History of Life Lecture Guide

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*Number in outline corresponds to slide number the PowerPoint presentation.

1. History of Life and Systematics
2. Earth. Star Date 0000.0
    a. Before we really dive into the diversity unit, it is important to understand the progression of organisms as they arose on the planet, a time line of life so to speak. The earth is somewhere around 4.5 billion years old, and the first evidence of life appears in the fossil record approximately 3.5 billion years ago.
    b. The conditions on the planet were drastically different than we know them now. In the beginning, earth teemed with volcanic activity, violent electrical storms and no oxygen gas present at all. In the first billion years of earth's existence the intense heat of the planet cooled, rocks formed and eventually cool enough for water to exist in liquid form. Once liquid water came onto the scene, that's when things really got interesting. With the appearance of water, life followed very quickly after.

3. In the Beginning…
    a. Recall that the smallest unit of life that can exist as its own entity is a cell. There are two basic types of cells that exist: Prokaryotes and Eukaryotes. Prokaryotes are the simpler of the two, and were the first to arise. We will learn more about these types of organisms in the next module, but for now just keep in mind that prokaryotes are also commonly known as bacteria.
    b. The first prokaryotes were most likely chemoautotrophs. Since oxygen gas is not yet present, the earliest cells used other methods of energy acquisition than the process that is most prevalent now: cellular respiration. Eventually however, cells with a new method of energy production evolved. Cells began to use the process of photosynthesis to obtain energy.
    c. Enter oxygen gas. Photosynthesis set the stage for drastic changes in earth's atmosphere and really was a major turning point in Earth's diversity of life. As oxygen content in the atmosphere increased, many species of bacteria were wiped out because oxygen was actually toxic to them. The phase in earth's history is sometimes called the oxygen holocaust. Along with the destruction of intolerant species, the increase in oxygen levels drove the evolution of bacteria that are capable of tolerating, and even utilizing the molecule.

4. Endosymbiont Hypothesis
    a. Life progressed slowly for ~1.5 billion years, and soon after oxygen tolerant bacteria began to evolve, the second type of cell, the eukaryote began to evolve. Eukaryotes are much more complex than prokaryotes. They are larger, with internal compartments that carry our specialized functions for the cell. Mitochondria, the organelle responsible for cellular respiration and chloroplasts, the organelle responsible for photosynthesis are two important examples of these specialized compartments.
    b. The most widely accepted hypothesis on how eukaryotes evolved, the one that has the most supporting evidence is known as the endosymbiont hypothesis. This hypothesis suggests that certain species of bacteria became reliant upon each other to develop a tolerance to the changing atmosphere. The endosymbiont theory suggests that in this new landscape, where both aerobic and anaerobic bacteria exist, anaerobes engulfed aerobic bacteria, and sometimes photosynthetic bacteria.
    c. Chance events resulted in these engulfed bacteria began to live and thrive off of the metabolic wastes of the host cell, and vice versa. The host cell began to benefit from the metabolic wastes of the bacteria that are living and reproducing inside of them. And thus eukaryotic cells, complete with mitochondria and chloroplasts, were born.

5. Life's Timeline
   a. From that point on, the sky was the limit in terms of the types of life that evolved, including the first multicellular organisms (most likely algae). Soft-bodied invertebrates such as worms and jelly fish followed, and then predatory animals such as arthropods (animals with an exoskeleton) and fishes (chordates) arose, followed shortly by a group of organisms known as fungi.
   b. At this point all life was restricted to the ocean. It is believed that algae and fungi began the migration inland around the same time, moving up freshwater sources. Moving onto land created a unique set of challenges to be overcome. Organisms now have to deal with the effects of gravity, as well as the dry conditions on land. Each group of organisms dealt with these challenges in their own way, and we will discuss them in turn as we explore the different kingdoms of life in the coming modules.

6. From Sea to Land
   a. Plants and animals took their own evolutionary paths, but often times influenced the direction each path went. For example, arthropods were the first animals to invade land, and were wildly successful. As a matter of fact, insects, a specific group of arthropods are the most diverse and abundant organisms on the planet, rivaled only by the diversity of flowering plants. And it was the insects that drove the vast diversity of flowering plants to evolve, utilizing the behaviors of these animals to fulfill their own reproductive lifecycles (Pollinators!)
   b. The progression of vertebrates moving inland also has its own story, starting with amphibians, which are still to this day tied and require water during part of its lifecycle. From amphibians arose the reptiles, evolving strategies to cut the apron strings that kept them tied to wet habitats. From the reptiles eventually came birds and mammals, often thought of as the pinnacle of the evolutionary process that began 200 million years ago. Although there are several conflicting theories on the evolution of the modern day human, the fossil record suggests we came on the scene only ~200,000 years ago, so we are babies in evolutionary time!

7. Tree of Life
   a. Now that we have an idea of the history of life, let's briefly discuss the ways in which we classify the different types and groups of life. The branch of biology that is responsible for classifying and naming organisms is called taxonomy, and was created by a man named Carl Linnaeus in the 1700's. He created a hierarchal system to label organisms which has 8 categories. At the top of this hierarchy is the domain.
   b. There are three domains that all life can be placed, two of which consist entirely of bacteria. The third domain includes all eukaryotic organisms. Thus, the domain is the most inclusive of all taxonomic categories, and the rest of the categories become increasingly exclusive. Within the domain Eukarya, there are 4 kingdoms: protista, fungi, plants, and animals. In the following modules we will explore these kingdoms in depth.

8. Taxonomy
   a. The rest of the taxonomic categories are demonstrated here in this slide using the classification of humans. Each rank tells us just a little bit more about the organisms classified in that group, until we reach the level of species, which includes populations of organisms that are capable of interbreeding and creating viable offspring that they themselves are capable of reproducing as well.
   b. If you can remember that Domain is at the top of the classification scheme, a commonly used pneumonic device to remember the order is <u>K</u>ing <u>P</u>hillip <u>C</u>ame <u>O</u>ver <u>F</u>or <u>G</u>reat <u>S</u>ex. ☺

9. What Does It All Mean?
   a. The easiest demonstration to why we want to use this classification system is to look at this group of organisms. We can easily see how closely each of these plants are related to each other based on the taxonomic ranks they fall under. Can you tell which are the most closely related and which are most distantly related?

10. Systematics

   a. The branch of biology that is responsible for understanding the evolutionary relationships of all the different groups of life is known as systematics. This basically means that systematics uses the process of taxonomy to look at how closely each group of organism are related to each other.

   b. Systematics relies on scientific data from the fossil record, DNA analysis, and comparative anatomy and morphology to study these relationships.

11. Phylogeny vs. Cladogram

   a. And there are two different ways that we can look at these relationships: The phylogeny and the cladogram. A phylogeny, emphasizes the common ancestry of a group of organisms, and can be thought of as a sort of time line of evolutionary progression of the different species found in that group.

   b. A cladogram on the other hand emphasizes the relative chronology of the appearance of new features within a group of organisms.

12. The Theory of Evolution

   a. We have thrown around the term evolution quite a bit in this lecture. Although the details of evolutionary processes and how it happens is outside the scope of this class, the theory, which is practically universally accepted by the scientific community, is still important and controversial enough to make a few comments on what exactly evolution is. And what it isn't.

   b. Evolution does not mean that a frog all of a sudden one day gave birth to a lizard. It means that environmental pressures in a habitat favored small, random adaptations that allowed a new branch to sprout out of the evolutionary tree. Frogs still begat frogs, but one family tree of frogs started to slowly develop, over the course of many millennia, characteristics that eventually were so different from their amphibian ancestors, that they can no longer be considered amphibians.