EVOLUTION, LECTURE 2: DARWIN & THE GENETIC BASIS OF EVOLUTION (458–467, 262–271)

Charles Darwin (1809–1882) "stood on the shoulders of giants." Hutton had envisioned a slow accumulation of gradual changes that shaped planet Earth over millions of years (Gradualism). Lyell had argued forcefully that the natural phenomena acting today also acted in the past, and he dispensed with notions of supernatural influences on the natural historical process (Uniformitarianism). Linnaeus had established a system of scientific nomenclature that was adopted broadly and that facilitated scientific communication and specimen organization. Cuvier and Owen revealed lost worlds of ancient creatures through their fossil reconstructions, and they established the reality of lineage extinction.

Darwin embarked on his 5-year voyage on the HMS Beagle with an excellent education, cutting edge scientific instrumentation, a collector's passion and curiosity, and an open mind. His geological, paleontological, and biological work in South America, the Galapagos, and Australia, convinced him that the separate creation of species (the traditional viewpoint of natural theology) did not fit the evidence.

There are three necessary components to a scientific theory of evolution: concept, mechanism, and pattern. The **concept** of evolution is simply the recognition that species have changed over time, and many pre-Darwinian thinkers had such a notion. The **mechanism** of evolution refers to the process that causes species to change over time (for Lamarck, the mechanism was the **principle of use and disuse** and the **inheritance of acquired characteristics**; for Darwin and Wallace, the mechanism was natural selection). The **pattern** of evolution refers to the manner and rate by which species change: Darwin argued that species evolved by "insensible degrees," by which he meant that change was slow, continuous, and gradual.

Darwin's evolutionary hypothesis—which he called "descent with modification"—was first published in his *On the Origin of Species by Means of Natural Selection* (1859). His argument in the book was built on his observations of: (1) **artificial selection** in domestic breeders, (2) variation among individuals in natural populations, and (3) the **struggle for existence** that occurs among individuals as result of organismal **fecundity** and environmental shortages of resources (this is the Malthusian insight applied to nature). He then proposed a new mechanism, **natural selection**, which explained the process whereby heritable variation could be amplified to produce new forms under natural conditions. Contempoary readers widely accepted Darwin's evidence for the reality of evolution (the concept), but disagreements over pattern and mechanism existed then as they do today.

The power of Darwin's theory rested on its ability to explain a wide range of disparate facts, including **anatomical homology**, **vestigial structures** (rudimentary organs), **comparative embryology**, and the **fossil record**. His theory also helped to explain why Linnaeus's **hierarchical system of nomenclature** worked so well (it is because it corresponds to the branching structure of the evolutionary tree). And his theory made sense of the **geographical distribution** of species on islands (they tend to resemble other species found locally on the mainland).

Darwin's theory also faced several obstacles, many of which Darwin foresaw and answered in his 1859 publication. For example, **is the Earth old enough** to allow a slow pattern of change to produce the diversity of species we see today? Why do we not see more **transitional forms** (clear intermediate links) in the fossil record (we will address this problem in a later lecture). And, finally, if characters are "blended" during the process of inheritance, how will natural selection be able to act on clear differences? This latter problem of **blending inheritance** was resolved after the work of Mendel came to prominence around 1900.