What is evolution?

- Inherited changes in organisms over time
- The result of changes in DNA
- At the population level
- Any change in allele frequency

Evolutionary Adaptations

- Inherited traits that enhance an organism’s ability to survive and reproduce in a particular environment
  - “Blue-footed Booby” – feet flipper-like, salt excretion glands (supraorbital gland), perm. closed nostrils
  - “Finches” – beaks tailored to food types
Descent with Modification

- Descent with modification
  - A key theory of evolution
  - Describes the process by which species of living things can undergo modification over time, with such change sometimes resulting in the formation of new, separate species
    - Geologic time
      - Life known to have existed for at least 3.8 billion years
    - stromatolites
  - Therefore all species on Earth have descended from other species, and a single, common ancestor lies at the base of the evolutionary tree

Natural Selection

- Natural selection
  - A second key principle in the theory of evolution
  - differential adaptation of individual organisms to their environment
  - Individuals better adapted to their CURRENT environment are more likely to survive
    - Therefore, more likely to produce offspring and possibly pass those favorable traits on to those offspring

Importance of Evolution as a Concept

- The theory of evolution has an importance beyond the domain of biology. Through it, human beings have become aware that:
  1. They are descended from other varieties of living things.
  2. The organisms that populate the living world are not fixed entities, but instead are constantly undergoing modification.
Darwin and the Theory of Evolution

- Charles Darwin
  - deserves primary credit for the theory of evolution.
    - Alfred Russel Wallace came up with it too
  - Developed existing ideas about descent with modification while providing a large body of evidence in support of them.
  - First to perceive natural selection as the primary process that drives evolution.

HMS Beagle
1831-1836

- Collected plants, animals and fossils
  - along South American coastline
- Fossils collected were similar to modern South American species
  - but much different from fossils of other continents
- Galapagos Islands
  - unique species (endemics)
- Influenced by Charles Lyell (geologist)
  - natural forces changing earth’s surface
    - Darwin observed collection of marine snails in Andes Mountains
- Also Thomas Malthus - population theorist (survival of fittest)
Descent with Modification is Accepted

- On the Origin of Species by Means of Natural Selection
  - Published in 1859
  - Descent with modification was accepted by most scientists not long after
  - Scientists accepted it because it explained so many facets of the living world

Controversy over Natural Selection

- Natural selection
  - Most important process underlying evolution
  - Not generally accepted (by non-scientists) until the mid 20th
  - Factor – use of “theory”
    - Many people may equate “theory” with speculation

Evidence for Evolution

Fossils

- Faunal Succession
  - Historical sequence of fossils
    - Oldest
      - Simplest prokaryotes and simple eukaryotes
        - 3.5 billion years ago
    - Most recent
      - Complex multicelled
Evidence for Evolution

- Types of fossils
  - Hard parts – bones, teeth, shells
  - Prints – leaf or foot
  - Entire organism – amber
  - Petrifaction – mineral replacement
    - Silica impregnation
  - Casts and molds

Evidence for Evolution

Biogeography
- Study of what organisms occur where
- Environment shaped adaptations of similar species
  - Convergent evolution
  - Bergmanns rule
- Movement of landmasses
  - Continental drift, plate tectonics

Evidence for Evolution

Pelvis and hind limb
Rhodocetus (predominantly aquatic) ~46 mya
Pakicetus (terrestrial) ~55 mya
Pelvis and hind limb
Dorudon (fully aquatic) ~40 mya

Evidence for Evolution

Evidence for Evolution

Evidence for Evolution
Evidence for Evolution

**Comparative Anatomy**
- Anatomical similarities among species gives signs of common descent
- Homologous structures
  - Similar structure despite different function

![Comparative Anatomy Diagram]

**Comparative Embryology**
- Structures that appear during development
  - Ex. Vertebrate gill arches
    - → gills
    - → jaws, hyoid, voice box, ears

![Comparative Embryology Diagram]

**Molecular Biology**
- Universality of genetic code → all life is related
- Related individuals have greater DNA similarities & resulting proteins
- Related species have greater DNA and protein similarities
  - Measured as % similarity or divergence

![Molecular Biology Diagram]
Evidence for Evolution

Laboratory
- Guppies in the wild
  - Not like aquarium fish
- Wild guppies placed in predator-free environments
- In less than 10 generations
  - Colors and tails became large and showy like aquarium guppies
- Placed back in predatory environments
  - Tails reduced and colors more drab in only a few generations

Artificial Selection

Artificial Selection
- Domesticated organisms give convincing evidence
- Breeding for specific characteristics
  - Wild Mustard
    - Broccoli, kale, brussel sprouts, and cabbage
  - Wolf
    - Domestic dog breeds
  - White Peppered Moth
    - Black

The Evolutionary Process

- Evolution acts on populations
  - while natural selection targets individual organisms
- Population:
  - Unit of evolution
  - A group of individuals of the same species
    - living in a specific area at that same time
    - Interbreeding
    - Gene pool
The Biological Species Concept

- Group of populations whose individuals have the potential to interbreed
- and produce fertile offspring
- Usually localized

The biological species concept is based on infertility rather than physical similarity. (horse × donkey = male)

The Smallest Unit of Evolution

- Misconception
- Organisms evolve
  - in the Darwinian sense, during their lifetimes
- Natural selection acts on individuals
  - but only populations evolve
- Genetic variations in populations contribute to evolution

- Microevolution
- A change in allele frequencies in a population over generations

Sources of genetic variation

- Mutation and sexual reproduction produce the variation in gene pools
- Contributes to differences among individuals
• Population geneticists
  • Measure polymorphisms in a population
    • By determining the amount of heterozygosity
    • At the gene and molecular levels
• Average heterozygosity
  • Measures the average percent of loci that are heterozygous in a population
• Nucleotide variability
  • Measured by comparing the DNA sequences of pairs of individuals

Variation Within Populations