

Unit 8: Evolution & Classification

Topic 2: Evolution

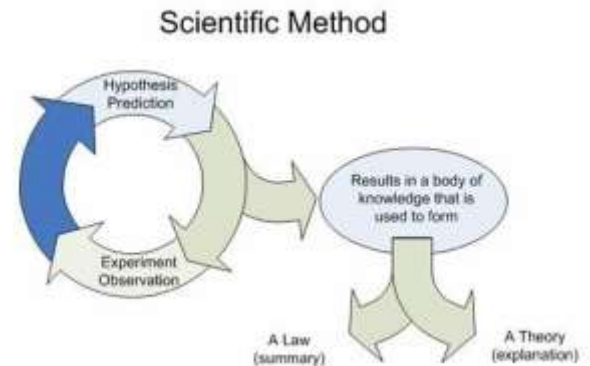
Topic 2 learning targets

- Differentiate between Lamarck and Darwin's theories of evolution.
- Explain the different types of evidence for evolution.
- Describe how new species are formed through evolution.

Guiding question: How does genetic variation among organisms affect survival and reproduction?

Revisiting vocabulary

- **Inference:** An interpretation based on prior knowledge and experience
- **Hypothesis:** A scientific explanation that can be tested (research based, written if-then)
- **Theory:** A well-tested explanation that unifies a broad range of observations and hypotheses
- **Law:** A statement based on repeated experimental observation



What is evolution?

A change in a population of species over a period of time (genotypic vs. phenotypic change)

- It acts on populations, not individuals
- It can occur at one of two levels:
 - **Microevolution:** small scale (molecular) → Seen in living populations
 - **Macroevolution:** large scale (speciation) → Seen in the fossil record

What is population?

A population is a group of individuals of the same species in an area (that can interbreed)

- Populations share a gene pool
- **Gene pool:** All of the genes (alleles) for all of the traits in a given population at any time
If all members of a population are homozygous for a particular allele, then the allele is fixed in the gene pool

Jean Baptiste Lamarck (1744-1829)

Lamarck proposed that all organisms have an inborn urge to become more complex and perfect.

- Organisms could change during their lifetimes by selectively using or not using various parts of their bodies. → **Use and Disuse**
- Individuals could then pass these acquired traits on to their offspring, enabling species to change over time. → **Inheritance of Acquired Characteristics**

Charles Darwin (1809-1882)

From his voyage on board the HMS Beagle, he found that species vary locally, globally, and over times
His most well-known studies involved finches and other animals in the Galapagos Islands

- Nature will select the organisms that have variation that allows them to better survive → **Natural Selection**
- Organisms evolved over long periods of time through descent from common ancestors → **Descent by Modification**

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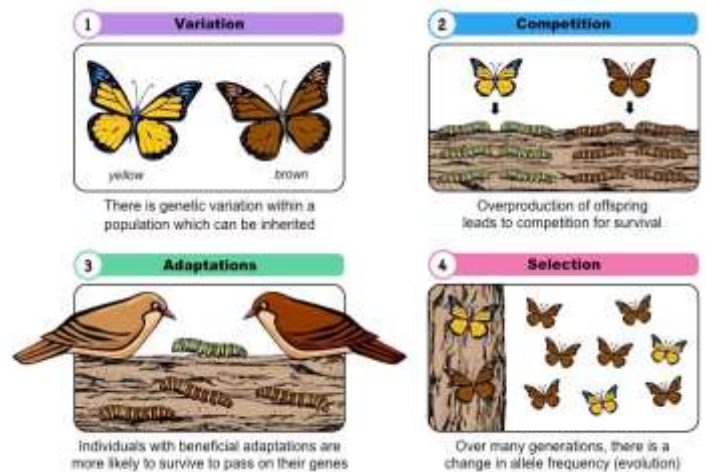
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Theory of Natural Selection

Natural Selection Mnemonic: ICE AGE

The key components to the process of natural selection are:

1. Inherited variation exists within the population
2. Competition results from an overproduction of offspring
3. Environmental pressures lead to differential reproduction
4. Adaptations which benefit survival are selected for
5. Genotype frequency changes across generations
6. Evolution occurs within the population



In the situation shown here, what characteristic is affecting the butterflies' fitness?

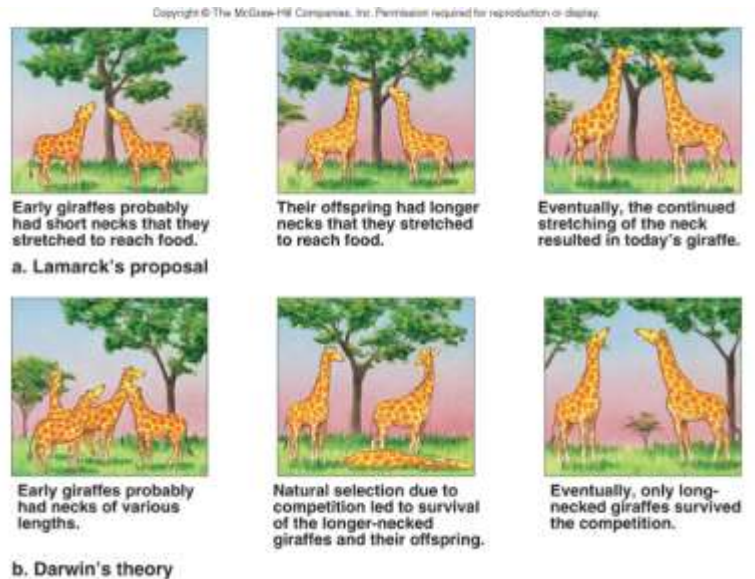
What can lead to variation?

Random mutation: Organisms with shorter generation times → higher mutation rates compared to organisms with longer generation times

Natural Selection vs. Evolution

- Natural selection and evolution are often interchangeable, but they are not the same thing.
- Natural selection is a mechanism of evolution and organisms can evolve in other ways beyond it such as random mutation, lateral gene transfer, genetic drift, and gene shuffling in sexual reproduction.

How did Lamarck influence Darwin's thinking?



Evidence of evolution

Evidence Mnemonic: FAME (Fossil, Anatomical, Molecular, Embryological)

Fossil evidence

Fossil: A trace of long-dead organism found in layers of sedimentary rock; minerals replace tissue

Fossil types to know:

- Trace: Any indirect evidence of activity left by an organism. *Example*: footprint, burrow
- Molds & casts: Impression of the organism. A cast is a mold filled with sediment
- Resin: Organisms preserved nearly perfectly in plant resin
- Living: Any living species that is nearly identical to species previously known only from fossils

What examples do we have for living fossils?

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Anatomical evidence

Evidences found from comparing structures in modern organisms with ancient organisms

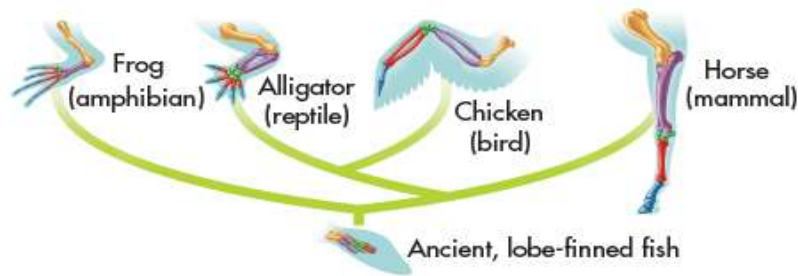
Three types of structures

1. Homologous: Structures that are shared by related species and that have been inherited from a common ancestor
2. Analogous: Structures that share a common function, but are different in structure
3. Vestigial: Structures that are inherited from ancestors, but have lost most of their original function due to different selection pressures acting on the descendants

Homologous Structures

Darwin proposed that animals with similar structures evolved from a common ancestor with a basic version of that structure

- Homologous structures are similar in structure, but may have different functions.
- When two or more distinct species share a common ancestor and yet evolved into different species, this is called divergent evolution.



Analogous Structures

- Analogous structures are different in structure, but have similar functions.
- When two or more distinct species independently evolve similar traits as a result of adapting to a similar environment, this is called convergent evolution.

What is an example of two organisms with an analogous structure?

Vestigial Structures

These structures are often called vestigial organs and demonstrate the evolutionary divergence of a species from a past activity. An example of a vestigial organ is the pelvic bone in whales that suggested that whale ancestors were terrestrial mammals.

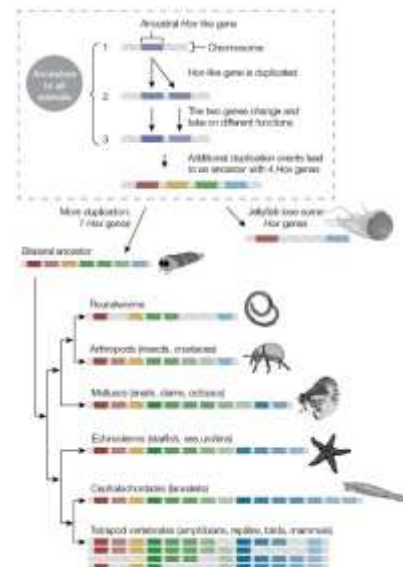
Molecular evidence

Evidence found from similarities in protein and DNA sequences (the fewer differences, the more closely related two organisms are)

- Universal genetic code: Organisms use the same triplet code and the same 20 amino acids in proteins.
- Similarly, all organisms have certain organic molecules in common.
 - Hemoglobin carries oxygen in blood.
 - Cytochrome C is a protein for cell respiration found in almost all living cells.
 - HOX genes to control development.

Where are these two organisms different in this DNA sequence?

Hippopotamus	TCC TGGCA GTCCA GTGGT
Humpback whale	CCC TGGCA GTGCA GTGCT



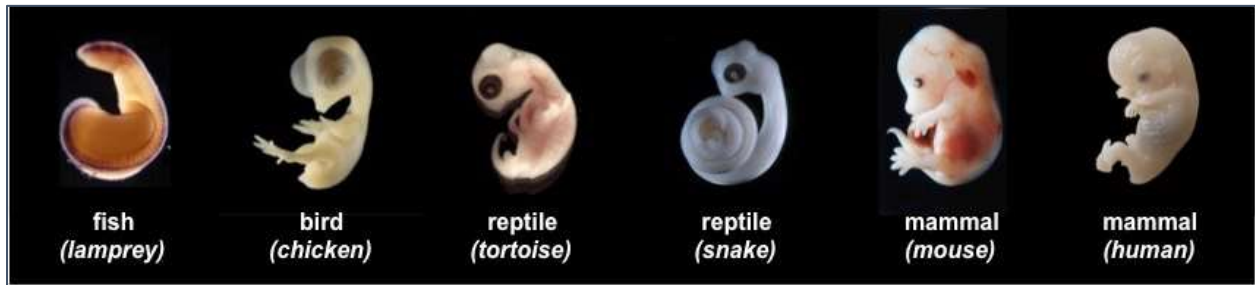
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Embryological evidence

Evidence found from similarities in embryos; organisms with a recent ancestor have more similar embryos

- All terrestrial animals have non-functioning gill slits (pharyngeal slits) as early embryos (suggesting an aquatic origin)
- Many vertebrates (including humans) demonstrate a primitive tail at an early stage of embryonic development



Natural selection

There are three types of natural selection.

1. Directional
2. Disruptive/diversifying
3. Stabilizing

Directional selection

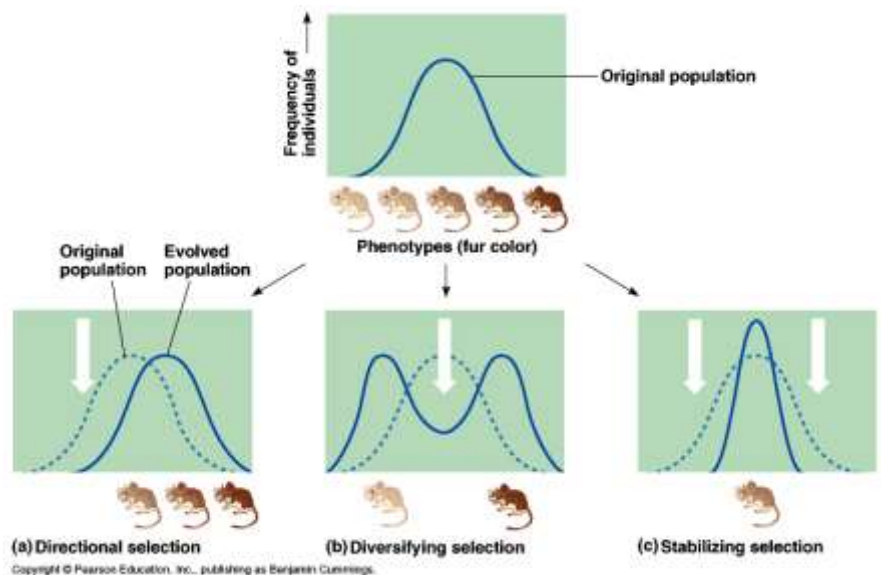
Individuals at one end of the curve have higher fitness than those in the middle or at the other end of the curve.

Disruptive/diversifying selection

Individuals at the upper and lower ends of the curve have higher fitness than those near the middle – this creates two different phenotypes.

Stabilizing selection

Individuals near the center of the curve have higher fitness than those at either end of the curve.



Sexual selection

- A process by which females choose males for mating based on certain traits.
- Males with the specific traits have higher fitness and reproductive success.
- Traits could be anything:
 - Bright colors
 - Large antlers
 - Food resources
 - Best combatant

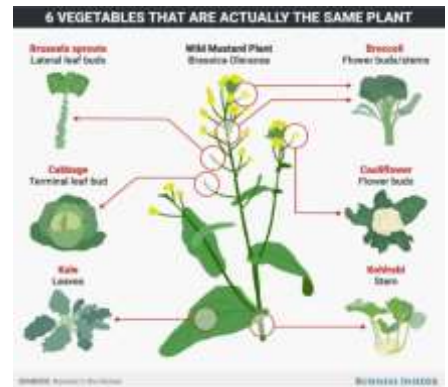
How might a specific trait on a male show fitness and reproductive success?

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Artificial selection

- Darwin studied change in nature by observed change produced from plant and animal breeders.
- Breeders knew that individual organisms vary, and that some of this variation could be passed from parents to offspring and used to improve crops and livestock. This process is called selective breeding.
- Overtime, selective breeding allowed the wild mustard plant to transform into 6 different vegetables that are still the same species.
- When humans “select” certain favorable characteristics in plants and animals, that is called artificial selection.



When does evolution create a new species (speciation)?

In order to answer this question, we must first define what a species is.

There are two different concepts of a species.

1. Morphological species: Internal and external structures are used to group organisms into species
2. Biological species: A population of organisms that can successfully interbreed

Causes of Speciation

Speciation is the process by which a new species is formed.

There are two main causes for speciation.

1. Geographic isolation
2. Reproductive isolation (prezygotic, postzygotic)

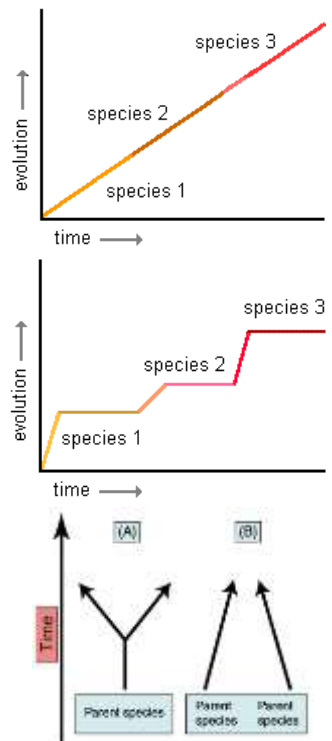
Models of speciation

- Gradualism: Change occurs slowly and at a constant rate
- Punctuated Equilibrium: Little or no change is followed by rapid change (often due to major changes in the environment)

Patterns of evolution

1. Divergent evolution: Two or more related populations/species become different (Example: Darwin's finches)
2. Convergent evolution: Organisms with different ancestors become very similar due to environmental factors (Example: Sharks and dolphins)
3. Coevolution: Change of two or more species in response to one another (predator/prey relationships)
4. Adaptive radiation: Rapid evolutionary diversification of a single ancestral line

Label the images to the right with the proper terminology (gradualism, punctuated equilibrium, divergent evolution, and convergent evolution).



Mechanisms of Variation

There are three main processes that promote variation within a population (biodiversity).

1. Mutation: A change in the genetic composition of an organism due to alterations in DNA base sequence. It can lead to a new trait that may be advantageous to have.
2. Sexual reproduction (nonrandom mating): Introduce new gene combinations in offspring via random mating and meiotic divisions
3. Gene flow (migration): Movement of alleles into (or out of) a population as a result of immigration or emigration

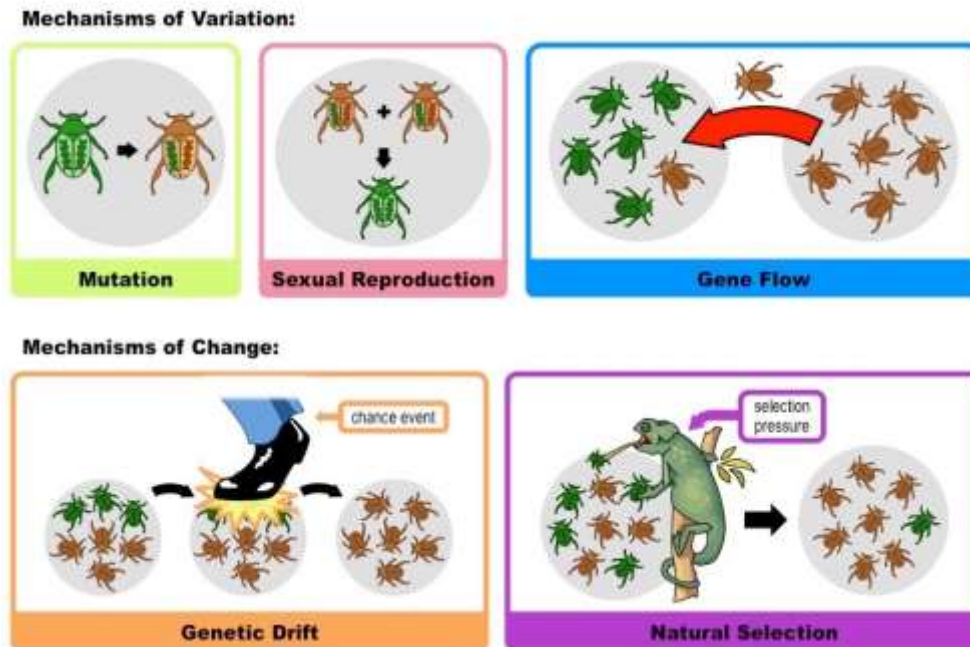
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Mechanisms of change

There are two main mechanisms for change which will reduce biodiversity within a population.

1. Genetic drift: The change in composition of a gene pool as a result from a random or chance event
 - a. Founder effect: Population splits due to migration event and an isolated population with distinct genotypes forms
 - b. Bottleneck effect: Population splits due to natural disaster and becomes restricted in genetic variability
2. Selection: Environmental factors dictate which traits are needed to survive (**natural selection**) or individuals bred for specific traits (**artificial selection**)



Speciation

Populations of a species must become reproductively isolated in order to develop into new species

Variations vs. Adaptations

Variations

- Differences that exist within a population that may have no effect on fitness
- Example: Length of your thumbs
- Causes for variation:
 - Mutation (ATC→AGC)
 - Events during meiosis (crossing over)
 - Random fusion of gametes (which sperm fertilizes which egg)

Adaptations

- A variation that all members of a population have inherited because that trait improves fitness
- Example: Opposable thumbs