9 Macroevolution.


Microevolution to macroevolution

- A basic idea of Darwinism and neo-Darwinism is that macroevolution is the result of the accumulated effects of microevolution.
- Darwin’s discussion of the evolution of the vertebrate eye is still regarded as correct and representative of how complex characters evolve.

Evolutionary novelties

- Most evolutionary novelties are greatly modified version of existing structures
  - A few characteristics had to be true novelties. Early chordates, such as the lancelet, had no limbs. In an early lineage leading to fishes, the first proto-limbs appeared. Limbs in vertebrates are greatly modified versions of the first limb-like structures.
  - The bones of the inner ear in mammals provide an example of a new structure that is derived from an existing structure in an ancestor. They are derived from parts of the jaw of species ancestral to mammals.
- Evolutionary novelties are often derived from repeated structures that become differentiated.
  - Alismatales is a group of monocots thought to be ancestral to orchids. Alismatales flowers are radially symmetric. In contrast, petals of orchid flowers are extremely differentiated.
  - Multigene families have evolved from a single ancestral gene. For example, $\alpha$- and $\beta$-globin, which together form the hemoglobin molecule in mammals, are derived from an ancestral globin gene. So are other members of the globin gene family.
- Origin vs. maintenance
  - One question about evolutionary novelties is whether the conditions that favor their maintenance are the same as the conditions that favored their origin.
  - For the vertebrate eye, they probably did.
  - For the wing in birds, possibly not. Dromaeosaurs were small dinosaurs that probably were ancestral to birds. Fossils of dromaeosaurs show clear evidence of feathers but without having wings capable of gliding or flight. Forerunners of what became wings might have been favored because they helped regulate body temperature or played a role in social interactions, and only later became useful for gliding and flying.
  - Characters that have changed function are called exaptations. Eyes are not exaptations; birds wings probably are. The swim bladder used for hearing in some fishes is an example of an exaptation.
Major changes in form can be caused by relatively minor changes occurring during growth and development.

- **Heterochrony.**
  - Heterochrony can result in the appearance of several coordinated changes because of a single change in the timing of some event during development. By looking only at the adult phenotype, it is not always easy to decide what character or characters evolved. Large difference might be the result of a simple change, as in the salamander foot, Fig. 24.16.
  - Paedomorphosis is one type of heterochrony. Some salamanders retain gills as adults. Gills are a juvenile character in most species of salamander.
  - Another example of how a subtle change during growth can cause a major change in morphology is the evolution of internode distances in plants. Internode distance depends on production of gibberellins and sensitivity to gibberellins during growth. If none is produced or if cells are not sensitive, then internode distances will decrease to almost zero, resulting in rosetate plants. In general, the production of gibberellins rather than the sensitivity has evolved in rosetate plants.

- **Homeotic genes.**
  - Homeotic or **Hox** genes control where specific structures are formed. They were first discovered in *Drosophila* but are now known in many plants and animals. The bithorax mutation in *D. melanogaster* is a mutation to a **Hox** gene that results in two pairs of wings. **Hox** genes form a large multigene family.
  - Changes in the locations where **Hox** genes are expressed during development were important for the evolution of vertebrates. One difference between fish and tetrapods is where on the limb bud a **Hox** gene is expressed, as illustrated in Fig. 24.18.

- **Hox genes in vertebrates.**
  - There were two duplications of the **Hox** gene cluster which may have resulted from two genomic duplications. The first duplication occurred about 520 mya and may have been a critical step in the evolution of vertebrates, and the second, about 425 mya may have permitted an increase in morphological complexity of vertebrates, as illustrated in Figure 24.19.

- **Natural selection and species selection**
  - Natural selection causes changes in each lineage.
  - Species selection causes changes in the numbers of species with different properties.
  - Do not confuse them.
  - **Species selection results from differences in the rate of speciation and extinction.**
  - Once a species makes an adaptive transition, the descendant species may have such an advantage that they will increase their geographic range, colonize new habitats, and evolve very rapidly. The result will be an adaptive radiation of species that share the new adaptation.
  - Bats and anteaters provide an illustration of species selection. Powered flight evolved only once in mammals, in the ancestor of bats. Bats have become very diverse and abundant because their ability to fly makes them effective predators and allows them to escape predation themselves. Bat species comprise roughly 25% of the 4000 species of mammals. They have a worldwide distribution and are abundant wherever
they are found. In contrast, anteater morphology has evolved three times in mammals — in the ancestors of echidnas, true anteaters, and pangolins. There are very few species in each of these groups (four species of echidna in New Guinea and Australia, four species of anteater in South America, eight species of pangolin in Africa and southeast Asia). Once that combination of characteristics evolved there was little opportunity for later diversification. Being an anteater appears to be an evolutionary dead end.

- Species selection determines the relative numbers of species with different adaptations. There are more species of bats than species of anteaters because of species selection. But the adaptations evolved in the ancestor of each group because of natural selection. Wings in species ancestral to bats evolved because wings were favored by natural selection. A long nose and tongue evolved in the species ancestral to echidnas because they were favored by natural selection.

## Questions

- **Which statement best explains why there are more species of bats than there are species of anteaters?**
  a. Bats evolved long before anteaters.
  b. Natural selection did not favor the evolution of wings in bats.
  c. Flying created many opportunities for speciation.
  d. Flying prevented gene flow.
  e. Anteaters evolved only in South America.

- **Which statement best provides the best definition of heterochrony?**
  a. A change in the timing or rate of an organism’s development.
  b. A change in the time of mating.
  c. A change in life span.
  d. A loss of radial symmetry of flowers.
  e. The differentiation of repeated structures.

- **Which pair of words best fills the blanks in the following sentence? The punctuated equilibrium theory is a generalization about the ______ of evolution seen in ______.**
  a. mechanism, Paleozoic
  b. theory, The Origin of Species.
  c. pattern, fossil record.
  d. fact, fossil record.
  e. repeatability, plants and animals.

- **The bithorax mutation in Drosophila melanogaster is an example of which one of the following?**
  a. Paedomorphosis.
  b. An exaptation.
  c. Species selection.
  d. An advantageous mutation.
  e. A mutation of a Hox gene.