

CHAPTER 25: THE HISTORY OF LIFE ON EARTH

>>A time line for planet earth

- The earth is very old, about 4.6 billion years old
- As earth cooled the oceans formed

How did life originate? Was it really **spontaneous generation**? Something from nothing?

- The building blocks of macromolecules can be formed from nonliving matter if the conditions are right.

>>>>>>In the 1920's and 1930's two researchers:

- **John Burdon Sanderson (J.B.S.) Haldane** in England and **Aleksandr I. Oparin**, a Russian biochemist, independently hypothesized that the atmosphere of the primitive Earth was probably very different from today's.

Early atmosphere had:

- little or no oxygen
- rich in hydrogen, methane, other hydrocarbons and ammonia
- Most of these can come from volcanic sources

- **Haldane** and Oparin suggested that the organic compounds in the first organisms could have been formed by the interaction of sunlight (UV radiation) and the heat (from volcanoes or lightning) with the chemicals in the atmosphere of the primitive Earth.
- This process of chemical evolution is called **prebiotic evolution**
 - o Evolution before life existed

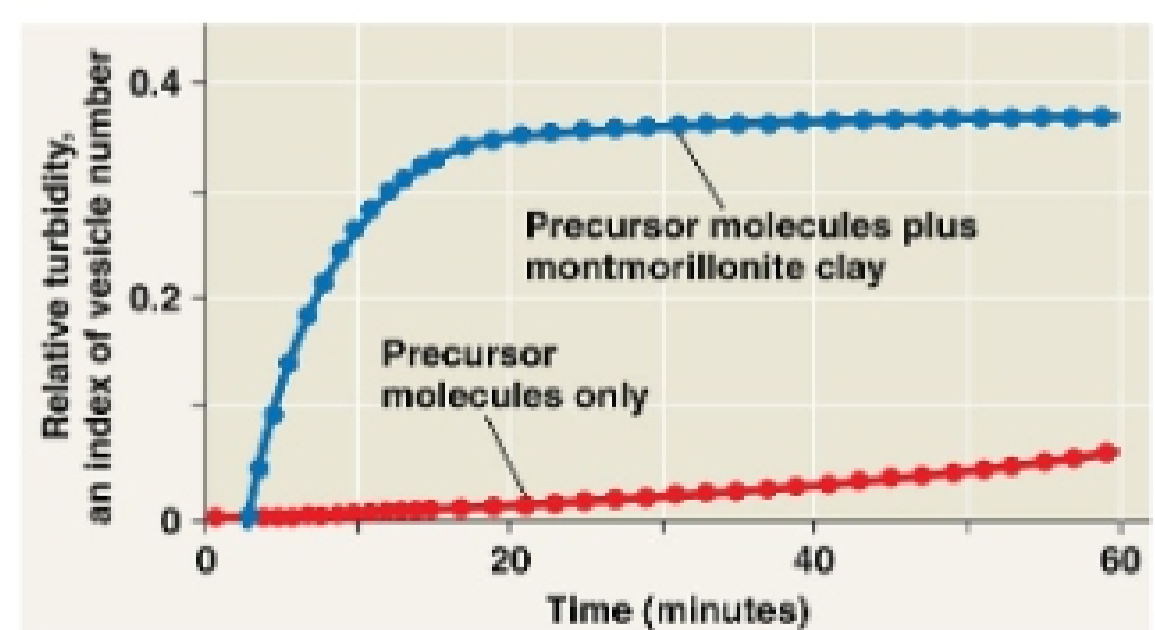
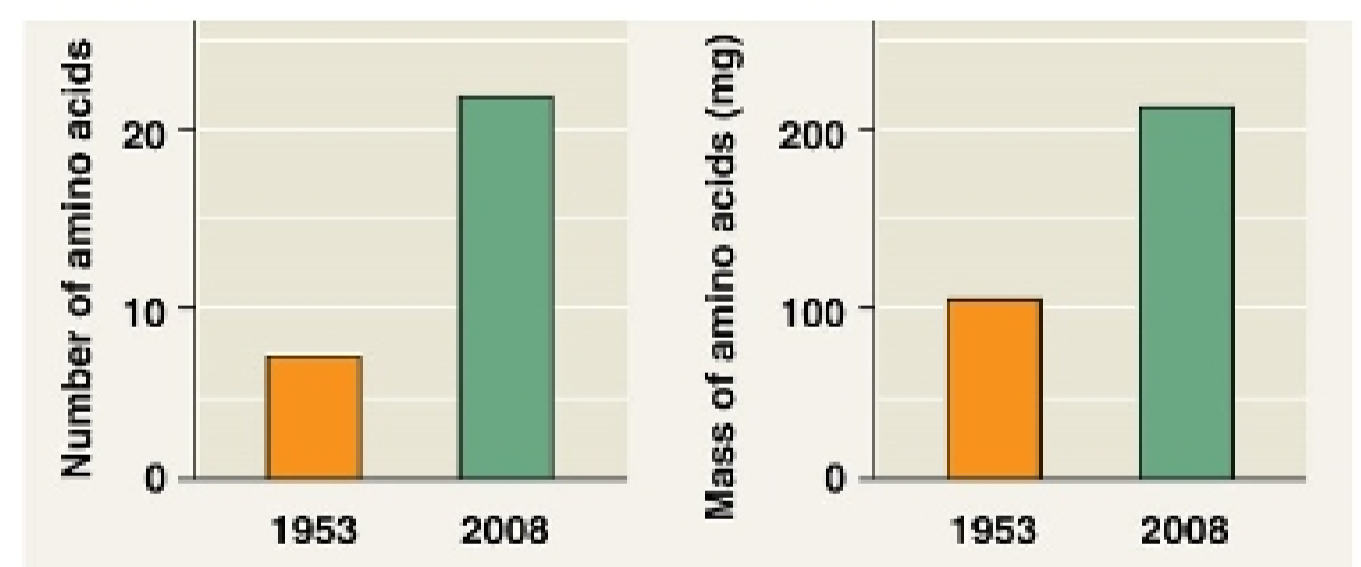
The hypothesis of abiotic formation of organic molecules was tested in 1953 in the laboratory of **Stanley Miller** and **Harold Urey** (see fig. 25.2).

- A variety of organic compounds were created.
 - o amino acids
 - o short proteins
 - o sugars
 - o fatty acids
 - o nucleotides

All the building blocks can arise without life.

>>>The building blocks accumulated and the simple molecules condensed into more complex ones

- **monomers** into **polymers**



(a) Self-assembly

- This might have taken place on the surface of minerals (clay) or in oily droplets floating in the prebiotic soup.

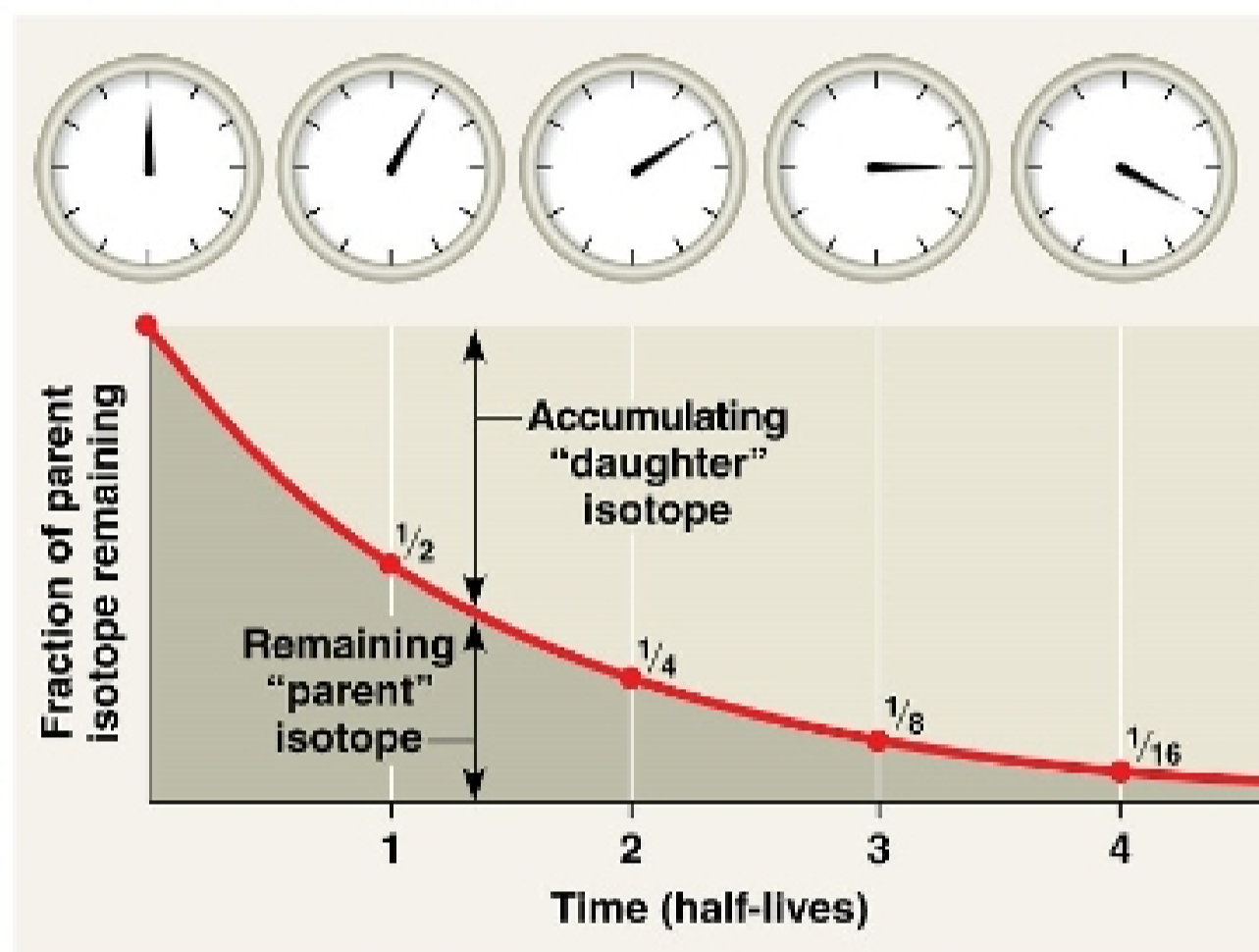
Sidney Fox showed that polypeptides (polymers of amino acids) could be produced abiotically.

>>>The polymers can form aggregates which could maintain an internal environment different from their surroundings and exhibit some biological process.

- A **protocell** is an example of one of these aggregates
 - o A protein membrane with an internal compartment.

>>>The ability to reproduce, one giant step for life.

- For life to persist after becoming established there must have been polymer molecules capable of replicating, or making copies of, themselves.
- The first self-replicating polymers were probably nucleic acids.
- One hypothesis is that RNA was probably the polymer which acted as the first genetic material.
- Some of the evidence for RNA as the first genetic information is:
 - o RNA molecules can self-replicate, up to 40 monomers can be connected abiotically into a polymer chain
 - o Some RNA molecules, like **ribozymes**, are autocatalytic. That is, the RNA molecules can act to modify themselves (or other RNA molecules).

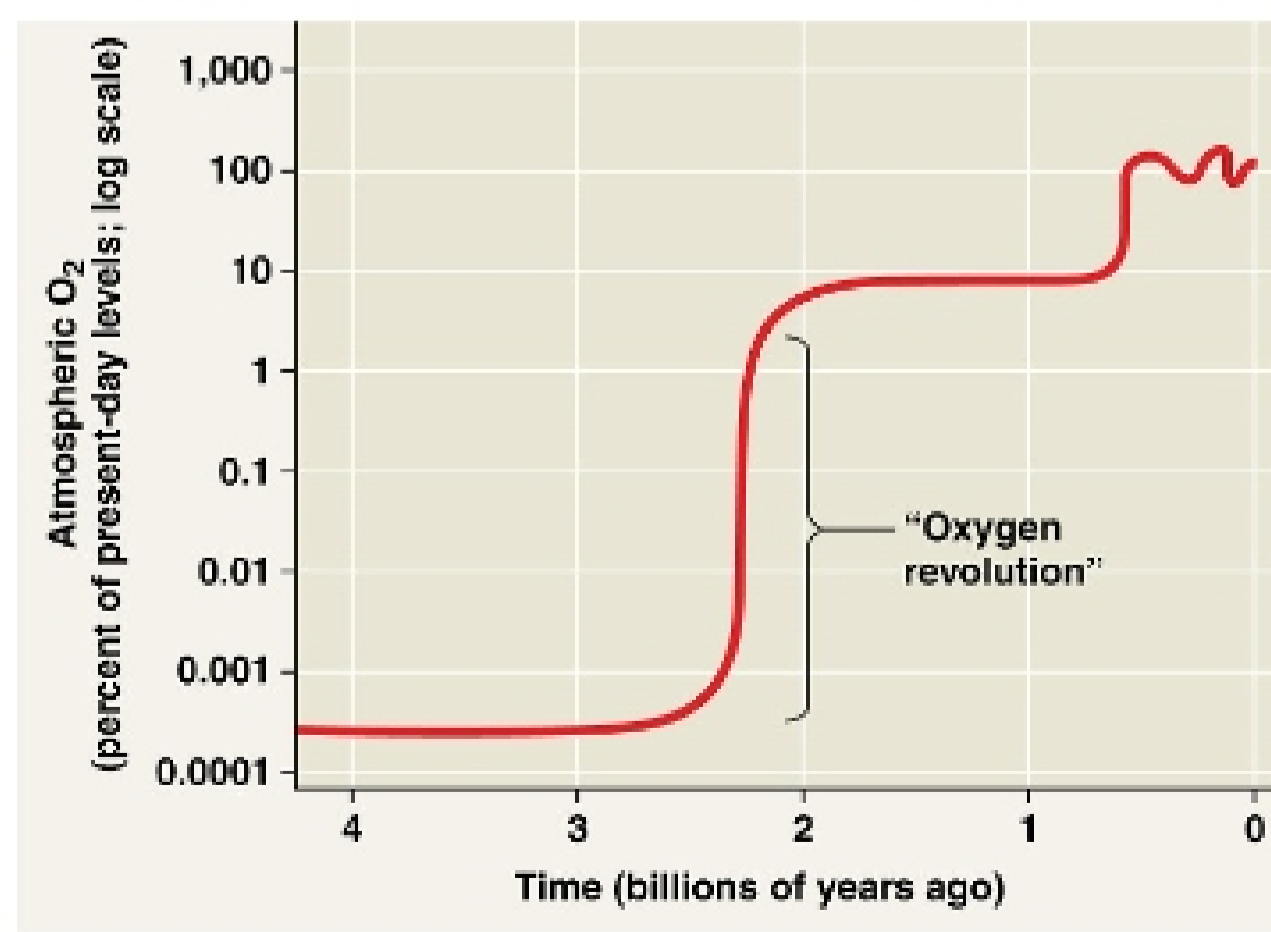


>>>>Why doesn't life arise today??

- The atmosphere has more oxygen and the presence of oxygen can break or prevent the formation of the chemical bonds which are needed for the abiotic formation of organic molecules.
- The atmosphere also has developed an ozone layer which blocks UV radiation that may have been an energy source for the abiotic formation of organic molecules.

>>>The first life forms

- According to fossil evidence, the first life forms (prokaryotes) showed up around 3.5 billion years ago



How do we know the age of the fossils?

- Radiometric dating (see fig 25.5)
- Since there was little or no oxygen these early life forms were **anaerobic**.
- Photosynthetic bacteria added oxygen to the atmosphere

>>>From prokaryotes to eukaryotes.

- The origin of chloroplasts and mitochondria
- **Endosymbiotic hypothesis** (see fig 25.9) is a hypothesis about the origin of the eukaryotic cell, maintaining that the forerunners of eukaryotic cells were symbiotic associations of prokaryotic cells living inside larger prokaryotes

Both of these organelles have prokaryotic traits.

- Size of the organelle
- Circular DNA
- Prokaryotic ribosomes
- Ability to "reproduce" by binary fission.

Endosymbiotic hypothesis

- The origin of the nucleus is harder to envision
- Not only the how but the why.

>>>Multicellularity

- Bigger is better
- Less chance of being eaten and better chance of eating something smaller
- But too big means more cells.
- The size of a single celled organism is limited by diffusion
- More cells eventually means specialization of some cells
- The first step toward tissues, organs, organ systems, etc.

>>>Transition to land means life without water

- Adaptation to land
- Protection from drying out.
- Plants made it to land first
 - o better light for photosynthesis
 - o more concentrated nutrients
- However needed a method of support
 - o Animals followed the plants

