Earth is constantly changing.

In the late 1700s a Scottish geologist named James Hutton began to question some of the ideas that were then common about Earth and how Earth changes. He found fossils and saw them as evidence of life forms that no longer existed. He also noticed that different types of fossilized creatures were found in different layers of rocks. Based on his observations of rocks and other natural evidence, Hutton came up with a new theory to explain the story told in the rocks. He was the first to present a hypothesis about Earth’s changing over time.
Hutton recognized that Earth is a constantly changing place. Wind, water, heat, and cold break down rocks. Other processes, such as volcanic eruptions and the building up of sediment, continue to form new rock. Earth’s interior is constantly churning with powerful forces that move, fold, raise, and swallow the surface of the planet.

The same processes that changed Earth in the past continue to occur today. A billion years ago a river would have carried particles of rock just as a river does today. Similarly, volcanoes in the past would have erupted just as volcanoes do today. Hutton’s theory of uniformitarianism (yoo-nuh-fawr-mih-TAIR-ee-uh-nihz-uhm) is the idea that

- Earth is an always-changing place
- the same forces of change at work today were at work in the past

Although this idea may seem simple, it is very important. The theory of uniformitarianism is the basis of modern geology.

Some changes on Earth are gradual. Mountains form and are worn down over many millions of years. Climate and the amount of ice on land can change over hundreds or thousands of years. Other changes are fast. A volcanic eruption, an earthquake, or a flood can cause huge changes over a period of minutes or days. Fast or slow, Earth is always changing.

**CHECK YOUR READING**

What was the new idea that Hutton had about Earth? Describe the idea in your own words.
The geologic time scale divides Earth’s history.

From a person’s point of view, 4.6 billion years is a tremendous amount of time. To help make sense of it, scientists have organized Earth’s history in a chart called the geologic time scale. The geologic time scale divides Earth’s history into intervals of time defined by major events or changes on Earth.

Scientists use information from fossils and radioactive dating to figure out what happened over the 4.6 billion years of Earth’s history. The oldest evidence of life is from about 3.8 billion years ago, but life may be even older. Organisms with more than one cell appeared around 1 billion years ago, and modern humans appeared only 100,000 years ago.

Imagine Earth’s history compressed into one year. If Earth forms on January 1, the first life we have evidence for appears in the beginning of March. Life with more than one cell appears months later, in the middle of October. Humans do not show up until 11 minutes before midnight on the last day of the year, and they do not understand how old Earth is until about a second before midnight.

If Earth’s history is compared to a calendar year, humans appear just before midnight on December 31.
Divisions of Geologic Time

The geologic time scale is divided into eons, eras, periods, and epochs (EHP-uhks). Unlike divisions of time such as days or minutes, the divisions of the geologic time scale have no fixed lengths. Instead, they are based on changes or events recorded in rocks and fossils.

**Eon** The largest unit of time is an eon. Earth’s 4.6-billion-year history is divided into four eons.

**Era** Eons may be divided into eras. The most recent eon is divided into three eras: the Paleozoic, the Mesozoic, and the Cenozoic.

**Period** Each era is subdivided into a number of periods.

**Epoch** The periods of the Cenozoic, the most recent era, are further divided into epochs.

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**Geologic Time Scale**

The geologic time scale divides Earth’s history into eons, eras, periods, and epochs.

**Hadean eon**

| 4.6 bya* |

**Archean eon**

| 4 bya | 3.5 bya | 3 bya | Carboniferous period |

| 4.6 bya* |

*bya = billion years ago
†mya = million years ago

**Paleozoic era**

- **Cambrian period**
- **Ordovician period**
- **Silurian period**
- **Devonian period**

| 544 mya | 490 mya | 443 mya | 417 mya | 354 mya | 290 mya |

For nearly 4 billion years, during most of Precambrian time, no plants or animals existed.

At the beginning of the Paleozoic era, all life lived in the oceans.
The Hadean, Archean, and Proterozoic eons together are called Precambrian time and make up almost 90 percent of Earth’s history. The fossil record for Precambrian time consists mostly of tiny organisms that cannot be seen without a microscope. Other early forms of life had soft bodies that rarely formed into fossils.

The Phanerozoic eon stretches from the end of Precambrian time to the present. Because so many more changes are recorded in the fossil record of this eon, it is further divided into smaller units of time. The smaller time divisions relate to how long certain conditions and life forms on Earth lasted and how quickly they changed or became extinct.

What part of geologic time makes up most of Earth’s history?
Rock layers offer clues about conditions on Earth when the layers formed.

**Reading Tip**
As you read, find each era in the geologic time scale on pages 476–477.

**Phanerozoic Eon**

The most recent eon, the Phanerozoic, began around 544 million years ago. Its start marks the beginning of a fast increase in the diversity, or variety, of life. The Phanerozoic eon is divided into three eras:

- the Paleozoic, whose name means “ancient life”
- the Mesozoic, whose name means “middle life”
- the Cenozoic, whose name means “recent life”

**The Paleozoic era** is the first era of the Phanerozoic eon. At the start of the Paleozoic, all life lived in the ocean. Fish, the first animals with backbones, developed during this time. Toward the end of this era, life moved onto land. Reptiles, insects, and ferns were common. A mass extinction occurred at the end of the Paleozoic era, 248 million years ago. A mass extinction is when many different life forms all die out, or become extinct, at once. The cause of this extinction is not completely understood.

**The Mesozoic era** spans the next 183 million years and is best known for the dinosaurs that ruled Earth. Mammals, birds, and flowering plants also first appeared during the Mesozoic. For some of this time, parts of North America were covered by a vast sea. The end of the
Mesozoic marks the end of the dinosaurs and many other animals in another mass extinction. This extinction may have been caused by one or more giant asteroids that slammed into Earth, throwing huge amounts of dust into the air. The dust blocked the sunlight, causing plants to die and, along with them, many animals.

The Cenozoic era, the most recent era, began 65 million years ago and continues today. The Cenozoic is often called the Age of Mammals because it marks the time when mammals became a main category of life on Earth.

The Cenozoic era is divided into two periods: the Tertiary and the Quaternary. The Quaternary period stretches from about 2 million years ago to the present. Most of the Quaternary has been a series of ice ages, with much of Europe, North America, and Asia covered in thick sheets of ice. Mammoths, saber-toothed cats, and other giant mammals were common during the first part of the Quaternary. Fossils of the first modern humans are also from this period; they are about 100,000 years old.

As the amount of ice on land shrank and grew, the ocean levels rose and fell. When the ocean levels fell, exposed land served as natural bridges that connected continents previously separated by water. The land bridges allowed humans and other animals to spread around the planet. It now seems that the end of Quaternary may be defined by the rise of human civilization.

How did falling ocean levels lead to the spread of humans and other animals on Earth?

KEY CONCEPTS
1. Describe the concept of uniformitarianism.
2. What does the geologic time scale measure?
3. What was life like on Earth for most of its history?

CRITICAL THINKING
4. Apply What period, era, and eon do you live in?
5. Evaluate Some cartoons have shown early humans keeping dinosaurs as pets. From what you know about Earth’s history, is this possible? Why or why not?

CHALLENGE
6. Infer How might the geologic time scale be different if the event that caused the mass extinction 65 million years ago had never occurred?