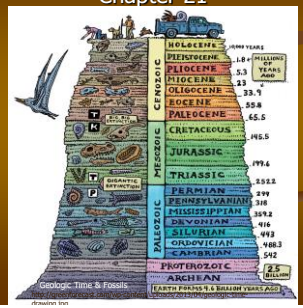
Geologic Time:
Fossils & the Rock Record
Chapter 21



Objectives: Geologic Time Scale

1. I understand how Earth's history is divided into sections of time called the geologic time scale. This means I can:
   A. Explain how major changes mark the boundaries between the sections.
   B. Discuss the general changes in organisms from the appearance of life on Earth to present day.

Objectives: Fossils

2. I can describe the characteristics Index Fossils and explain how Index Fossils are used.
3. Discuss how fossils can be used to interpret Earth's past physical and environmental history.

Objectives: Dating of Rocks

4. I can apply the principles for determining relative age to interpret rock sequences. This means I can:
   A. Determine the oldest and youngest layers using the Law of Superposition.
   B. Determine the relative age of layers and intrusions.
   C. Match rock layers in different areas using Correlation.
5. I can apply the principles for determining absolute age using radioactive decay rates and half-lifes.

Measuring Time

- According to current theories, the Earth has existed for 4.6 billion years
- The geologic time scale divides all those years into sections
  - A book is divided into Units, then Chapters, then Sections, then Pages
- Each section is unique

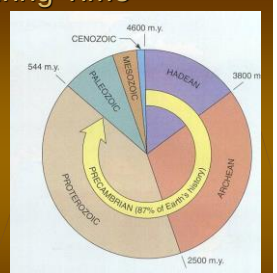
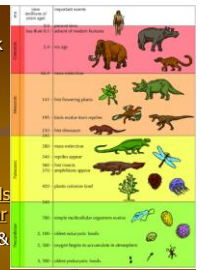


FIGURE 6–14 Proportions of geologic time encompassed by the Precambrian and its divisions, the Hadean, Archean, and Proterozoic eons.

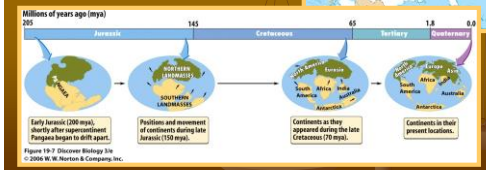
How is Time Divided?

1. Major changes in Earth's history mark the boundaries between the time divisions.
2. Most eras were divided because a major organism appeared or went extinct. Examples:
   - Boundary between Paleozoic & Mesozoic Eras: Many ocean animals become extinct & dinosaurs appear
   - Boundary between Mesozoic Eras & Cenozoic Eras: Dinosaurs become extinct & mammals become abundant



How is Time Divided?

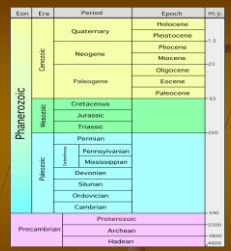
3. Other divisions based on land formation. Examples:
   - North America is covered by shallow seas
   - Pangea breaks up
   - Rocky Mountains form
   - Grand Canyon forms



What Units of Time are Used to Measure Earth's History??

The 4 Main Units:

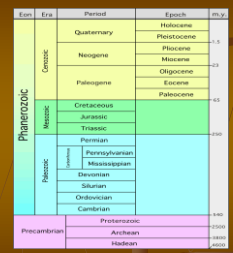
1. Eon: Largest amount of time
2. Era
3. Period
4. Epoch: Smallest amount of time



What Units of Time are Used to Measure Earth's History??

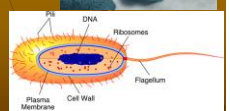
How Are They Listed?

1. Oldest listed at bottom
2. Recent at top



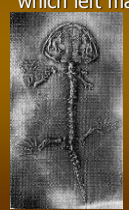
Precambrian Time

1. Began with the formation of the Earth (4.6 billion years ago)
2. At first, there was no oxygen or living things
3. The first organisms appeared in the oceans 3.6 billion years ago
   - They were single-celled bacteria



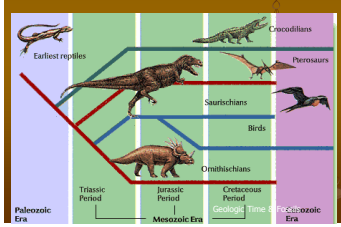
Cambrian Explosion – Beginning of Paleozoic Era

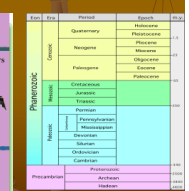
1. The CAMBRIAN EXPLOSION marks the boundary between Precambrian Time & Paleozoic Era.
   - MANY new and complex life forms appeared
   - Organisms had hard parts (shells, exoskeletons) which left many more fossils



Beginning of Mesozoic Era

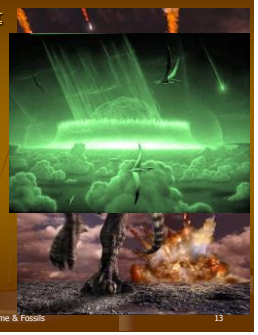
1. Many ocean animals became extinct at the boundary between the Paleozoic & Mesozoic Eras.
2. Dinosaurs appear
3. Mesozoic Era is known as the "Age of Reptiles"





End of Mesozoic Era

1. All dinosaurs and many animals & plants went extinct
2. Theory:
   - Scientists think an asteroid hit Earth
   - Dust clouds blocked the sun, causing plants to die, then herbivores, then carnivores.



Cenozoic Era

1. Current era – the one we are living in
2. AKA: Age of mammals.
3. Humans appear.
4. We know the most about this era because the fossils are in the top layers and are easier to find

Ever-changing Earth

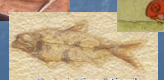
- Land & climate has changed a lot
- BIG QUESTION:
  What big change will happen that will end this era & start the next?

Remains of Organisms in Rock Record

1. Fossil = Remains or evidence of a once-living plant or animal
2. Fossils help scientists approximate:
   A. When life began
   B. Types of animals and plants
   C. Extinction of species
3. Most organisms decay and don't become fossils

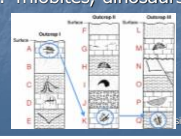
Remains of Organisms in Rock Record

4. Fossils are more likely to form if:
   A. Quick burial occurs
      A. Protects the fossil from being eaten by predators
      B. Prevents it from being weathered.
   B. Organism has hard body parts (bones, teeth, shells)



Index Fossils

1. Index Fossils = Fossils used to **match** rock layers or to determine the age of a rock layer.
2. Characteristics needed to be an Index Fossil:
   - Easily recognized
   - Abundant (large numbers) & widespread
   - Lived during a short time to identify a specific time period
3. Examples: Trilobites, dinosaurs



Trace Fossils

1. Trace Fossils = INDIRECT evidence of the activity of life.
2. Examples include:
   - Fossilized tracks
   - Trails and burrows
   - Fossilized dung (coprolites) – can help scientists learn about eating habits of ancient animals

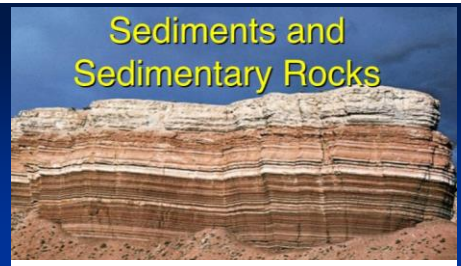


Relative-Age Dating of Rocks

Section 21.2

How scientists study Earth's history

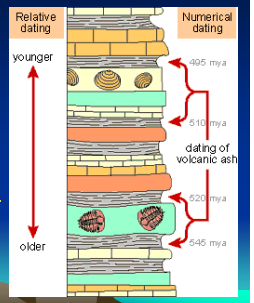
Sediments and Sedimentary Rocks



- Rock layers can be seen on this exposed cliff. Each layer represents a certain span of time.
- What techniques can scientists use to estimate the age of the rock?

Two Types of Dating

1. Relative Dating simply classifies rocks or fossils as older or younger
2. Absolute Dating determines the actual NUMERICAL age in years



Ways to Determine Relative Age

1. Law of Superposition can be used in **rock that is not disturbed (moved around by tectonic forces)**

   A. Older rocks on bottom.

   B. Younger rocks on top.
   - **Like laundry in a basket**
   - **Like papers piled in locker**


Ways to Determine Relative Age

2. Uniformitarianism = Theory that states the processes happening on Earth today have been occurring since Earth began.

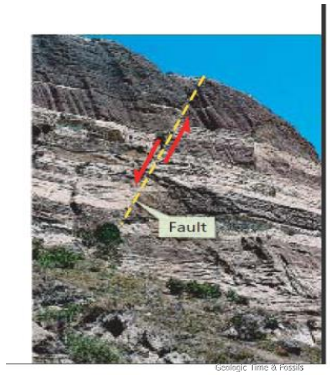
Ways to Determine Relative Age

3. 2 types of processes:
   - Slow everyday processes
     - take thousands of years to change the land
     - Erosion, deposition, etc
   - Violent & sudden events
     - change the land instantly
     - earthquakes, asteroid collision, etc.

4. Exceptions to Law of Superposition

A. Earthquakes, volcanism, flooding, weathering & erosion:
   - Disturb the rock layers
   - Make it difficult to use the Law of Superposition

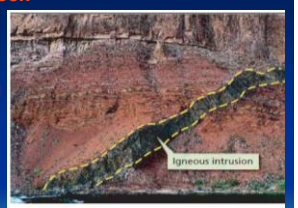
B. **Intrusion**: Magma that flows into cracks of existing rocks and cools into igneous rock:
   - Intrusions are always YOUNGER than the layers they pass through



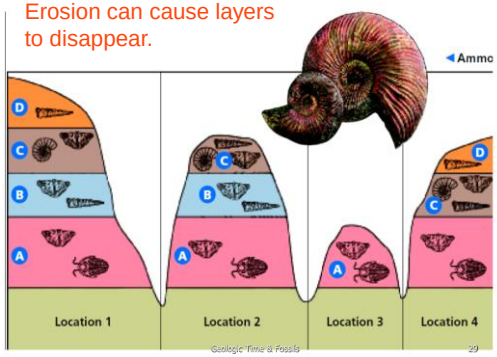
Faults cause layers to shift up or down

Intrusions must be younger than the rock they pass through.

You cannot go through something unless it was there first!

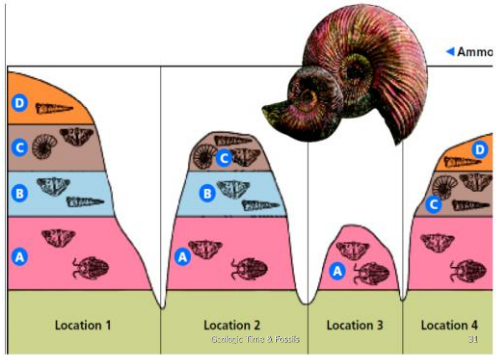


Erosion can cause layers to disappear.



5. Distinctive Sediment Layers

A. **Correlation** is matching rock layers from one location to another by matching unique fossils and/or minerals. Examples:
   - Sandstone containing oil, ammonite fossils
   - Grand Canyon (Arizona), Zion (Utah), Bryce (Utah)



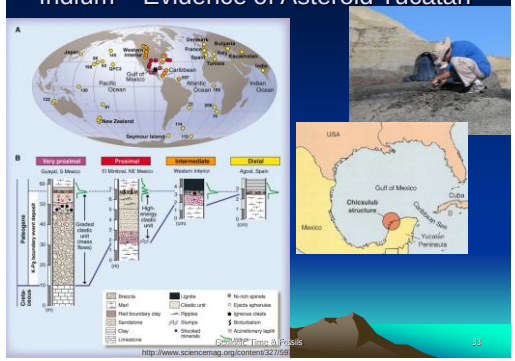
Distinctive Sediment Layers Continued

B. Short-lived events such as asteroid impact or massive volcanic eruption form distinctive layers used to determine relative age

Examples:

- Mount St. Helen's 1980 – ash over several states makes a layer known to have been made in 1980
- Asteroid impact at the boundary of Mesozoic and Cenozoic left a layer of space material.
  - Layer is age of the dinosaur extinction

Iridium – Evidence of Asteroid Yucatan



Mini-Activity
Relative Dating with Footprints

Absolute -Age Dating of Rocks

SECTION 21.3

HOW SCIENTISTS STUDY EARTH'S HISTORY

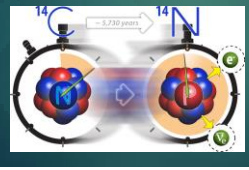
Geologic Time & Fossils

Radioactive Decay

Review: Absolute Dating determines the actual NUMERICAL age in years

Radioactive decay of elements is used to determine the absolute age of rocks

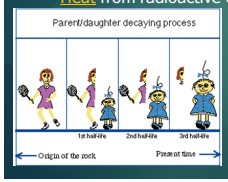
1. Radioactive elements decay into a new element
   - Example: Carbon changes into nitrogen

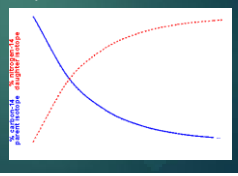


Geologic Time & Fossils

Parent / Daughter Element

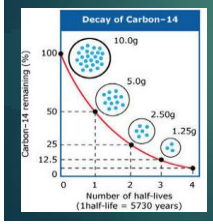
2. Original element = parent element
3. New element = daughter element
4. Over time there is less parent element and more daughter element
5. During radioactive decay, much energy is given off.
   - Heat from radioactive decay heats the inside of the earth.

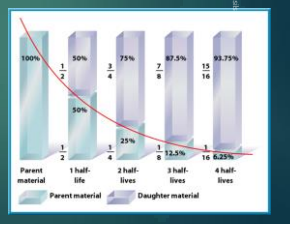


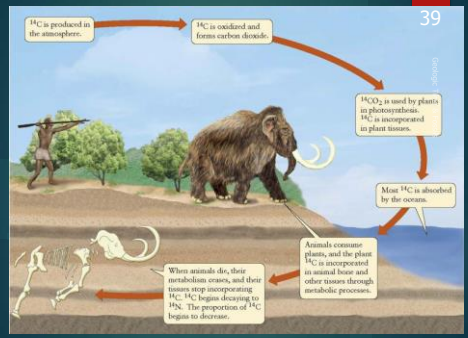


Half-Life

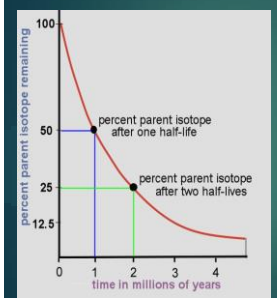
1. The **half-life** of an isotope is the time it takes for half (50%) of the atoms in the element to decay into the daughter element.
2. By measuring the percent of parent isotope left, absolute age can be determined.







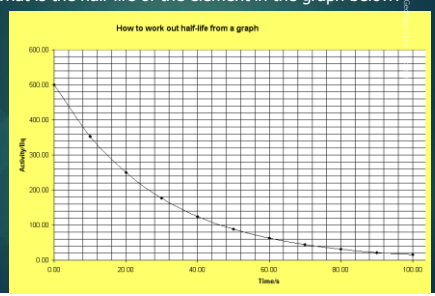
Example: How Can You Determine Half-Life from a Graph?



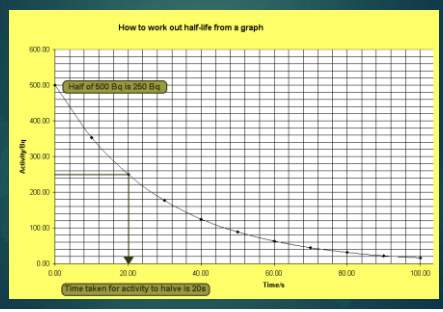
What is the half life represented in this graph?

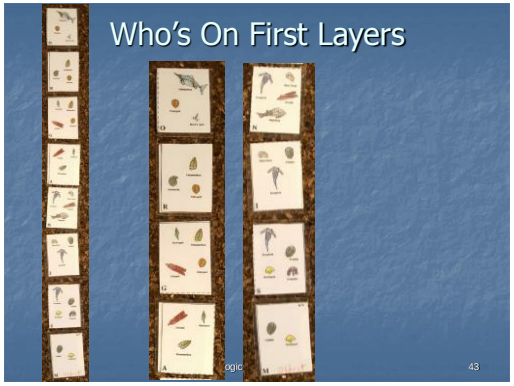
Your Turn: Half-Life Determination from Graph

What is the half-life of the element in the graph below?



Answer: Half-Life Determination from Graph




Who's On First Layers
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