Age of Earth/Geologic Time

Vocabulary
Geologic Time

Big Ideas
Earth Structures

• Identify current methods for measuring the age of Earth and its parts, including the law of superposition and radioactive dating.
Geologic Time

Misconception
• The Earth is less than ten thousand years old

Reality
• Radioactive dating shows that the Earth is billions of years old
Age of Earth/Geologic Time

• Relative Age
  – The relative age of a rock is its age compared to other rocks
  – Relative age of a rock does not tell us how many years have passed since it was created
Age of Earth/Geologic Time

• Law of Superposition
  – In undisturbed horizontal sedimentary layers, the oldest rock is at the bottom
  – As you move toward the top layer, rocks become younger
• Rock layers in the Grand Canyon
Age of Earth/Geologic Time

• Clues from Igneous Rock
  – Extrusive rock is always younger than the rock beneath it
  – Intrusive rock is younger than the rock beneath and around it
Age of Earth/Geologic Time

• Clues from Faults
  – A fault is always younger than the rock it cuts through
Intrusion
An intrusion cuts through rock layers.

Fault
Rock layers break and shift along a fault.
Age of Earth/Geologic Time

• Clues from Fossils
  – An **index fossil** represents an organism that was widely distributed
  – The organism also existed for a short period of geologic time
  – Index fossils tell us the relative ages of rock layers in which they appear
Age of Earth/Geologic Time

• Gaps in the geologic record
  – Most of the Earth’s geologic record has been lost to erosion
  – Gaps in the geologic record and folding can change the position in which rock layers appear
Age of Earth/Geologic Time

• Gaps in the geologic record
  – When rock layers erode away, an older rock surface may be exposed
  – The deposition begins and new rock layers are built up
  – A surface where a new rock layer meets an much older one beneath is called an unconformity
Age of Earth/Geologic Time

• Gaps in the geologic record
  – Sometimes, forces inside the Earth fold rock layers so much that the layers are turned over completely.
  – These are called **folds**
Sedimentary rocks form in horizontal layers.

**Unconformity**

- Folding bends the rock layer.
- The surface is eroded.
- New sediment is deposited, forming rock layers above the unconformity.

**Overturned Fold**

- Folding bends the rock layer.
- Folding continues, further bending the rock layer.
- Over time, the layers may fold completely over. This is called an overturned fold.
Classwork 1 – Relative Age

1. What is the youngest rock layer? Explain.
2. Is the extrusion older or younger than rock layer B? Explain.
3. Is the fault older or younger than rock layer A? Explain.
4. How could a geologist use the fossil in rock layer B to date a rock layer in another location?
Age of Earth/Geologic Time

• Absolute Age
  - The absolute age of a rock is the number of years that have passed since it was created.
Geologic Time

• Absolute Ages of Rocks
  – Radioactive Elements
    • Less stable nuclei undergo **radioactive decay**
    • Particles and energy are released
    • The nucleus becomes more stable
    • The form of an element that undergoes radioactive decay is known as a **radioactive element**
    • Sometimes a new element is formed in the process (transmutation)
Determining Absolute Age

• Half-life
  – The half-life of a radioactive element is the amount of time required for half of the atoms to decay
  – Each radioactive element (or parent) has a characteristic half-life
  – New elements formed by radioactive decay are called daughters
Determining Absolute Age

- Half-Life Gizmo
Geologic Time

• Absolute Ages of Rocks
  – Radioactive Dating
    • Radioactive elements occur naturally in igneous rocks
    • We can measure the amounts of parent and daughter elements present
    • Since we know the half-life, we can determine the time elapsed since an igneous rock was created
<table>
<thead>
<tr>
<th>Radioactive Element</th>
<th>Half-life (years)</th>
<th>Dating Range (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14</td>
<td>5,730</td>
<td>500–50,000</td>
</tr>
<tr>
<td>Potassium-40</td>
<td>1.3 billion</td>
<td>50,000–4.6 billion</td>
</tr>
<tr>
<td>Rubidium-87</td>
<td>48.8 billion</td>
<td>10 million–4.6 billion</td>
</tr>
<tr>
<td>Thorium-232</td>
<td>14 billion</td>
<td>10 million–4.6 billion</td>
</tr>
<tr>
<td>Uranium-235</td>
<td>713 million</td>
<td>10 million–4.6 billion</td>
</tr>
<tr>
<td>Uranium-238</td>
<td>4.5 billion</td>
<td>10 million–4.6 billion</td>
</tr>
</tbody>
</table>
Geologic Time

• Absolute Ages of Rocks
  – Potassium-Argon Dating
    • Scientists often use the radioactive element potassium-40 to determine absolute age of rocks
    • Its half-life is 1.25 billion years
    • Potassium 40-decays to form argon-40
    • We can measure the amounts of potassium-40 and argon-40 to determine an igneous rock’s age
Geologic Time

• Absolute Ages of Rocks
  – Carbon Dating
    • All forms of life contain carbon, including radioactive carbon-14
    • When an organism dies, the carbon-14 decays to nitrogen-14
    • We can measure the amount of carbon-14 remaining and compare it to the amount of non-radioactive carbon-12 to determine the age.
    • The useful range is up to 50,000 years
1. Scientists use the method of ___ ___ to determine the age of a rock
2. An element that breaks down and releases particles and energy is said to be ___
3. ___ ___ is a way to determine the absolute age of rocks
4. A rock from the moon contains 12.5 % of the potassium 40 it began with. How old is the rock? (12.5 % = 1/8); half-life 1.25 billion yr
5. A fossil contains 1/16 of the carbon-14 it began with. How old is the fossil? Half-life 5730 yr

Copy the questions into your notebook (right-side) and answer them
Geologic Time

• Absolute Ages of Rocks
  – Age of the Earth
    • Since rocks on Earth have changed over time, they cannot be used to determine the age of the Earth.
    • Rocks only formed after the Earth cooled, so they would be younger than the Earth.
Geologic Time

• Absolute Ages of Rocks

  – Age of the Earth

  • Scientists infer that the Moon formed when an object collided with the Earth when it was still molten

  • The Moon does not have tectonic activity or erosion, so rocks on the surface have not changed much since they were created
Geologic Time

• Absolute Ages of Rocks
  – Age of the Earth
    • Radioactive dating of rocks from the Moon show them to be 4.6 billion years old.
    • Scientists infer that the Earth is the same age as the Moon
Geologic Time

• The Geologic Time Scale

– The time span of Earth’s past is great
– So geologists use the geologic time scale to show Earth’s history
– The **geologic time scale** is a record of the geologic events and evolution of life forms as shown in the fossil record
Geologic Time

• The Geologic Time Scale
  – As geologists studied fossils, they found major changes in life forms at certain times
  – They used these to mark when one unit of time ends and another begins
  – At certain of these changes, large percentages of organisms became extinct at the same time
  – These are known as mass extinctions
Geologic Time

• The Geologic Time Scale
  – Divided (from longest to shortest) into:
    • Eons  Half a billion years or more
    • Eras   Several hundred million years
    • Periods
    • Epochs  Tens of millions of years
    • Ages   Millions of years

Source: International Commission on Stratigraphy
Geologic Time

• The Geologic Time Scale
  – Create an acrostic for the five divisions of geologic time.
  – An acrostic is a memory device for remembering vocabulary
  – An acrostic has words that begin with the first letter of each of the words
  – Example: Elissa Excitedly Participates Every A-day

Source: International Commission on Stratigraphy
Geologic Time

• The Geologic Time Scale
  – Divisions
    • Precambrian Time
      – Few fossils survive
      – 88% of Earth’s history
      – Ended 542 MYA
      – Divided into three eons
        » Hadean
        » Archaen
        » Proterozoic
Geologic Time

• The Geologic Time Scale
  – Divisions
    • Phanerozoic Eon
      – Divided into three eras
        » Paleozoic (ended with mass extinction 248 mya)
        » Mesozoic (ended with mass extinction 65 mya)
        » Cenozoic – current era
Geologic Time

• The Geologic Time Scale

  – Divisions
    • Eras are divided into periods
    • Periods are often named for places where geologists first described rocks from them
    • Examples:
      – Devonian
      – Cambrian
      – Mississippian
Geologic Time

• The Geologic Time Scale

  – Divisions

  • The Tertiary and Quaternary Periods of the Cenozoic Era are divided into epochs

  • Note: The period from 10 mya to 650 thousand years ago is also referred to as the Neogene Period

  • Examples:

    – Paleocene Epoch (first in Tertiary Period)
    – Holocene Epoch (last in Quaternary Period)
### Geologic Time Scale, 650 Million Years Ago to the Present

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proterozoic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late</td>
<td>Cambrian</td>
<td>first fishes, first chordates</td>
</tr>
<tr>
<td></td>
<td>Ordovician</td>
<td>sudden diversification of metazoan families</td>
</tr>
<tr>
<td></td>
<td>Silurian</td>
<td>first vascular land plants</td>
</tr>
<tr>
<td></td>
<td>Devonian</td>
<td>jawed fishes diversify</td>
</tr>
<tr>
<td></td>
<td>Carboniferous</td>
<td>first reptiles, scale trees, seed ferns</td>
</tr>
<tr>
<td></td>
<td>Mississippian</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pennsylvanian</td>
<td></td>
</tr>
<tr>
<td><strong>Mesozoic</strong></td>
<td>Jurassic</td>
<td>dinosaurs diversify, first birds</td>
</tr>
<tr>
<td></td>
<td>Triassic</td>
<td>first mammals</td>
</tr>
<tr>
<td></td>
<td>Cretaceous</td>
<td>first flowering plants, first primates</td>
</tr>
<tr>
<td></td>
<td>Tertiary</td>
<td>mammals diversify</td>
</tr>
<tr>
<td><strong>Cenozoic</strong></td>
<td>Quaternary</td>
<td>evolution of humans</td>
</tr>
</tbody>
</table>

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Geologic Time Scale
An acrostic to remember it all

<table>
<thead>
<tr>
<th>Pregnant</th>
<th>Precambrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>camels often sit down carefully. Perhaps their joints can't tolerate quickness.</td>
<td>Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian-</td>
</tr>
<tr>
<td></td>
<td>periods of Paleozoic era</td>
</tr>
<tr>
<td>Possible early oiling might prevent permanent hardening</td>
<td>Triassic, Jurassic, Cretaceous - periods of Mesozoic era</td>
</tr>
<tr>
<td></td>
<td>Tertiary, Quaternary - periods of Cenozoic era</td>
</tr>
<tr>
<td></td>
<td>Paleocene, Eocene, Oligocene, Miocene, Pliocene - epochs of Tertiary period</td>
</tr>
<tr>
<td></td>
<td>Pleistocene, Holocene - epochs of Quaternary period</td>
</tr>
</tbody>
</table>
Geologic Time

• Absolute Ages of Rocks
  – Uniformitarianism
    • Geologic processes that operate today operated in the past
    • Natural process such as weathering, erosion and plate tectonics have reshaped the Earth’s surface
    • The distribution of land and water on Earth’s surface has changed over time
Classwork 3 – Geologic Time

1. Did any of the rock in this part of the Grand Canyon form before the Paleozoic Era began? Explain.
2. During which period did the Redwall limestone form?
3. During which period did the Bright Angel shale form?
4. During which period did the Coconino sandstone form?
5. Did any of the rock that forms the Grand Canyon form during the Mesozoic Era? Explain.
6. What periods of the Paleozoic Era are not represented by rock of the Grand Canyon? How might you account for such gaps?

Copy these questions on the right-hand page of your journal.
When you are finished, I will show you the diagram you need to answer them.
As the Colorado River cut down through Earth's crust to form the Grand Canyon, it exposed layer after layer of sedimentary rock.

- Permian Period
- Carboniferous Period
- Devonian Period
- Cambrian Period
- Precambrian Time
- Colorado River