Unit 7: Geologic Time Scale
Parent Guide

SES4. Obtain, evaluate, and communicate information to understand how rock relationships and fossils are used to reconstruct the Earth's past.

Uniformitarianism is the idea that what is happening to the Earth in the present is what has happened to the Earth in the past. We can trace this idea through the rocks that we see every day looking at fossils and radioactive isotopes in them. By understanding how to date rocks both relatively and absolutely, we can recreate The Geologic Time Scale and use it as a tool to help us understand Earth's past.

- During the seventeenth and eighteenth centuries, ***catastrophism*** influenced the formulation of explanations about Earth. Catastrophism states that Earth's landscapes have been developed primarily by great catastrophes. By contrast, ***uniformitarianism***, one of the fundamental principles of modern geology advanced by ***James Hutton*** in the late 1700s, states that the physical, chemical, and biological laws that operate today have also operated in the geologic past. The idea is often summarized as "The present is the key to the past." Hutton argued that processes that appear to be slow-acting could, over long spans of time, produce effects that were just as great as those resulting from sudden catastrophic events.

- The two types of dates used by geologists to interpret Earth history are (1) ***relative dates***, which put events in their ***proper sequence of formation***, and (2) ***numerical dates***, which pinpoint the ***time in years*** when an event took place.

- Relative dates can be established using the ***law of superposition, principle of original horizontality, principle of cross-cutting relationships, inclusions, and unconformities.*** Unconformities Video

- ***Correlation***, the matching up of two or more geologic phenomena in different areas, is used to develop a geologic time scale that applies to the entire Earth.

- ***Fossils*** are the remains or traces of prehistoric life. The special conditions that favor preservation are ***rapid burial*** and the possession of ***hard parts*** such as shells, bones, or teeth.

- Fossils are used to ***correlate*** sedimentary rocks from different regions by using the rocks' distinctive fossil content and applying the ***principle of fossil succession***. It states that fossil organisms succeed one another in a definite and determinable order, and therefore any time period can be recognized by its fossil content.

- Each atom has a nucleus containing ***protons*** (positively charged particles) and ***neutrons*** (neutral particles). Orbiting the nucleus are negatively charged ***electrons***. The ***atomic number*** of an atom is the number of protons in the nucleus. The ***mass number*** is the number of protons plus the number of neutrons in an atom's nucleus. ***Isotopes*** are variants of the same atom, but with a different number of neutrons and hence a different mass number.

- ***Radioactivity*** is the spontaneous breaking apart (decay) of certain unstable atomic nuclei. Three common types of radioactive decay are (1) emission of alpha particles from the nucleus, (2) emission of beta particles (electrons) from the nucleus, and (3) capture of electrons by the nucleus.

- An unstable ***radioactive isotope***, called the ***parent***, will decay and form stable ***daughter products***. The length of time for half of the nuclei of a radioactive isotope to decay is called the ***half-life*** of the isotope. If the half-life of the isotope is known and the parent/daughter ratio can be measured, the age of a sample can be calculated.

- The ***geologic time scale*** divides Earth's history into units of varying magnitude. It is commonly presented in chart form, with the oldest time and event at the bottom and the youngest at the top. The principal subdivisions of the geologic time scale, called ***eons***, include the ***Hadean, Archean, Proterozoic*** (together, these three eons are commonly referred to as the ***Precambrian***), and, beginning about 540 million years ago, the Phanerozoic. The Phanerozoic (meaning "visible life") eon is divided into the following ***eras: Paleozoic*** ("ancient life"), ***Mesozoic*** ("middle life"), and ***Cenozoic*** ("recent life").

- A significant problem in assigning numerical dates to units of time is that ***not all rocks can be dated radiometrically***. A sedimentary rock may contain particles of many ages that have been weathered from different rocks that formed at various times. One way geologists assign numerical dates to sedimentary rocks is to relate them to datable igneous masses, such as dikes and volcanic ash beds.

- The ***Precambrian*** spans about 88 percent of Earth history, beginning with the formation of Earth about 4.5 billion years ago and ending 540 million years ago with the diversification of life that marks the start of the Paleozoic era. It is the least understood span of Earth's history because most Precambrian rocks are buried from view. However, on each continent there is a "core area" of Precambrian rocks called the ***shield***. The iron-ore deposits of Precambrian age represent the time when oxygen became abundant in the atmosphere and combined with iron to form iron oxide.

- Earth's primitive atmosphere consisted of such gases as water vapor, carbon dioxide, nitrogen, and several trace gases that were released in volcanic emissions, a process called ***outgassing***. The first life forms on Earth, probably ***anaerobic bacteria***, did not require oxygen. As life evolved, plants, through the process of ***photosynthesis***, used carbon dioxide and water and released oxygen into the atmosphere. Once the available iron on Earth was oxidized (combined with oxygen), substantial quantities of oxygen accumulated in the atmosphere. About 4 billion years into Earth's existence, the fossil record reveals abundant ocean-dwelling organisms that require oxygen to live.

- The most common middle Precambrian fossils are ***stromatolites***. Microfossils of bacteria and blue-green algae, both primitive prokaryotes whose cells lack organized nuclei, have been found in chert, a hard, dense, chemical sedimentary rock in southern Africa (3.1 billion years of age) and near Lake Superior (1.7 billion years of age). ***Eukaryotes***, with cells containing organized nuclei, are among billion-year-old fossils discovered in Australia. Plant fossils date from the middle Precambrian, but animal fossils came a bit later, in the late Precambrian. Many of these fossils are ***trace fossils***, and not of the animals themselves.

- The ***Paleozoic era*** extends from 540 million years ago to about 248 million years ago. The beginning of the Paleozoic is marked by the ***appearance of the first life forms with hard parts***, such as shells. Therefore, abundant Paleozoic fossils occur, and a far more detailed record of Paleozoic events can be constructed. During the early Paleozoic (the Cambrian, Ordovician, and Silurian periods) the vast southern continent of ***Gondwana*** existed. Seas inundated and receded from North America several times, leaving thick evaporite beds of rock salt and gypsum. Life in the early Paleozoic was restricted to the seas and consisted of several invertebrate groups. During the late Paleozoic (the Devonian, Mississippian, Pennsylvanian, and Permian periods), ancestral North America collided with Africa to produce the original northern Appalachian Mountains, and the northern continent of ***Laurasia*** formed. By the close of the Paleozoic, all the continents had fused into the supercontinent of ***Pangaea***. During most of the Paleozoic, organisms diversified dramatically. Insects and plants moved onto the land, and amphibians evolved and diversified quickly. By the Pennsylvanian period, large tropical swamps, which became the major coal deposits of today, extended across North America, Europe, and Siberia. At the close of the Paleozoic, altered climatic conditions caused one of the most dramatic biological declines in all of Earth history.

- The ***Mesozoic era***, often called the "***age of dinosaurs,***" began about 248 million years ago and ended approximately 65 million years ago. Early in the Mesozoic much of the land was above sea level. However, by the middle Mesozoic, seas invaded western North America. As Pangaea began to break up, the westward-moving North American plate began to override the Pacific plate, causing crustal deformation along the entire western margin of the continent. Organisms that had survived extinction at the end of the Paleozoic began to diversify in spectacular ways. ***Gymnosperms*** (cycads, conifers, and ginkgoes) quickly became the dominant trees of the Mesozoic because they could adapt to the drier climates. Reptiles quickly became the dominant land animals, with one group eventually becoming the birds. The most awesome of the Mesozoic reptiles were the ***dinosaurs***. At the close of the Mesozoic, many reptile groups, including the dinosaurs, became extinct.

- The ***Cenozoic era***, or "***era of recent life,***" began approximately 65 million years ago and continues today. It is ***the time of mammals,*** including humans. The widespread, less disturbed rock formations of the Cenozoic provide a rich geologic record. Most of North America was above sea level throughout the Cenozoic. Because of their different relations with tectonic plate boundaries, the eastern and western margins of the North American continent experienced contrasting events. The stable eastern margin was the site of abundant sedimentation as isostatic adjustment raised the eroded Appalachians, causing the streams to downcut with renewed vigor and to deposit their sediment along the continental margin. In the west, building of the Rocky Mountains was coming to an end, the Basin and Range Province was forming, and volcanic activity was extensive. The Cenozoic is often called "***the age of mammals***" because these animals replaced the reptiles as the dominant land life. Two groups of mammals, the ***marsupials*** and the ***placentals***, evolved and expanded to dominate the era. One tendency was for some mammal groups to become very large. However, a wave of late ***Pleistocene*** extinctions rapidly eliminated these animals from the landscape. Some scientists believe that humans hastened the decline of these animals by selectively hunting the larger species. The Cenozoic could also be called the "***age of flowering plants.***" As a source of food, flowering plants strongly influenced the evolution of both birds and herbivorous (plant-eating) mammals throughout the Cenozoic era.