Darwinism and the Evidence for Evolution

Lecture Outline

I. Theories of Species Creation and Diversity prior to Evolutionary Theory

A. Theory of Special Creation
1. Pattern Component—Species are unchanged through time and are independent of one another.

B. Theory of Spontaneous Generation
1. Pattern Component—New living organisms may appear suddenly wherever conditions are suitable. Examples: Flies appear on rotting meat; microorganisms appear in old milk and puddles of rainwater.
2. Process Component—Some new life-forms arise spontaneously from streams, soils, rotting meat, and other nonliving materials; not all life arises directly from living organisms.

II. Evidence That Species Are Not Independent of One Another, but Are Related

A. Geographic Proximity of Similar Species—Similar, but distinct, species are often found living close together in the same geographic area.

B. Homologies
1. Structural—similarities in body parts of different organisms. Example: Bone structures in human arm, horse leg, and bat wing.
2. Developmental—similarities in the overall morphology of embryos and in the fate of embryonic tissues. Example: Vertebrate embryos, groups of cells in the same position develop into the same structures in different species.
3. Genetic—similarities in genes and protein sequences in different organisms. Example: Similar genes control eye development in fruit flies and mammals.
4. Distinguishing Homology from Analogy
   a. Analogous structures appear similar, but are different in structure, organization, or function. Example: Morphology of ichthyosaurs (reptiles) and dolphins (mammals).
   b. Homologous structures appear similar, and are similar in structure, organization, and function. Example: the *HOM* genetic loci of insects and the *Hox* loci of vertebrates.

III. Evidence That Species Have Changed through Time

A. Law of Succession—A particular geographic area frequently contains fossils that show a striking similarity to living species found in the same area. Example: Fossil sloths and living sloths are found only in South America.

B. Extinction of Species—Fossil record shows organisms that are unlike any living organisms. Example: "Irish elk" described by Cuvier.

C. Vestigial Traits—Rudimentary structures that have no function, but are homologous to functioning structures in similar organisms. Examples: Human coccyx to primate tailbone, human appendix to the caecum of other vertebrates.

IV. Theories of Evolution

A. Prior to Darwin: Inheritance of Acquired Characteristics—Lamarck
   1. Pattern Component—New simple life-forms arise by spontaneous generation and change over time into more complex forms.
   2. Process Component—Individuals change in response to their environment, and the changes are passed to the next generation. Example: A giraffe stretches to reach leaves on the highest tree branches; the giraffe's neck grows longer, and the trait of having a longer neck is passed to its offspring.

B. Theory of Evolution by Natural Selection (Darwin and Wallace, 1858)
   1. Pattern Component—Species are related to one another, and they change over time. Species existing today have descended from other preexisting species ("descent with modification").
   2. Process Component—Natural selection acts on individuals; individuals with certain favorable characteristics will survive and reproduce more. If the advantageous characteristics are heritable, the traits can be passed to their offspring, and over time, the population can change.
   3. Darwin vs. Wallace
      a. Darwin travels the world on the HMS *Beagle*, observing organisms in many parts of the world. He writes paper on evolution in 1842, but does not publish for 17 years while he refines it and collects more data.
      b. Wallace studies natural history specimens in Malaysia; writes brief paper outlining the logic of evolution by natural selection, sends it to Darwin for review in 1858.
      c. Pressure from Wallace spurs Darwin to publish; both papers are read simultaneously at the Linnean Society of London in 1858.

V. How Natural Selection Works

A. Four postulates of natural selection, the outcome of which is evolution:
   1. Individual organisms in a population vary in traits (size, shape, color, etc.).
   2. Some variations in the population are heritable and can be passed on to offspring.
   3. More offspring are produced than can survive; that is only a subset will survive to reproduce.
   4. Individuals with traits that confer an advantage will more likely survive to reproduce; and if the favorable traits are heritable, evolution of the population results.

B. Fitness
   1. The ability of an individual to survive and reproduce = "Darwinian fitness."
   2. Fitness is estimated by measuring the number of offspring produced by one individual vs. another in the population.

C. Adaptation—a heritable trait that increases the fitness of the individual with the trait relative to others that lack the trait.

VI. Evolution in Action: Antibiotic Resistance in the Tuberculosis Bacterium

A. Historical Background
   1. Prior to antibiotics, TB caused 25% of all deaths in New York City and 33% of all deaths in Paris in the 1800s.
   2. 1950 to 1990—Antibiotics are successful at treating TB in developed nations.
   3. Late 1980s—Resurgence in TB in developed countries due to strains carrying antibiotic resistance.

B. Case Study
   1. Patient admitted to hospital in Baltimore with active TB.
   2. Lung cultures taken at week 1—TB bacteria are present.
   3. Patient is given rifampin antibiotic for 40 weeks, released when lung cultures show no bacteria.
   4. Week 48—Patient is readmitted with TB symptoms; lung cultures again show TB bacteria.
   5. Patient is given further antibiotic treatment, but dies in 10 days.

C. Evidence That Evolution of Resistance in TB Bacteria Occurred in the Patient
   1. TB bacteria from lung cultures at week 1 are sensitive to rifampin, but TB bacteria cultured at week 48 are resistant to rifampin.
   2. DNA of TB bacteria from week 1 and week 48 are sequenced and compared; they differ by one nucleotide in the gene coding for RNA polymerase enzyme.
      a. Rifampin binds to the RNA polymerase enzyme of week-1 TB bacteria and interferes with enzyme activity. This prevents growth of the bacteria.
      b. Rifampin does not bind to the mutant form of RNA polymerase in the bacteria from week 48, due to a single amino acid change in the enzyme; thus the enzyme functions and the bacteria grow.
   3. The development of antibiotic resistance in the TB patient exhibits the 4 postulates of natural selection:
      a. The two populations of TB bacteria show variability in their characteristics, and the variation is heritable—the difference is in a gene (**natural selection postulates 1 and 2**).
      b. Nonrandom selection occurred—That is, only those bacteria that developed resistance to rifampin survived to reproduce (**natural selection postulates 3 and 4**).