

Chapter 14 – Principles of Evolution

I. 14.1 How did Evolutionary thought evolve?

- a. **Evolution** is the change over time in the characteristics of a **population** (not individuals)
- b. Unifying theme for all biology
- c. The foundation of evolutionary thought developed over centuries
- d. The ideas of evolution were not accepted until after Darwin published *On the Origin of Species* in 1859
- e. Early biological thought did not include the concept of evolution
 - i. Pre-Darwinian: all organisms were created simultaneously by God, no change over time
 - ii. **Plato** (427–347 B.C.): each object on Earth was merely a temporary reflection of its divinely inspired “ideal form”
 - iii. **Aristotle** (384–322 B.C.): arranged all organisms on a linear scale of increasing complexity (the “ladder of Nature”)
- f. Fossils showed that life has changed over time
 - i. Many of the fossilized species were extinct
- g. A few scientists speculated that life had **evolved**
- h. **Different** types of organisms had lived at **different** times in the past
 - i. This **countered** the view that species were created at one time and did not change
- i. Older fossils are less similar to modern species than younger ones
- j. Evolution has falsifiable predictions
- k. *****No rabbits in the Cambrian period. Why?*****
- l. A few scientists speculated that life had **evolved**
 - i. **LeClerc/Buffon** (1707–1788) proposed that some modern species had evolved through natural processes, having originated at creation from a small number of **founding** species
 - ii. **Smith** (1769–1839), a British surveyor, recognized that certain fossils were always found in the same layers of rock
 1. **Concluded different** types of organisms had lived at **different** times in the past
 - iii. **Cuvier** (1769–1832) proposed the theory of **catastrophism**
 1. Catastrophes destroyed many species, modern day species are the survivors of these catastrophes
- m. Geology provided evidence that the Earth is exceedingly old
 - i. **Hutton** (1726–1797) & **Lyell** (1797–1875) considered the forces of wind, water, earthquakes, and volcanoes
 - ii. They developed the theory of **uniformitarianism**: geologic change resulted from slow, continuous actions similar to those at work today
 - iii. Rock formations reflect repeated cycles of geologic change occurring over vast periods of time
 1. Floods lay down sediment, which turns into sedimentary rock
 2. Volcanoes periodically erupt, laying down new layers of lava
- n. Geology provided evidence that the Earth is exceedingly old (*continued*)
 - i. The geological evidence led to several conclusions
 1. Earth >>> 6,000 years old (as proposed by theologians)
 2. Ample time for evolution to occur
 3. Modern geologists estimate that the Earth is about **4.6 billion years old**
- o. Some pre-Darwin biologists proposed mechanisms for evolution

- i. **Lamarck** (1744–1829) proposed that organisms evolved through the inheritance of **acquired** characteristics
 - 1. He theorized that organisms are modified during their lifetime through “**use or disuse**” of different parts
 - 2. These modifications are passed to offspring
- ii. This idea was incorrect... acquired characteristics are **not** heritable
- p. **Darwin & Wallace** proposed a mechanism of evolution
 - i. By the mid-1880s, evolution was popular but the **mechanism** was unclear – this was the most important question of the era
 - 1. Both traveled extensively, studied plants & animals
 - 2. 1858: Darwin and Wallace independently provided evidence of evolution and propose a mechanism how it occurs
 - 3. Concluded: species **do** change over time
 - 4. Darwin published “**On the Origin of Species by Means of Natural Selection**” in 1859

II. 14.2 How Does Natural Selection Work?

- a. Darwin and Wallace proposed that life’s diverse forms arose through the process of *descent with modification*
 - i. Offspring differ slightly from their parents
 - ii. Over long time periods, small differences accumulate to produce major transformations
- b. Darwin and Wallace’s theory rests on four postulates...
- c. **Postulate 1:** *Variation* in a population
- d. **Postulate 2:** Some of the differences between members of a population are due to *inherited* characteristics (not understood at the time though)
- e. **Postulate 3:** *Differential* survival and reproduction in each generation
- f. **Postulate 4:** Individuals with advantageous traits survive longest and leave the most offspring, a process known as **natural selection** (remember: an *individual* cannot evolve, but a *population* can)

III. 14.3 How do we Know That Evolution Has Occurred?

- a. Four main lines of evidence support evolution
 - i. Fossils provide evidence of evolutionary change over time
 - 1. Fossils of ancient species tend to be simpler in form than modern species
 - 2. Several series of fossils show the evolution of body structures over time
 - a. Suggest that new species evolved from, and replaced, previous species
 - 3. Example: modern **whales** evolved from land-dwelling ancestors
 - ii. Comparative anatomy gives evidence of descent with modification
 - 1. Comparing bodies of different species can reveal similarities suggesting shared ancestry
 - 2. **Homologous structures:** structures with the same evolutionary origin despite their current appearance or function – result of **divergent evolution**
 - a. *Example:* Bird and mammalian forelimbs
 - b. Similar anatomy/structure but different uses
 - 3. **Analogous structures:** structures similar in appearance, but differ in their evolutionary origin – result of **convergent evolution**
 - a. *Example:* Insect and bird wings
 - b. Different anatomy/structure but similar uses

4. **Vestigial structures** (remnants of structures that are inherited from ancestors) provide evidence of evolution
 - a. Humans: appendix, tailbone, wisdom teeth
 5. **Molar teeth** in vampire bats, which live off blood (don't chew their food)
 6. **Pelvic bones** in whales and in certain snakes also serve no function in modern species
 7. **Idea:** as animals evolved into new habitats, some of their structures that made them less fit were reduced to the point of insignificance
- iii. Embryological similarity suggests common ancestry
1. All vertebrate embryos resemble one another in their early development
 2. All vertebrate embryos possess genes that direct development of gill slits and a tail
 3. Humans are born without gills & a tail because the genes are active only during early development
 4. **Idea:** ancestral vertebrates possessed genes that directed the development of gills and tails, and all their descendants still have those genes
- iv. Modern biochemical and genetic analyses reveal relatedness among diverse organisms
1. All organisms share related biochemical processes
 - a. All cells use DNA as a genetic blueprint
 - b. All use RNA, ribosomes, and approximately the same genetic code for translation
 - c. All use the same 20 amino acids to build proteins
 - d. All use ATP to transfer energy
 - e. DNA nucleotide sequences of human and mouse *cytochrome c gene* is very similar, suggesting shared ancestry

IV. 14.4 What Is the Evidence that Populations evolve by Natural Selection?

- a. Controlled breeding modifies organisms
 - i. **Artificial selection** is selective breeding to produce organisms that possess desirable traits
 1. All modern dogs are descended from wolves (a few thousand years of breeding)
 2. In only a few thousand years, humans artificially selected for all breeds of modern dogs
 3. Humans have created tremendous variation in several species over relatively short periods of time through artificial selection (dogs, pigeons, various crops)
- b. Evolution by natural selection occurs today
- c. Female **GUPPIES** prefer to mate with brightly colored males; however, brightly colored males are more likely to be eaten by predators
 - i. Males found in areas *lacking* predators were brightly colored
 - ii. Males found in areas *with* predators were duller by comparison (predators eliminated brightly colored males before they could reproduce)
 - iii. The conclusion was that **when fewer predators are present**, brighter coloration can evolve
 - iv. Natural experiments and manipulations confirmed this conclusion
- d. **INSECT PESTS** have evolved a resistance to pesticides
 - i. In Florida, the insecticide bait Combat® was successfully used to kill roaches