Earth Science Basics Unit 1

Lesson 1: What is Earth science?

Earth scientists seek to understand the beautiful sphere on which we live. Earth is a very large, complex set of systems. While most Earth scientists study one aspect of the planet, many of these specialties may also include other branches of science such as physics, chemistry, and biology. Researchers work together to answer complicated questions. The major branches of Earth science are described below.

Geology

Geology is the study of the solid Earth. There are many other branches of geology. There is so much to know about our home planet that most geologists become specialists in one area. There is probably an expert in almost anything you can think of related to Earth.

For example, the field of **mineralogy** focuses on the study of minerals and their properties (**Figure** left).

(left) Mineralogists focus on all kinds of minerals. (right) Seismographs are used to measure earthquakes and pinpoint their origins.

Scientists specializing in **volcanology** brave molten lava to study volcanoes. Scientists specializing in **seismology** monitor earthquakes worldwide to help protect people and property from harm (**Figure right** above). The field of **paleontology** is interested in fossils and how ancient organisms lived. Scientists who compare the geology of other planets to Earth are in the field of **planetary geology**. Some geologists study the Earth's moon and its geology in a field called **selenology**.

Geologists specializing in **limnology** might study rivers and lakes, while those in **hydrology** investigate the underground water found between soil and rock particles. Scientists who explore glaciers to gain insights into Earth's history are classified in the field of **glaciology**.

Earth scientists need **geographers** who explore the features of Earth's surface. They work with **cartographers**, who make maps. Studying the layers of rock beneath the surface helps us to understand the history of planet Earth (**Figure** below).

These folded rock layers have bent over time. Studying rock layers helps scientists to explain these layers and the geologic history of the area.

Geologists ask a lot of questions. They wonder what they need to know about earthquakes to be able to predict them in time to evacuate a region. They ask what will happen to shorelines as sea level rises. Some even wonder what would happen if the magnetic field reverses!

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Oceanography

While the word oceanology might be more accurate, the science of oceanography began with mapping the oceans. **Oceanography** is the study of the oceans, which comes from the roots "ology" for "the study of" and "graph" referring to mapmaking.

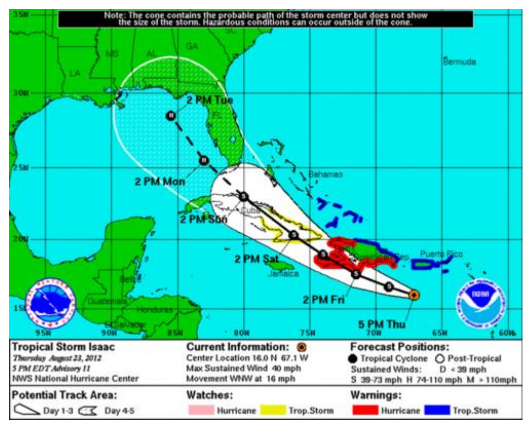
More than 70% of Earth's surface is covered with water. Almost all of that water is in the oceans. Scientists have visited the deepest parts of the ocean in submarines. Remote vehicles go where humans can't (**Figure** below). Yet much of the ocean remains unexplored. Some people call the ocean "the last frontier."

The Alvin research vessel is specially designed to explore the seas.

There are many branches of oceanography. **Physical oceanography** is the study of water movement, like waves and ocean currents, or ask when or if a tsunami will hit a shoreline. **Marine geology** is the study of rocks and structures in the ocean basins. These scientists ask how new ocean crust forms. **Chemical oceanography** is the study the natural elements in ocean water. Chemical oceanographers might be concerned with where carbon dioxide goes in the oceans. **Marine biology** is a branch that explores all the living things found in the ocean. There are lots of questions to ask about marine life!

Meteorology and Climatology

Meteorologists don't study meteors—they study the atmosphere! The atmosphere is a thin layer of gas that surrounds Earth. The word "meteor" refers to things in the air. **Meteorology** includes the study of weather patterns, clouds, hurricanes, and tornadoes. Meteorology is very important. Using radars and satellites, meteorologists work to predict, or forecast, the weather (**Figure** right). Meteorologists are getting better at predicting the weather all the time. Meteorologists wonder how to better predict the weather. They wonder what the effects of rising water vapor in the atmosphere will be on the weather.



Climatology is the study Earth's climate, which is defined as weather over a period of time. These scientists work to understand the climate as it is now and compare it to Earth's climate in the past. They use their knowledge to make predictions about Earth's future climate and how it might affect Earth's resources and living things.

Environmental Science

Environmental science is the study of the effects people have on their environment and Earth's resources. This includes the landscape, atmosphere, water, and living things. These scientists ask all sorts of questions about how Earth systems are changing as a result of human actions. They try to predict what changes will occur in the future.

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Ecology is the study lifeforms and the environments they live in (**Figure** right). While this branch is often associated with life science, a knowledge of Earth's resources helps scientists to predict the chain reactions that could occur when one part of the ecosystem is disrupted. We hope to find better ways of living that can help the environment – both living and nonliving parts.

In a marine ecosystem, coral, fish, and other sea life depend on each other for survival.

Astronomy

Astronomy is the study of outer space and the physical bodies beyond planet Earth. Astronomers use telescopes to see things far beyond what the human eye can see. Astronomers help to design spacecraft or satellites that travel into space and send back information about faraway places (**Figure** left).

The Hubble Space Telescope.

Astronomers ask a wide variety of questions. How do strong bursts of energy from the Sun, called solar flares, affect communications? How might an impact from an asteroid affect life on Earth? What are the properties of black holes? Astronomers ask bigger questions too. How was the Universe created? Is there life on other planets? Are there resources on other planets that people could use for space travel? Astronomers use what Earth scientists know about our planet to make comparisons with other planets.

Explore More

What do you know about the Earth? Watch the Intro to Earth Science video on EDPuzzle and use the links to learn about our next unit.

Summary

- The study of Earth science includes many different fields, including geology, meteorology, oceanography, and astronomy.
- Each type of Earth scientist investigates the processes and materials of the Earth.
- Some specialties may also include other branches of science, such as physics, chemistry, and biology.
- Like other scientists, Earth scientists ask questions and use many different tools to gather data.

Think About It

1. Why is Earth science considered a "combination science"?
2. Explain why an environmental scientist might need knowledge of earth science and biology.
3. How would a volcanologist use chemistry to investigate magma?

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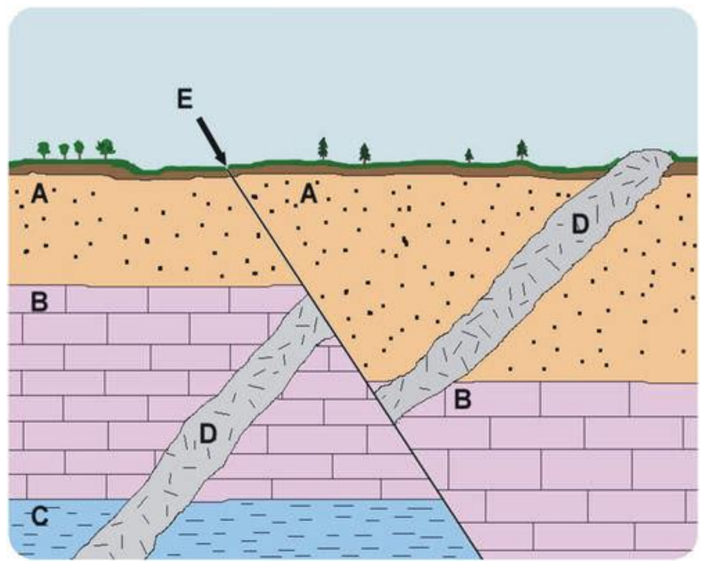
Lesson 2: The Present is the Key to the Past

The way things happen now is the same way things happened in the past. Earth processes have not changed over time. Mountains grow and mountains slowly wear away, just as they did billions of years ago. As the environment changes, living creatures adapt. They change over time. Some organisms may not be able to adapt. They become **extinct**, meaning that they die out completely.

Historical geologists study the Earth's past using clues from rocks and fossils to figure out the order of events. The way a specific rock forms, comparing rocks in different areas to find common features, and examining fossils provide clues to help us understand the history of the Earth.

Laws of Stratigraphy

The study of rock strata is called **stratigraphy**. The laws of stratigraphy can help scientists understand Earth's past. The laws of stratigraphy are usually credited to a geologist from Denmark named Nicolas Steno. He lived in the 1600s. The laws are illustrated in **Figure at** right.



Laws of Stratigraphy. This diagram illustrates the laws of stratigraphy. A = Law of Superposition, B = Law of Lateral Continuity, C = Law of Original Horizontality, D = Law of Cross-Cutting Relationships

Refer to the figure as you read about the laws below.

A. Superposition	Superposition refers to the position of rock layers and their relative ages. **Relative age** means the age of a specific rock in comparison with other rocks, either younger or older. New rock layers are always deposited on top of existing rock layers. The rock layers we see at the bottom of a cliff are older than those at the top.
B. Lateral Continuity	Rock layers extend laterally, or out to the sides. They may cover very broad areas, especially if they formed at the bottom of ancient seas. Erosion may have worn away some of the rock, but layers on either side of eroded areas will still "match up." We can see layers of the same rock types across canyons at the Grand Canyon.
C. Original Horizontality	Sediments were deposited in ancient seas in **horizontal**, or flat, layers. If sedimentary rock layers are tilted, they must have moved after they were deposited. We can see layers in many sedimentary rocks, which shows how sediments were layered in a river bed or bottom of a lake.
D. Cross-Cutting Relationships	Rock layers may have another rock cutting across them, like igneous rock that can cut across a rock layer. Which rock is older? To determine this, we use the law of cross-cutting relationships. The cut rock layers are older than the rock that cuts across them.

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Unconformities

Geologists can learn a lot about Earth's history by studying sedimentary rock layers. But in some places, there's a gap in time when no rock layers are present. A gap in the sequence of rock layers is called an **unconformity**.

James Hutton came up with this idea in the late 1700s based on the idea that the "present is the key to the past." He called this the **principle of uniformitarianism**. It works like this: we understand a geological process that happens now. We see the outcome of that process, say a rock. Then we find evidence that the same process happened in the past, in a similar rock. We can assume that the process operated the same way in the past.

Look at the rock layers in **Figure** below. They are an example of Hutton's unconformity. Hutton saw that the lower rock layers are very old. The upper layers are much younger. There are no layers in between the ancient and recent layers. Hutton thought that the intermediate rock layers eroded away before the more recent rock layers were deposited.

Hutton's unconformity, in Scotland.

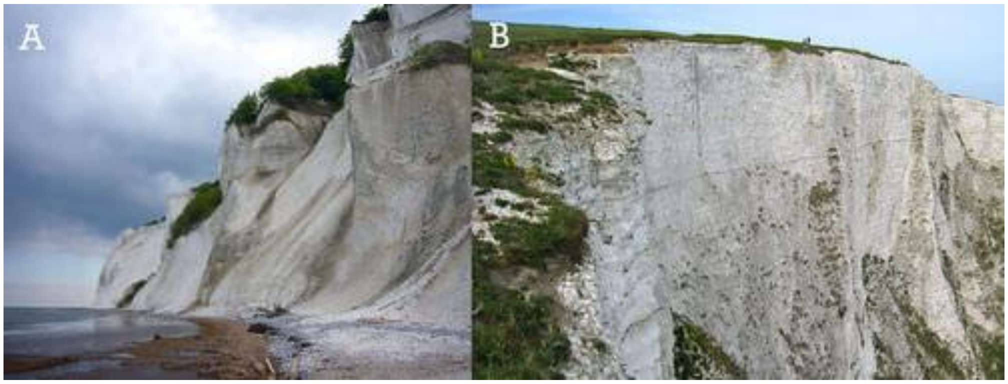
Hutton's discovery was a very important event in geology! Hutton determined that the rocks were deposited over time. Some were eroded away. Hutton knew that deposition and erosion are very slow. He realized that for both to occur would take an extremely long time. This made him realize that Earth must be much older than people thought. This was a really big discovery! It meant there was enough time for life to evolve gradually.

Matching Rock Layers

When rock layers are in the same place, it's easy to give them relative ages. But what if rock layers are far apart? What if they are on different continents? What evidence is used to match rock layers in different places?

Some rock layers extend over a very wide area. They may be found on more than one continent or in more than one country. For example, the famous White Cliffs of Dover are on the coast of southeastern England. These distinctive rocks are matched by similar white cliffs in France, Belgium, Holland, Germany, and

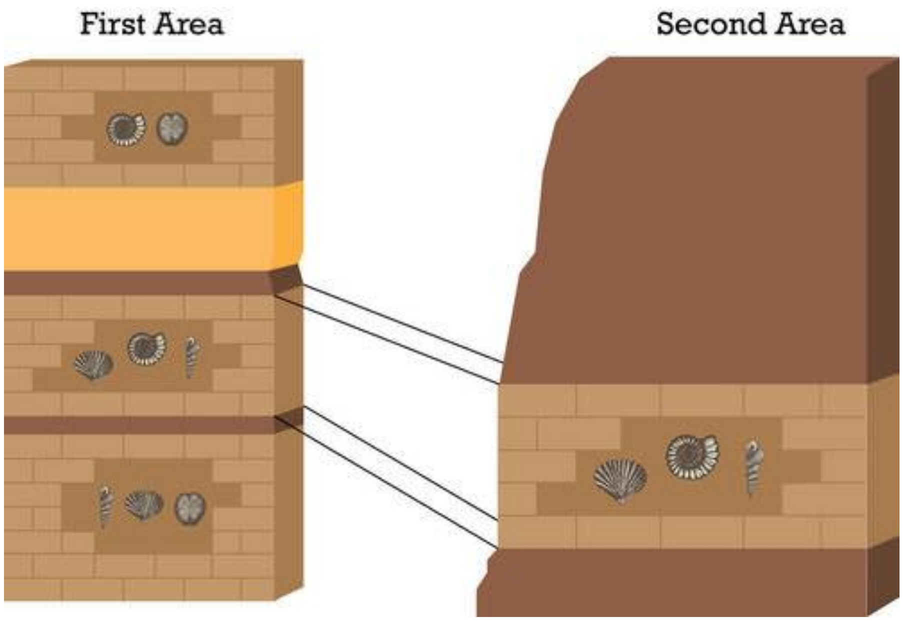
Denmark (see **Figure** below). It is important that this chalk layer goes across the English Channel. The rock is so soft that the Channel Tunnel connecting England and France was carved into it!



Chalk Cliffs. (A) Matching chalk cliffs in Denmark and (B) in Dover, U.K.

Key beds, which are thin layers of rock, are used to match rock layers. The rock must be unique and widespread. For example, a key bed from around the time that the dinosaurs went extinct is very important. A thin layer of clay was deposited over much of Earth's surface. The clay has a large amount of the element iridium. Iridium is rare on Earth but common in asteroids. This unusual clay layer has been used to match rock up layers all over the world. It also led to the hypothesis that a giant asteroid struck Earth and caused the dinosaurs to go extinct.

Index fossils are commonly used to match rock layers in different places. You can see how this works in **Figure** below. If two rock layers have the same index fossils, then they're probably about the same age.



Using Index Fossils to Match Rock Layers. Rock layers with the same index fossils must have formed at about the same time. The presence of more than one type of index fossil provides stronger evidence that rock layers are the same age.

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Explore More

Watch the Dinosaur Ridge video on EDPuzzle to learn more about these concepts and answer the questions on the video.

Lesson Summary

- The idea that the present is the key to the past was recognized by James Hutton in the late 1700s. If you see something forming by a process today and then find the end results of that process in the rock record, you can assume that the process operated the same way in the past.
- The study of rock layers is called stratigraphy. Laws of stratigraphy help scientists determine the relative ages of rocks. The main law is the law of superposition. This law states that deeper rock layers are older than layers closer to the surface.
- An unconformity is a gap in rock layers. They occur where older rock layers eroded away completely before new rock layers were deposited.
- Other clues help determine the relative ages of rocks in different places. They include key beds and index fossils.

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Lesson 3: The Geologic Time Scale

According to scientists, Earth formed 4.5 billion years ago. Geologists divide this time span into smaller periods with many of the divisions marking major events in life history. Divisions in Earth history are recorded on the **geologic time scale**. For example, the Cretaceous ended when the dinosaurs went extinct. European geologists were the first to put together the geologic time scale. So, many of the names of the time periods are from places in Europe. The Jurassic Period is named for the Jura Mountains in France and Switzerland, for example.

To create the geologic time scale, geologists correlated rock layers. Steno's laws were used to determine the relative ages of rocks. Older rocks are at the bottom and younger rocks are at the top. The early geologic time scale could only show the order of events. The discovery of radioactivity in the late 1800s changed that. Scientists could determine the exact age of some rocks in years. They assigned dates to the time scale divisions. For example, the Jurassic began about 200 million years ago. It lasted for about 55 million years.

The largest blocks of time on the geologic time scale are called "**eons**." Eons are split into "**eras**." Each era is divided into "**periods**." Periods may be further divided into "**epochs**." Geologists may just use "early" or "late." An example is "late Jurassic," or "early Cretaceous." **Figure** below shows you what the geologic time scale looks like.

EON	ERA	PERIOD	MILLIONS OF YEARS AGO
Phanerozoic	Cenozoic	Quaternary	1.6
		Tertiary	66
	Mesozoic	Cretaceous	138
		Jurassic	205
		Triassic	240
	Paleozoic	Permian	290
		Pennsylvanian	330
		Mississippian	360
		Devonian	410
		Silurian	435
		Ordovician	500
		Cambrian	570
Proterozoic	Late Proterozoic Middle Proterozoic Early Proterozoic		2500
Archean	Late Archean Middle Archean Early Archean		3800?
Pre-Archean			

The Geologic Time Scale.

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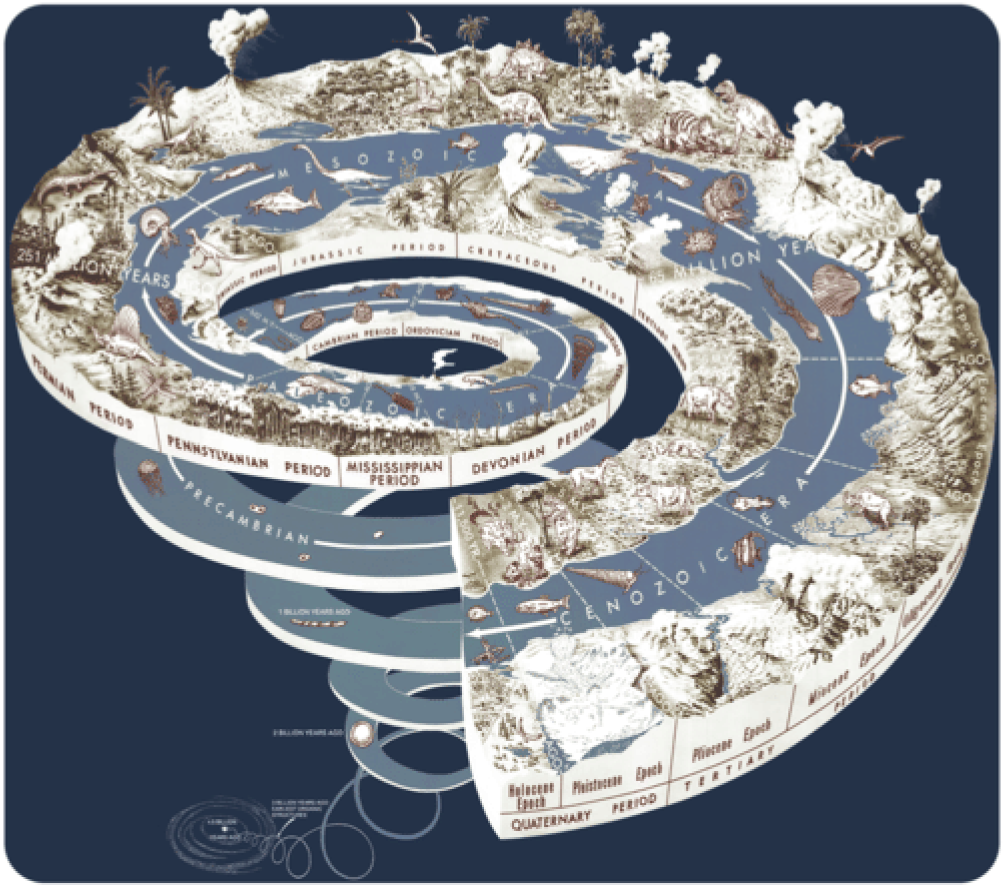
Life and the Geologic Time Scale

The geologic time scale may include illustrations of how life on Earth has changed. Major events on Earth may also be shown. These include the formation of the major mountains or the extinction of the dinosaurs. **Figure** below is a different kind of the geologic time scale. It shows how Earth's environment and life forms have changed.



The evolution of life is shown on this spiral.

Your Place in Geologic Time

We now live in the Phanerozoic Eon, the Cenozoic Era, the Quaternary Period, and the Holocene Epoch. "Phanerozoic" means "visible life." During this eon, rocks contain visible fossils.

Before the Phanerozoic, life was microscopic. The Cenozoic Era means "new life." It encompasses the most recent forms of life on Earth. The Cenozoic is sometimes called the Age of Mammals.

Before the Cenozoic came the Mesozoic and Paleozoic. Mesozoic means "middle life." This is the age of reptiles, when dinosaurs ruled the planet. The Paleozoic is "old life." Organisms like invertebrates and fish were the most common lifeforms.

Explore More

1) How do scientists use fossil evidence to explain the history of Earth? Watch the National Geographic's Tar Pits video on EDPuzzle to complete your notes and answer the quiz questions.

2) Watch the Fossils video on EDPuzzle to learn more about how fossils form and how they are used to provide clues about Earth's past. Answer the questions as you watch the video.

Lesson Summary

- Scientists use the geologic time scale to illustrate the order in which events on Earth have happened.
- The geologic time scale was developed after scientists observed changes in the fossils going from oldest to youngest sedimentary rocks. They used relative dating to divide Earth's past in several chunks of time when similar organisms were on Earth.
- The geologic time scale is divided into eons, eras, periods, and epochs based on major events in Earth's history and its living things.