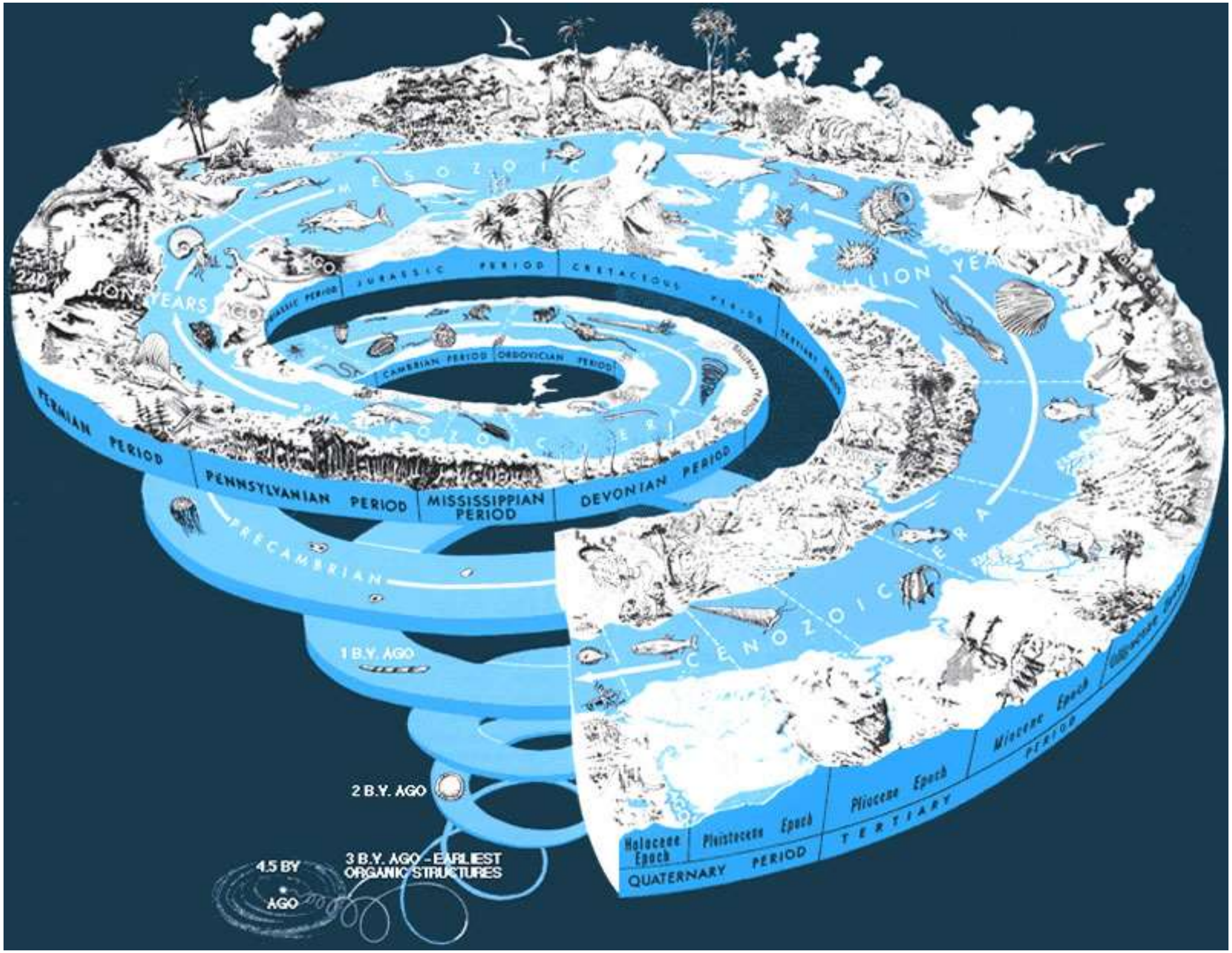
Geologic Time & the Rock Record



8th Grade Earth & Space Science

Putting It in Perspective

- How long ago was a million seconds?

12 days ago

- How long ago was a billion seconds?

32 years ago

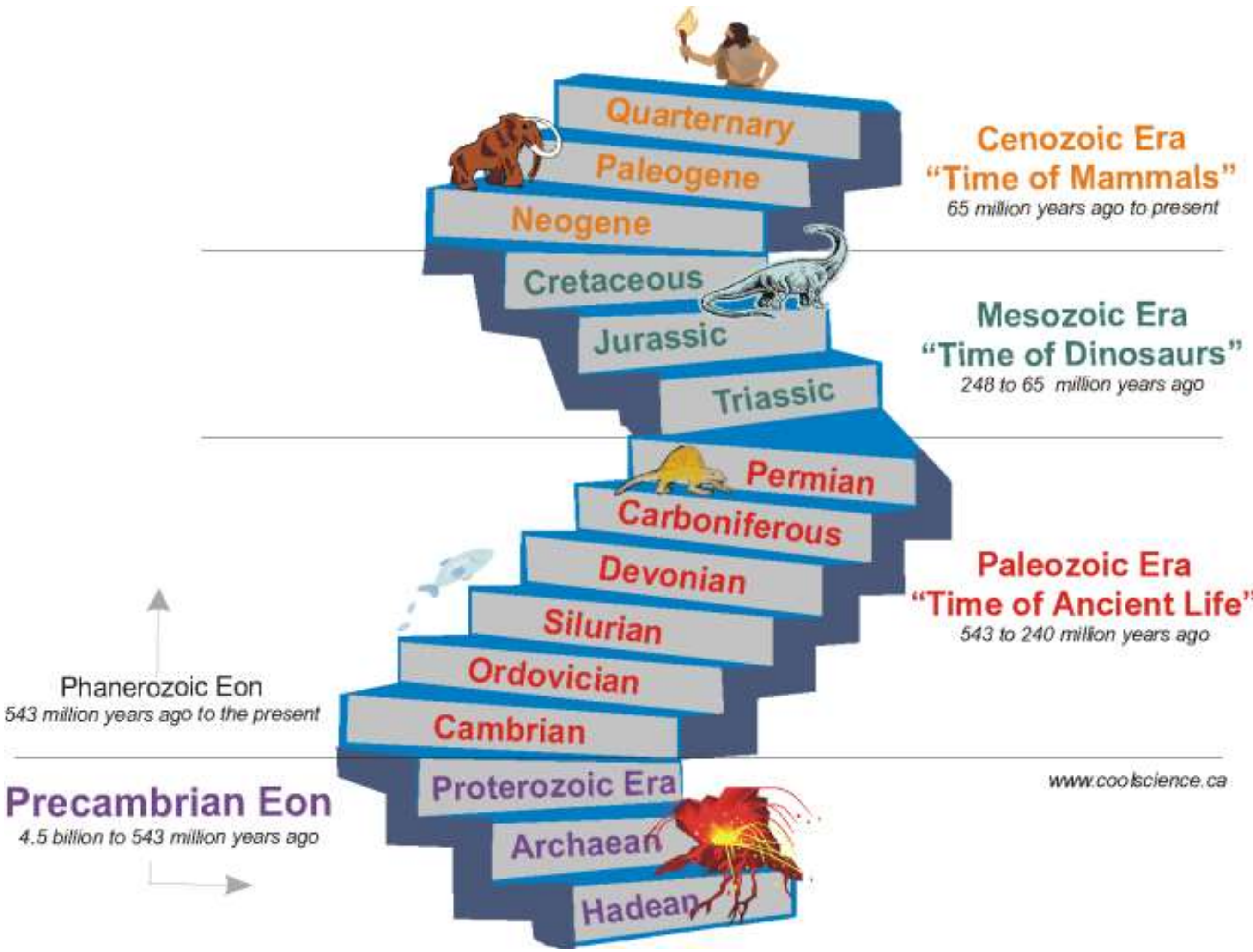
- How long ago was a trillion seconds?

32,000 years ago

How Geologic Time is Organized

- Geologists have divided the Earth's history into time units based on rock layers and the fossils found in those layers.
- These time units make up *the geologic time scale* → record of the Earth's history
- Started in 1795 but constantly revised with new data

The Geologic Time Scale



Understanding Geologic Time

- *Eons* – largest of all time units; encompasses all others
  - Supereon Precambrian (88% of geologic time)
    - Sub-divided into 3 eons (Hadean, Archaen, Proterozoic)
    - Littlest known about this era – why do you think?
  - Phanerozoic
    - Abundant animal life
    - We are currently in this eon

Understanding Geologic Time

- *Eras* – eons are made up of eras; smaller than eons
  - Last tens to hundreds of millions of years
  - Defined by the different life forms found in the rocks
- Label your diagram:
  1. Paleozoic means "ancient life" (pre-dinosaurs)
  2. Mesozoic means "middle life" (dinosaurs)
  3. Cenozoic means "recent life" (mammals)
     - We are currently in this era!

Understanding Geologic Time

- *Periods* – make up eras; generally tens of millions of years long

- Label your diagram:
    1. Ordovician – first vertebrates (jawless fish); ended with freezing period and 2nd largest mass extinction of all time
    2. Silurian – first land plants and animals
    3. Devonian – age of the fish
    4. Carboniferous – first shelled eggs
    5. Permian – "the Great Dying" (mass extinction event - 95% of all life wiped off the planet)

    1. Triassic – Pangaea (the super-continent) formed and started to come apart
    2. Jurassic – age of the dinosaurs
    3. Cretaceous – mass extinction of dinosaurs

    "Tertiary Period"

    9. Paleogene – age of mammals
    10. Neogene – beginning of the "Ice Age"

    11. " Quaternary Period" – rise of the humans

Understanding Geologic Time

- *Epochs* – make up periods; generally hundreds of thousands to millions of years
- All periods are divided into epochs, but let’s just look at those in the current Cenozoic Era

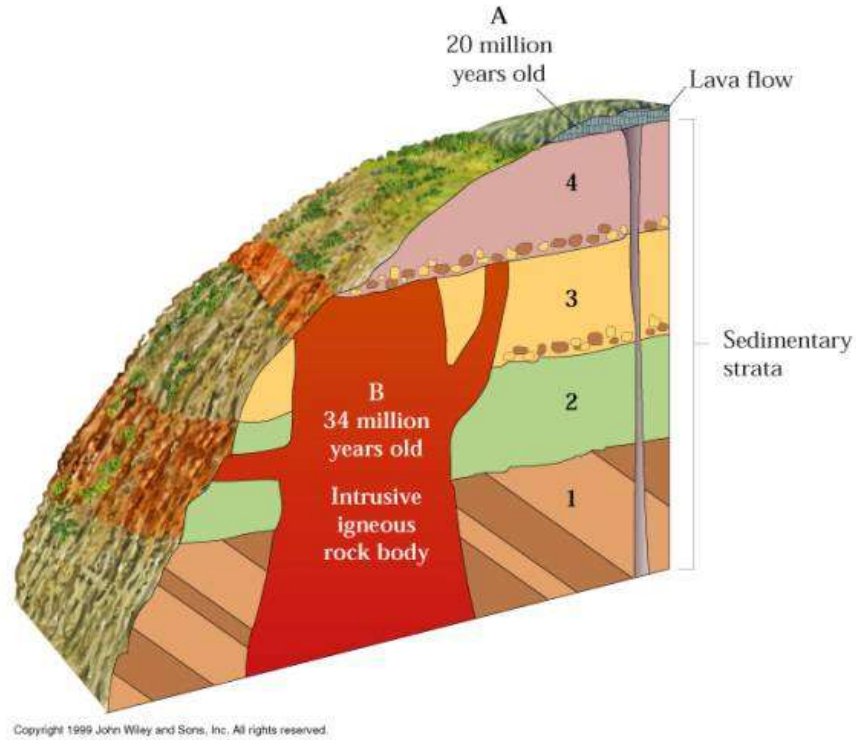
Paleogene Period

- Paleocene – “terror birds”, reptiles, 1^{st} cacti and palm trees
- Eocene – ancestors of horses, giant penguins, lots of reptiles, whales
- Oligocene – rise of grazing mammals (early horses, camels, etc.), widespread grasses

Neogene Period

- Miocene – age of apes and hominids, giant crocodiles thrived
- Pliocene – saber-tooth tiger, wooly mammoth, disappearance of “terror birds”
- Pleistocene – 11 “interglacial periods”, extinction of saber-tooth tiger, wooly mammoth, extinction of large reptiles
- Holocene – “warm period” of Earth, pretty much all of recorded history of man

Relative-Age Dating



8th Grade Earth and Space Science

Class Notes

James Hutton

- One of the 1st scientists to believe the Earth was very old
- Attempted to explain that the earth changed over a very long period of time by the same processes

Uniformitarianism

- States that geological processes occurring today have been occurring since the Earth first formed

Relative-Age Dating

- Because of uniformitarianism, scientists can learn about the past by studying the present and the future

- Relative-age dating does not allow scientists to determine exact age, but it gives a better understanding of the geologic events in the Earth's history

Relative-Age Dating - example

Use relative age dating to place the following events in U.S. History in the correct order:

1. Civil War
2. World War I
3. Revolutionary War
4. Vietnam War

Principles of Relative Dating

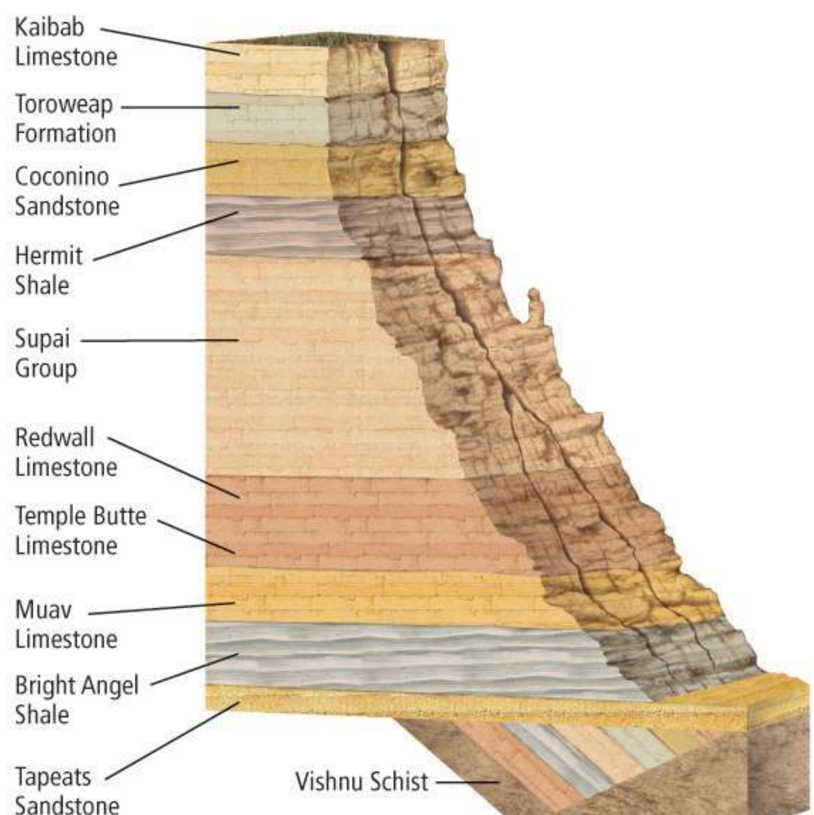
- Used to determine relative ages

- Original horizontality
- Superposition
- Cross-cutting relationships
- Inclusions

- Let’s look at each separately!

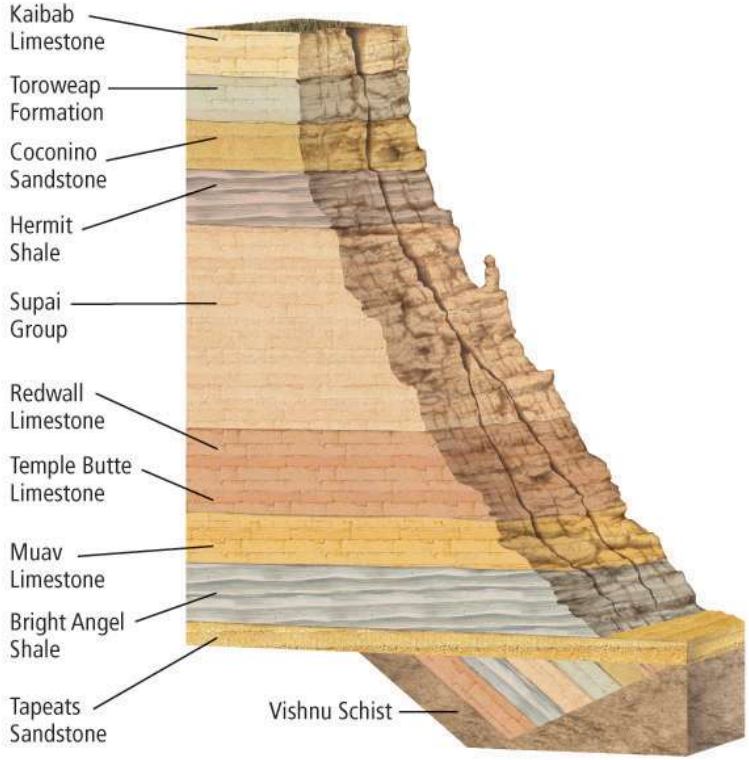
Original Horizontality

- Principle that sedimentary rocks are deposited in horizontal (or nearly horizontal) layers



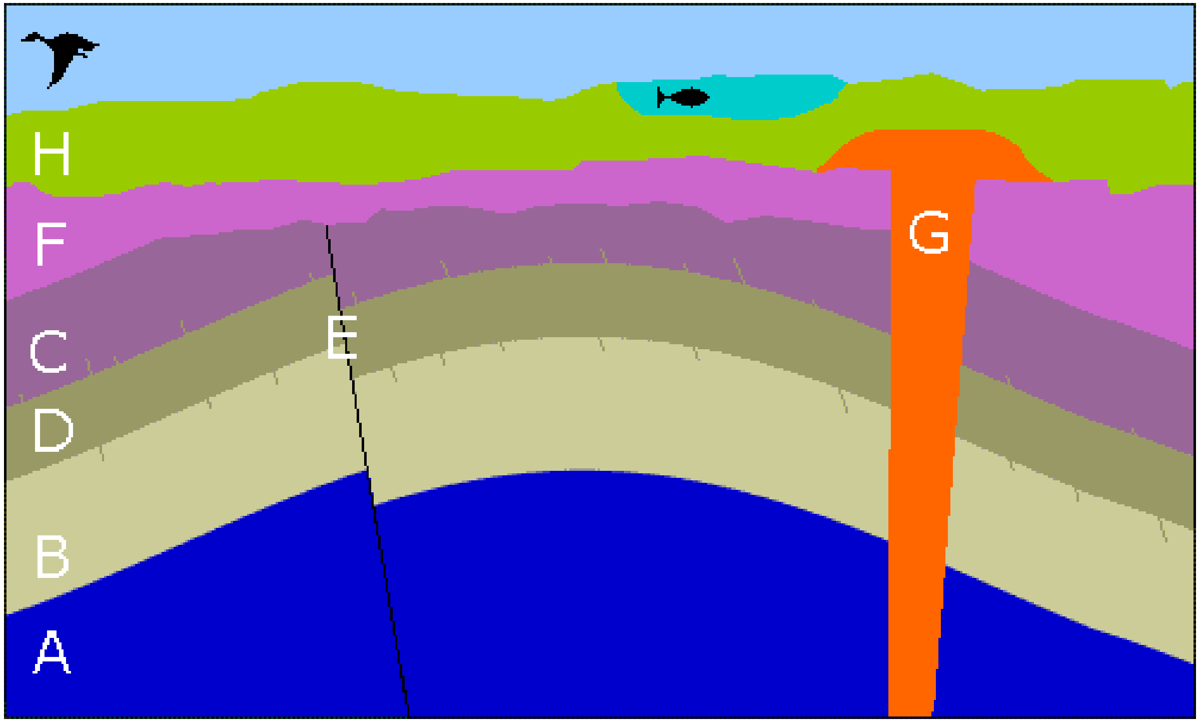
Superposition

- States that in an undisturbed rock sequence, the oldest rocks are at the bottom and each consecutive layer is younger than the layer beneath it



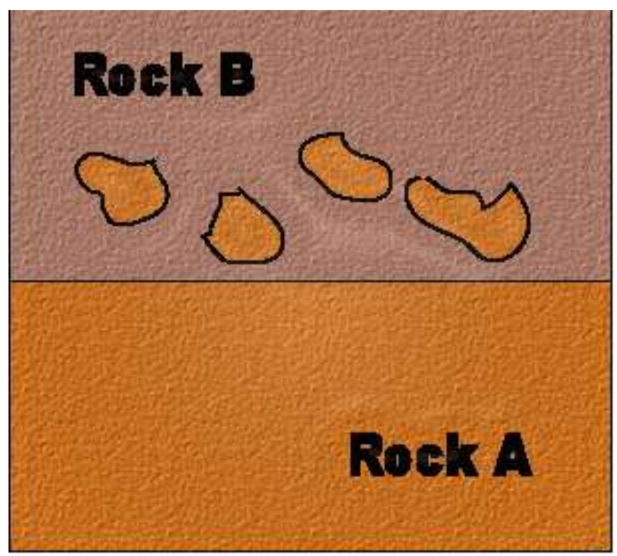
Cross-cutting Relationships

- States that intrusions are younger than the rock it cuts across
  - *This also applies to faults*



Inclusions

- States that fragments (inclusions) in a rock layer must be older than the rock layer that contains them



Exceptions - Unconformities

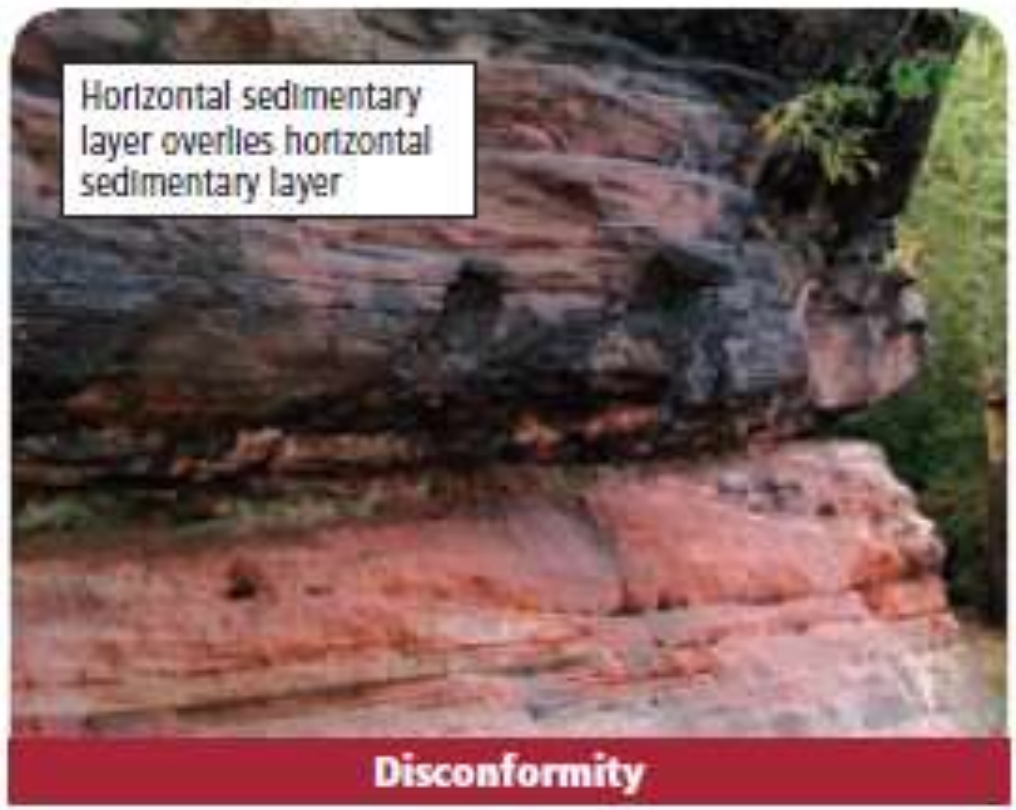
- *Buried surfaces of erosion*
  - Leaves a “gap” in the rock record

- Three main types:
  - Disconformity
  - Nonconformity
  - Angular unconformity

- Let’s examine these!

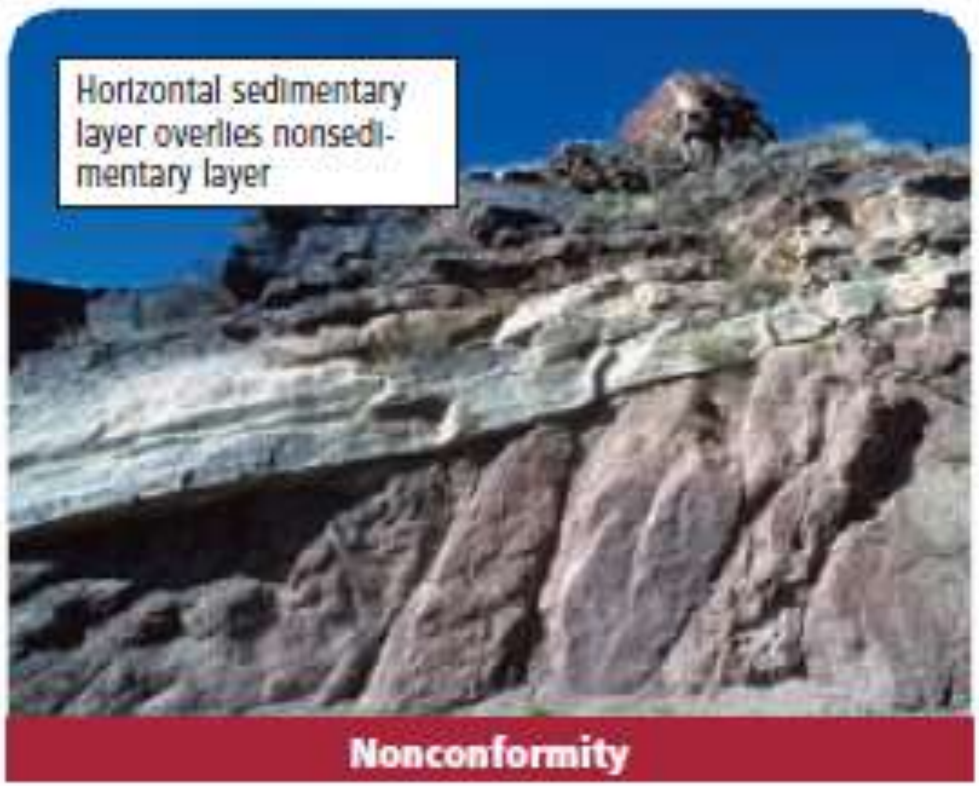
Disconformity

- When a horizontal layer of sedimentary rock overlies another horizontal layer of sedimentary rock after a period of erosion



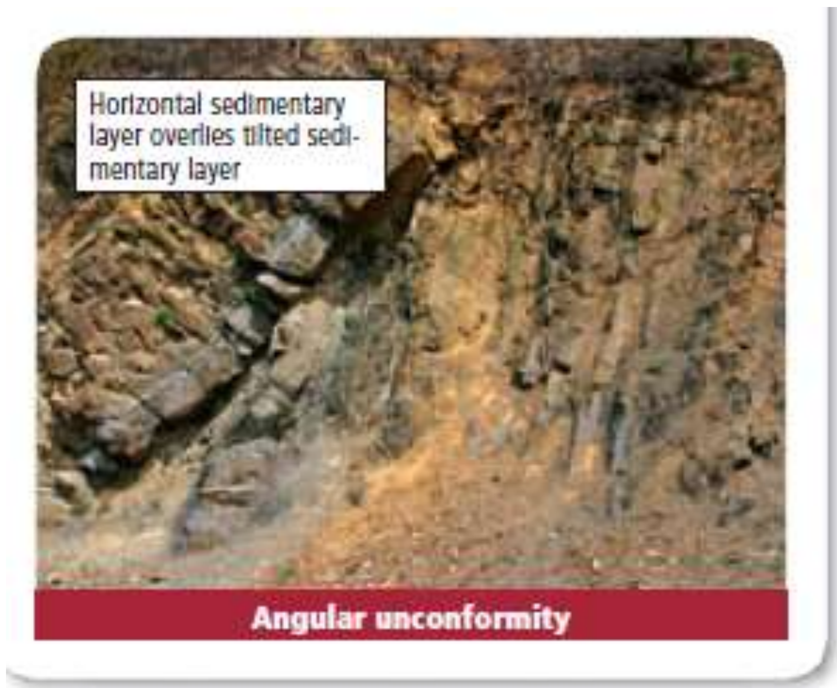
Nonconformity

- When a layer of sedimentary rock overlies a layer of igneous or metamorphic rock



Angular Unconformity

- When a horizontal layer of sedimentary rock is later laid down on top of the tilted, eroded layers
  - – Usually occurs during mountain building



Correlation

- Matching of unique rock outcrops or fossils exposed in one geographic region to similar outcrops exposed in other geographic regions

- Example – The Grand Staircase

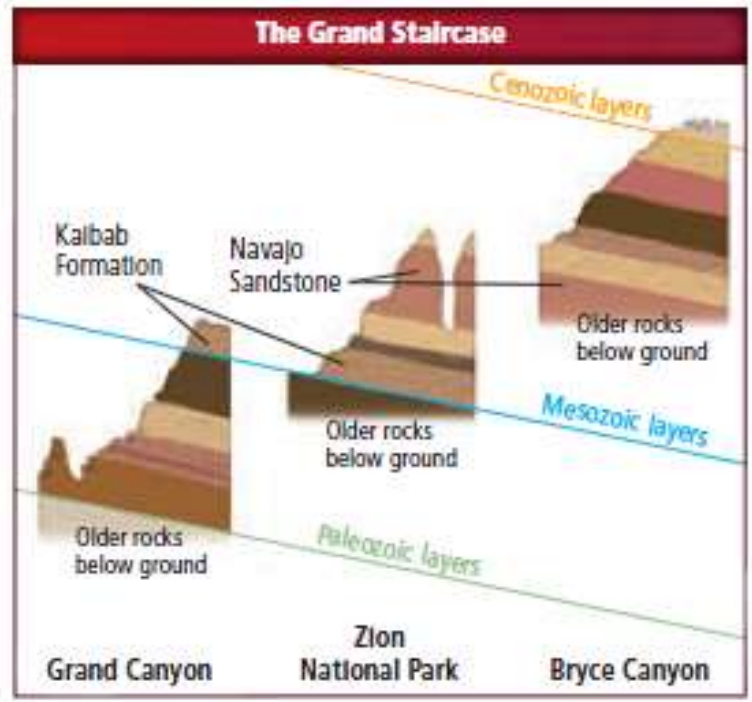


Figure 21.11 The top layers of rocks at the Grand Canyon are identical to the bottom layers at Zion National Park, and the top layers at Zion are the bottom layers at Bryce Canyon.

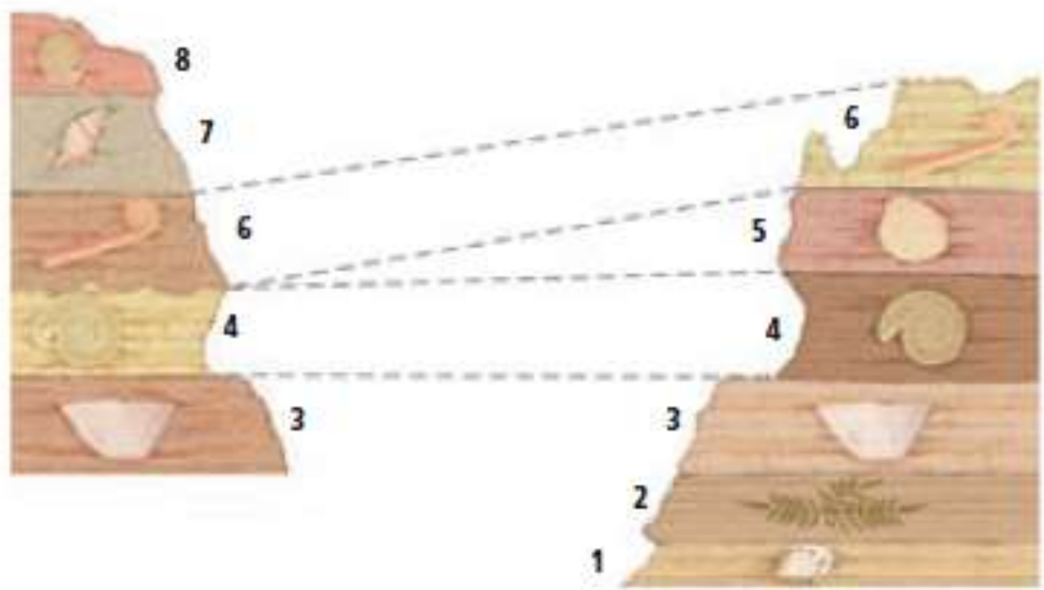
Key Beds

- A rock or sediment layer that serves as a time marker in the rock record and results from volcanic ash or meteorite-impact debris that spread out and covered large areas of Earth

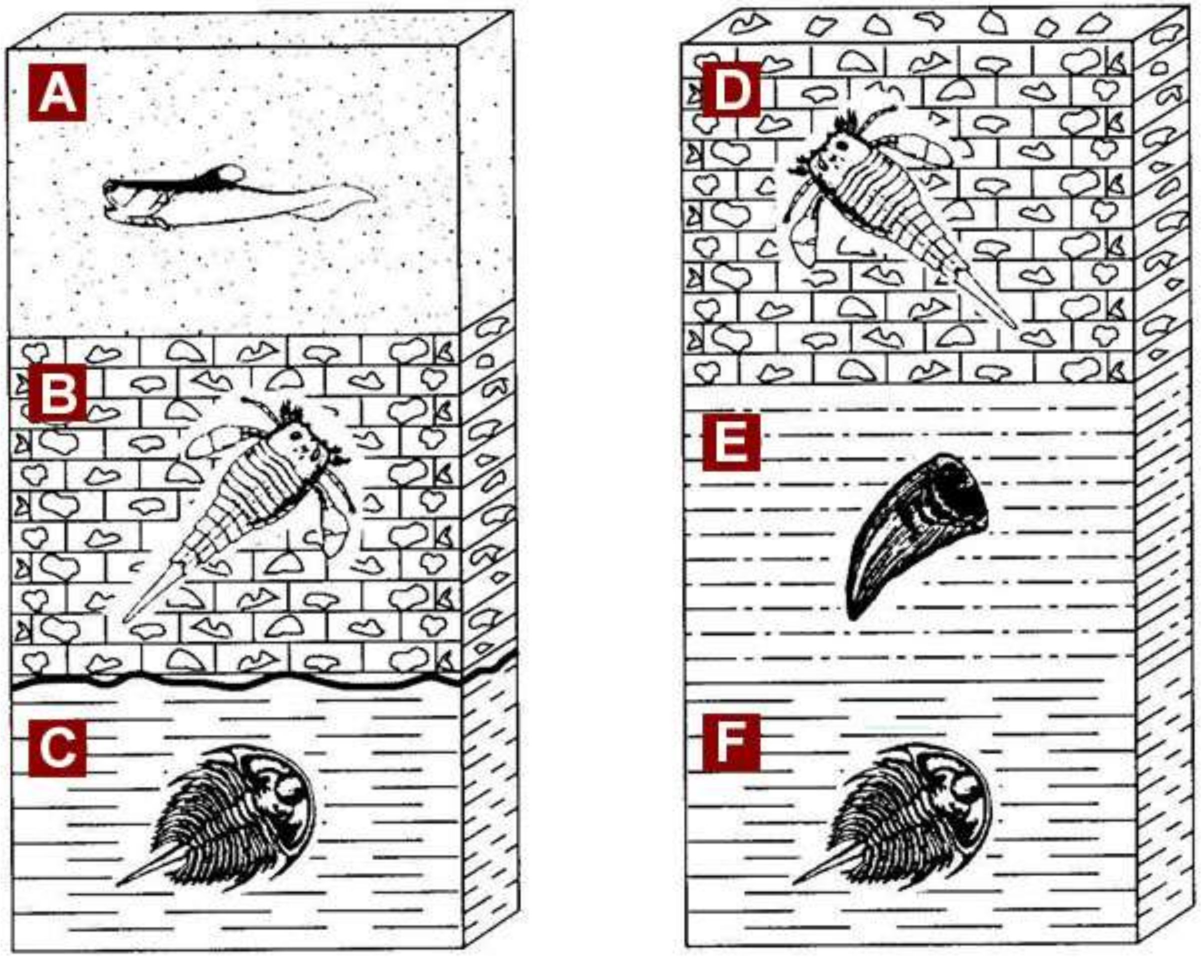
Fossil Correlation

- Correlating fossils from rock layers in one location to rock layers in another location shows that the layers were deposited during roughly the same time period, even though the layers are of different material

Figure 21.12 Correlating fossils from rock layers in one location to rock layers in another location shows that the layers were deposited during roughly the same time period, even though the layers are of different material.

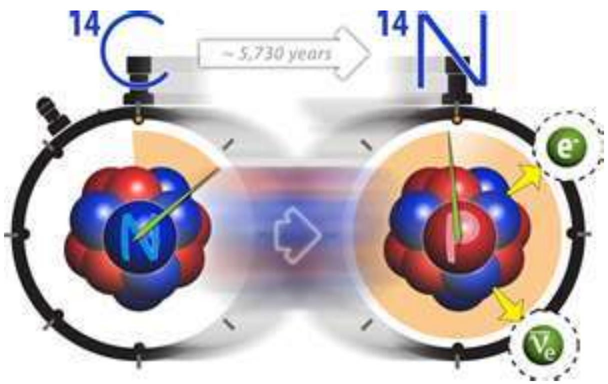


Example of Fossil Correlation




GEOLOGIC
TIME

Absolute-Age Dating



8th Grade Earth and Space Science

Class Notes

Absolute-Age Dating

- Allows scientists to determine the numerical age of rocks and other objects

- Scientists measure the decay of radioactive isotopes in igneous & metamorphic rocks in addition to the remains of organisms preserved in sediments.

Radioactive Decay

- ***<u>Remember:</u>*** Radioactive isotopes emit nuclear particles; this changes the proton number and the identity of the element

- Parent – original element
- Daughter – new element

- Can detect how much of the “parent” and “daughter” are present in your sample to give it an age

Example

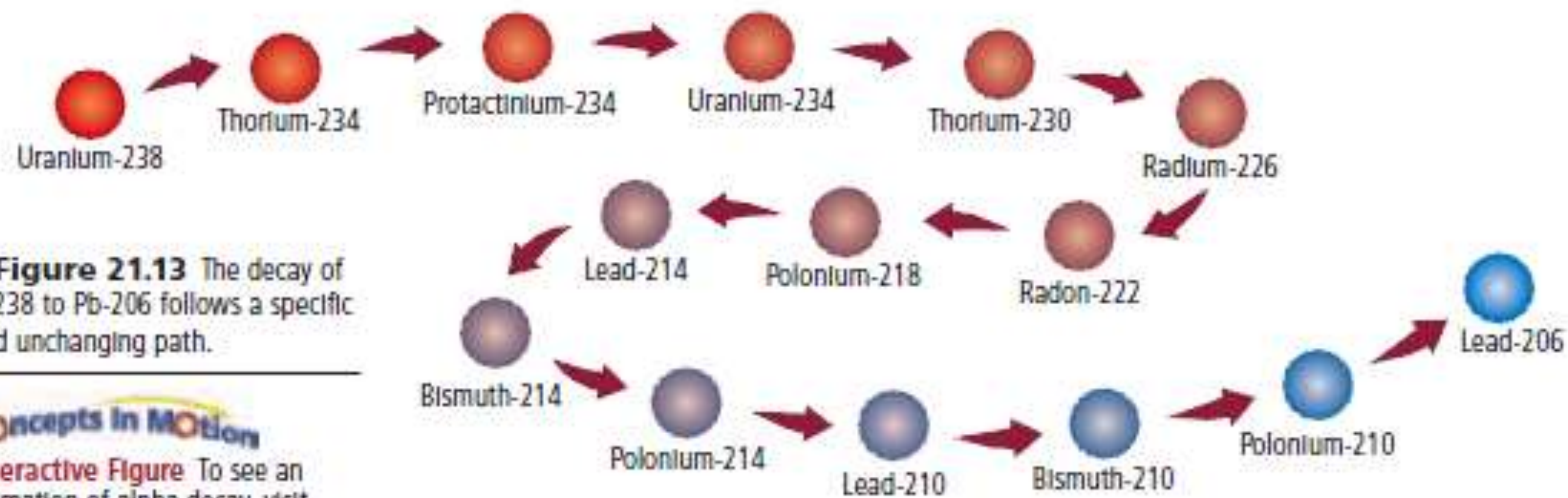


Figure 21.13 The decay of U-238 to Pb-206 follows a specific and unchanging path.

Concepts In Motion

Interactive Figure To see an animation of alpha decay, visit glencoe.com.

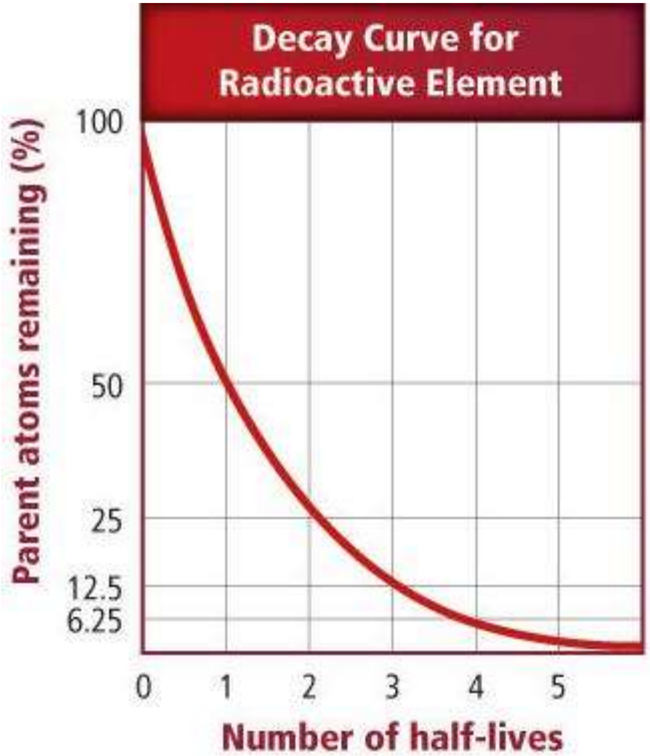
- See page 601 in your book!

Radiometric Dating

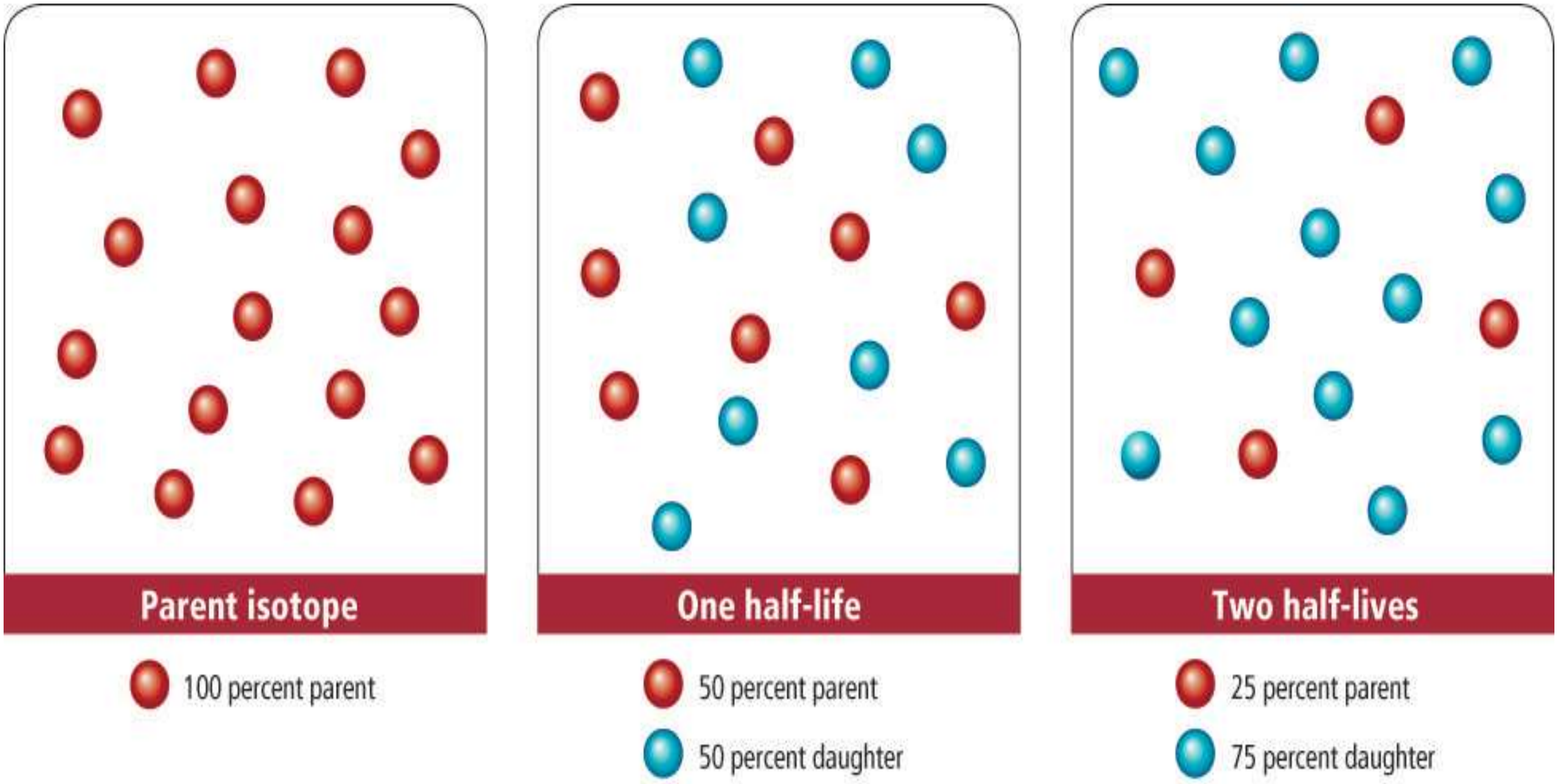
- Scientists look at how much of the parent and daughter are remaining to determine the age

  – This works because as the amount of the parent decreases the amount of daughter increases

Radiometric Dating



Half-Life


Parent isotope
One half-life
Two half-lives
100 percent parent
50 percent parent
50 percent daughter
25 percent parent
75 percent daughter

Half-Life

- *The length of time it takes for ½ of the original isotope to decay*
  - After one half-life – 1:1 ratio of parent to daughter (50% / 50%)
  - After two half-lives – 1:3 ratio of parent to daughter (25% / 75%)
  - After three half-lives – (12.5 % / 87.5 %)
  - After four?

Dating Rocks

- Can be used to date igneous and metamorphic rocks - why not sedimentary?
- Examine ratio of parent : daughter in rock
- Isotope used depends on approximate age of the rock
  - Uranium-235 would be best for a rock that is a few tens of millions years old (half-life = 700 million years)
  - Urianium-238 would be best for a rock that older (half-life = 4.5 billion years)

Radiocarbon Dating

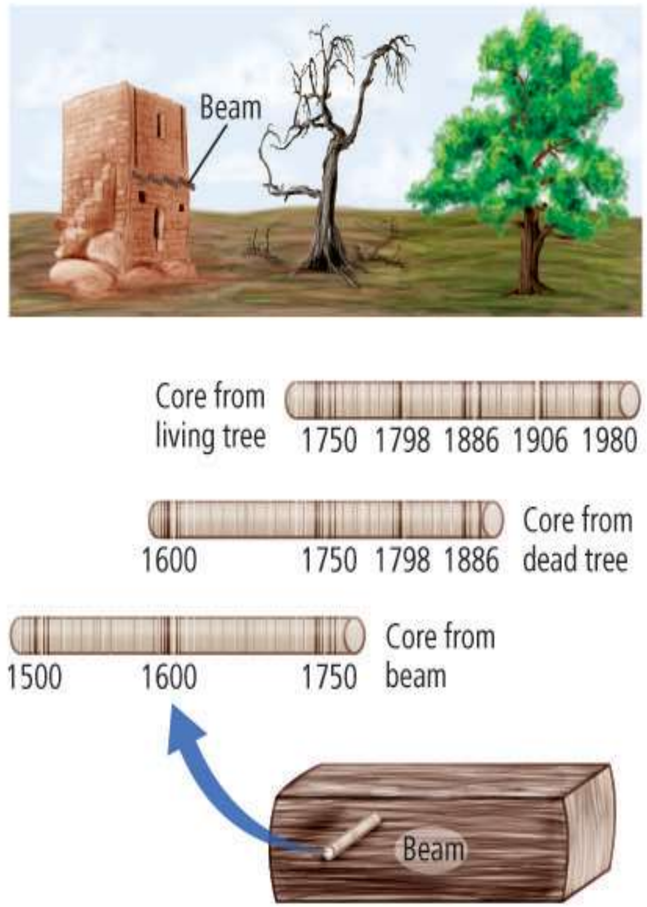
- Carbon-14 has relatively short half-life (5730 years); it is used to date organic materials
- This works because all living things contain C-14 that is replenished throughout life but begins to decay into nitrogen at death

Using Radiocarbon Dating

Tree Rings

- *Dendrochronology* – using tree rings to determine absolute age
- Width of the rings tells you a lot about the environment
  - *Wide rings = fast growth*
  - *Narrow rings = slow growth*
- Can also be used to date structures, tools, etc. made from wood

Using Tree Rings



Ice Cores

- Ice cores contain a record of past environmental conditions in annual layers of snow deposition.
- Geologists use ice-core chronologies to study glacial cycles through geologic history.
- Also used to study climate change

Varves

- Bands of alternating light and dark sediments
- Usually in lakes
- Sand-sized particles usually represent summer and traces of living things
- Thinner, fine-grained sediments can represent winter

Fossils

8th Grade Earth and Space Science

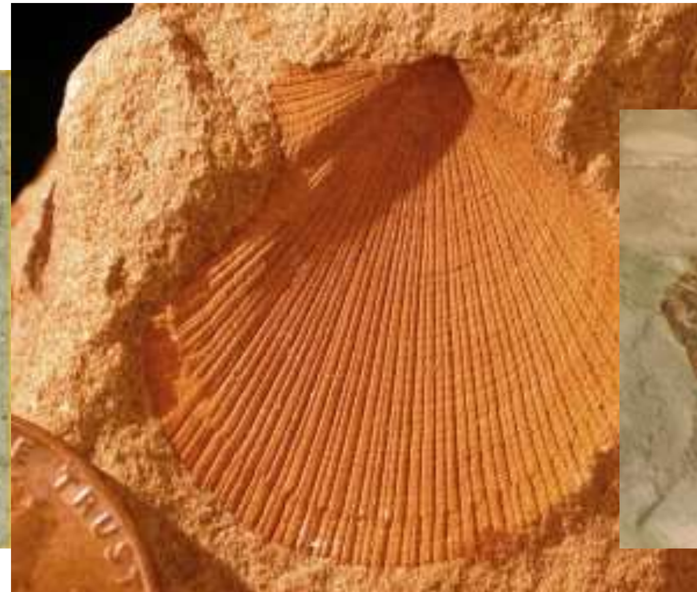
Class Notes

Fossil Remains

- *Fossil* – preserved remains of once-living organisms

- Provide evidence of past existence
- Provides evidence of evolution (change in a species over a LONG period of time)

Examples of Fossils



Fossils and Rocks

- When geologists find fossils in rocks, they know the rocks are about the same age as the fossil
  - They can then infer that the same fossils found elsewhere are also of the same age

Original Preservation

- *Remains of plants and animals that have been altered very little since the organism's death*
- Rare
- Examples: soft parts of mammoths in the La Brea tar pit, wood parts of plants frozen in the Alaskan bogs

La Brea Tar Pits

Zed

State Fossil of California

Altered Hard Parts

- *Fossil whose soft material has worn away but whose hard parts are preserved*

- Two methods:
  - Mineral replacement
  - Recrystallization

Mineral Replacement

- *Pore spaces of an organisms buried hard parts are filled in with minerals from groundwater*
- Ground water comes in contact and gradually replaces the hard parts original mineral material with a different mineral
- Examples: a shell's calcite being replaced with silica, petrified wood (from volcanic ash)

Example of Mineral Replacement

Petrified wood from Petrified Forest National Park in Arizona

“The petrified wood of the Petrified Forest is the "State Fossil" of Arizona. The pieces of wood are from a family of trees that is extinct in the Northern Hemisphere today. During the Late Triassic period, this desert region was located in the tropics and was seasonally wet and dry. In seasonal flooding, the trees washed from where they grew and accumulated in sandy river channels, where they were buried periodically by layers of gravelly sand, rich in volcanic ash from volcanoes further to the west. The volcanic ash was the source of the silica that helped to mineralize the buried logs, replacing wood with silica, colored with oxides of iron and manganese. “

-Excerpt from Petrified National Park Website

Recrystallization

- *Occurs when a buried hard part is subjected to changes in temperature and pressure over time*
  - Similar to mineral replacement BUT the original mineral in this case is transformed into a new mineral

- Example: aragonite (forms snails' shells) is transformed into the more stable mineral calcite

Recrystallization

Molds and Casts

- *Mold* – Sediments cover the hard part of an organism and the hard part is later removed (by erosion or weathering)
  - *Hollowed-out impression*

- *Cast* – when the mold later becomes filled with a mineral

Molds and Casts

Trace Fossils

- *Indirect fossils*
  - Examples: tracks, footprints, worm paths, gastroliths (rocks from dinosaurs stomachs), coprolites (fossilized solid waste)

Trace Fossils

Index Fossils

- *Fossils that are easily recognized, abundant, widely distributed geographically, and from organisms who lived in a relatively short period of time*
  - Allows scientists to quickly date rock layers