

Topic: The History of Life

Reading: Chapter 17

Main concepts:

- Experiments by Francesco Redi, Lazzaro Spallanzani, and Louis Pasteur showed that living things arise from other living things. Pasteur's experiment led to the rejection of the theory of Spontaneous Generation. But if living things give rise to living things, where did the first living things come from?
- Life has a point of origin. While evidence showing how life began is scant, there is good evidence that organic molecules can spontaneously form in the conditions that existed when the earth was young. Properties of organic and inorganic molecules suggest ways that they could have combined to lead to the first self-replicating molecules and cell-like structures. While science has ideas about how the first living things could have formed, we do not know what actually happened.
- The first known living things were anaerobic prokaryotic bacteria or bacteria-like organisms. At the time there was little or no free oxygen in the atmosphere.
- The evolution of photosynthetic bacteria changed the earth's atmosphere by releasing free oxygen. This was the world's first pollution problem. This enormous environmental change selected for bacteria that could either hide in anaerobic environments (such as deep mud) or could tolerate oxygen. The development of aerobic metabolic pathways gave some bacteria a strong advantage.
- The eukaryotic cell may have arisen through symbiotic relationships between early aerobic prokaryotes. Mitochondria, which are in all eukaryotic cells, and chloroplasts, which are in plant cells, have their own DNA and have features that are very prokaryote-like, suggesting that these organelles are actually symbiotic organisms. Because mitochondria are universal among eukaryotes, this symbiotic relationship must have developed very early.
- Colonies of early eukaryotic one-celled organisms most likely led to specialization that eventually produced the first multicellular organisms.
- Organisms that colonized land masses had to have certain traits that prevented them from drying out, supported them out of water, and allowed reproduction outside of the water. Plants were the first organisms to colonize the land, beginning with algae that could tolerate some dryness. Arthropods were the first animals to live entirely on the land. The abundance of arthropods on land, providing a protein-rich food source, is what allowed early proto-amphibians to successfully colonize land. These eventually gave rise to other land vertebrates.
- Mass extinctions are a part of earth's history. We do not know the causes of all of the extinctions. Some evidence suggests that the extinction event that occurred at the end of the Cretaceous era and that killed % of the species on earth (including the dinosaurs, which were already in decline) may have been caused by a large asteroid. We are living in a major extinction event, and we humans are the cause of it.
- Fossil and molecular evidence suggests that humans and the great apes evolved from earlier primates. Human and hominid fossils are rare, so the human evolutionary family tree is not well understood. There is strong evidence that the genus *Homo* arose in Africa and eventually migrated over most of the planet.

Common misconceptions:

- "Bacteria are still prokaryotic because they stopped evolving." Bacteria, in fact, evolve much more rapidly than many other organisms. Remember that evolution is the change in the genetic of a population over time. It is not an inevitable progression from "primitive" to "advanced."
 - "Evolution says that man came from monkeys." Modern monkeys and modern humans may be related genetically, but modern monkeys are not our ancestors. What evolution suggests is that all primates, including apes, monkeys, humans, lemurs, and gibbons, have a common ancestor.
 - "Evolution can't be 'proven' until science describes exactly how it happened." There is overwhelming evidence that: organisms change genetically over time; the earth is several billion years old; organisms exist today that did not exist in the past; over 90% of the organisms that have ever lived have gone extinct. We may not know exactly how all species formed, but we can see, observe, and measure genetic change over time and genetic relationships between species.
 - "The next step in human evolution is...(bigger brains, loss of little fingers, etc.)" There is no inevitable "next step" in evolution. We can't assume, looking at past events, that the organisms we see today represent a
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goal toward which evolution was striving. Traits will only increase if that increase is selected for. Likewise, traits will only disappear if they are selected against.

Reading notes:

- Describe how Louis Pasteur's experiment refuted the idea of spontaneous generation, and why this was important.
- Describe Stanley Miller's experiments and what insights the results give to the possible ways biological molecules and early life could have formed. Do the experiments tell us exactly how life formed?
- Describe why RNA is the prime candidate for the first self-replicating molecule. Define "ribozyme." Look up "ribosome" in the textbook (see chapter 10 for the role of the ribosome in constructing proteins from information in the DNA). Could ribosomes be described as ribozymes?
- Describe how vesicles suggest how primitive membranes could have formed.
- What evidence suggests that the earliest organisms were anaerobic prokaryotes?
- What problems arose as the first photosynthetic organisms released free oxygen?
- Describe hypotheses regarding how eukaryotic organisms arose. What evidence suggests that mitochondria and chloroplasts are symbiotic organisms?
- What problems did organisms have to overcome to colonize the land? What adaptations led to successful colonization?
- What are the major causes of global mass extinctions?

Useful websites:

- "Miller-Urey experiment" <http://www.ucsd.tv/miller-urey/> is an interactive animation that will allow you to recreate the classic experiments. What happens if oxygen is added to the mix?
 - "Stories from the Fossil Record" <http://www.ucmp.berkeley.edu/education/explorations/tours/stories/index.html> is an online tutorial aimed at middle school students that explains what fossils are and what we can learn from them. While it is a bit simplistic in some parts, it does provide a good introduction.
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