Prentice Hall

EARTH SCIENCE

Tarbuck ◆ Lutgens

Chapter

12

Geologic Time

12.1 Discovering Earth's History

Rocks Record Earth History

- Rocks record geological events and changing life forms of the past.
- We have learned that Earth is much older than anyone had previously imagined and that its surface and interior have been changed by the same geological processes that continue today.

12.1 Discovering Earth's History

A Brief History of Geology

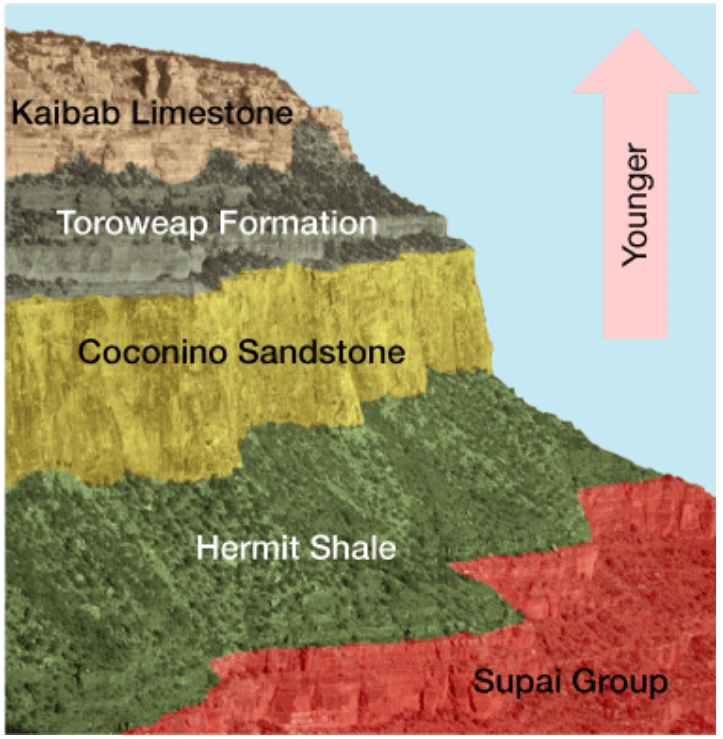
- **Uniformitarianism** means that the forces and processes that we observe today have been at work for a very long time.

12.1 Discovering Earth's History

Relative Dating—Key Principles

- **Relative dating** tells us the sequence in which events occurred, not how long ago they occurred.
- Law of Superposition
  - The **law of superposition** states that in an undeformed sequence of sedimentary rocks, each bed is older than the one above it and younger than the one below it.

Ordering the Grand Canyon's History



12.1 Discovering Earth's History

Relative Dating—Key Principles

- Principle of Original Horizontality
  - The **principle of original horizontality** means that layers of sediment are generally deposited in a horizontal position.

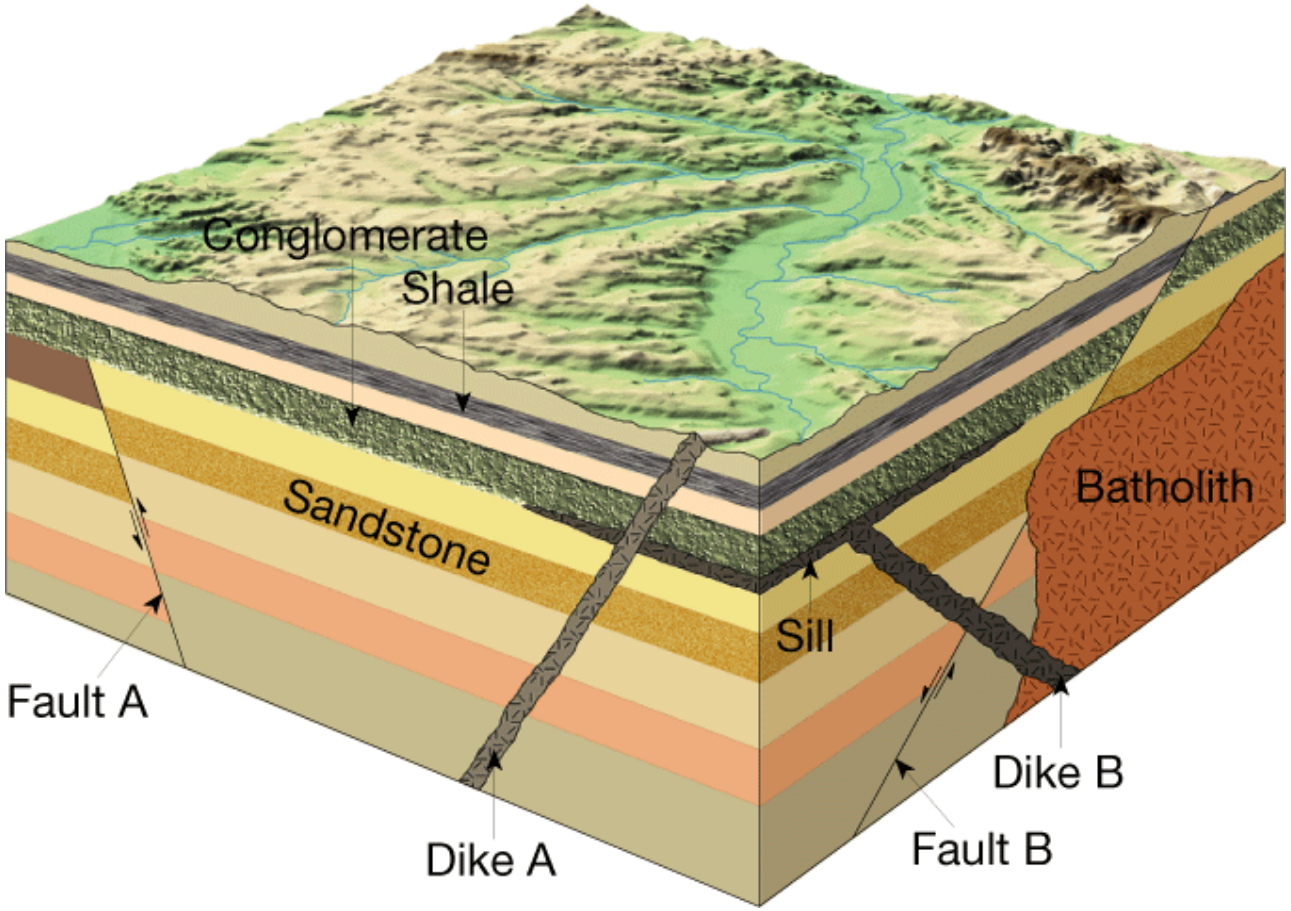
Disturbed Rock Layers

12.1 Discovering Earth's History

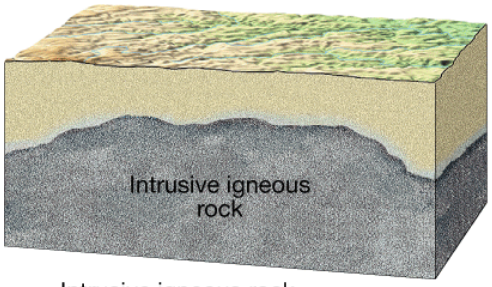
Relative Dating—Key Principles

- Principle of Cross-Cutting Relationships
  - The **principle of cross-cutting relationships** states that when a fault cuts through rock layers, or when magma intrudes other rocks and crystallizes, we can assume that the fault or intrusion is younger than the rocks affected.
- Inclusions
  - Inclusions are rocks contained within other rocks.
  - Rocks containing inclusions are younger than the inclusions they contain.

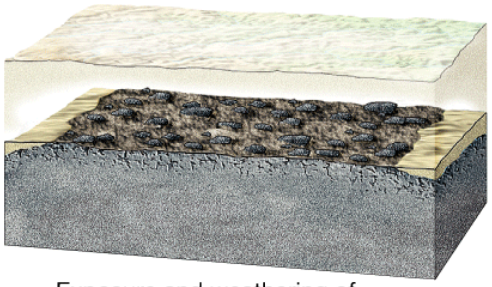
Applying Cross-Cutting Relationships



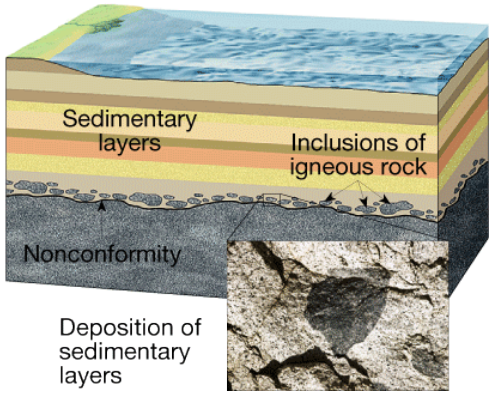
Formation of Inclusions



Intrusive igneous rock



Exposure and weathering of intrusive igneous rock



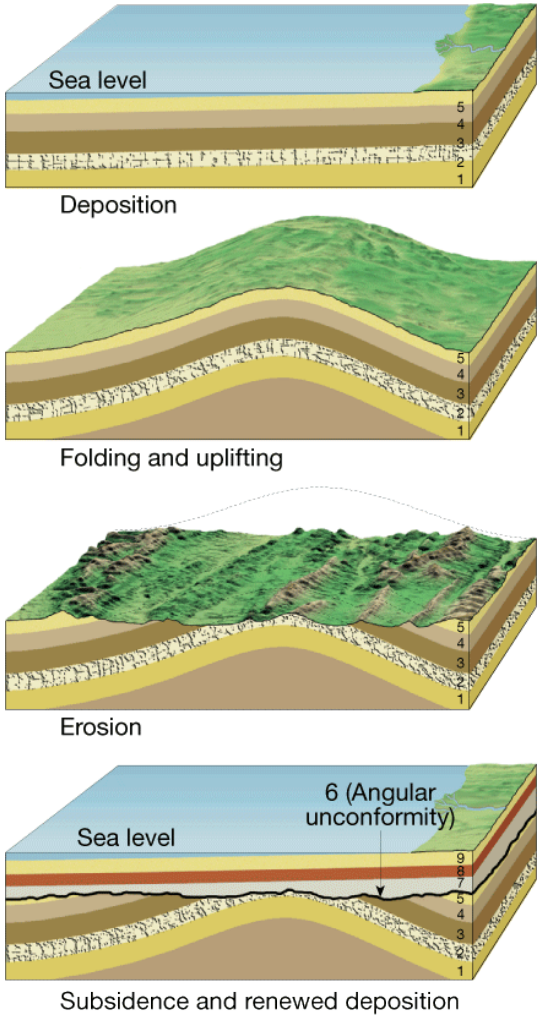
Deposition of sedimentary layers

12.1 Discovering Earth's History

Relative Dating—Key Principles

- Unconformities
  - An **unconformity** represents a long period during which deposition stopped, erosion removed previously formed rocks, and then deposition resumed.
  - An angular unconformity indicates that during the pause in deposition, a period of deformation (folding or tilting) and erosion occurred.

Formation of an Angular Conformity

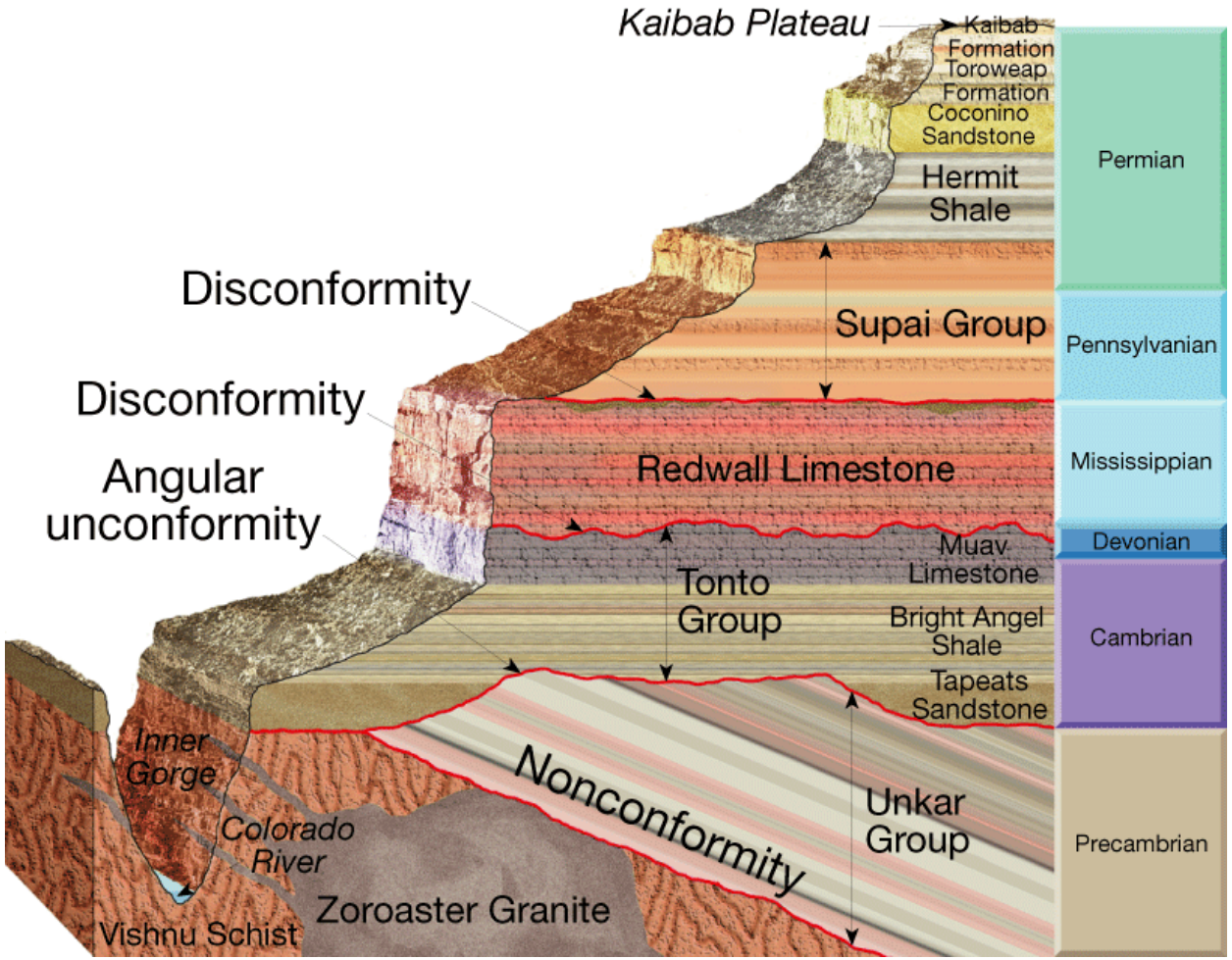


12.1 Discovering Earth's History

Relative Dating—Key Principles

- Unconformities
  - A nonconformity is when the erosional surface separates older metamorphic or intrusive igneous rocks from younger sedimentary rocks.
  - A disconformity is when two sedimentary rock layers are separated by an erosional surface.

A Record of Uplift, Erosion, and Deposition

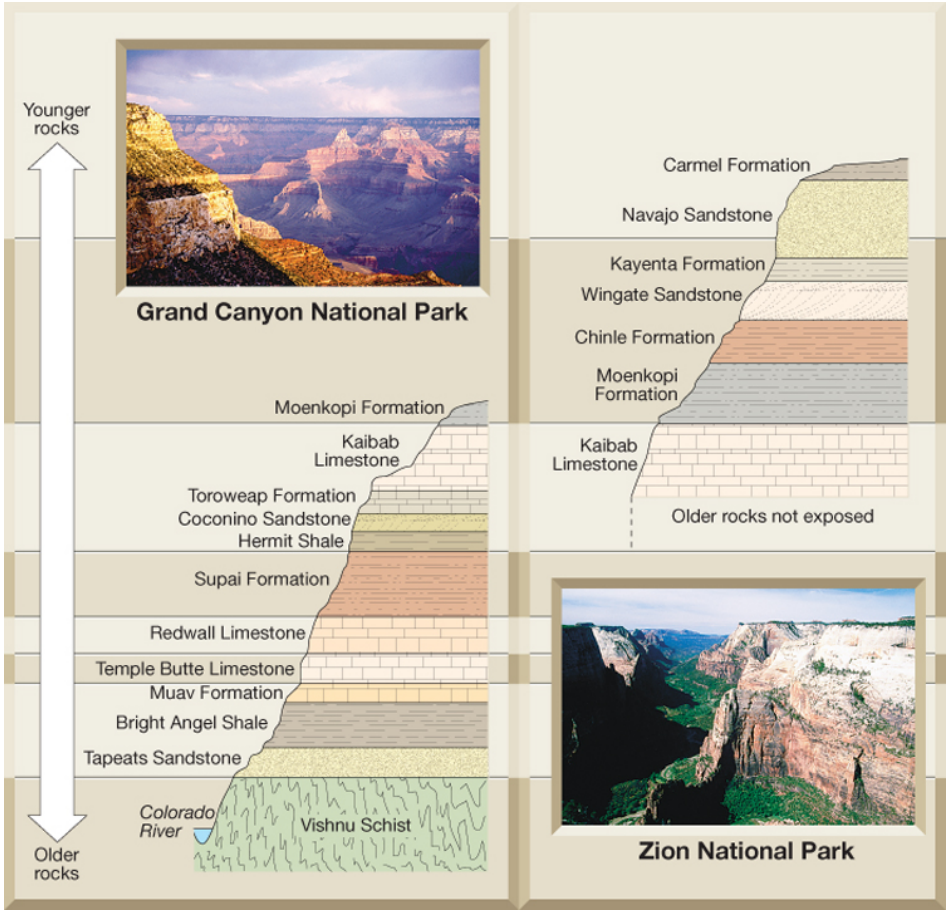


12.1 Discovering Earth's History

Correlation of Rock Layers

- **Correlation** is establishing the equivalence of rocks of similar age in different areas.

Correlation of Strata at Two Locations



12.2 Fossils: Evidence of Past Life

Fossil Formation

- **Fossils** are the remains or traces of prehistoric life. They are important components of sediment and sedimentary rocks.
- The type of fossil that is formed is determined by the conditions under which an organism died and how it was buried.
- Unaltered Remains
  - Some remains of organisms—such as teeth, bones, and shells—may not have been altered, or may have changed hardly at all over time.

12.2 Fossils: Evidence of Past Life

Fossil Formation

- Altered Remains
  - The remains of an organism are likely to be changed over time.
  - Fossils often become petrified or turned to stone.
  - Molds and casts are another common type of fossil.
  - Carbonization is particularly effective in preserving leaves and delicate animals. It occurs when an organism is buried under fine sediment.

12.2 Fossils: Evidence of Past Life

Fossil Formation

- Indirect Evidence
  - Trace fossils are indirect evidence of prehistoric life.
- Conditions Favoring Preservation
  - Two conditions are important for preservation: rapid burial and the possession of hard parts.

Types of Fossilization

12.2 Fossils: Evidence of Past Life

Fossils and Correlation

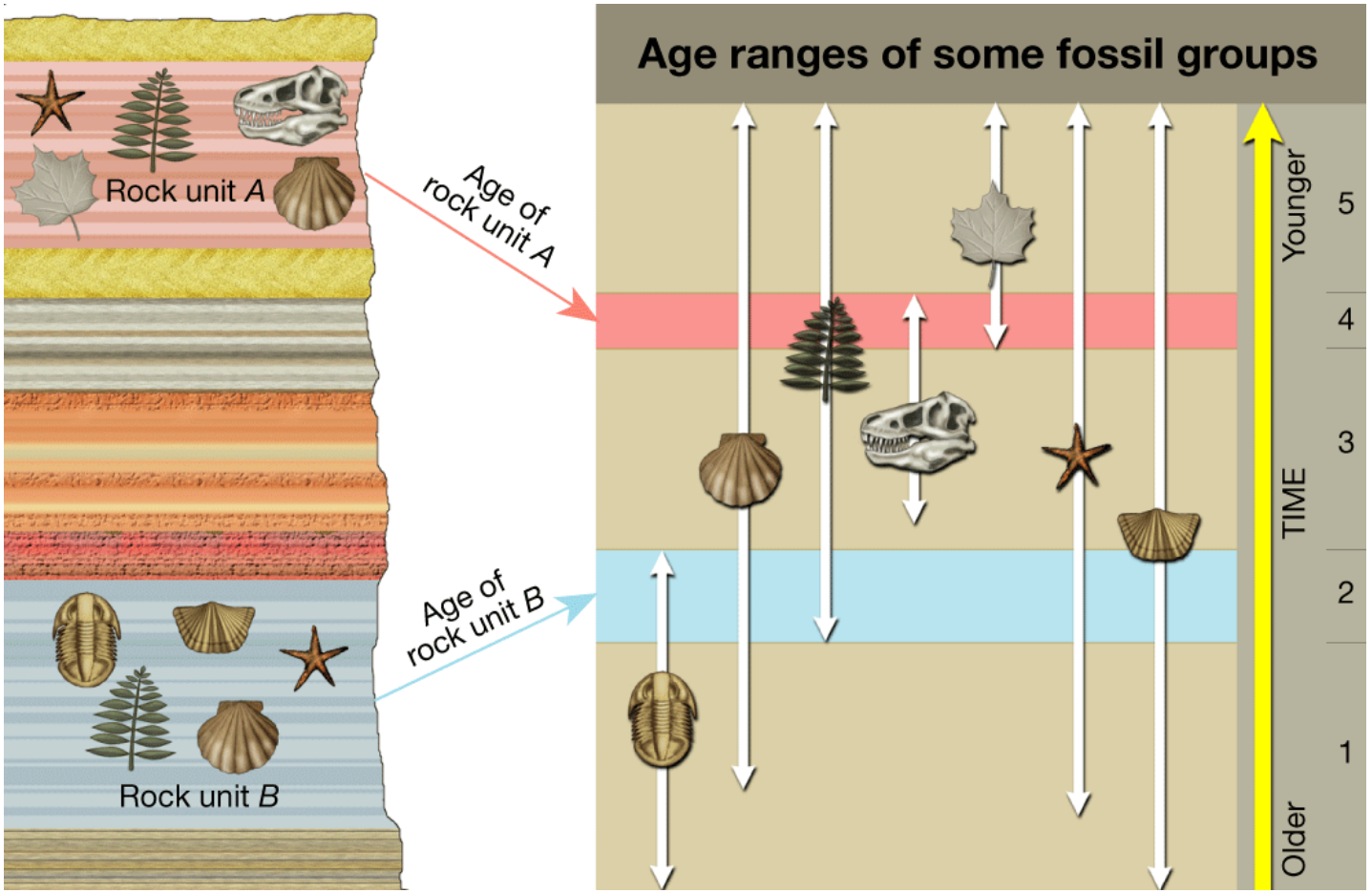
- The principle of fossil succession states that fossil organisms succeed one another in a definite and determinable order. Therefore, any time period can be recognized by its fossil content.
- **Index fossils** are widespread geographically, are limited to a short span of geologic time, and occur in large numbers.

12.2 Fossils: Evidence of Past Life

Fossil Formation

- Interpreting Environments
  - Fossils can also be used to interpret and describe ancient environments.

Overlapping Ranges of Fossils



12.3 Dating with Radioactivity

Basic Atomic Structures

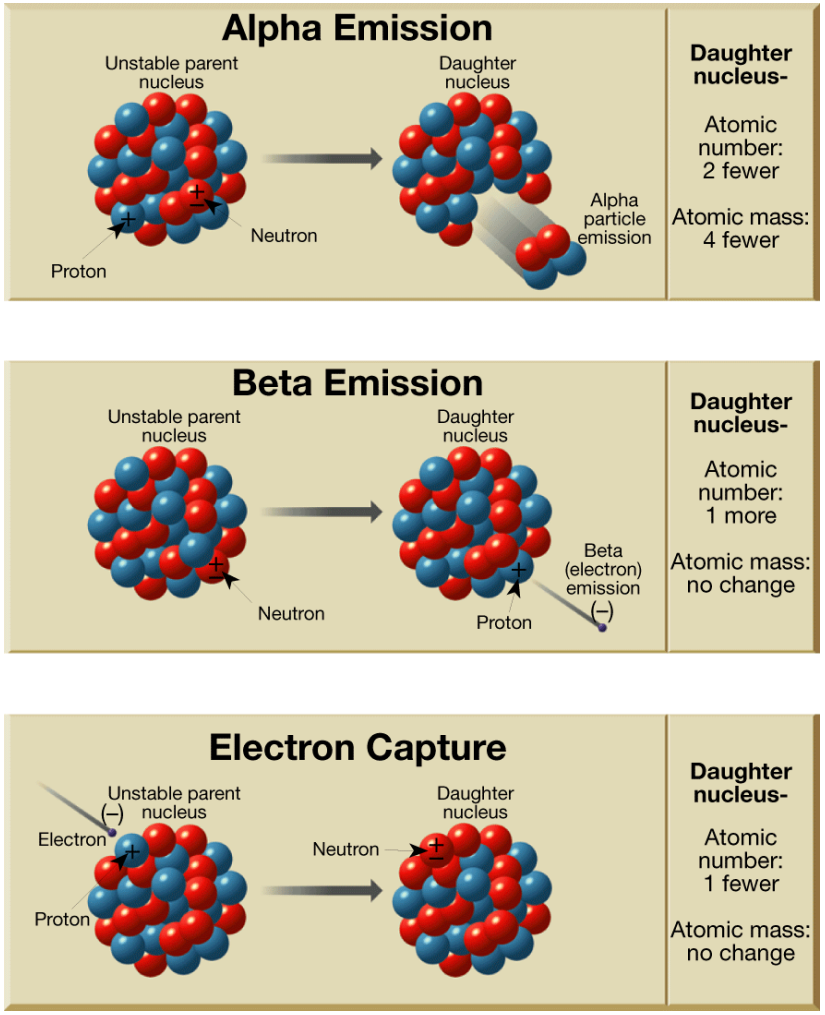
- Orbiting the nucleus are electrons, which are negative electrical charges.
- Atomic number is the number of protons in the atom's nucleus.
- Mass number is the number of protons plus the number of neutrons in an atom's nucleus.

12.3 Dating with Radioactivity

Radioactivity

- **Radioactivity** is the spontaneous decay of certain unstable atomic nuclei.

Common Types of Radioactive Decay

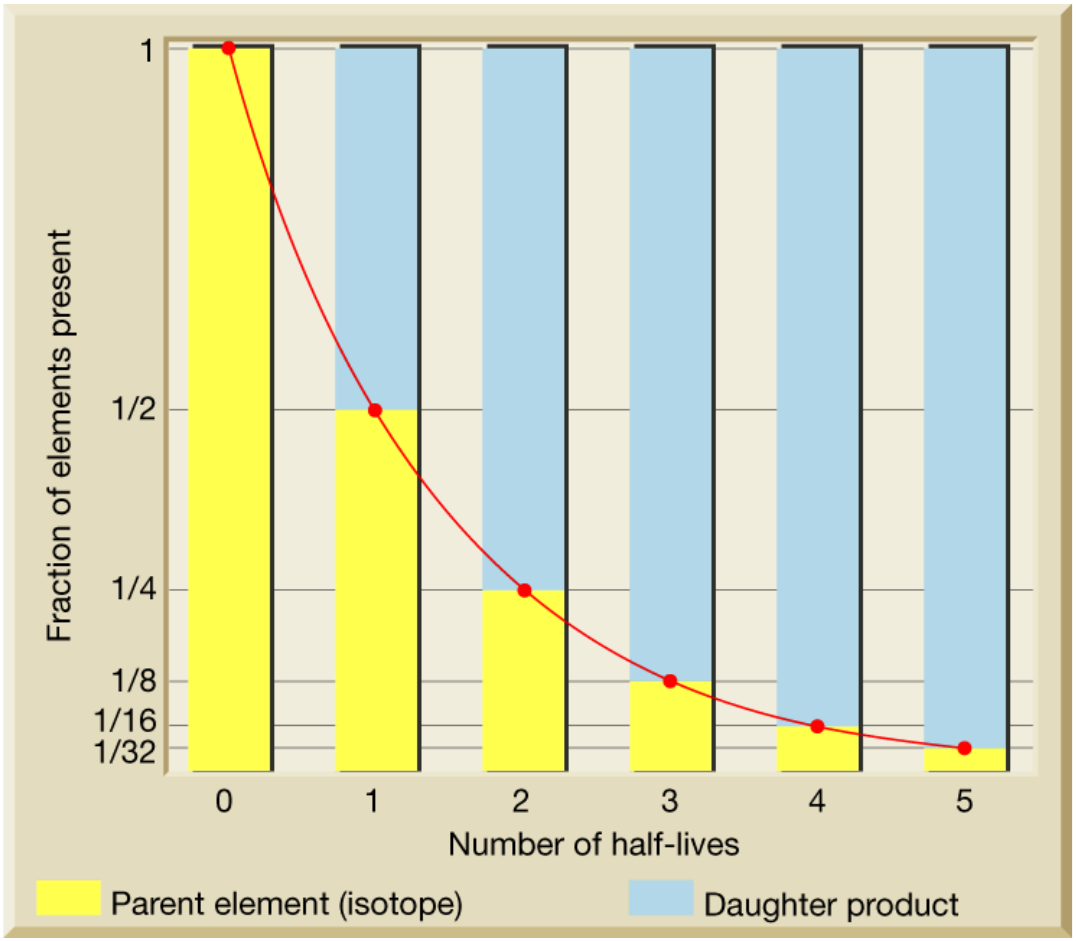


12.3 Dating with Radioactivity

Half-Life

- A **half-life** is the amount of time necessary for one-half of the nuclei in a sample to decay to a stable isotope.

The Half-Life Decay Curve



12.3 Dating with Radioactivity

Radiometric Dating

- Each radioactive isotope has been decaying at a constant rate since the formation of the rocks in which it occurs.
- **Radiometric dating** is the procedure of calculating the absolute ages of rocks and minerals that contain radioactive isotopes.

12.3 Dating with Radioactivity

Radiometric Dating

- As a radioactive isotope decays, atoms of the daughter product are formed and accumulate.
- An accurate radiometric date can be obtained only if the mineral remained in a closed system during the entire period since its formation.

Radioactive Isotopes Frequently Used in Radiometric Dating

Table 1 Radioactive Isotopes Frequently Used in Radiometric Dating		
Radioactive Parent	**Stable Daughter Product**	**Currently Accepted Half-Life Values**
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
Potassium-40	Argon-40	1.3 billion years

12.3 Dating with Radioactivity

Dating with Carbon-14

- **Radiocarbon dating** is the method for determining age by comparing the amount of carbon-14 to the amount of carbon-12 in a sample.
- When an organism dies, the amount of carbon-14 it contains gradually decreases as it decays. By comparing the ratio of carbon-14 to carbon-12 in a sample, radiocarbon dates can be determined.

12.3 Dating with Radioactivity

Importance of Radiometric Dating

- Radiometric dating has supported the ideas of James Hutton, Charles Darwin, and others who inferred that geologic time must be immense.

12.4 The Geologic Time Scale

Structure of the Time Scale

- Based on their interpretations of the rock record, geologists have divided Earth's 4.56-billion-year history into units that represent specific amounts of time. Taken together, these time spans make up the **geologic time scale**.

12.4 The Geologic Time Scale

Structure of the Time Scale

- **Eons** represent the greatest expanses of time. Eons are divided into **eras**. Each era is subdivided into **periods**. Finally, periods are divided into smaller units called **epochs**.
- There are three eras within the Phanerozoic eon: the Paleozoic, which means “ancient life,” the Mesozoic, which means “middle life,” and the Cenozoic, which means “recent life.”

12.4 The Geologic Time Scale

Structure of the Time Scale

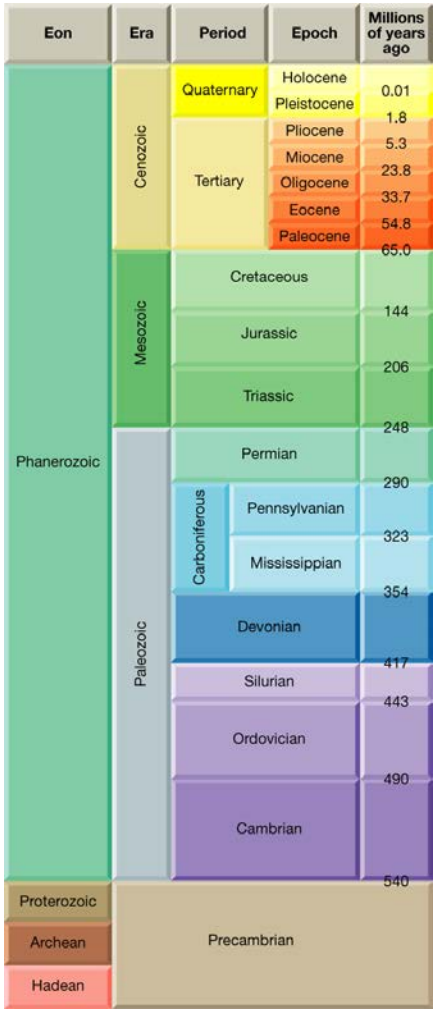
- Each period within an era is characterized by somewhat less profound changes in life forms as compared with the changes that occur during an era.
- The periods of the Cenozoic era are divided into still smaller units called epochs, during which even less profound changes in life forms occur.

12.4 The Geologic Time Scale

Precambrian Time

- During Precambrian time, there were fewer life forms. These life forms are more difficult to identify and the rocks have been disturbed often.

The Geologic Time Scale



12.4 The Geologic Time Scale

Difficulties With the Geologic Time Scale

- A sedimentary rock may contain particles that contain radioactive isotopes, but these particles are not the same age as the rock in which they occur.
- The age of a particular mineral in a metamorphic rock does not necessarily represent the time when the rock was first formed. Instead, the date may indicate when the rock was metamorphosed.

Using Radiometric Methods to Help Date Sedimentary Rocks