

## Outline 7: Evolution and the Fossil Record

### The Study of Evolution

- Two domains: the present and the past
- The present: Biology
- Genetics
- Comparative Anatomy
- The past: Paleontology or Paleobiology
- Comparative Anatomy of Fossilized organisms

### Natural Selection

- Natural selection is one of the prime mechanisms of evolutionary change. The other mechanism is mass extinction.
- Charles Darwin, 1859: *The Origin of Species by Natural Selection*.

### Natural Selection: Key Points

- 3 facts lead to a conclusion:
- Fact 1. Overproduction of offspring
- Fact 2. Variation within populations
- Fact 3. Competition for resources
- Conclusion: Survival of the fittest

### Sources of Variation

- Random mutations of DNA
- >>99.9% are harmful or neutral
- adaptive mutations are rare
- Sexual recombination
- new variants created by mixing of genes
- you have 4096 direct ancestors going back 12 generations ( $2^{12}$ )

## Evidence of Evolution

- Homology
- Analogous organs or Convergent Evolution
- Vestigial organs
- Adaptive radiation

### Homology

- The recognition of common ancestry of features. e.g. all primates have 5 fingers; apes and humans lack a tail; all tetrapods have similar limb bones.
- Studied by comparative anatomy of living and fossil organisms.

### Analogous Organs or Convergent Evolution

- Produced by evolutionary convergence. Independent origin of similar features is called convergent evolution.
- Shows natural selection in operation.
- e.g., insects, birds, bats, and pterosaurs all evolved wings independently

### Vestigial Organs

- Organs no longer used show clear evidence of evolutionary change.
- e.g., pelvic bones of whales, vestiges of former legs
- e.g., human body hair, a vestige of former fur

### Adaptive Radiation

- Natural selection can fill a variety of niches starting with a single species.
- e.g., Darwin's finches in the Galapagos Islands, 14 species evolved from one ancestral species
- e.g., all birds evolved from *Archaeopteryx*

## The Origin of New Species: Speciation

- Natural selection by itself will not increase the number of species on the planet.
- Species definition: Interbreeding populations reproductively isolated.
- New species must be reproductively isolated from their ancestral species.

### Speciation, cont'd

- Allopatric speciation: produced by geographic isolation of populations.
- Natural selection causes an isolated population to adapt to its local environment.
- Given enough time, and no outside interbreeding, a new species will evolve.

### Rates of Evolution

- Phyletic gradualism - continuous and gradual change over time
- Punctuated Equilibrium - long periods of stasis punctuated by rapid change, probably associated with a bottleneck in population size.

### Rates of Evolution

- Large populations evolve very slowly or almost not at all. Advantageous mutations pass very slowly through a population.
- Small populations can evolve very rapidly. Advantageous mutations can be passed very quickly through the population.

### Evolution in Action

- Passing through a bottleneck:
- Pesticide resistant insects
- Antibiotic resistant bacteria

## Role of the Fossil Record

- Provides the only actual record of evolutionary change over geologic time.
- Provides data on the timing of evolutionary origins.
- Shows mass extinctions to be a major cause of evolutionary change.
- Rates of evolution.

## Evolutionary Origins

- Oldest life: 3.5 BY
- Oldest nucleated cells: 2.1 BY
- First animals: 600 MY
- First tetrapods: 375 MY
- First dinosaurs: 220 MY
- First mammals: 220 MY
- First hominids: 4 MY

## Mass Extinctions

- Survival of the luckiest?
- Over geologic time, mass extinctions may subvert the notion of survival of the fittest.
- Is evolutionary history predictable?

## Rates of Evolution

- Biologists cannot measure evolutionary rates. They have only the present. Darwin assumed gradual rates.
- Paleontologists can measure evolutionary rates. They have found punctuated equilibria to be the major pattern in fossil species rather than gradual change.