

Evolution lecture #7 -- **Early earth, continental drift, early life** -- Nov. 17<sup>th</sup>, 2008  
507-520 (ch. 25) 8th; 492-493, 512-533 (ch. 26) 7th

## • Summary of topics

- **Early Earth**
- **Origin of life**
- **Fossils** -- their kinds & how they are made
- Division of **eras** into **periods** and **epochs**
- **Continental drift** (plate tectonics)

## • Early Earth (movies)

**Solar System:** Our sun formed from the collapse of a cloud of gas and dust in the outskirts of the Milky Way Galaxy about 4.6 BYA. This cloud began to rotate, and lumps in it began to stick together, eventually forming planets (which continued collecting debris)

**Impacts:** were a major feature of early earth; they became less frequent about 4.0 - 3.8 BYA as the extra matter in the solar system was mostly collected into the planets.

**Appearance of life:** definitely present 3.5 BYA; perhaps as early as 3.9 BYA. Definitive evidence is presence of fossil cells of bacteria. Suggestive evidence of a slightly earlier origin in the isotopic signal of life in the rocks (carbon-12 enrichment, more later).

**Early Earth had no atmosphere**, the first real atmosphere developed along with the first ocean about 4.0 - 3.8 BYA and was composed of CO<sub>2</sub> and many other compounds such as hydrogen, nitrogen, methane, hydrogen sulfide, and ammonia (some serious greenhouse gases -- temperature at the surface was around 85<sup>0</sup>C! ).

## • Origin of life

**Stanley Miller:** studied chemical reactions simulating those of early earth (1950's).

**early atmosphere of earth:** as described above, plenty of organic compounds and water vapor, but **no free oxygen** was present. Much volcanism, lightening, and UV radiation.

**Miller's experimental results:** Within a few hours the system contained numerous simple organic compounds. In water these were rapidly converted into amino acids, simple acids and other compounds, and because these molecules are relatively stable, they quickly accumulate in solution.

Comparable results are obtained, including production of DNA and RNA, under a variety of conditions, provided that free oxygen is absent. Thus, once earth cooled enough for water to condense and form oceans, molecules of many kinds formed spontaneously, and they probably accumulated until they reached relatively high concentrations.

Life may have emerged from non-life in such an anaerobic "primordial soup", and non-living materials became ordered into molecular aggregates that were eventually capable of replication and metabolism. Because of the presence of oxygen in our atmosphere now life cannot spontaneously occur. And even if it did, something now living would probably eat it!

Life may also have evolved around deep-sea vents, or it may have resulted from extraterrestrial sources.

## • Fossils

**fossil:** any **remains, impressions** or **trace** of a living thing of a former geologic age, as a skeleton, footprint etc. (Fig. 25.4 (8 & 7th)).

Most species that have ever lived left no fossils.

Most fossils that have formed have been destroyed.

Only a minute fraction of existing fossils have been discovered.

Most fossils are formed from the **hard** parts of animals and plants, such as shells, bones, teeth, or wood.

Fossilization is a very **chancy** process and happens rarely.

The burial process is usually by sand or mud washed down by water, or in a desert sandstorm.  
Most fossils occur in sedimentary rocks – sandstone, clays, shales, chalk.

Animals and plants have also been preserved in peat and coal (swampy plants), oil (tiny plankton plants), tar, ice, and amber (the resin of ancient trees), and may still have DNA.

Fossils may be virtually unchanged from the originals (rare), or they may be mineral replacements, casts or molds (impressions), "mummies", or impressions of the skin, feathers, and some soft tissues may be preserved.

Eggs, footprints, and burrows can be fossilized.

Some animals are more likely to be fossilized than others, e.g., those with shells.

#### **Four types of Fossils**

**Intact** - The pollen was preserved intact because no decomposition occurred.

**Compression** - Sediments accumulated on top of the leaf and compressed it into a thin carbon-rich film.

**Cast** - The branch decomposed after it was buried. This left a hole that filled with dissolved minerals, faithfully creating a cast of the original.

**Permineralized** - The wood decayed very slowly, allowing dissolved minerals to gradually infiltrate the cells and then harden into stone.

#### **What do fossils tell us?**

bones: size and shape of animal, muscle attachment sites and size;

defense mechanisms: horns, claws, etc.;

teeth: diet;

footprints: movement of animals, speed, whether or not they lived in herds, etc.;

eggs: fossil eggs can reveal evidence of nesting and parental behavior in animals;

skin: type of skin, armor plates in dinosaurs, etc.

**Principle of Superposition, Steno's Law:** in an **undisturbed** sequence of rocks, the oldest layer is at the bottom and the youngest is at the top.

**index fossils:** the rock strata at one location can often be correlated with strata at another location by the presence of similar fossils. (William Smith, 1769 -1839, geology of England)

**radioactive dating:** a method of determining the age of fossils and rocks using half-lives of radioactive isotopes (Fig. 25.5 (8th), Fig. 26.7 (7th)).

When molten rock cools, forming what are called igneous rocks, radioactive atoms are trapped inside. Afterwards, they decay at a predictable rate. By measuring the quantity of unstable atoms left in a rock and comparing it to the quantity of stable atoms in the rock, scientists can estimate the amount of time that has passed since that rock formed.

**bracketing the fossils:** fossils are generally found in sedimentary rock, not igneous rock. Sedimentary rocks can be dated using radioactive carbon, but because carbon decays relatively quickly, this only works for rocks younger than about 50 thousand years.

In order to date most older fossils, scientists look for layers of igneous rock or volcanic ash above and below the fossil. Scientists date igneous rock using elements slower to decay, such as

uranium and potassium. By dating these surrounding layers, they can figure out the youngest and oldest that the fossil might be; this is known as “bracketing” the age of the sedimentary layer in which the fossils occur.

Half-life of  $^{13}\text{N}$  is 10 minutes  
Half-life of  $^{238}\text{U}$  is 4.5 billion years  
Half-life of  $^{14}\text{C}$  is 5600 years

Since half-life of  $^{14}\text{C}$  is 5600 years,

And living material has 16 units of radioactivity per gram of carbon

*Calculate these ages:*

Human hair from a cemetery in pre-dynastic Egypt has 8 units left and is therefore \_\_\_\_\_ yrs old

Charcoal from the Lascaux Caves in France has 2 units left and is therefore \_\_\_\_\_ yrs old.

### • Division of eras into periods and epochs

**Eras:** See Table 25.1 (8th), Table 26.1 (7th)

Precambrian (4.6 billion to 542 Myr)

Paleozoic (542 to 251 Myr)

Mesozoic (251 to 65 Myr),

Cenozoic (65 Myr to present).

These eras are **not** evenly spaced time intervals - but are based on major changes in the fossil record: the beginning of an abundant fossil record at the start of the **Paleozoic**, and very major extinction events at the end of the **Paleozoic** and **Mesozoic** eras Fig. 25.14 (8th), Fig. 28.6 (7th).

**Mass extinctions:** are relatively sudden events where a large fraction of biodiversity is lost. At least some of these (maybe all?) are linked to impacts with asteroids.

**Other factors** to keep in mind that have affected patterns of biodiversity: climate and sea levels have changed dramatically, and the positions of the continents on earth with respect to each other has changed.

**Time periods in earth history** to know for this class:

<u>Era</u>	<u>Period</u>	<u>Epochs</u>
Paleozoic	Cambrian	
	Ordovician	
	Silurian	
	Devonian	
	Carboniferous:	Mississippian, Pennsylvanian
Mesozoic	Permian	
	Triassic	
	Jurassic	
	Cretaceous	
Cenozoic	Paleogene:	Paleocene, Eocene, Oligocene,
	Neogene:	Miocene, Pliocene, Pleistocene (1.8 Myr), Holocene (Recent) (10,000 yrs)

### **Summary of Eras (more next two lectures)**

#### Precambrian Era

- Earth is 4.6 billion years old
- Life began about 3.5 billion years ago
- By end of era there are pro- and eukaryotes and multicellular marine invertebrates

#### Paleozoic Era

- Begins and ends with marine invert. radiation and extinction.
- Movement onto land by plants and animals
- Vertebrates appear

#### Mesozoic Era

- Rise and fall of the dinosaurs
- Origin of mammals, birds and flowers

#### Cenozoic Era

- Pollinating insects diversify
- Appearance of *Homo sapiens*

#### **Memory games:**

1. **C**amels **O**rdinarily **S**it **D**own **C**arefully, **P**erhaps **T**heir **J**oints **C**reak, **P**ossibly **E**arly **O**iling **M**ight **P**revent **P**remature **R**usting.
2. **C**ampbell's **O**rdinary **S**oup **D**oes **M**ake **P**eter **P**ale,  
**T**rial by **J**ury in the **C**retaceous,  
**P E O M P P H.**

## • Continental drift (plate tectonics)

**continental drift:** changing of the positions of the continents.

**Gondwanaland:** Africa, South America, India, Antarctica, Australasia.

**Pangaea:** all the world's continents united in one land mass.

**Wegener:** proposed theory of continental drift in 1915.

**plate tectonics:** the earth's crust is divided into seven enormous plates and several smaller ones: the theory that explains the movement of continents is called plate tectonics (Fig. 25.12 (8th), Fig. 26.18 (7th)).

**geological consequences of plate tectonics:** Many important geological phenomena, including mountain building, volcanic eruptions and earthquakes, happen at plate boundaries, e.g., the San Andreas fault is part of a border where two plates slide past each other.

## CONTINENTAL DRIFT (major features) (Fig. 25.13 (8th), Fig. 26.20 (7th))

**Cambrian** – Gondwanaland forms

**Permian** - Pangaea forms

**Cretaceous** - Major breakup of Pangaea

**Eocene** - Australia, Antarctica, India, S. America, Africa all "island" continents.

**Miocene** - Similar to present day

**Pliocene** - Connection of N. and S. America

## Paleontological evidence of continental drift:

1. The Carboniferous rocks both of North America and Europe have yielded virtually the same fossil floras and faunas, associated with coal swamps and an equatorial climate.
2. The late Carboniferous and early Permian rocks of the southern continents (South America, Africa, India, Australia and Antarctica) on the other hand, all show evidence of extensive glaciation.
3. Triassic reptiles of S. America and Africa match.

### **Introduction to some biogeographic terms:**

**endemic:** A group of indigenous species which is restricted to, and native to, a particular geographic area.

**vicariance:** separation of a continuously distributed ancestral population or species into separate populations, due to the development of a topographic or ecological barrier. (more later).

### **Questions relating to lecture on Early earth, continental drift, early life**

1. Do self-quiz questions #'s 1-3, 6 and 8 on pages 532-533 of the textbook (8th edition), or:  
Do self-quiz questions #'s 1, 5-7, and 9 on pages 532-533 of the textbook (7th edition)
2. What are the conditions of early earth that made origin of life possible?
3. Why couldn't it happen again now?
4. Discuss why some scientists believe life began at deep-sea vents.