

# Chapter 5: Clues to Earth's Past

Section 1: Fossils

Section 2: Relative Ages of Rocks

Section 3: Absolute Ages of Rocks

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## Traces of the Distant Past

- Paleontologists, scientists who study fossils, can learn about extinct animals from their fossil remains.



Using fossil remains scientists:  
learn how dinosaurs looked and moved.

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## Formation of Fossils

- **Fossils** are the remains, imprints, or traces of prehistoric organisms.

Fossils are evidence of :

1. when and where organisms once lived,
2. how they lived.



## Formation of Fossils

- For the most part, the remains of dead plants and animals disappear quickly.
  1. Scavengers eat and scatter remains of dead organisms
  2. Fungi and bacteria invade, causing the remains to rot and disappear.

## 1 Conditions Needed For Fossil Formation

A dead organism becoming a fossil depends on:

1. how well it is protected from:
  - a. scavengers
  - b. other agents of physical destruction such as:  
waves and currents.

One way a dead organism can be protected is  
for sediment to bury the body quickly.

## Conditions Needed For Fossil Formation

- Organisms have a better chance of becoming fossils if they have hard parts such as bones, shells, or teeth.
- Most fossils are the hard parts of organisms, such as fossil teeth.



### **Types of Preservation:**

- **Mineral Replacement**
- **Carbon Films**
- **Molds and Casts**
- **Coal**
- **Original Remains**
- **Trace Fossils**
  - **Trails and Burrows**

## Types of Preservation Mineral Replacement

- Most hard parts of organisms such as bones, teeth, and shells have tiny spaces within them.
- If the hard part is buried, groundwater can seep in and deposit minerals in the spaces.
- **Permineralized remains** are fossils in which the spaces inside are filled with minerals from groundwater.



## Types of Preservation Mineral Replacement

- Sometimes minerals replace the hard parts of fossil organisms.
- For example, a solution of water and dissolved silica might flow into and through the shell of a dead organism.
- If the water dissolves the shell and leaves silica in its place, the original shell is replaced.

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## Carbon Films

- Sometimes fossils contain only carbon.
- Fossils usually form when sediments bury a dead organism.
- As sediment piles up, the organism's remains are subjected to pressure and heat.
- These conditions force gases and liquids from the body.
- A thin film of carbon residue is left, forming a silhouette of the original organism called a **carbon film**.

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## Coal

- In swampy regions, large volumes of plant matter accumulate.
- Over millions of years, these deposits become completely carbonized, forming coal.

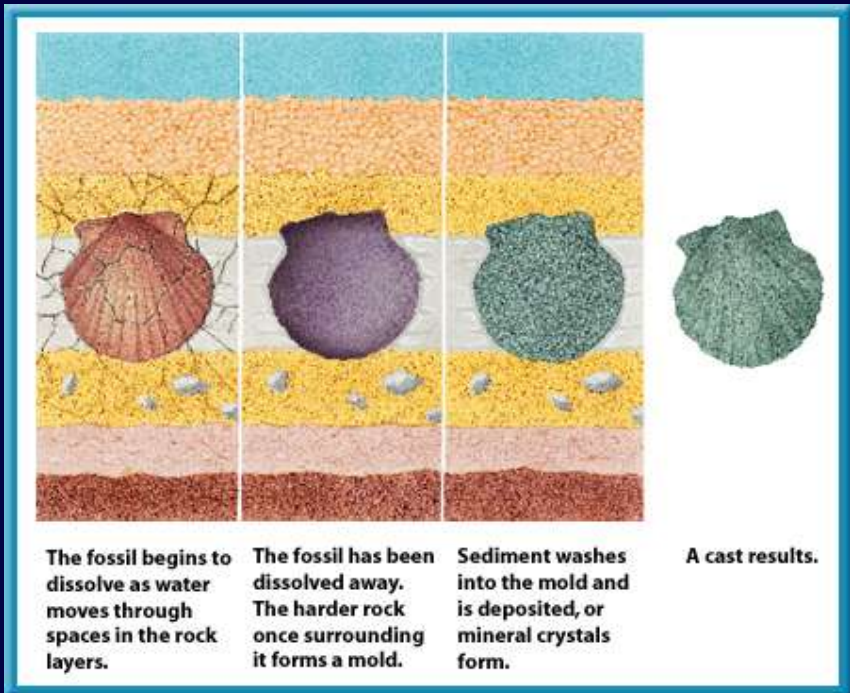


## Molds and Casts

- Impressions form when seashells or other hard parts of organisms fall into a soft sediment such as mud.
- **Compaction and cementation** (the deposition of minerals from water into the pore spaces between sediment particles) **turns the sediment into rock.**
- Other open pores in the rock then let water and air reach the shell or hard part.

## Molds and Casts

- The hard part might decay or dissolve, leaving behind a cavity in the rock called a **mold**.
- Later, mineral-rich water or other sediment might enter the cavity, form new rock, and produce a copy or **cast** of the original object.



## Original Remains

- Sometimes conditions allow original soft parts of organisms to be preserved for thousands or millions of years.
- For example, insects can be trapped in amber, a hardened form of sticky tree resin.
- Some organisms have been found preserved in frozen ground.
- Original remains also have been found in natural tar deposits.

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## Trace Fossils

- Trace fossils are fossilized tracks and other evidence of the activity of organisms.
- In some cases, tracks can tell you more about how an organism lived than any other type of fossil.



## Trails and Burrows

- Other trace fossils include trails and burrows made by worms and other animals.
- These too, tell something about how these animals lived.
- For example, by examining fossil burrows you can sometimes tell how firm the sediment the animal lived in was.

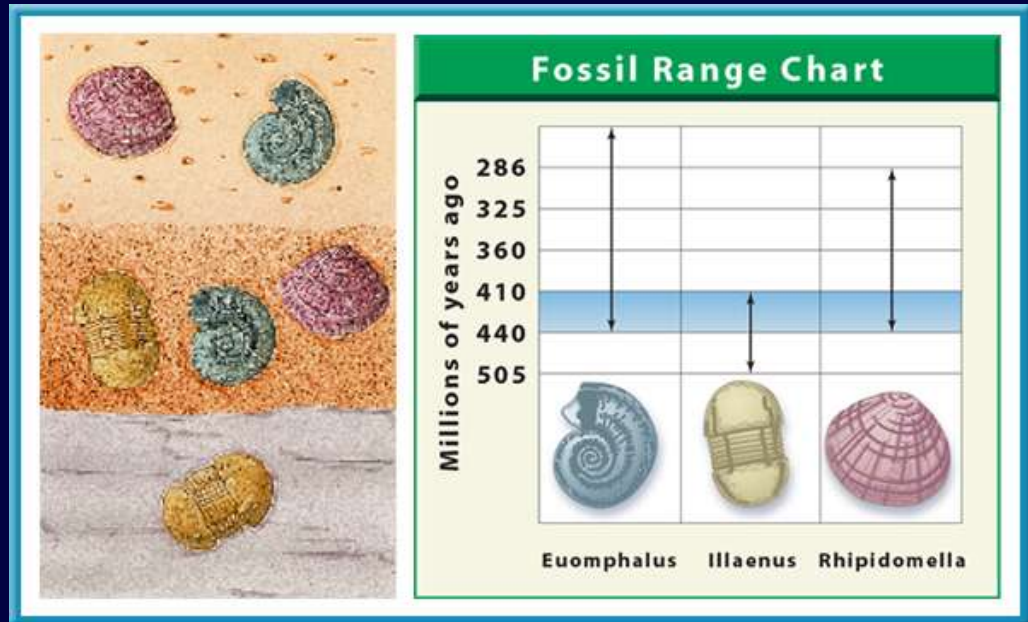


## Index Fossils

- **Index fossils** are remains of species that existed on Earth for relatively short periods of time, were abundant, and were widespread geographically.
- Because the organisms that became index fossils lived only during specific intervals of geologic times, geologists can estimate the ages of the rock layers based on the particular index fossils they contain.

## Index Fossils

- Another way to approximate the age of a rock layer is to compare the spans of time, or ranges, over which more than one fossil appears.
- The estimated age is the time interval where ranges overlap.



## Fossils and Ancient Environments

- Scientists can use **fossils** to determine what **the environment** of an area was like long ago.
- Using **fossils**, you might be able to find out **whether an area was land** or whether it was **covered by an ocean** at a particular time.

# Fossils and Ancient Environments

- *Fossils also are used to determine the past climate of a region.*
- For example, **rocks in parts of eastern United States contain fossils of tropical plants.**



# Fossils and Ancient Environments

- Because of the fossils, scientists know that it was tropical when these plants were living.



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## Shallow Seas

- When the fossil crinoids were alive, a shallow sea covered much of western and central North America.
- The crinoid hard parts were included in rocks that formed from the sediments at the bottom of this sea.

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### Question 3

How do permineralized remains differ from casts?

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### Answer

Permineralized remains are fossils in which the spaces within organisms' hard structures are filled with minerals from groundwater. Some original material from the fossil organisms' bodies might be preserved.

A cast is a fossil that forms when the mold of a completely decayed organism fills with sediment or minerals.





## Superposition

### Oldest Rocks on the Bottom

- According to the **principle of superposition**, in undisturbed layers of rock, the oldest rocks are on the bottom and the rocks become progressively younger toward the top.

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## Rock Layers

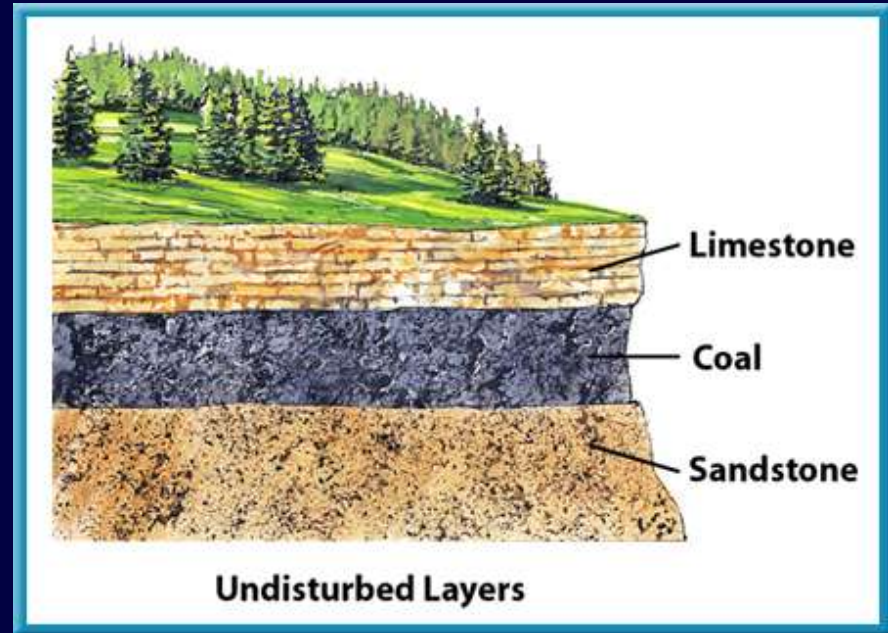
- Sediment accumulates in horizontal beds, forming layers of sedimentary rock.
- Because of this, the oldest rocks are at the bottom.
- When layers have been turned upside down, it's necessary to use other clues in the rock layers to determine their original positions and relative ages.

## Relative Ages

- The **relative age** of something is its age in comparison to the ages of other things.
- Geologists determine the relative ages of rocks and other structures by examining their places in a sequence.
- Relative age determination doesn't tell you anything about the age of the rock layers in actual years.

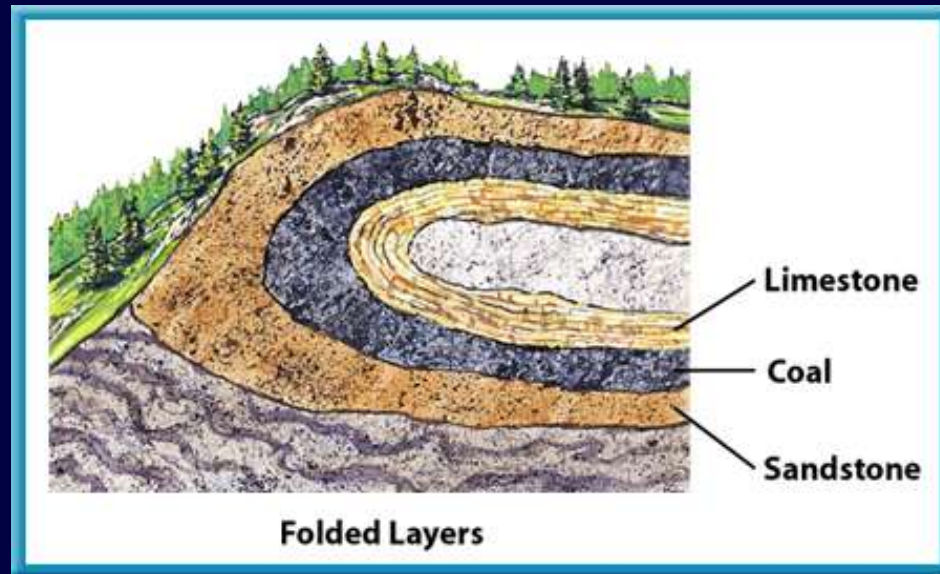
## Other Clues Help


- Determination of relative age is easy if the rocks haven't been faulted or turned upside down.
- In cases where rock layers have been disturbed you might have to look for fossils and other clues to date the rocks.



## Other Clues Help

- If you find a fossil in the top layer that's older than a fossil in the lower layer, you can hypothesize that the layers have been turned upside down by folding during mountain building.



- 
- Unconformity
    - Angular unconformity
    - Disconformity
    - Nonconformity

## Unconformities

- Most rock sequences are incomplete—layers are missing. These gaps in rock sequences are called **unconformities**.
- Unconformities develop when agents of erosion such as running water or glaciers remove rock layers by washing or scraping them away.

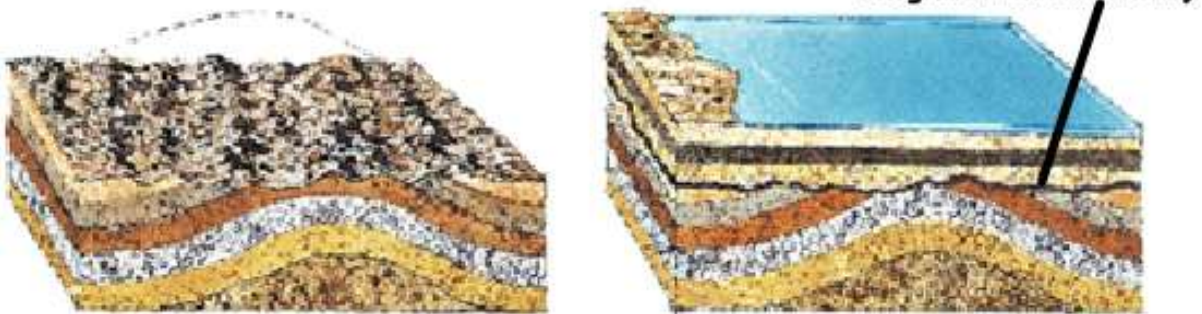
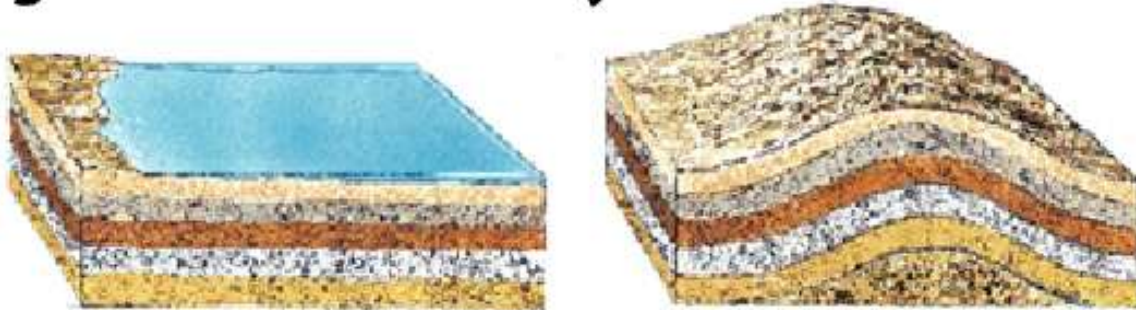
## Angular Unconformities

- Horizontal layers of sedimentary rock often are tilted and uplifted.
- Erosion and weathering then wear down these tilted rock layers.
- Eventually, younger sediment layers are deposited horizontally on top of the tilted and eroded layers.
- Geologists call such an unconformity an angular unconformity.



# Angular Unconformities

## Angular Unconformity



### 2

## Disconformity

- Suppose you're looking at a stack of sedimentary rock layers.
- If you look closely, you might find an old surface of erosion.
- This records a time when the rocks were exposed and eroded.
- Even though all the layers are parallel, the rock record still has a gap.
- This type of unconformity is called a disconformity.

## Nonconformity

- Another type of unconformity, called a nonconformity, occurs when metamorphic or igneous rocks are uplifted and eroded.
- Sedimentary rocks are then deposited on top of this erosion surface.
- The surface between the two rock types is a nonconformity.

## Matching Up Rock Layers— Evidence Used for Correlation

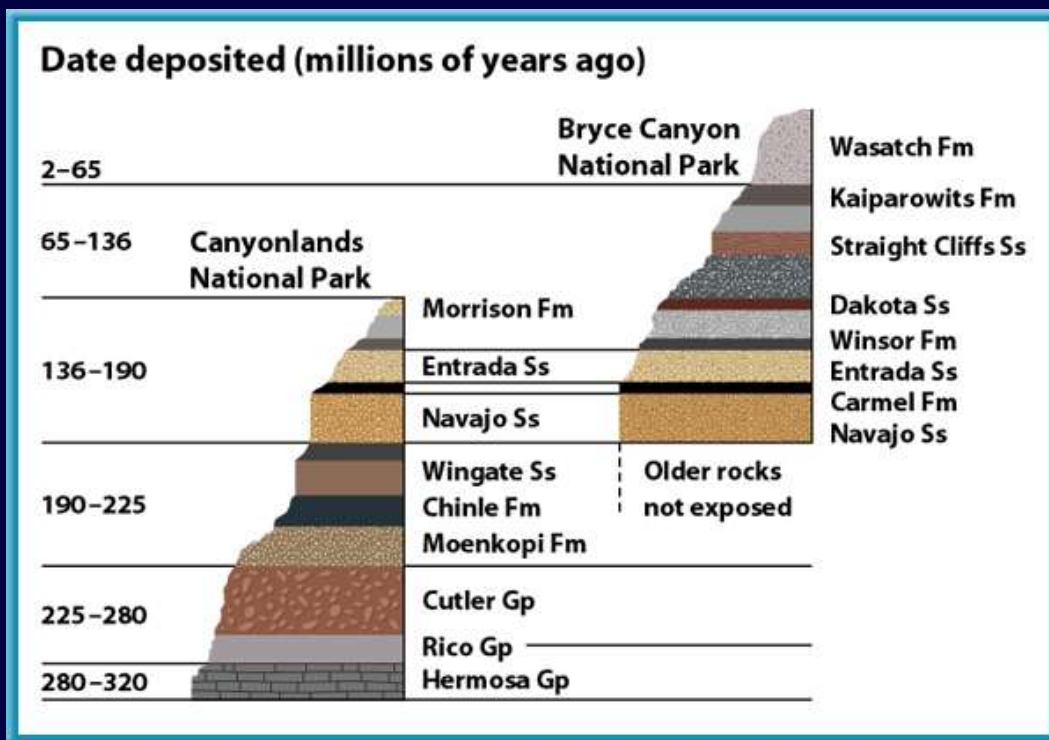
- Geologists often can match up, or correlate, layers of rocks over great distances.



- Sometimes it's possible to walk along the layers for kilometers and prove that it's continuous.

## Matching Up Rock Layers— Evidence Used for Correlation

- In other cases, the rock layers are exposed only where rivers have cut through overlying layers of rock and sediment.



## Matching Up Rock Layers— Evidence Used for Correlation

- If the same types of fossils were found in the limestone layer in both places, it's a good indication that the limestone at each location is the same age, and therefore, one continuous deposit.

### Question 1

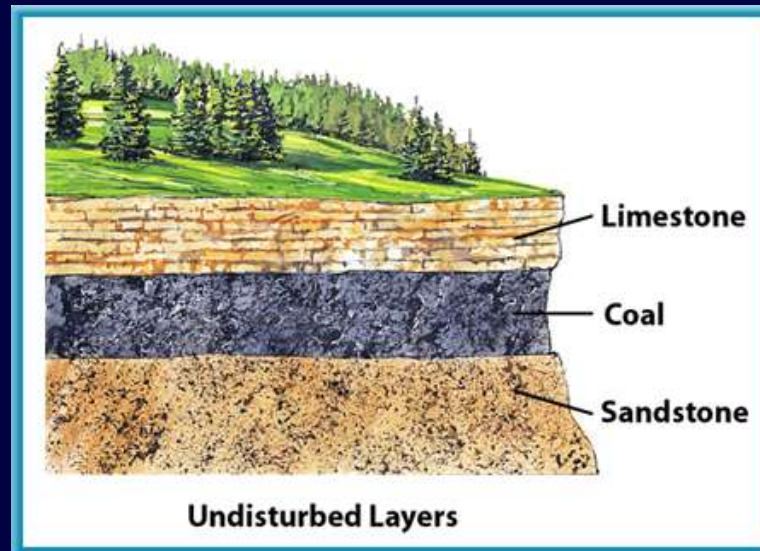
According to the principle of superposition, what do you expect to find in the bottom layer of undisturbed rock?

- A. abundant fossils
- B. few fossils
- C. oldest rock
- D. youngest rock

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## Answer

The answer is C. Sediment accumulates in horizontal layers to form sedimentary rock. According to the principle of superposition, in undisturbed layers of rock, the oldest rocks are on the bottom.





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### Question 2

Gaps in rock sequences are called \_\_\_\_\_.

- A. decay pockets
- B. folds
- C. unconformities
- D. voids

2

### Answer

The answer is C.

Unconformities develop when agents of erosion remove rock layers.

2

### Question 3

Compare and contrast using a triple column chart to describe the differences between a disconformity and a nonconformity.

2

### Answer

A disconformity begins with sedimentary rock layers that have missing layers due to erosion (or a period of time during which there was no new deposition of sediment)

A nonconformity occurs when metamorphic or igneous rocks are uplifted and eroded.

## Absolute Ages

- **Absolute age** is the age, in years, of a rock or other object.
- Geologists determine absolute ages by using properties of the atoms that make up materials.

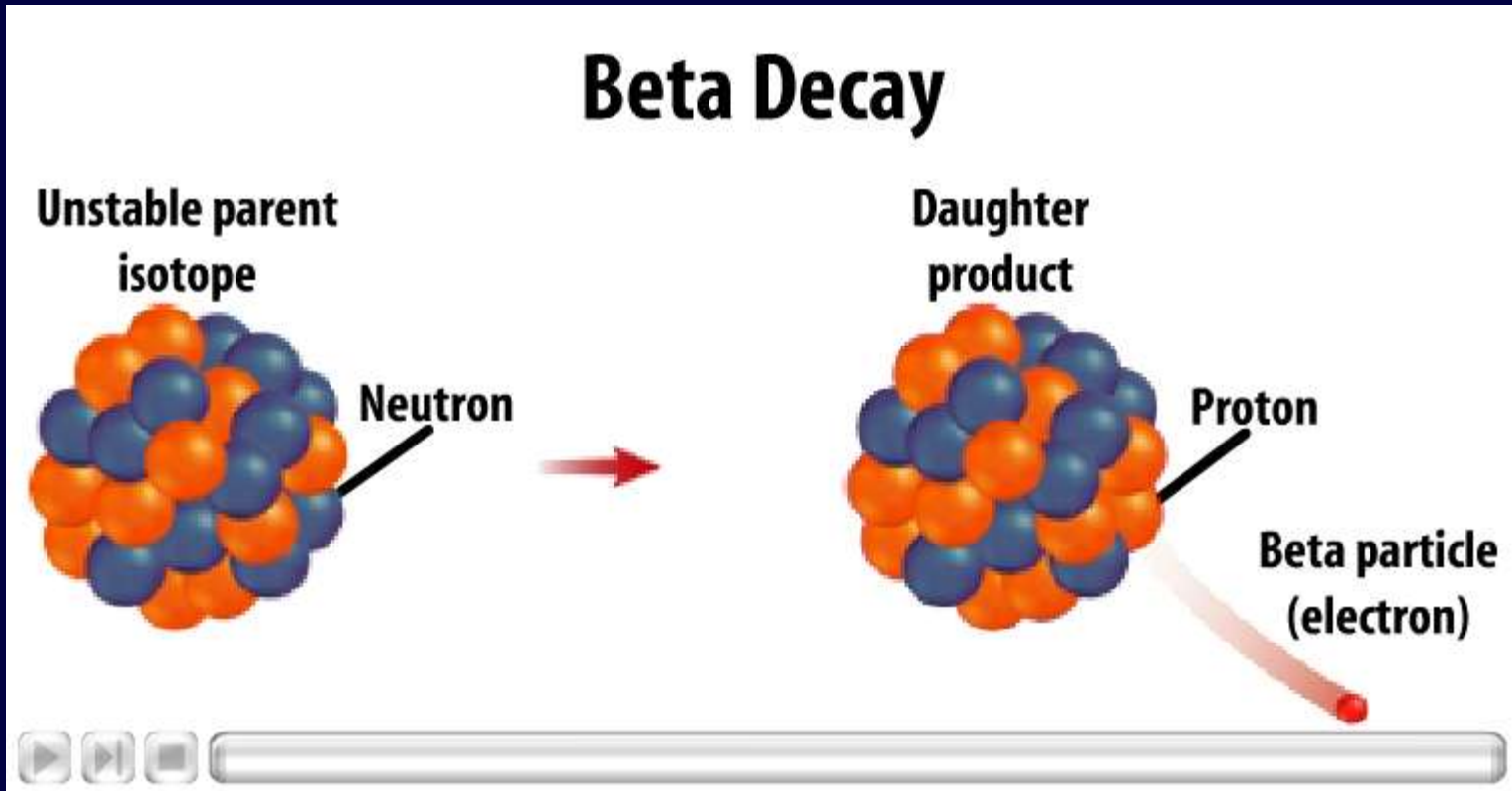
## Radioactive Decay

- Some isotopes are unstable and break down into other isotopes and particles.
- Sometimes a lot of energy is given off during this process.
- **Radioactive decay is** the process of an unstable isotope breaking down.

## Alpha and Beta Decay

- Beta decay isotopes where a neutron breaks down into a proton and an electron.
- Alpha decay an isotope gives off two protons and two neutrons in the form of an alpha particle.

# Alpha and Beta Decay

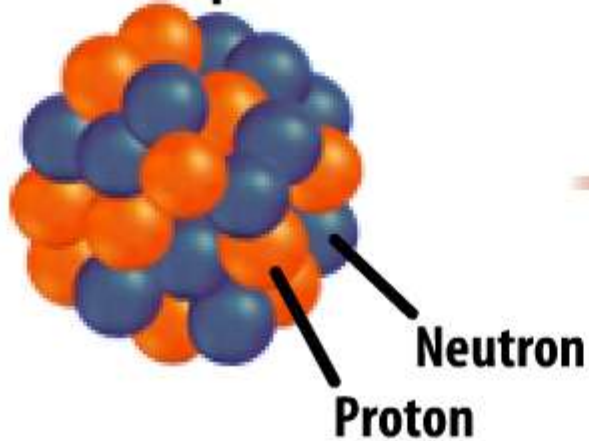




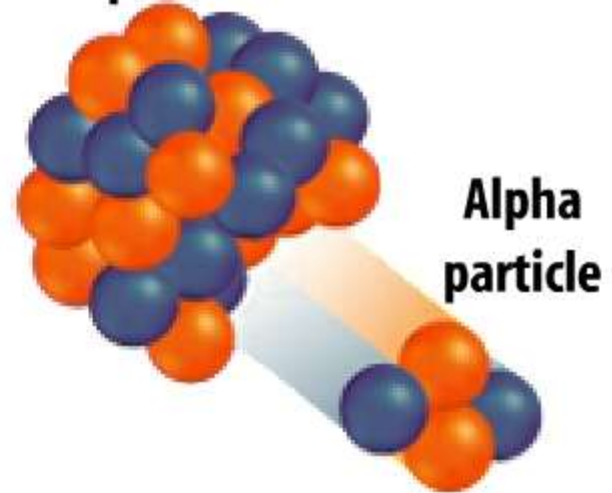
# Alpha and Beta Decay

## Alpha Decay

Unstable parent isotope



Daughter product



## Half-Life

- The **half-life** of an isotope is the time it takes for half of the atoms in the isotope to decay.
- After two half-lives, one fourth of the original isotope still remain.
- After three half-lives, one eighth of the original isotope still remain.

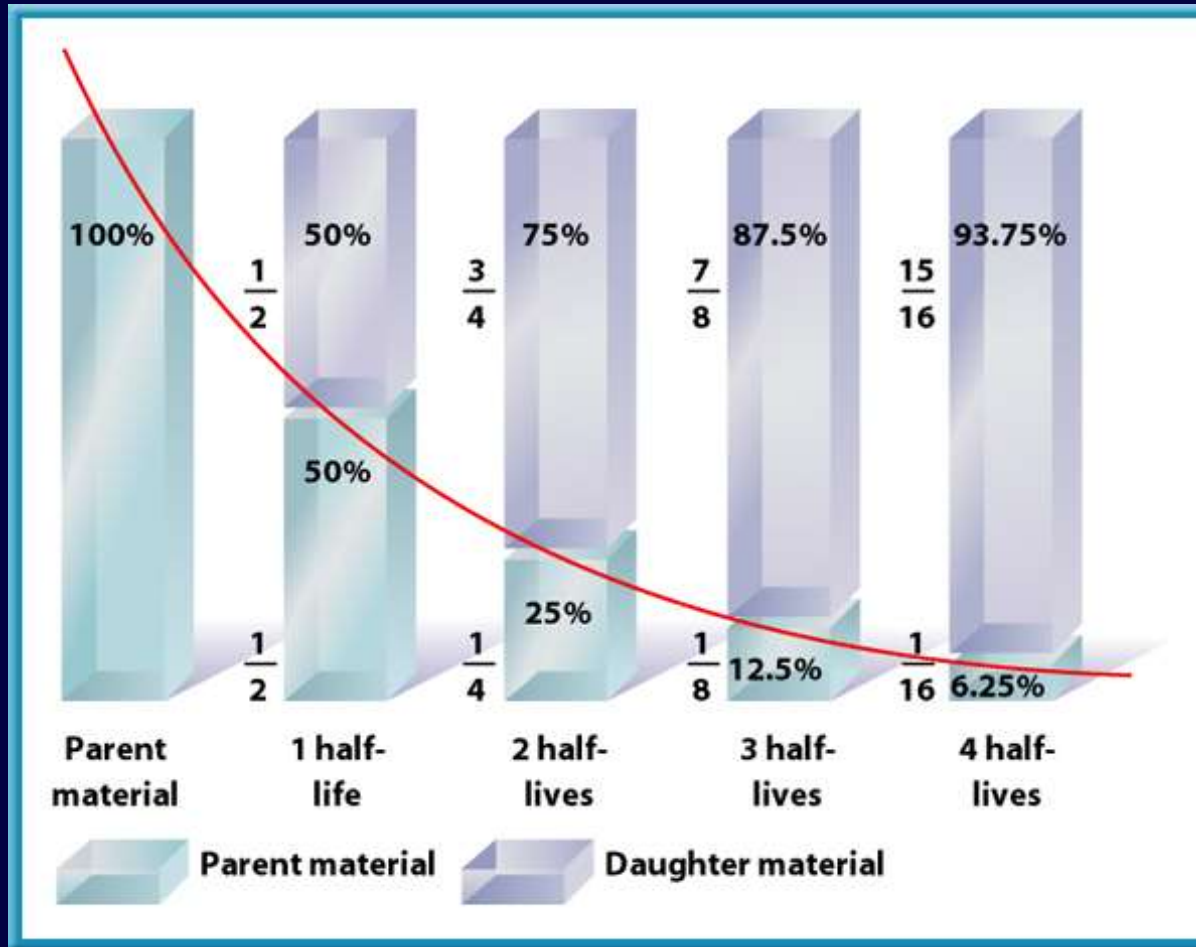
## Radiometric Ages

- As time passes, the amount of parent isotope in a rock decreases as the amount of daughter product increases.
- By measuring the ratio of parent isotope to daughter product in a mineral and by knowing the half-life of the parent, in many cases you can calculate the absolute age of a rock. This process is called **radiometric dating**.

# Absolute Ages of Rocks

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## Radiometric Ages



## 3

### Radiometric Dating

- Carbon-14 is useful for dating bones, wood, and charcoal up to 75,000 years old.
- Living things take in carbon from the environment to build their bodies.
- After the organism dies, the carbon-14 slowly decays.
- By determining the amounts of the isotopes in a sample, scientists can evaluate how much the isotope ratio in the sample differs from that in the environment.

## Age Determination

- Igneous and metamorphic rocks can be radiometrically using carbon-14 dating
- Most sedimentary rocks cannot be dated by this method.
- This is because many sedimentary rocks are made up of particles eroded from older rocks.

## The Oldest Known Rocks

- Radiometric dating has been used to date the oldest rocks on Earth.
- These rocks are about 3.96 billion years old.
- By dating meteorites and using other evidence, scientists have estimated the age of to be about 4.5 billion years.

## Uniformitarianism

- Before the discovery of radiometric dating, many people estimated that Earth is only a few thousand years old.
- But in the 1700's, Scottish scientist James Hutton estimated that Earth is much older.



## Uniformitarianism

- He used the principle of **uniformitarianism**. This principle states that Earth processes occurring today are similar to those that occurred in the past.
- Hutton's principle is often paraphrased as “the present is the key to the past.”

## Uniformitarianism

- Scientists recognize that Earth has been shaped by two types of change: **slow, everyday processes that takes place over millions of years** and **Faster more violent**, (unusual events such as the collision of a comet or asteroid about 65 million years ago that might have caused the extinction of the dinosaurs)

