EVOLUTION, LECTURE 7: MACROEVOLUTION & EVO-DEVO (501–504, 525–531)

Macroevolution refers to evolutionary change on the grand scale, including the formation of species, the diversification of species, and the appearance of major evolutionary novelties. Macroevolution also encompasses problems related to mass extinction events, the subject of a later lecture.

Is macroevolution simply microevolution "writ large," or is macroevolution characterized by a distinct set of evolutionary forces and mechanisms?

The tempo and mode of evolution. Gould and Eldredge contrasted their model of **punctuated equilibrium** with Darwin's model of **phyletic gradualism**. A key observation behind the idea of punctuated equilibrium is that fossil lineages tend to appear abruptly in the fossil record, and then they persist relatively unchanged over long periods of time. Thus, long periods of **stasis** are punctuated by brief episodes of speciation.

A key question is whether this pattern is the result of the imperfections of the fossil record, or whether the pattern reflects something real about the tempo and mode of evolutionary change.

Given rates of sedimentation in the deposition of geological strata, the sudden appearance of a new morphology could reflect tens of thousands of years (or more) of time. How quickly can new species, and higher taxonomic groups, evolve?

Striking examples of evolutionary stasis (in morphology) are given by "**living fossils**," such as horseshoe crabs, coelacanths, and tuataras. But many other examples of stasis have been recorded in the fossil record, such as in the evolution of molluscs in East Africa.

It is likely that both punctuated change (**cladogenesis**) and phyletic gradualism (**anagenesis**) are important in evolutionary history.

Steven Stanley argued that species themselves undergo a type of selection ("**species selection**") that is analogous to the selection that acts on individual organisms in populations ("natural selection"). Species that diversify frequently and rapidly while avoiding extinction have a disproportionate effect on the shape of local clades.

The origin of major **evolutionary novelties** has long been a problem for evolutionary biologists. Some complex novelties, such as the eyes of cephalopods, can be seen as having evolved incrementally from simpler constructions (with similar functions) in related lineages.

Other complex novelties, such as avian flight feathers, may be viewed as **exaptations** of structures that originally evolved for a distinct function (such as insulation). Exaptation refers to the cooptation of an existing structure for use in a new functional context. This kind of "**tinkering**" is very typical of the evolutionary process. Many plant structures, including many of the anatomical contrivances used by carnivorous plants for capturing animal prey, evolved from pre-existing organs.

Evolutionary developmental biology (**Evo-Devo**) is an exciting new field that studies the genetic mechanisms that regulate ontogenetic process in a comparative evolutionary framework. Evo-Devo is a unifying field that links distantly related organisms on the basis of commonalities conserved in the fundamental architecture of the DNA. We discussed **homeotic genes** (master regulatory genes in animals), and the role of ***Hox* genes** in the evolution of modern vertebrates from early vertebrate and invertebrate ancestors, and we looked at a specific example of the *Hox* gene *Ubx* in the evolution of the insect body plan.

Please make sure that you are able to define the following terms, and be ready to provide relevant examples of them: **allometry**, **heterochrony** (including **hypermorphosis** and **paedomorphosis**), and **homeosis**. Please consider the role of these mechanisms in the evolution of broad scale trends in the history of life.