

Evolution and Natural Selection

ENVS 10
Lecture 8

Persistent Pests - Agriculture

- In agricultural systems, pesticides are used to control insect pests.
- Often produce encouraging early results
 - Maybe 99% of insects killed initially.
- But insects don't go away altogether and don't go away forever.
- What's going on?

Pesticide Resistance

- The few survivors of the first pesticide spray are insects with genes that somehow enable them to resist the chemical attack.
- Survivors then reproduce and the offspring may inherit the genes for pesticide resistance.
- With each generation, individuals with pesticide resistance increases.

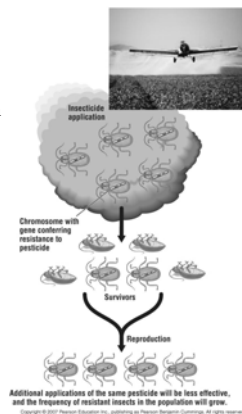


Figure 13.1

- Everywhere, all the time, populations of organisms are fine-tuning adaptations to local environments through the **evolutionary process of natural selection**.
- The basic idea of natural selection is that a **population** of organisms can **change over the generations if** individuals having **certain heritable traits leave more offspring** than other individuals.
- Result of natural selection is **evolutionary adaptation** - a population's increase in the frequency of traits that are suited to the environment.

Evolution...

- Is the change in the frequency of *genetically* determined characteristics within a *population* over time.

Evidence of Evolution - The Fossil Record

- Fossils are preserved remnants or impressions left by organisms that lived in the past.
- The fossil record is the ordered sequence of fossils as they appear in rock layers.
- Reveals the appearance of organisms in a historical sequence.
- Fits with other evidence of evolution.

Paleontologists have discovered many transitional forms that link past and present

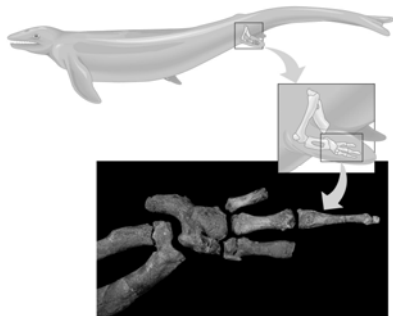


Figure 13.9

Evidence of Evolution - Biogeography

- Biogeography
 - Is the study of the geographic distribution of species.
 - First suggested to Darwin that today's organisms evolved from ancestral forms.
 - Many examples from biogeography support evolutionary theory.

Unique Australian wildlife evolved on that island continent in isolation from regions where early placental mammals diversified.



Figure 13.10

Evidence of Evolution - Comparative Anatomy

- Comparative Anatomy is the comparison of body structures between different species.
- Certain anatomical similarities among species shows signs of evolutionary history.
- Shows that evolution is a remodeling process in which ancestral structures that originally functioned in one capacity become modified as they take on new functions - descent with modification.

Homology - is the similarity in structure due to common ancestry.

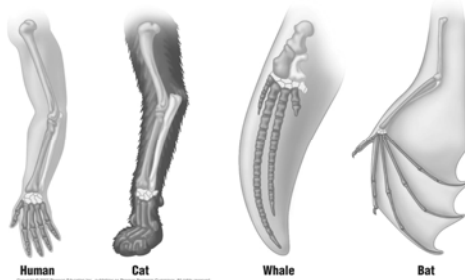
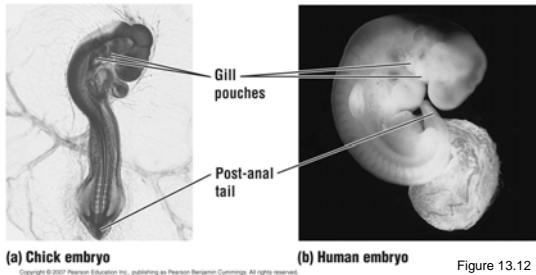


Figure 13.11

Evidence of Evolution - Comparative Embryology

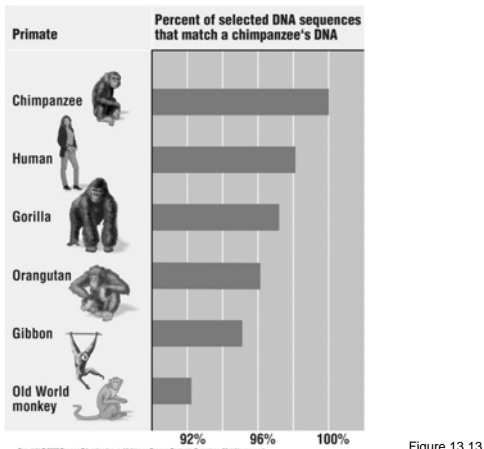
- Comparative Embryology is the comparison of anatomical structures that appear during the early stages of the development of different organisms.
- Closely related organisms share similar stages in their embryonic development.
- Comparative embryology of vertebrates supports evolutionary theory.

All vertebrates have gill pouches in early embryonic development



Evidence of Evolution - Molecular Biology

- Hereditary background of an organism is documented in its DNA and in the proteins encoded by the DNA.
- Molecular comparisons of diverse organisms have allowed biologists to develop hypotheses about the relatedness of organisms.



Charles Darwin and *The Origin of Species*

- Darwin's *On the Origin of Species by Means of Natural Selection* was published on November 24, 1859.
- In it, Darwin argued two main concepts:
 - Contemporary species arose from ancestors through a process of "descent with modification", his phrase for evolution.
 - Mechanism for how life evolves: natural selection.

Darwin's Theory of Natural Selection

- Based on two key observations.
- Observation 1:
 - **Overproduction:** a population can produce more offspring than the environment can support with resources. This overpopulation causes a struggle for coexistence.

- Example of Overproduction: Fungus producing millions of spores.
- Only a tiny fraction of the spores will actually result in offspring that survive and reproduce.



Figure 13.14

Darwin's Theory of Natural Selection

- Observation 2:
 - **Individual Variation:** Individuals in a population vary in many heritable traits.

There is a genetic basis to variation among individuals in a population.



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Figure 13.16

Darwin's Theory of Natural Selection

- **Differential Reproductive Success:**
Individuals with traits best suited for their environment generally leave more surviving and fertile offspring.
- In other words, natural selection promotes evolutionary adaptations.

Darwin's Theory of Natural Selection: A Review

1. All populations produce more offspring than can survive.
2. Genetic variation exists among individuals in a population and this variation is often passed to offspring.
3. Individuals with traits that aid in survival and reproduction have a better chance of contributing to the next generation.

A Key Point about Natural Selection

- Natural Selection is more of an editing process than a creative process.
 - Ex: A pesticide does not create resistant individuals, but selects for resistant insects that were already present in the population.

The Process of Science: Does Predation Drive the Evolution of Lizard Horn Length?

Flat-tailed horned lizard



(a)

Figure 13.17a

Does Predation Drive the Evolution of Lizard Horn Length?

- Scientists concluded that defensive behavior against predators is one factor driving natural selection of horn length among this lizard species.

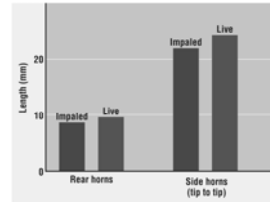


Figure 13.17 c

Modern Synthesis: Darwinism Meets Genetics

- Darwin - evolution by natural selection.
- Mendel - hereditary (genetic) processes needed for evolution by natural selection.
- Mid 1900's - **Modern Synthesis**
 - The fusion of genetics with evolutionary biology.
 - One key element of modern synthesis is the emphasis on population biology (genetics).

Population Biology

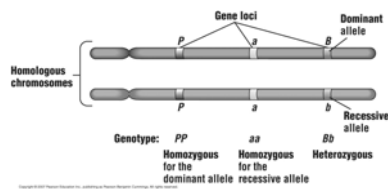
- Population - group of individual of same species living in the same place at same time.
- Smallest biological unit that can evolve.
- Natural selection works on individuals, inherited characteristics affect their survival and reproductive success.
- But evolutionary impact of natural selection is only apparent when we track how a population changes over time.

Population Genetics

- Focuses on populations as the evolutionary units.
- Tracks the genetic makeup of populations over time.

Individual Genetics: A Review

- **Gene** – a portion of DNA that determines a characteristic.
- **Locus** – specific place on a chromosome where a particular gene is located.
- **Alleles** – *Two or more* different forms of a gene located at the same locus.



- **Genotype:** genetic makeup of an organism. The hereditary material or set of genetic instructions that determines an organism's characteristics.
- **Phenotype:** physical expression of genotype
 - Results from interaction between genotype and the environment.
- Therefore, one genotype may produce numerous phenotypes based on environmental conditions.

Population Genetics

- Only the genetic component of variation is relevant to natural selection.
- Populations can have more than 2 alleles:
 - Example - 3 alleles for human blood type (A, B & O).
- **Gene Pool** - All alleles in a population at any one time from which next generation draws its genes.

Population Genetics

- **Genetic diversity** - describes genetic differences among members of a population.
 - High – many different kinds of alleles for each characteristic.
 - Low – nearly all individuals have same alleles.
- **Allele frequency** – describes how common a specific allele is compared to other alleles of the same characteristic.
 - It is possible to have two populations of the same species with the same alleles but very different frequencies.

Microevolution as Change in a Gene Pool

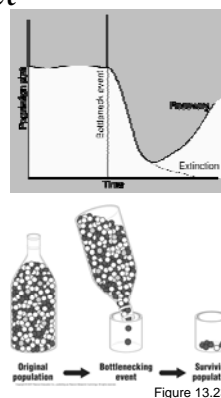
- Microevolution is defined as a generation-to-generation change in a population's frequencies of alleles.
- Main Causes:
 - Genetic Drift
 - Gene Flow
 - Mutations
 - Natural Selection

Genetic Drift

- Change in the gene pool of a small population due to chance.
 - **The Bottleneck Effect** - genetic drift due to drastic reduction in population size.
 - **The Founder Effect** - genetic drift due to few individuals starting a new population.

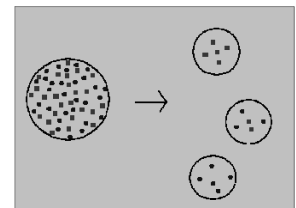
The Bottleneck Effect

- A larger population suddenly contracts to a smaller size.
- Usually reduces the genetic variation in a population because some alleles are likely to be lost from the gene pool.
 - E.g., cheetah



The Founder Effect

- The Founder Effect is the loss of genetic variation when a new colony is established by a very small number of individuals from a larger population.



Gene Flow

- Is genetic exchange with another population (transfer of alleles).
- Tends to reduce genetic differences between populations.
- Fertile individuals move into or out of a population (or gametes like plant pollen).
- Results in gain/loss of alleles.

Gene Flow and Human Evolution



Figure 13.26

Mutation

- Is the change in an organism's DNA (specifically, the change in the nucleotide sequence).
- A mutation does not have a substantial effect on a large population in a single generation. But mutant allele will spread if individuals carrying the mutant allele are producing more offspring than others that then also survive and reproduce.
- Mutation can be beneficial, harmful, or have no effect.
- Mutations serve as the raw material for natural selection.

Natural Selection in the Context of Microevolution

- Genetic drift, gene flow, and mutation cause microevolution but don't necessarily lead to adaptation.
- Only natural selection promotes adaptation.

Darwinian Fitness

- Is the contribution an individual makes to the gene pool of the next generation relative to the contributions of other individuals.
- Production of fertile offspring is the only score that counts in natural selection.

Three outcomes of Natural Selection

- Directional Selection
 - Shifts the phenotypic “curve” of a population by selecting in favor of some extreme phenotype.
 - Ex: common when local environment changes.

Three outcomes of Natural Selection

- Disruptive Selection
 - Can lead to a balance between two or more contrasting morphs in a population.
 - Ex: Common when local environment patchy.

Three outcomes of Natural Selection

- Stabilizing Selection
 - Maintains variation for a particular trait within a narrow range.
 - Ex: Common when in relatively stable environments.

Three Outcomes of Natural Selection

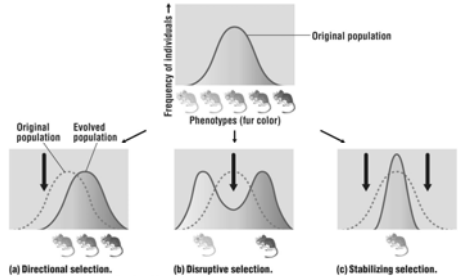


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