Evolution: Descent with Modification Notes
AP Biology Mrs. Laux

Evolution (organic or organismic, as opposed to geologic)
→changes in populations, species, or groups of species
-occurs because populations vary by frequency of heritable traits that appear from one generation to the next
-traits represented by alleles for genes that modify morphology (form and structure), physiology, or behavior
-changes in alleles (heritable information)
-therefore, evolution is change in allele frequencies over time

Two main areas of evolutionary study
1. Microevolution→how populations of organisms change from one generation to the next and how new species originate
-ex: thumb in humans
2. Macroevolution→patterns of changes in groups of related species over broad periods of geologic time
-ex: reptiles→humans
-story of major events of life as revealed by the fossil record
-these patterns determine phylogeny (The evolutionary development and history of a species or higher taxonomic grouping of organisms), which determines evolutionary relationships, which determines taxonomy among species and groups of species

Main theme in biology→evolution
-processes that have transformed life on earth from its earliest forms to the dynamic diversity that characterizes it today

First convincing case for evolution was a book published by Charles Darwin (1859)→<u>On the Origin of Species by Means of Natural Selection</u>

Up until this point, people believed that the earth was only a few thousand years old and was populated by unchanging life forms made by God, during a single week; therefore, Darwin's book was challenged by both prevailing scientific views and the roots of western culture

How did Darwin come to his conclusions?
-he was influenced by a number of scientists before him and during his time
1. Georges Cuvier (1769-1832)-**the study of fossils, paleontology, was largely developed by this French anatomist; he noted that each stratum was characterized by a unique group of fossil species and the deeper (older) the stratum, the more dissimilar the fossils are from modern life; he even recognized that extinction had been a common occurrence in the history of life; from stratum to stratum new species appear and others disappear; he did not believe in evolution, but advocated catastrophism; each boundary between strata corresponded in time to a flood or drought, that destroyed**

many species living at that time; then foreign species migrated in; the study of fossils helped lay the groundwork for Darwin's ideas

2. James Hutton (1726-1797)-**Scottish geologist explained Earth's geologic features by the theory of gradualism, which holds that profound change is the cumulative product of slow but continuous processes**

Catastrophism and gradualism were competing ideas.

3. Jean Baptiste de Lamarck (1744-1829)-**published his theory of evolution in 1809, the year that Darwin was born; he is remembered for the mechanism he proposed to explain how specific adaptations evolve; first, was the idea of use and disuse, that those parts of the body used extensively to cope with the environment become larger and stronger while those that are not used deteriorate; (correct with regard to hypertrophy and atrophy); second, was the inheritance of acquired characteristics, the modifications an organism acquires during its lifetime can be passed along to its offspring; (incorrect) third was the natural transformation of species- organisms produced offspring with changes, transforming each subsequent generation into a slightly different form toward some ultimate, higher order of complexity. Species did not become extinct, nor did they change into 2 or more species. (incorrect)** ***Lamarck deserves much credit for his theory, which was visionary in many respects: its claim that evolution is the best explanation for both the fossil record and the current diversity of life; its recognition of the great age of Earth; and especially in its emphasis on adaptation to the environment as a primary product of evolution***

4. Carolus Linnaeus (1707-1778)-**a Swedish physician and botanist, who sought to discover order in the diversity of life "for the greater glory of God," he developed the two-part, or binomial, system of naming organisms according to genus and species. He also adopted a system for grouping similar species into a hierarchy of increasingly general categories: species, genus, family…Darwin later used this taxonomic system as a focal point in his arguments for evolution**

5. Charles Lyell (1797-1875)-**the leading geologist of Darwin's era, a Scot, incorporated Hutton's gradualism into a theory known as uniformitarianism, meaning that geologic processes have not changed throughout the Earth's history, but the forces that shape the Earth are the same as in the past. Darwin was strongly influenced by the observations of Hutton and Lyell. First, if geologic change results from slow, continuous actions rather than sudden events, then Earth must be very old, and second, very slow and subtle processes persisting over a long period of time can add up to substantial change**
He encouraged Darwin to publish before someone else. Lyell's prediction came true.

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Charles Darwin (1809-1882)-born on the same day as Abraham Lincoln, February 12th.
- **-1831-journeyed on the HMS Beagle**
  - **-mission→chart South American coastline**
  - **-he collected flora (plants) and fauna (animals)**
- **-Galapagos Islands (newly formed islands: 2 to 5 million years old)**
  - **-on equator ~900 km west of So. America**
  - **-animal species on Galapagos are unique to those islands, but resemble species that were living on mainland**

- **-14 different finches**
  - **-some unique to individual islands**
  - **-others found on 2 or more islands close together**
  - **-found out that 14 different finches were all different species**
- **-Lead to:**
  - **-origin of new species and adaptation were closely related processes**
  - **-a new species could arise by gradually accumulating adaptations to a different environment**
  - **-ex: 2 species could be isolated (as finches on islands) in different environments and could diverge as each adapted to new conditions**
  - **-over many generations, the 2 populations could be dissimilar enough to be designated separate species**
  - **-finches→beaks adapted to specific foods available on their home islands**

By 1840s-theory of natural selection; delayed publishing

6. Alfred Wallace (1823-1913)-**a young British naturalist**; **In June, 1858, he sent a letter to Darwin stating his theory of natural selection (essentially identical to Darwin; asked Darwin to read and send to Lyell, if merited publication; Darwin complied, writing to Lyell, "I never saw a more striking coincidence…so all my originality, whatever it may account to, will be smashed."); although he wrote up his ideas for publication first, Darwin developed and supported the theory of natural selection so much more extensively that Darwin is known as its main architect; Darwin's notebooks prove that he formulated his theory 15 years before reading Wallace's manuscript**

Some books use the Darwin-Wallace theory of natural selection.

<u>The Origin of Species</u>
2 main points
A. Descent with modification
- **-there was unity in life-common ancestor**

-diverse modifications (adaptations) accumulated over millions of years, as descendants from this common ancestor moved to different habitats

-Metaphor→branching tree

-at each fork or branch point is a common ancestor

-more closely related individuals share a common ancestor at recent branch point (closer)

-less-earlier branch point

-most branches are dead ends-99% of all species are extinct

-could apply to Linnaeus' system of taxonomy

-could be related into different taxonomic levels by relatedness to a common ancestor

Natural Selection: Observations and Inferences

Observation #1: All species have such great potential fertility that their population size would increase exponentially if all individuals that are born reproduced successfully.

Observation #2: Populations tend to remain stable in size, except for seasonal fluctuations.

Observation #3: Environmental resources are limited.

Inference #1: Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction of offspring surviving each generation.

Observation #4: Individuals of a population vary extensively in their characteristics; no two individuals are exactly alike.

Observation #5: Much of this variation is heritable.

Inference #2: Survival in the struggle for existence is not random but depends in part on the hereditary constitution of the individuals. Those individuals whose inherited traits best fit them to their environment are likely to leave more offspring than less fit individuals.

Inference #3: This unequal ability of individuals to survive and reproduce will lead to a gradual change in a population, with favorable characteristics accumulating over the generations.

Natural selection

→differences in survival and reproduction among individuals in a population as a result of interactions with the environment

Organisms→possess genotypes→generate phenotypes (traits)→enable organism to cope in environment
-more successful→more offspring
-superior traits→adaptations to the environment
-increase fitness (relative ability to survive; leave offspring)
-trait favors survival of organism-organism is more "fit" to environment
-favorable traits→adaptive
-unfavorable traits→maladaptive

What is some evidence to back up Darwin's ideas?

Anatomical Homologies-**many of the same skeletal elements make up the forelimbs of humans, cats, whales, bats, and all other mammals, although these appendages have very different functions. The basic similarity of these forelimbs is the consequence of the descent of all mammals from a common ancestor. Forelegs, wings, flippers, and arms are variations on a common structural theme. Structures were modified for function.**

Homologous-same structure, different function
Homoplastic (Analogous)-same function, different structure

Embryological Homologies-**All vertebrate embryos have structures called pharyngeal pouches in their throat regions at some stage in their development. These structures develop into homologous structures with very different functions, such as the gills of fish or the Eustachian tubes in humans and other mammals.**

Molecular Homologies-**All species of life use the same basic genetic machinery of DNA and RNA, and the genetic code is essentially universal. It has been passed along through all branches of the tree of life ever since the code's inception in an early life-form.**

Biogeography-**species tend to be more closely related to other species from the same area than to other species with the same way of life but living in different areas**

The Fossil Record-**Biochemistry, molecular biology, and cell biology place prokaryotes as the ancestors of all life and predict that prokaryotes should precede all eukaryotic life in the fossil record, and indeed, the oldest known fossils are prokaryotes. Vertebrate descent is consistent with the fossil record as well.**