Evolution and Biodiversity
Chapter Four

4.6 BYA – How Do We Know?

- James _____ – Principle of Uniformitarianism: current geologic process are the same today as the past
- Nicholas Steno – Law of _____: undeformed sedimentary rock layers are older than layers above them
    - Sedimentary rock in glacial lakes have clear, consistent sedimentation rates. Age may be determined by counting the layers (varves).
- Radiometric Dating: Elements emit particles and energy at a constant measurable rate based on half-life. Common elements used include U-238, K-40, C-14
- Fission Track Dating measures damage tracks from the spontaneous fission of U-238
- Thermoluminescence Dating measures how much time has passed since object was heated
- Solar Evolution: The sun is approximately _____ billion years old based on its mass and the ratio of hydrogen and helium

The Fossil Record

- _____ study fossils to learn about the earth's history
- Fossils remains of plants or animals from a previous geological time that provide clues for climate, geologic events, and evolution
- Fossil are only found in _____ rock
- Trace Fossils are parts, footprints, burrows, etc

Formation of Fossils

- There are many types of fossils
    - Mummification – drying, often in desert
    - _____ – hardened tree sap
    - Tar Beds – thick petroleum at surface
        - (La Brea Tar Pit in CA is 15,000 years old)
    - Freezing – often in Siberia
    - Petrification – _____ solutions (ground water) replace original organic materials
    - Imprints, Molds, and Casts in sand or mud
    - Coprolites – fossilized dung or waste (poop!)
    - Gastroliths – fossilized digestive stones or eggs
- _____ fossils are found exclusively in rock layers of a particular geologic age
    - Trilobites are 245 – 570 million years old

Geologic Time

Four Eras: Precambrian, Paleozoic, Mesozoic, Cenozoic
Important Periods: Permian, Cretaceous

Are We In a New Epoch?

- First proposed in 2000, the _____ is used to describe the current epoch due to the significant influence humans have had on the planet in the last 150 years.

Chemical Evolution

- Chemical evolution of the organic molecules, bipolymers, and systems of chemical reactions were first necessary to form the first protocells took about one billion years.
- Russian biochemist Alexander _____ first hypothesized that energy from lightning, volcanoes, and intense UV light created the first organic molecules from inorganic chemicals. This has been proven true in a number of experiments since 1953.

Biological Evolution

- Biological evolution is the change in a population's genetic makeup through successive generations.
  - it is VERY important to understand that _____, not individuals, evolve by becoming genetically different
  - microevolution describes the small _____ changes that occur in a population
  - macroevolution describes long-term, large-scale evolutionary changes among groups of species

Microevolution

- Microevolution works through four processes:
  - _____ of the structure or number of DNA molecules
  - natural selection for individuals of a population that have genetically based traits that cause them to survive and produce more offspring than other individuals
  - gene _____, which is the movement of genes between populations
  - genetic drift; fluctuations of gene frequency in the gene pool (genetic composition of a population)

Natural Selection

- The process of natural selection occurs when some individuals of a population have genetically based traits that cause them to better survive and produce offspring.
  - This trait is called an _____, or adaptive trait.
  - A factor in a population's environment that causes natural selection to occur is known as a selective pressure.
- The concept of natural selection was developed by Charles _____ in 1846 and was published in *On the Origin of Species by Means of Natural Selection* (1859). Natural selection is based on three conditions:
  - natural variability of a trait within a population
  - the trait is heritable
  - the trait leads to differential _____
- There are three types of natural selection:
  - directional natural selection causes _____ (gene forms) frequencies to shift toward one end of the normal range, eliminating the other end
  - stabilizing natural selection causes allele frequencies to shift toward the _____ of the normal range, eliminating both ends
  - diversifying natural selection causes allele frequencies to shift toward both ends, eliminating the middle

Common Examples of Transitional Forms

- Left Above: ***Eohippus***
- Right Above: ***Acanthostega***
- Right Below: ***Archaeopteryx***
- Left Below: ***Ambulocetus***

Speciation

- Speciation is the process by which two species arise from one.
  - The first step in speciation is geographic _____, which is the physical separation of two groups of the same population for fairly long periods into areas with different environmental conditions.
- The second step is reproductive isolation, which is when the two groups become so different, through mutation and natural selection, that they are no longer able to interbreed.

Biodiversity

- Speciation leads to greater species diversity. Species diversity, or species _____, of a community is the number of species it contains. Biodiversity can refer to genetic, species and habitat diversity.
- The relative abundance of individuals within each of those species is species _____.

Species Diversity

- The differences in species diversity between ecosystems is explained by Robert MacArthur and Edward O. Wilson, who in 1960 developed the species equilibrium model or the theory of _____ _____
    - the species diversity of an island is determined by a balance between two factors: the immigration rate and the extinction rate.
    - Immigration and extinction rates are affected by the size of the island and its distance from a mainland source of immigrant species.

Generalist vs. Specialist

- Generalist species have broad _____. They can tolerate a wide range of environmental conditions. (ex. mice, white-tailed deer, channel catfish, cockroaches, humans)
- Specialist species have narrow niches, which makes them prone to becoming endangered when environmental conditions change. (ex. tiger salamanders, spotted owls, giant _____)

Species Classification

- Native species are species that normally live and thrive in a particular ecosystem.
- Species that migrate into an ecosystem or, more commonly, are introduced by humans (either by accident or deliberately), are known by several names: introduced, nonnative, _____, or alien species.
- Indicator species are species whose presence or absence demonstrates a distinctive aspect of an ecosystem.
- _____ species are species that play a pivotal role in the integrity of an ecosystem.

Modern Evolutionary Theory

- Modern evolutionary theory has progressed far beyond Darwinism to reflect new advances in science.
    - _____ _____ (Stephen Jay Gould & Niles Eldredge) - Evolution consists of long periods of time of little change with brief periods of rapid change (tens of thousands of years)
    - Hardy-Weinberg Equilibrium - Allele frequencies of a population stay constant over time unless specific disturbing influences occur (ie. mutations, selection, genetic drift)
    - Genetic Engineering &Artificial Selection - Human manipulation of genetic structure and/or breeding has led to new species or new traits in existing species

Extinction

- When environmental conditions change, a species may either evolve or become extinct
- _____% of all species that have ever existed on Earth are now extinct. Speciation and extinction are affected by several major factors
    - large scale movements of the continents
    - gradual climate changes (continental drift, orbit shifts of the earth)
    - rapid climate change (large volcanic eruptions, asteroid impact)
    - human influence
- Genetically diverse populations are more likely to survive these stressors.

- Inevitably, some species disappear at some low rate called background extinction. (1-10 species per year)
- An abrupt rise in extinction rates above the background level is classified as a mass extinction.
    - There have been five major mass extinction events in the earth's history. The largest was _____, 250 million years ago, with the disappearance of 90% of all marine species. The last mass extinction was the _____, 65 million years ago, marking the end of the dinosaurs.