1.2D	Evaluate scientific explanations in a peer review process or discussion format.	**Student Edition:** *Communicating Your Data* 25, 45, 111, 201, 321, 383, 533, 608, 681, 715, 733 *Lab* 80-81, 228-229
E1.2E	Evaluate the future career and occupational prospects of science fields.	**Student Edition:** *Integrate Career* 106, 131, 197, 239, 287, 315, 332, 497, 522, 550, 604, 638 *Science Online* 168 *Unit Projects* 423
	STANDARD E2: EARTH SYSTEMS *Students describe the interactions within and between Earth systems. Students will explain how both fluids (water cycle) and solids (rock cycle) move within Earth systems and how these movements form and change their environment. They will describe the relationship between physical process and human activities and use this understanding to demonstrate an ability to make wise decisions about land use.*	
	E2.1 Earth Systems Overview The Earth is a system consisting of four major interacting components: geosphere (crust, mantle, and core), atmosphere (air), hydrosphere (water), and biosphere (the living part of Earth). Physical, chemical, and biological processes act within and among the four components on a wide range of time scales to continuously change Earth's crust, oceans, atmosphere, and living organisms. Earth elements move within and between the lithosphere, atmosphere, hydrosphere, and biosphere as part of geochemical cycles.	
E2.1A	Explain why the Earth is essentially a closed system in terms of matter.	**Student Edition:** 91-93, 109 *Section Review* 93
E2.1B	Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.	**Student Edition:** 182-187, 188-194, 210-214, 215-220, 222-227, 238-248, 253-254, 255-258, 363-369, 435-438, 484-487, 549-556 *National Geographic* 92 *Launch Lab* 237 *Integrate Chemistry* 401

STANDARDS		PAGE REFERENCES
E2.1C	Explain, using specific examples, how a change in one system affects other Earth systems.	**Student Edition:** 210-214, 215-220, 238-248, 313-316, 336-343, 492-502, 557-561 *Launch Lab* 209 *MiniLAB* 493 *National Geographic* 494-495 *Science and History* 506
	E2.2 Energy in Earth Systems Energy in Earth systems can exist in a number of forms (e.g., thermal energy as heat in the Earth, chemical energy stored as fossil fuels, mechanical energy as delivered by tides) and can be transformed from one state to another and move from one reservoir to another. Movement of matter and its component elements, through and between Earth's systems, is driven by Earth's internal (radioactive decay and gravity) and external (Sun as primary) sources of energy. Thermal energy is transferred by radiation, convection, and conduction. Fossil fuels are derived from plants and animals of the past, are nonrenewable, and, therefore, are limited in availability. All sources of energy for human consumption (e.g., solar, wind, nuclear, ethanol, hydrogen, geothermal, hydroelectric) have advantages and disadvantages.	
E2.2A	Describe the Earth's principal sources of internal and external energy (e.g., radioactive decay, gravity, solar energy).	**Student Edition:** 94, 130, 210, 285, 377-378, 435-438, 439-443, 484, 497, 729-732 *Integrate Physics* 213 *National Geographic* 441 *MiniLAB* 485
E2.2B	Identify differences in the origin and use of renewable (e.g., solar, wind, water, biomass) and nonrenewable (e.g., fossil fuels, nuclear [U-235]) sources of energy.	**Student Edition:** 120-129, 130-135, 147 #17-#19, 149 #11-#16 *Launch Lab* 119 *Integrate Life Science* 121 *Science Online* 125, 133 *National Geographic* 126
E2.2C	Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.	**Student Edition:** 285, 435-437, 449 #21, 451 #21 *MiniLAB* 285, 437
E2.2D	Identify the main sources of energy to the climate system.	**Student Edition:** 484-487, 492-502, 509 #19, 509 #30, 663-665 *MiniLAB* 485 *Applying Science* 486 *National Geographic* 494-495 *Lab* 680-681

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	E2.3 Biogeochemical Cycles The Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Most elements can exist in several different states and chemical forms; they move within and between the geosphere, atmosphere, hydrosphere, and biosphere as part of the Earth system. The movements can be slow or rapid. Elements and compounds have significant impacts on the biosphere and have important impacts on human health.	
E2.3A	Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans.	**Student Edition:** 121-122, 379, 426-427, 449 #22, 499-502, 511 #13-#17 *Science Online* 499
	E2.4 Resources and Human Impacts on Earth Systems The Earth provides resources (including minerals) that are used to sustain human affairs. The supply of nonrenewable natural resources is limited and their extraction and use can release elements and compounds into Earth systems. They affect air and water quality, ecosystems, landscapes, and may have effects on long-term climate. Plans for land use and long-term development must include an understanding of the interactions between Earth systems and human activities.	
E2.4A	Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits.	**Student Edition:** 120-129, 130-135, 147 #17-#19, 149 #21, 537 #22 *Science Online* 125, 133 *National Geographic* 126 *Applying Skills* 135 *Accidents in Science* 144 *Integrate Physics* 582
E2.4B	Explain how the impact of human activities on the environment (e.g., deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems.	**Student Edition:** 196-199, 432-433, 499-502, 557-561, 578-584, 600-607, 609-615 *Science Online* 501 *Applying Science* 581 *Lab* 608 *Science and History* 618

STANDARDS		PAGE REFERENCES
	STANDARD E3: THE SOLID EARTH *Students explain how scientists study and model the interior of the Earth and its dynamic nature. They use the theory of plate tectonics, the unifying theory of geology, to explain a wide variety of Earth features and processes and how hazards resulting from these processes impact society.*	
	E3.p1 Landforms and Soils *(prerequisite)* Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruptions, and deposition of sediments transported in rivers, streams, and lakes through watersheds. Destructive forces include weathering and erosion. The weathering of rocks and decomposed organic matter result in the formation of soils. *(prerequisite)*	
	E3.p2 Rocks and Minerals *(prerequisite)* Igneous, metamorphic, and sedimentary rocks are constantly forming and changing through various processes. As they do so, elements move through the geosphere. In addition to other geologic features, rocks and minerals are indicators of geologic and environmental conditions that existed in the past. *(prerequisite)*	
	E3.p3 Basic Plate Tectonics *(prerequisite)* Early evidence for the movement of continents was based on the similarities of coastlines, geology, faunal distributions, and paleoclimatelogical data across the Atlantic and Indian Oceans. In the 1960s, additional evidence from marine geophysical surveys, seismology, volcanology, and paleomagnetism resulted in the development of the theory of plate tectonics. *(prerequisite)*	
	E3.1 Advanced Rock Cycle Igneous, metamorphic, and sedimentary rocks are indicators of geologic and environmental conditions and processes that existed in the past. These include cooling and crystallization, weathering and erosion, sedimentation and lithification, and metamorphism. In some way, all of these processes are influenced by plate tectonics, and some are influenced by climate.	
E3.1A	Discriminate between igneous, metamorphic, and sedimentary rocks and describe the processes that change one kind of rock into another.	**Student Edition:** 90-93, 94-97, 99-102, 103-109, 115 #25, 117 #11-#15, 182-187 *MiniLAB* 91 *National Geographic* 92 *Applying Skills* 93, 102 *Science Online* 96 *Lab* 98, 110-111
E3.1B	Explain the relationship between the rock cycle and plate tectonics theory in regard to the origins of igneous, sedimentary, and metamorphic rocks.	**Student Edition:** 90-93, 94-97, 99-102, 106-109, 117 #16-#17, 117 #21, 277, 345-349 *National Geographic* 92, 283

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	E3.2 Interior of the Earth The Earth can also be subdivided into concentric layers based on their physical characteristics: (lithosphere, asthenosphere, lower mantle, outer core, and inner core). The crust and upper mantle compose the rigid lithosphere (plates) that moves over a "softer" asthenosphere (part of the upper mantle). The magnetic field of the Earth is generated in the outer core. The interior of the Earth cannot be directly sampled and must be modeled using data from seismology.	
E3.2A	Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated.	**Student Edition:** 309-311, 662, 685 #24
E3.2B	Explain how scientists infer that the Earth has interior layers with discernable properties using patterns of primary (**P**) and secondary (**S**) seismic wave arrivals.	**Student Edition:** 304-311
E3.2C	Describe the differences between oceanic and continental crust (including density, age, composition).	**Student Edition:** 283-287 *National Geographic* 283
	E3.3 Plate Tectonics Theory The Earth's crust and upper mantle make up the lithosphere, which is broken into large mobile pieces called tectonic plates. The plates move at velocities in units of centimeters per year as measured using the global positioning system (GPS). Motion histories are determined with calculations that relate rate, time, and distance of offset geologic features. Oceanic plates are created at mid-ocean ridges by magmatic activity and cooled until they sink back into the Earth at subduction zones. At some localities, plates slide by each other. Mountain belts are formed both by continental collision and as a result of subduction. The outward flow of heat from Earth's interior provides the driving energy for plate tectonics.	
E3.3A	Explain how plate tectonics accounts for the features and processes (sea floor spreading, mid-ocean ridges, subduction zones, earthquakes and volcanoes, mountain ranges) that occur on or near the Earth's surface.	**Student Edition:** 276-278, 280-289, 300-303, 327 #12, 332-335, 544-545 *National Geographic* 283 *Lab* 290-291, 320-321 *Communicating Your Data* 291
E3.3B	Explain why tectonic plates move using the concept of heat flowing through mantle convection, coupled with the cooling and sinking of aging ocean plates that result from their increased density.	**Student Edition:** 276-277, 285, 295 #22, 297 #20 *MiniLAB* 285

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E3.3C	Describe the motion history of geologic features (e.g., plates, Hawaii) using equations relating rate, time, and distance.	**Student Edition:** 288-289, 297 #16, 355 #20 *Applying Skills* 278 *Lab* 279 *Applying Math* 295 *Science Online* 337 *MiniLAB* 412
	E3.4 Earthquakes and Volcanoes Plate motions result in potentially catastrophic events (earthquakes, volcanoes, tsunamis, mass wasting) that affect humanity. The intensity of volcanic eruptions is controlled by the chemistry and properties of the magma. Earthquakes are the result of abrupt movements of the Earth. They generate energy in the form of body and surface waves.	
E3.4A	Use the distribution of earthquakes and volcanoes to locate and determine the types of plate boundaries.	**Student Edition:** 286-288, 300-301, 333-335 *Science Online* 282 *Lab* 290-291, 320-321 *Communicating Your Data* 291
E3.4B	Describe how the sizes of earthquakes and volcanoes are measured or characterized.	**Student Edition:** 313-315 *Applying Math* 317, 325
E3.4C	Describe the effects of earthquakes and volcanic eruptions on humans.	**Student Edition:** 313-319, 330-331, 343, 357 #23 *Science Stats* 322 *Integrate Health* 339 *Accidents in Science* 352
	STANDARD E4: THE FLUID EARTH *Students explain how the ocean and atmosphere move and transfer energy around the planet. They also explain how these movements affect climate and weather and how severe weather impacts society. Students explain how long term climatic changes (glaciers) have shaped the Michigan landscape. They also explain features and processes related to surface and ground-water and describe the sustainability of systems in terms of water quality and quantity.*	
	E4.p1 Water Cycle *(prerequisite)* Water circulates through the crust and atmosphere and in oceans, rivers, glaciers, and ice caps and connects all of the Earth systems. Groundwater is a significant reservoir and source of freshwater on Earth. The recharge and movement of groundwater depends on porosity, permeability, and the shape of the water table. The movement of groundwater occurs over a long period time. Groundwater and surface water are often interconnected. *(prerequisite)*	
	E4.p2 Weather and the Atmosphere *(prerequisite)* The atmosphere is divided into layers defined by temperature. Clouds are indicators of weather. *(prerequisite)*	

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	E4.p3 Glaciers *(prerequisite)* Glaciers are large bodies of ice that move under the influence of gravity. They form part of both the rock and water cycles. Glaciers and ice sheets have shaped the landscape of the Great Lakes region. Areas that have been occupied by ice sheets are depressed. When the ice sheet is removed, the region rebounds (see also climate change). *(prerequisite)*	
	E4.1 Hydrogeology Fresh water moves over time between the atmosphere, hydrosphere (surface water, wetlands, rivers, and glaciers), and geosphere (groundwater). Water resources are both critical to and greatly impacted by humans. Changes in water systems will impact quality, quantity, and movement of water. Natural surface water processes shape the landscape everywhere and are affected by human land use decisions.	
E4.1A	Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).	**Student Edition:** 238-248, 249-254 *Science Online* 242, 246 *National Geographic* 244-245 *MiniLAB* 247 *Applying Math* 251, 265 *Lab* 260-261
E4.1B	Explain the features and processes of groundwater systems and how the sustainability of North American aquifers has changed in recent history (e.g., the past 100 years) qualitatively using the concepts of recharge, residence time, inputs, and outputs.	**Student Edition:** 249-254
E4.1C	Explain how water quality in both groundwater and surface systems is impacted by land use decisions.	**Student Edition:** 267 #17, 557-561, 600-607, 621 #25 *National Geographic* 603 *Integrate Health* 606 *Lab* 608
	E4.2 Oceans and Climate Energy from the sun and the rotation of the Earth control global atmospheric circulation. Oceans redistribute matter and energy around the Earth through currents, waves, and interaction with other Earth systems. Ocean currents are controlled by prevailing winds, changes in water density, ocean topography, and the shape and location of landmasses. Oceans and large lakes (e.g., Great Lakes) have a major effect on climate and weather because they are a source of moisture and a large reservoir of heat. Interactions between oceanic circulation and the atmosphere can affect regional climates throughout the world.	
E4.2A	Describe the major causes for the ocean's surface and deep water currents, including the prevailing winds, the Coriolis effect, unequal heating of the earth, changes in water temperature and salinity in high latitudes, and basin shape.	**Student Edition:** 518-523, 539 #18-#19 *Launch Lab* 513 *Science Online* 519 *MiniLAB* 521

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E4.2B	Explain how interactions between the oceans and the atmosphere influence global and regional climate. Include the major concepts of heat transfer by ocean currents, thermohaline circulation, boundary currents, evaporation, precipitation, climatic zones, and the ocean as a major CO_2 reservoir.	**Student Edition:** 442-443, 484-487, 493, 518-520, 539 #15 *Integrate Environment* 468 *MiniLAB* 493 *National Geographic* 494-495
	E4.3 Severe Weather Tornadoes, hurricanes, blizzards, and thunderstorms are severe weather phenomena that impact society and ecosystems. Hazards include downbursts (wind shear), strong winds, hail, lightning, heavy rain, and flooding. The movement of air in the atmosphere is due to differences in air density resulting from variations in temperature. Many weather conditions can be explained by fronts that occur when air masses meet.	
E4.3A	Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).	**Student Edition:** 465-469, 479 #28, 481 #11, 481 #14-#16 *National Geographic* 467
E4.3B	Describe the damage resulting from, and the social impact of thunderstorms, tornadoes, hurricanes, and floods.	**Student Edition:** 246-247, 465-469 *Science Online* 466
E4.3C	Describe severe weather and flood safety and mitigation.	**Student Edition:** 469, 481 #19 *Section Review* 469
E4.3D	Describe the seasonal variations in severe weather.	**Student Edition:** 468-469, 479 #25
E4.3E	Describe conditions associated with frontal boundaries that result in severe weather (thunderstorms, tornadoes, and hurricanes).	**Student Edition:** 463-469
E4.3F	Describe how mountains, frontal wedging (including dry lines), convection, and convergence form clouds and precipitation.	**Student Edition:** 458-461, 481 #8

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	STANDARD E5: THE EARTH IN SPACE AND TIME *Students explain theories about how the Earth and universe formed and evolved over a long period of time. Students predict how human activities may influence the climate of the future.*	
	E5.p1 Sky Observations *(prerequisite)* Common sky observations (such as lunar phases) can be explained by the motion of solar system objects in regular and predictable patterns. Our galaxy, observable as the Milky Way, is composed of billions of stars, some of which have planetary systems. Seasons are a result of the tilt of the rotation axis of the Earth. The motions of the moon and sun affect the phases of the moon and ocean tides. *(prerequisite)*	
	E5.1 The Earth in Space Scientific evidence indicates the universe is orderly in structure, finite, and contains all matter and energy. Information from the entire light spectrum tells us about the composition and motion of objects in the universe. Early in the history of the universe, matter clumped together by gravitational attraction to form stars and galaxies. According to the Big Bang theory, the universe has been continually expanding at an increasing rate since its formation about 13.7 billion years ago.	
E5.1A	Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe.	**Student Edition:** 740-745 *Launch Lab* 723 *MiniLAB* 742 *National Geographic* 744
	E5.2 The Sun Stars, including the Sun, transform matter into energy in nuclear reactions. When hydrogen nuclei fuse to form helium, a small amount of matter is converted to energy. Solar energy is responsible for life processes and weather as well as phenomena on Earth. These and other processes in stars have led to the formation of all the other chemical elements.	
E5.2A	Identify patterns in solar activities (sunspot cycle, solar flares, solar wind).	**Student Edition:** 730-731 *Section Review* 732 *Lab* 733
E5.2B	Relate events on the Sun to phenomena such as auroras, disruption of radio and satellite communications, and power grid disturbances.	**Student Edition:** 731, 753 #9 *Science Online* 731
E5.2C	Describe how nuclear fusion produces energy in the Sun.	**Student Edition:** 129, 729, 735-739
E5.2D	Describe how nuclear fusion and other processes in stars have led to the formation of all the other chemical elements.	**Student Edition:** 739

STANDARDS		PAGE REFERENCES
	E5.2x Stellar Evolution Stars, including the Sun, transform matter into energy in nuclear reactions. When hydrogen nuclei fuse to form helium, a small amount of matter is converted to energy. These and other processes in stars have led to the formation of all the other chemical elements. There is a wide range of stellar objects of different sizes and temperatures. Stars have varying life histories based on these parameters.	
	E5.3 Earth History and Geologic Time The solar system formed from a nebular cloud of dust and gas 4.6 Ga (billion years ago). The Earth has changed through time and has been affected by both catastrophic (e.g., earthquakes, meteorite impacts, volcanoes) and gradual geologic events (e.g., plate movements, mountain building) as well as the effects of biological evolution (formation of an oxygen atmosphere). Geologic time can be determined through both relative and absolute dating.	
E5.3A	Explain how the solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 Ga (billion years ago).	**Student Edition:** 692, 721 #25 *Integrate Physics* 692 *National Geographic* 693 *Section Review* 694
E5.3B	Describe the process of radioactive decay and explain how radioactive elements are used to date the rocks that contain them.	**Student Edition:** 377-381 *MiniLAB* 378 *Science Online* 380 *Applying Science* 380 *Applying Math* 387
E5.3C	Relate major events in the history of the Earth to the geologic time scale, including formation of the Earth, formation of an oxygen atmosphere, rise of life, Cretaceous-Tertiary (K-T) and Permian extinctions, and Pleistocene ice age.	**Student Edition:** 392-399, 400-406, 408-413, 421 #21-#22 *Unit Projects* 359 *Integrate Chemistry* 401 *Science Online* 404 *Applying Math* 411, 419 *Lab* 414-415
E5.3D	Describe how index fossils can be used to determine time sequence.	**Student Edition:** 367-369, 389 #22, 397-398, 419 #17 *Science Online* 374 *Section Review* 399 *MiniLAB* 402

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	E5.3x Geologic Dating Early methods of determining geologic time, such as the use of index fossils and stratigraphic principles, allowed for the relative dating of geological events. However, absolute dating was impossible until the discovery that certain radioactive isotopes in rocks have known decay rates, making it possible to determine how many years ago a given mineral or rock formed. Different kinds of radiometric dating techniques exist. Technique selection depends on the composition of the material to be dated, the age of the material, and the type of geologic event that affected the material.	
	E5.4 Climate Change Atmospheric gases trap solar energy that has been reradiated from the Earth's surface (the greenhouse effect). The Earth's climate has changed both gradually and catastrophically over geological and historical time frames due to complex interactions between many natural variables and events. The concentration of greenhouse gases (especially carbon dioxide) has increased due to human industrialization, which has contributed to a rise in average global atmospheric temperatures and changes in the biosphere, atmosphere, and hydrosphere. Climates of the past are researched, usually using indirect indicators, to better understand and predict climate change.	
E5.4A	Explain the natural mechanism of the greenhouse effect, including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone).	**Student Edition:** 499-502, 511 #8-#10 *Science Online* 499 *Lab* 503
E5.4B	Describe natural mechanisms that could result in significant changes in climate (e.g., major volcanic eruptions, changes in sunlight received by the earth, and meteorite impacts).	**Student Edition:** 496-498, 509 #22, 509 #29 *Applying Skills* 502 *Science and History* 506
E5.4C	Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years.	**Student Edition:** 500-502, 511 #14
E5.4D	Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity of the biosphere).	**Student Edition:** 500-502, 509 #25, 511 #17 *Integrate Environment* 468