Early Earth

Age:
______________________ years old

How do we know?
_________________________________

Early Earth conditions:
• Hot!
• _______________________________

Formation of the oceans (about 4 billion years ago):
• From condensed ________________.

Early atmosphere from volcanic gasses:
______________________,
______________________,
______________________,
First life: ______________________years ago
• Single celled. Prokaryotic (____________)
• Developed in the ________________.
• Most likely heterotrophic (consumers) and anaerobic (live without oxygen)

Photosynthetic life: 3.5 billion years ago
______________________________ in the ocean
• __________________ waste by-product
• took about a billion years to build
• up in the ________________.
Fossils

Definition: A record of life that_________

Types:

• **Permineralization/petrification:** Minerals________________________ material.
• **Natural Casts:** impression is filled in with minerals.
• **Trace Fossils:** record of activity (nests, ____________ of leaves and feathers, footprints)
• **Amber:** trapped in fossilized ____________.
• **Preserved:** whole organisms preserved from decay (bogs, ____________, volcanic ash)
Why are complete fossils so rare?
• ________________
• Not yet exposed
• Very specific ________________

Relative Dating: ________________ of fossils in rock layer help determine ________________ age.
Radiometric Dating

Relies on _______________of unstable isotopes.

**Half-life**: The amount of time for ___________of an isotope to decay.

Determining age: Compare the amount of the ____________ vs. ____________ isotope and apply the known ______________.

Carbon 14 decays to Nitrogen 14
Half life= 5700 years
Chlorine 36 decays to Argon 36
Half life – 300,000 years
<table>
<thead>
<tr>
<th>Event</th>
<th>Approximate Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth formation</td>
<td>_____ million years ago</td>
</tr>
<tr>
<td>___________ formed</td>
<td>3800 million years ago</td>
</tr>
<tr>
<td>First life (bacteria)</td>
<td>_____ million years ago</td>
</tr>
<tr>
<td></td>
<td>3700 million years ago</td>
</tr>
<tr>
<td>Complex single celled (eukaryotic)</td>
<td>2000 million years ago</td>
</tr>
<tr>
<td>Multi-cellular organisms</td>
<td>1000 million years ago</td>
</tr>
<tr>
<td>Simple animals (ocean)</td>
<td>600 million years ago</td>
</tr>
<tr>
<td>___________ plants</td>
<td>475 million years ago</td>
</tr>
<tr>
<td>___________ / extinction of dinosaurs</td>
<td>65 million years ago</td>
</tr>
<tr>
<td>Primates</td>
<td>33 million years ago</td>
</tr>
<tr>
<td>Anatomical “Modern” Human</td>
<td>0.2 million years ago</td>
</tr>
</tbody>
</table>
Absolute dating is:

A. A way to determine the exact age of rocks and fossils.
B. Using radiometric dating to determine approximate ages.
C. Using index fossils in rock layers to determine the age of fossils.
D. Using the position of a fossil in the rock layers to determine its age.
Early ideas:
**Spontaneous Generation** - Early 1600’s: Life from _____________________.

Ex: Flies from meat, fish from mud, mice from rags or straw.

Redi’s experiment with _______ & _______. (1668).

Louis Pasteur’s experiment with ___________ and _______________ (1800’s):

**Biogenesis:**
Life comes from ___________________.
How did life begin?

3 requirements:

- Formation of ____________ organic molecules
- Formation of ____________ organic molecules
- Formation of ____________

Miller and Urey’s experiment 1953:
Used early ____________ molecules and ____________ (“lightning”) to develop simple ____________ (amino acids).
Hypotheses of how life started

Meteorite Hypothesis:
Organic molecules from ______________. Over 90 amino acids found.

Iron sulfide bubble hypothesis:
Protective “bubbles” could allow _______________ for life to combine. Energy from sulfide from volcanic vents.

Lipid membrane hypothesis:
Lipid membranes formed first. “______________”.

RNA as early genetic material: Can catalyze ________________.
Prokaryotic vs. Eukaryotic


Endosymbiosis theory:
Eukaryotic cells developed through small ___________ incorporating itself inside larger ___________ developing into mitochondria for ______________ and chloroplasts for _____________________.

Significance:
These more complex cells allowed __________________organisms to evolve.
Evidence for endosymbiosis:
Mitochondria and Chloroplasts have their own ________ material and can ______________ themselves.

Right size and ____________ similar to bacteria.

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Endosymbiosis in a nutshell:

1. Start with two independent bacteria.
2. One bacterium engulfs the other.
3. One bacterium now lives inside the other.
4. Both bacteria benefit from the arrangement.
5. The internal bacteria are passed on from generation to generation.

Modern animal and plant cells contain many organelles that serve as compartments for different cellular activities.

Oxygen-breathing bacterium
Photosynthetic bacterium
Most membrane-enclosed organelles, including the nucleus, ER and Golgi, probably originated from deep folds in the plasma membrane.
Mitochondria and chloroplasts originated as bacterial cells that came to live inside larger cells.

The young earth supported many types of bacteria.
Order the following based on age (oldest to youngest)

- Oceans formed
- Earth formed
- Photosynthetic organisms
- First life
- First land organisms
- Multi-cellular life
- Oxygen starts building up in the atmosphere
- Mammals
Which description best matches Redi’s experiment:

A. Using S-shaped Flasks to show biogenesis applies to bacteria.
B. Using Flies and Meat to disprove spontaneous generation.
C. Using fossil evidence to show how species have changed over time.
D. Using early atmospheric gases and lightning to show how simple organic molecules can be formed.
Briefly explain what the endosymbiosis hypothesis states: