MAMMOTH SCIENCE

EST 2022

PUBLISHING

Biodiversity & Evolution

- *Define biodiversity and explain why it is important to study and protect it.*
- *Describe the different levels of biodiversity (species, genetic, ecosystem) and give examples of each.*
- *Explain the theory of evolution by natural selection and how it relates to the origin of species.*
- *Understand the concept of adaptation and give examples of how it contributes to the survival of species.*
- *Describe the different types of evidence that support the theory of evolution (fossils, comparative anatomy, comparative embryology, molecular biology, and biogeography).*
- *Explain the concept of speciation and give examples of how it can occur.*
- *Understand the difference between microevolution and macroevolution and give examples of each.*
- *Explain the process of natural selection and how it can lead to the evolution of new traits and species.*
- *Understand the importance of genetic variation in natural selection and how it can lead to the adaptation of populations to changing environments.*

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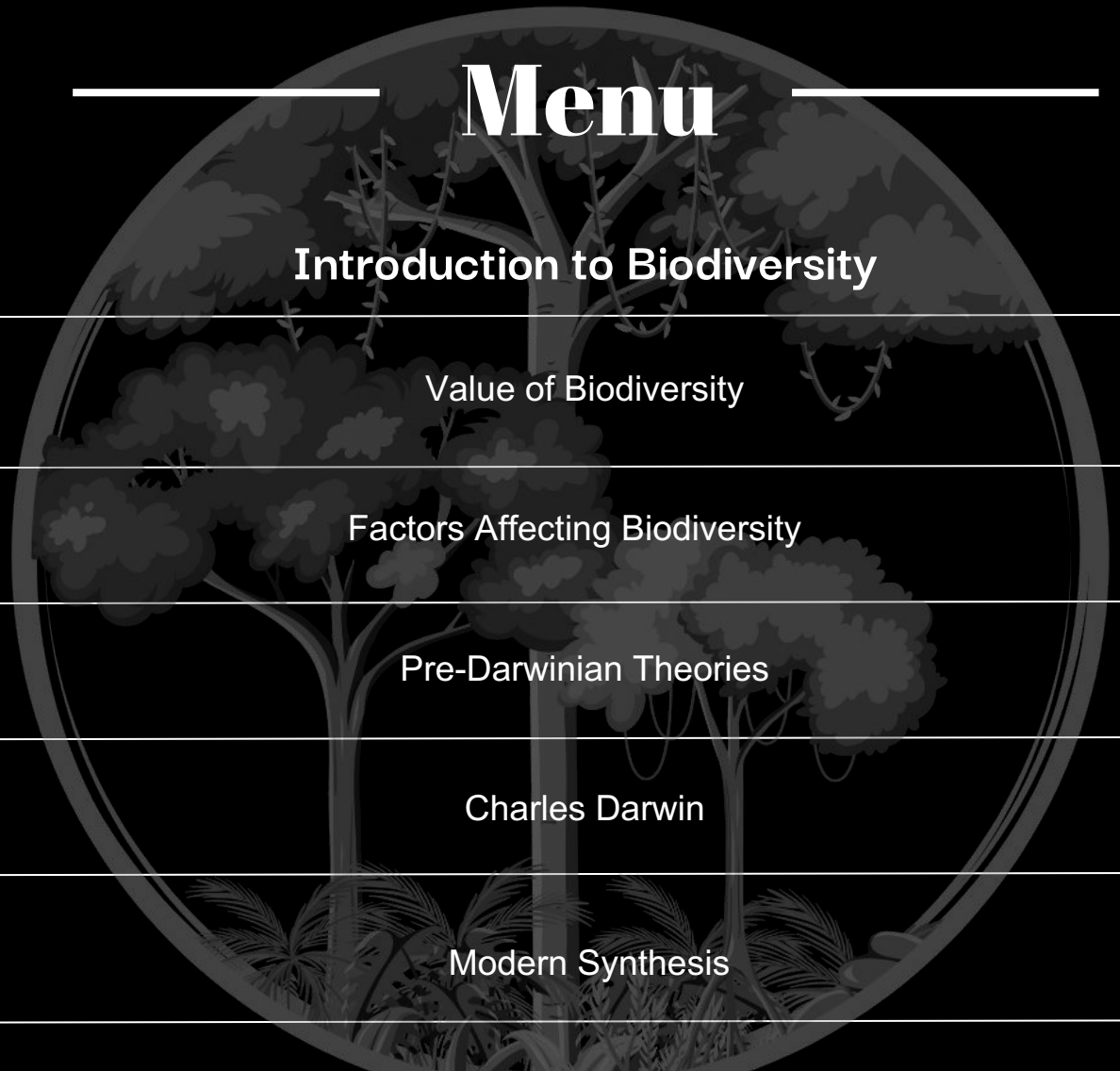
Menu



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Menu

5 Evidences of Evolution: Fossil Record

Fossil Record - Law of Superposition

Comparative Anatomy

Comparative Anatomy - Analogous

Comparative Embryology

Molecular Biology - DNA & Amino Acids

Biogeography

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Menu

Introduction to Biodiversity

I. Biodiversity

B. Definition of biodiversity

3. **Biodiversity** refers to the **variety** of living **organisms** that exist on **Earth**.
4. It includes:
    - **e. diversity in species**
    - **f. genes**
    - **g. ecosystems.**

https://siwi.org/wp-content/uploads/2021/05/biodiversityday-768x319.jpg

B. Importance of biodiversity

1. Biodiversity is **essential** for the **health** and **stability** of ecosystems. It provides **numerous** ecosystem **services**:

Value of Biodiversity

a. **such as air and water purification**

b. **nutrient cycling**

c. **soil formation.**

2. Biodiversity also has **economic**, **cultural**, and **aesthetic** value.

   a. **Biodiversity** has **economic** value because:

      2. it provides a wide range of goods and services that are essential for human survival and well-being. For example, many medicines are derived from plants and animals, and a diverse ecosystem provides a variety of ecosystem services such as pollination, water filtration, and soil fertility.

   c. **Biodiversity** also has **cultural** value as it is often intertwined with the cultural identity and practices of local communities.

      4. Many cultures around the world have developed unique relationships with their local ecosystems, which are reflected in their traditional knowledge and practices related to agriculture, hunting, and gathering.

      5. Biodiversity also provides inspiration for art, music, and literature, and is an important part of the world's cultural heritage.

Factors Affecting Biodiversity

a. Finally, **biodiversity** has **aesthetic** value as it provides beauty and inspiration for people.

2. Many people derive pleasure from observing and experiencing the natural world, and the diversity of life forms found in different ecosystems adds to the richness and diversity of our experiences.

C. Factors that affect biodiversity

1. including**:**

b. habitat loss

c. climate change

d. pollution

e. overexploitation of resources

f. and invasive species.

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Pre-Darwinian Theories

II. History of Evolutionary Theory

A. Pre-Darwinian Theories

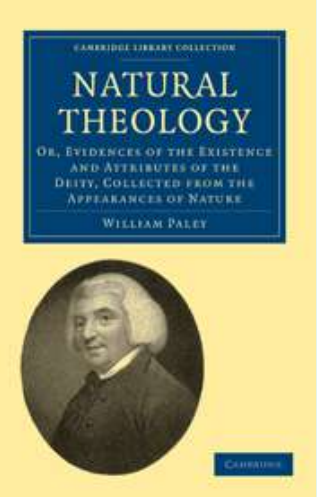
2. **Lamarckism** - proposed by Jean-Baptiste Lamarck in the early 19th century, this theory suggested that organisms could acquire new traits during their lifetime and pass them on to their offspring. Lamarckism also proposed that organisms could evolve in response to environmental changes.

1. **Catastrophism** - this theory, proposed by Georges Cuvier in the late 18th and early 19th centuries, suggested that the Earth's history was marked by catastrophic events that caused the extinction of many species. According to this theory, new species were created to replace those that had gone extinct.

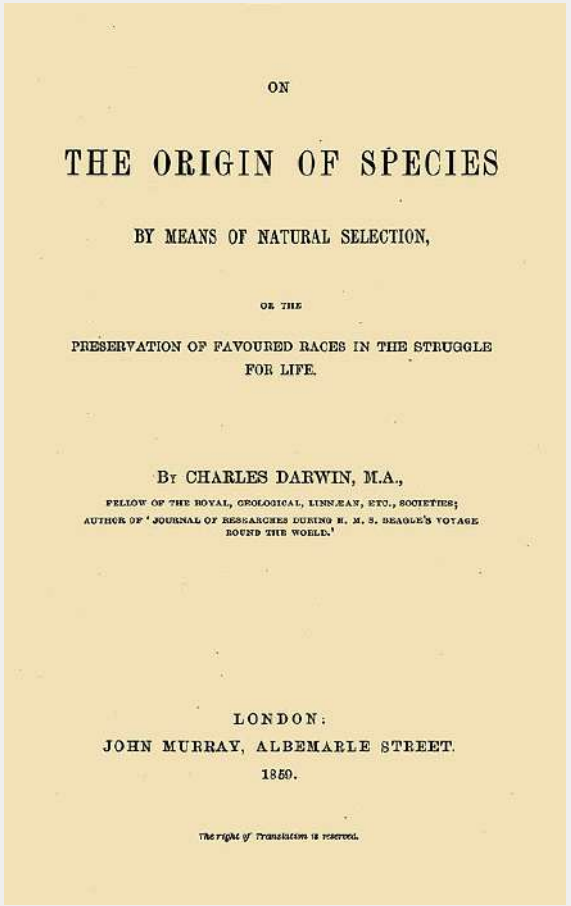
Pre-Darwinian Theories Cont'

1. **Uniformitarianism** - proposed by geologist Charles Lyell in the early 19th century, this theory suggested that geological processes that shaped the Earth's surface were slow and gradual, occurring over long periods of time. Lyell argued that the Earth was much older than previously thought, and that its history was marked by gradual, rather than catastrophic, changes.

1. **Natural Theology** - this theory, popular in the 18th and early 19th centuries, held that the complexity and beauty of living organisms could only be explained by the existence of a divine creator.



Charles Darwin


ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

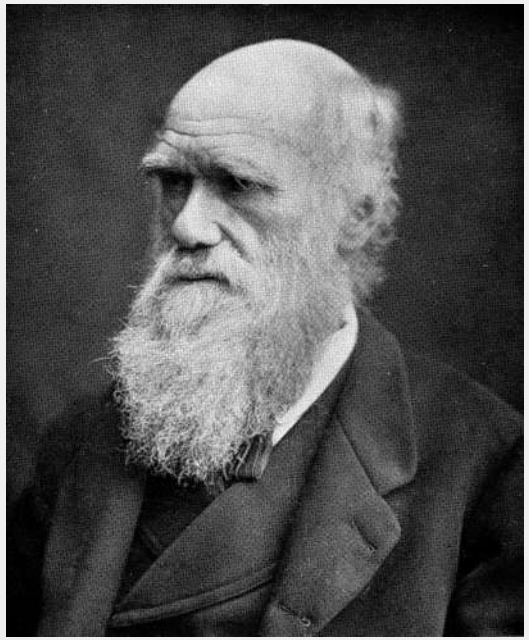
OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.



B. Charles Darwin and The Origin of Species

1. Charles Darwin is credited with proposing the theory of evolution by natural selection.
2. He published his book, **The Origin of Species**, in 1859, which presented evidence for evolution and explained the mechanism of natural selection.

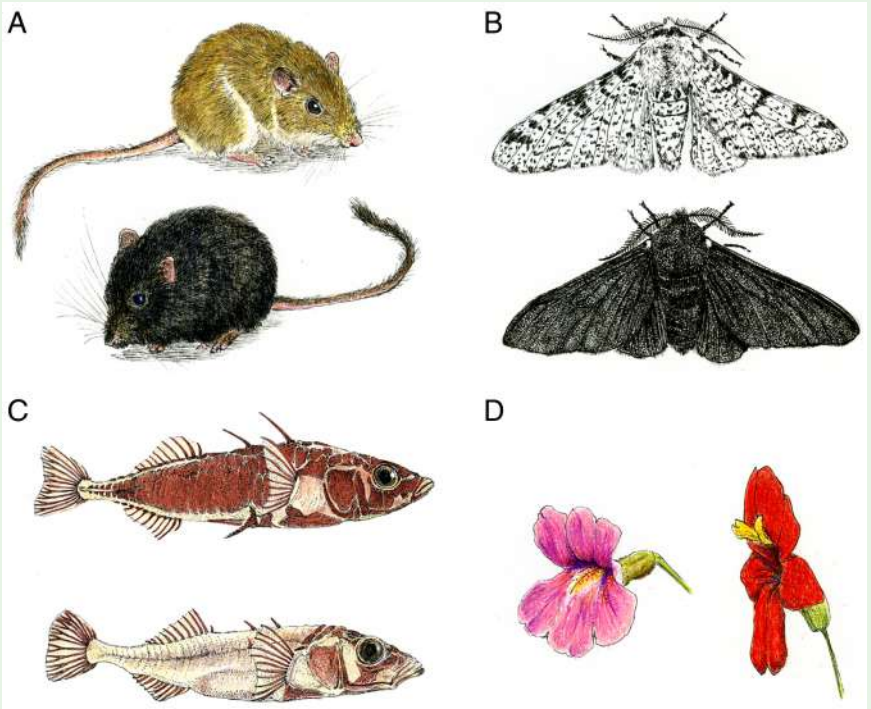
Modern Synthesis

C. Modern Synthesis

1. The **modern synthesis**, also known as the **neo-Darwinian synthesis**, is a **combination** of **Darwin's theory** of evolution by **natural selection** and **modern genetics.**
2. It explains how variation and natural selection can lead to evolutionary change.
3. **Mutation and recombination -** the modern synthesis recognized that genetic variation arises from mutation and recombination, which provides the raw material for natural selection to act upon.
4. **Population genetics -** the modern synthesis integrated the study of genetic variation within populations with Darwin's theory of natural selection. This allowed for a quantitative understanding of how evolution occurs in populations.
5. **Gradualism -** the modern synthesis emphasized the importance of gradual change over long periods of time in the evolution of species.
    f. Proposed as alternative to Gradualism - **Punctuated equilibrium**
        7. Suggests that species may remain relatively stable for long periods of time, or exhibit stasis, with little change in their morphology or behavior.
        8. However, when a species does undergo evolutionary change, it does so rapidly and in a punctuated manner, rather than gradually over time.

Natural Selection & Adaptation

1. **The role of natural selection -** the modern synthesis emphasized the central role of natural selection in driving evolutionary change. It recognized that natural selection acts on individual organisms, but its effects are observed at the level of populations over time.
2. **The concept of adaptation -** the modern synthesis clarified the concept of adaptation, which refers to traits that increase an organism's **fitness** in a particular environment.
   c. **Adaptation** occurs through the process of natural selection, which selects for traits that confer a fitness advantage.



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5 Evidences of Evolution: Fossil Record

III. Evidences for Evolution

A. Fossil Record

2. The fossil record is the collection of all known fossils, which are the preserved remains or traces of ancient organisms.
    - **c. Bones**
    - **d. Teeth**
    - **e. Imprints** of feathers, plants
6. It provides a historical record of the diversity of life on Earth, and is an important source of evidence for the theory of evolution.
7. The fossil record is not complete, as it only represents a small fraction of all the organisms that have ever lived on Earth.

h. The chances of an organism becoming a fossil are relatively low, as it requires the organism to be buried in sediment quickly after death and for the sediment to be preserved and later exposed by geological processes.

Fossil Record - Law of Superposition

a. As a result, many organisms are not fossilized, and the fossil record may be biased towards organisms that lived in environments that were conducive to fossilization, such as those with hard shells or bones.

2. Despite its incompleteness, the fossil record provides important evidence for the theory of evolution. One of the most important aspects of the fossil record is the presence of **transitional** fossils.

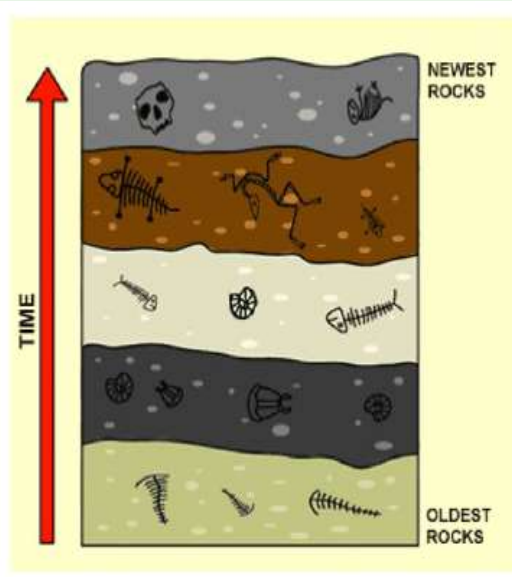
c. **Transitional** fossils are fossils that show intermediate forms between two different species, or between a species and its ancestors.

d. These fossils provide evidence of **evolutionary change** over time and demonstrate the **gradual** nature of evolutionary transitions.

5. **The Law of Superposition** is a geological principle that states that in undisturbed rock layers, the **oldest** rocks are on the **bottom** and the **youngest** rocks are on **top**.

f. This principle is important for understanding the **relative ages** of fossils found in different **layers** of rock.

g. By examining the layers of rock and the fossils found within them, scientists can determine the relative ages of the fossils and make **inferences** about the order in which different species evolved.



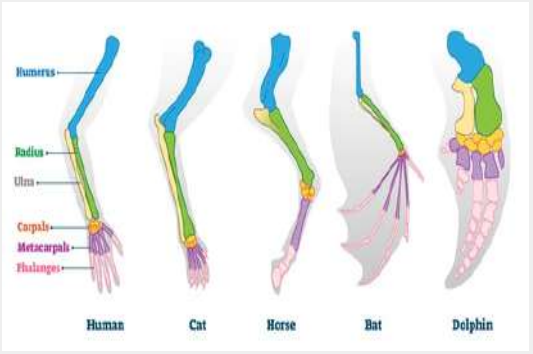
Comparative Anatomy

B. Comparative Anatomy

1. **Comparative anatomy** compares the anatomical structures of different organisms to identify similarities and differences. It provides evidence for common ancestry and evolutionary relationships between different groups of organisms.

b. Homology

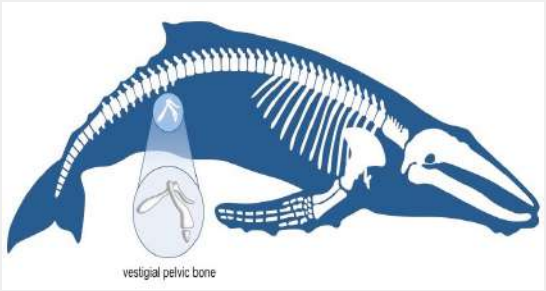
3. **Homology** refers to similarities in the **structure** of **different** organisms that are due to their **common ancestry**.
4. Homologous structures have **similar** underlying **anatomy** and development, but may have **different functions** in different species.



https://www.shutterstock.com/image-vector/homologous-structures-vector-illustration-biological-260nw-1603198606.jpg

b. Vestigial structures

1. Vestigial structures are **structures** that have **no known function** in an organism but are **remnants** of structures that were **functional** in **ancestral** species.
2. Vestigial structures provide **evidence** of the **evolutionary history** of an organism.



https://ib.bioninja.com.au/_Media/vestigial-structure_med.jpeg

Comparative Anatomy - Analogous

c. Analogy

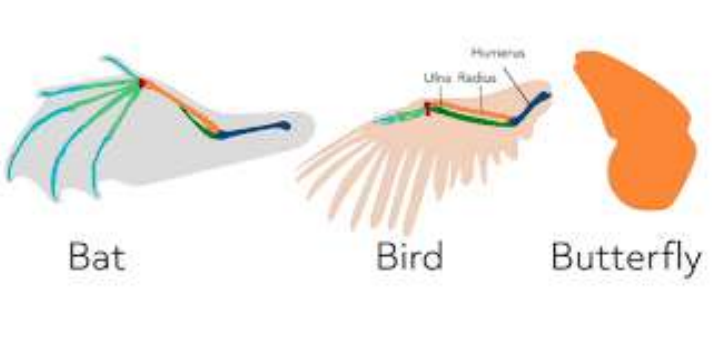
1. **Analogous** structures are structures that have a **similar function** in different species but have **different** underlying **anatomy** and development.
2. Analogous structures are the result of **convergent** evolution, where different species evolve similar structures **independently** in response to **similar environmental** pressures.

d. Examples

1. Examples of **homologous** structures include the forelimbs of mammals, birds, and reptiles.
2. Examples of **vestigial** structures include the human appendix.
3. Examples of **analogous** structures include the wings of birds and bats.

e. Significance

1. Comparative anatomy is an important source of evidence for the theory of evolution, as it provides clues about the evolutionary history of organisms.

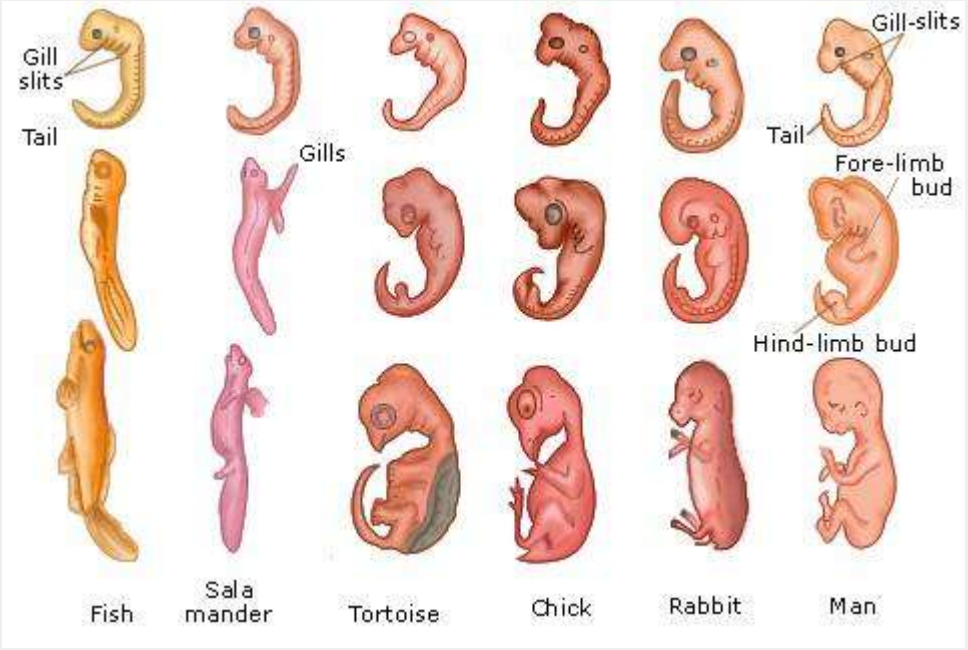


https://cdn-academy.pressidium.com/academy/wp-content/uploads/2022/02/Analogous-Structures.png

Comparative Embryology

C. Embryology

1. **Embryology** compares the development of **embryos** of **different** organisms to identify **similarities** and **differences**.
2. It provides evidence for **common ancestry** and **evolutionary relationships** between different groups of organisms.



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Molecular Biology - DNA & Amino ~~Acids~~

D. Molecular Biology

1. **Molecular biology** compares the **DNA** and **protein sequences** of **different** organisms to identify similarities and differences.
2. It provides evidence for **common ancestry and evolutionary relationships** between different groups of organisms.

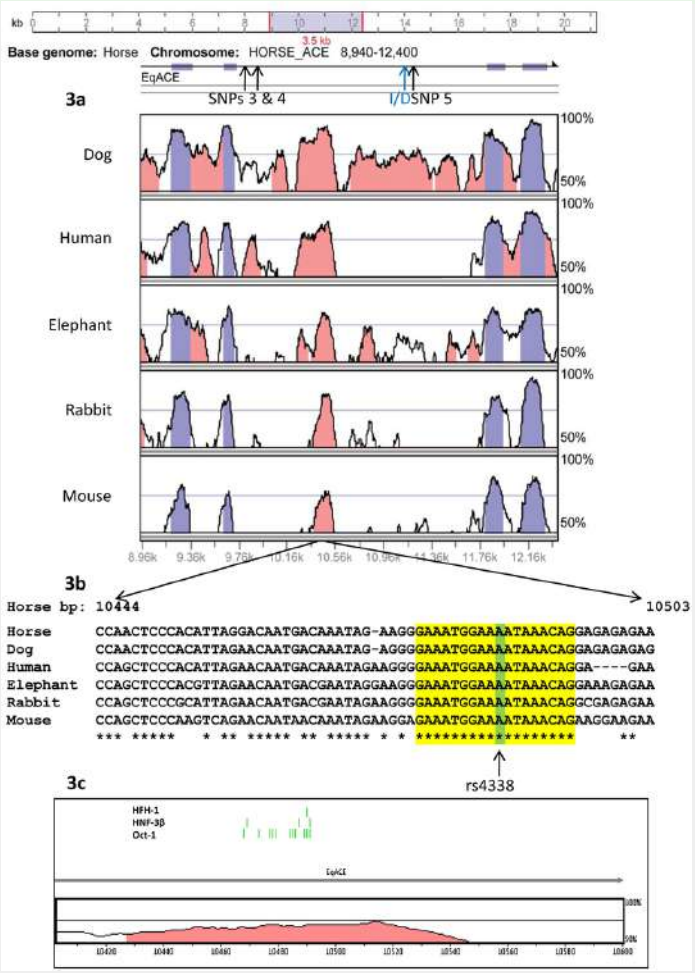


Table 6

Species Pairings	Number of Differences in amino acid
Human-chimpanzee	0
Human-fruit fly	29
Human-horse	12
Human-pigeon	12
Human-rattlesnake	14
Human-red bread mold	48
Human-rhesus monkey	1
Human-screwworm fly	27
Human- snapping turtle	15
Human-tuna fish	21
Human-wheat	43

Table 7

Species Pairings	Number of Differences in amino acid
Fruit fly-dogfish shark	26
Fruit fly-pigeon	25
Fruit fly-screwworm	2
Fruit fly-silkworm moth	15
Fruit fly-tabacco hornworm moth	14
Fruit fly-wheat	47

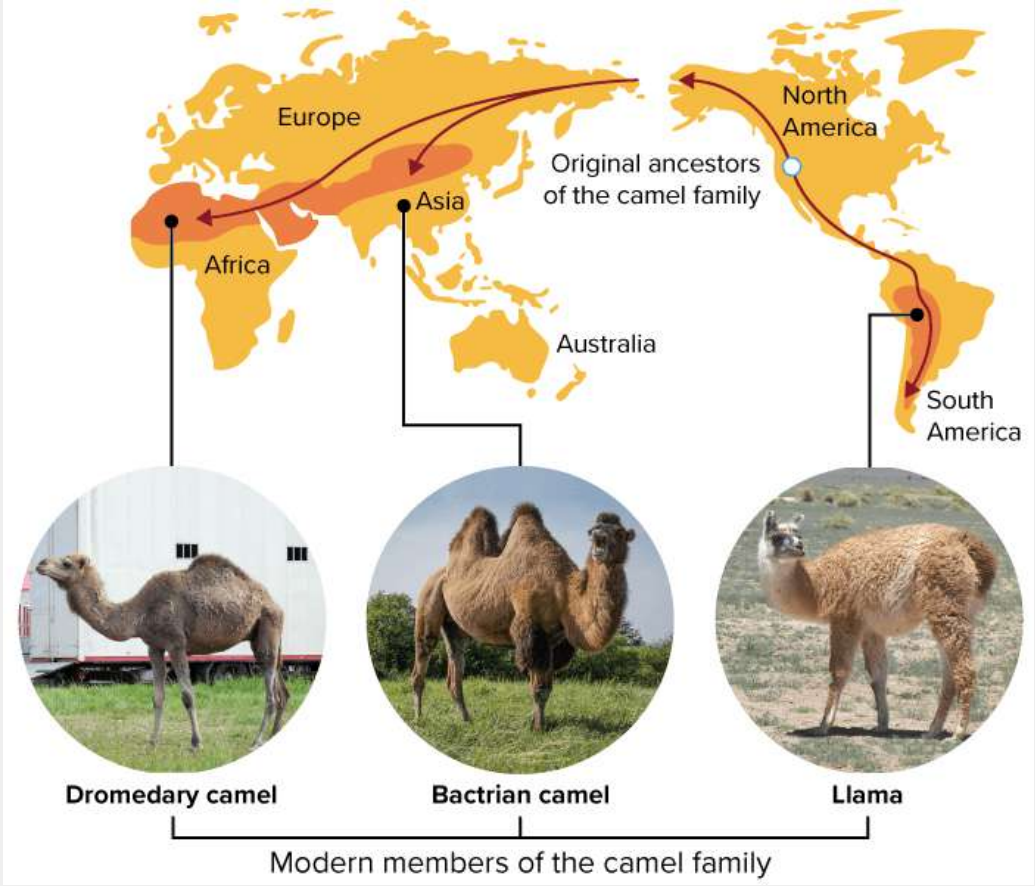
2. In a graphing paper, plot the information on Table 6 and Table 7 in a bar graph, and use different colors to represent each pairing of species.

https://www.coursehero.com/qa/attachment/17654860/

Biogeography

E. Biogeography

1. **Biogeography** compares the **distribution** of organisms in **different r**egions to identify similarities and differences.
2. It provides evidence for how **organisms** have **migrated** and **evolved** in response to **changes in their environment.**



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Natural Selection - Mechanisms

IV. Natural Selection

A. Definition of **Natural Selection**

2. Natural selection is the process by which organisms that are better **adapted** to their **environment** are more likely to **survive** and **reproduce**.

B. Mechanisms of Natural Selection

1. The mechanisms of natural selection include **variation, inheritance, and differential survival and reproduction.**

b. Variation:

3. Variation refers to the fact that **individuals** within a **species differ** from one another in their traits or **characteristics**.

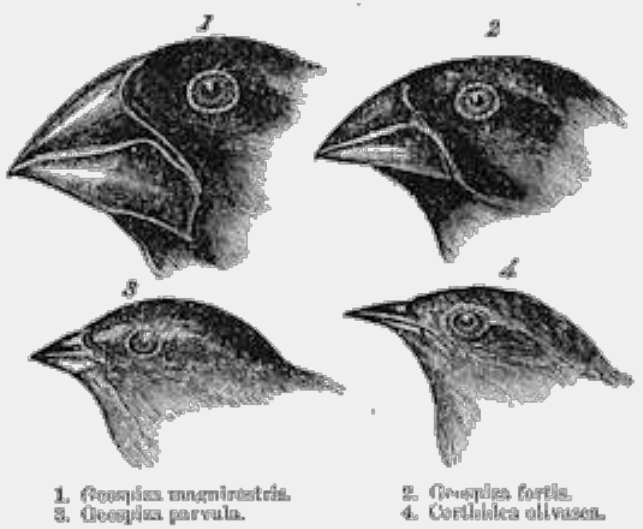
4. These **differences** can be caused by **genetic factors, such as:**

e. mutations

f. by environmental factors, such as: differences

vii.differences in nutrition

viii.exposure to disease**.**



https://www.lutheranscience.org/home/180015283/180015283/Images/300w%20Darwin%20Finches.png

Mechanisms - Cont'

b. **Inheritance:**
    1. **Inheritance** refers to the **transmission** of genetic **traits** from parents to **offspring.**
    2. **Offspring i**nherit **some** of the **traits** of their **parents** through the **passing** of genetic material from one **generation** to the **next**.

c. **Differential survival and reproduction:**
    1. **Natural selection** occurs when **individuals** with certain **traits** are **more likely** to **survive** and **reproduce** than individuals with **other traits.**
    2. **Traits** that **increase** an individual's **chances** of **survival** and **reproduction** will tend to be **passed** on to the next **generation**, while **traits** that **decrease** an individual's chances of **survival** and **reproduction** will tend to be **lost**.

d. **Time:**
    1. Over time, natural selection **leads** to **changes** in the **characteristics** of a **population**, as **advantageous** traits become **more** common, while **disadvantageous** traits become **less** common.

Evolution by Selection

C. Evolution by Natural Selection

1. **Evolution** by natural selection occurs when the **frequency** of certain **traits** in a **population** changes over time due to **differential** reproductive **success.**
2. **Individuals** with **traits** that are better **adapted** to their environment ar**e more likely** to **survive** and **reproduce, passing** on those advantageous **traits** to their **offspring.**
3. Over time, this can lead to the **evolution** of **new species.**

https://ichef.bbci.co.uk/news/976/cpsprodpb/14195/production/_89852328_carbtypmating2005.jpg

Types of Selection

V. Types of Selection

A. Directional Selection

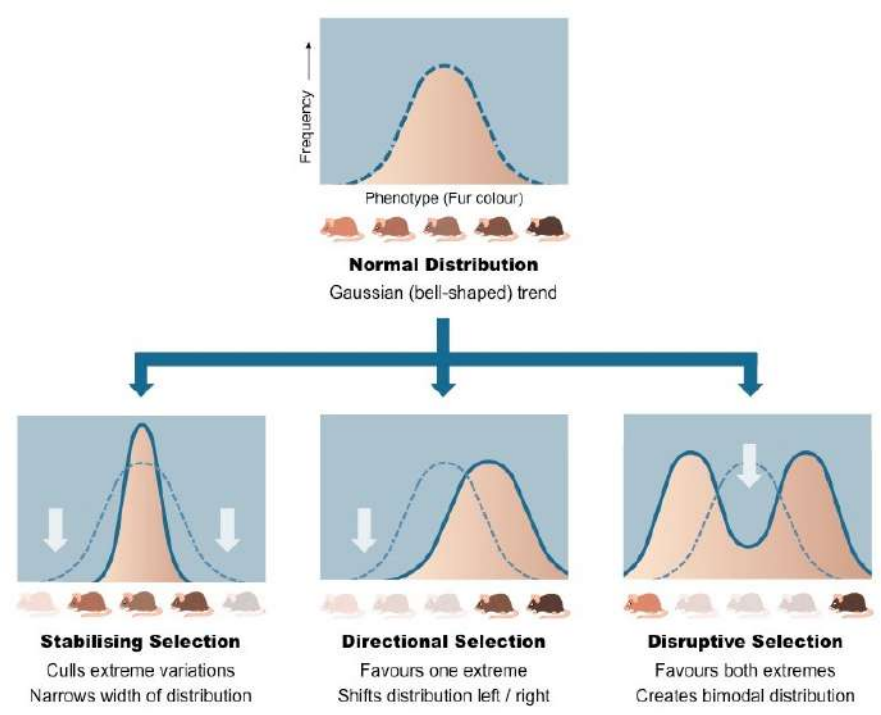
2. **Directional selection** occurs when individuals with **extreme traits** have a **higher** fitness than those with **average** traits.
3. This can lead to the **evolution of new traits** in a **population.**

B. Stabilizing Selection

1. **Stabilizing selection** occurs when individuals with **intermediate traits** have a **higher** fitness than those with **extreme traits.**
2. This can lead to the **maintenance of existing traits** in a **population.**

C. Disruptive Selection

1. **Disruptive selection** occurs when individuals with **extreme traits** at **both** ends of a spectrum have a **higher fitness** than those with **intermediate traits.**
2. This can lead to the evolution of **new traits** and the **formation** of **new species.**



https://ib.bioninja.com.au/_Media/types-of-selection_med.jpeg

Sexual Selection

D. Sexual Selection

1. **Sexual selection** is a type of natural selection that occurs when **individuals** with certain **traits** have a **higher reproductive success** than others.
2. This can lead to the **evolution** of **exaggerated traits** that are used in **courtship** or **competition** for **mates**.

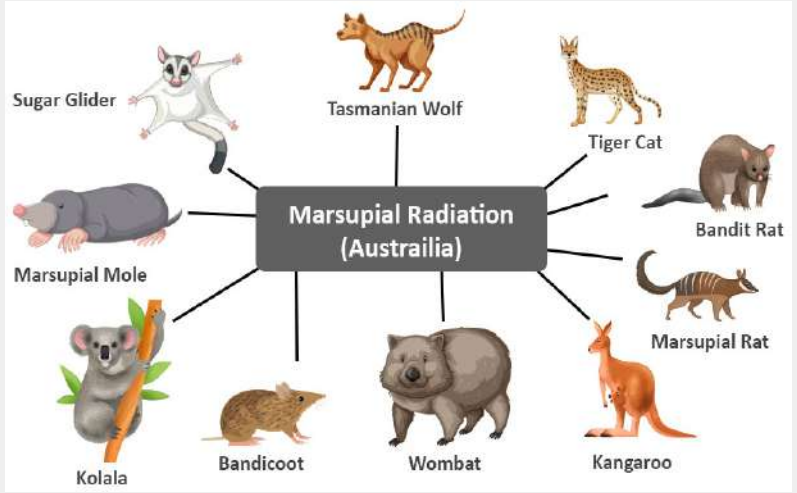
https://www.darwinproject.ac.uk/sites/default/files/Peacock-1.jpg

Adaptive Radiation

IV. Reasons for Adaptation and Speciation

A. Adaptive Radiation

2. **Adaptive radiation** occurs when a **single** ancestral species **diversifies** into **multiple new species** in response to different **ecological niches.**
    c. **Niche:** is the **role** or **position** that an organism occupies within its **environment,** including its **interactions** with other **living** and **nonliving** components of the **ecosystem.**
        4. It encompasses the organism's use of resources, such as food and habitat, as well as its **relationships** with other species, including predators, prey, and competitors.
        5. The niche of an organism is defined by a complex set of environmental factors, such as **temperature**, **precipitation**, and availability of **resources**, and can be very specific to a particular location or ecosystem.
        6. An organism's niche can have a significant impact on its survival and reproductive success, as it determines the resources that are available to the organism and the interactions that it has with other species in the ecosystem.
7. This can lead to the formation of **new species** and the development of **diverse ecosystems.**



https://media.geeksforgeeks.org/wp-content/uploads/20220606162141/Group7.jpg

Convergent Evolution

B. Convergent Evolution

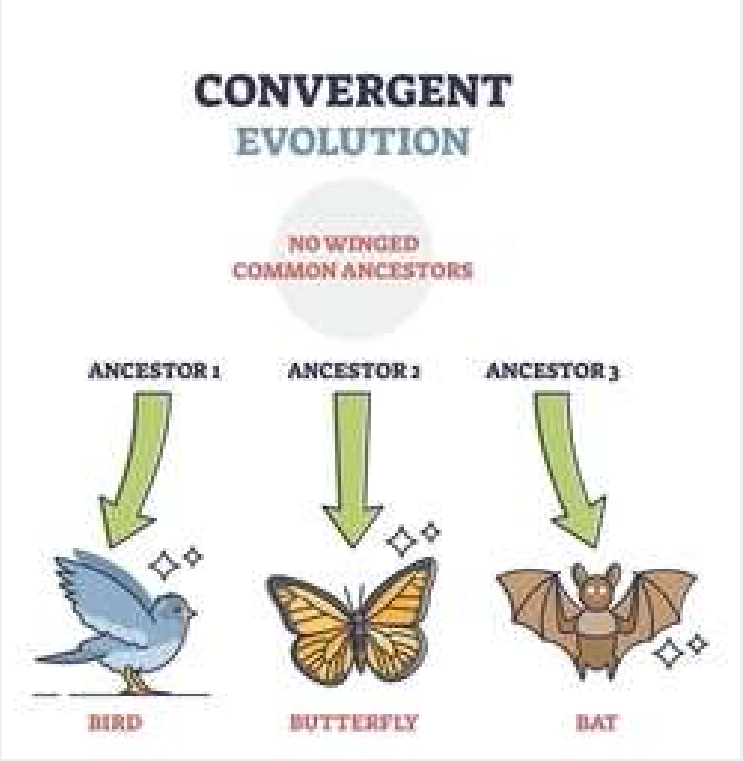
1. **Convergent evolution** occurs when **unrelated species** evolve **similar** traits due to **similar selective pressures** in their environment**.**
2. This can lead to the **development** of **analogous structures** in different species**.**
3. **Examples:**

d) Wings in birds, bats, and insects:

- Birds, bats, and insects all have wings that allow them to fly, but the underlying anatomy and development of their wings is very different.
- The wings of birds are modified forelimbs, while the wings of bats are modified hands with elongated fingers, and the wings of insects are composed of thin, membranous structures attached to the body by flexible joints.

b) Thorns in cacti and acacias:

- Cacti and acacias are both plants that evolved in environments with intense grazing pressure.
- Both types of plants have evolved thorns to deter herbivores and protect their leaves and stems.



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Convergent Evolution - Cont'

c) **Eyes in cephalopods and vertebrates:**

- Cephalopods, such as squid and octopuses, have evolved complex, camera-like eyes that are structurally and functionally similar to those of vertebrates.
- This convergence is thought to have occurred because cephalopods and vertebrates share a similar need for high-quality visual information in order to navigate their environments.

d) **Echolocation in bats and whales:**

- Bats and toothed whales both use echolocation to navigate and locate prey in their environments.
- Despite the fact that bats and whales are mammals, they have independently evolved similar mechanisms for producing and detecting echolocation signals.

https://www.science.org/do/10.1126/article.30946/abs/201012531.jpg

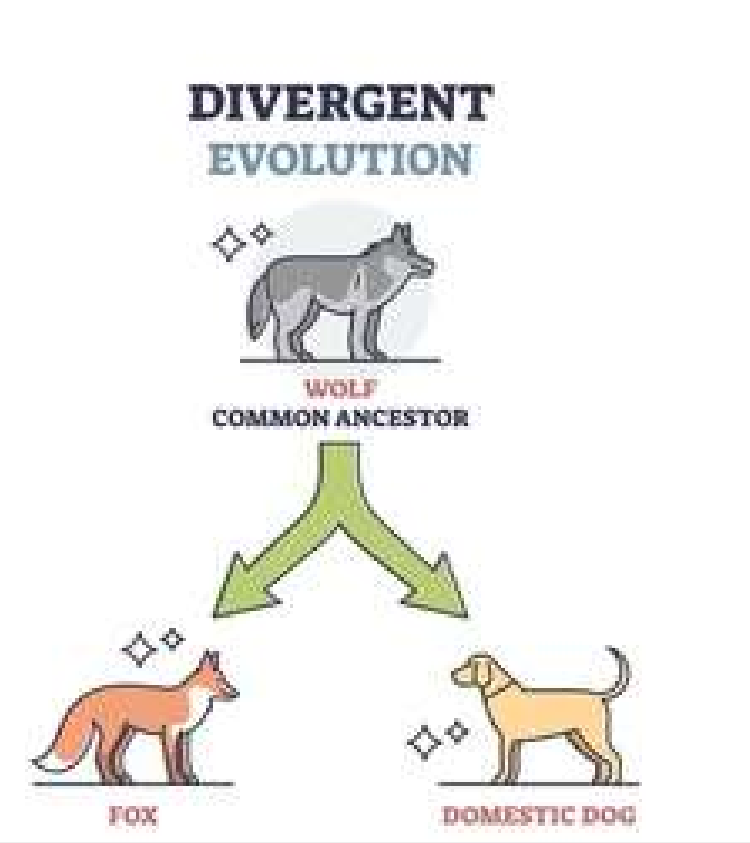
Divergent Evolution

C. Divergent Evolution

1. **Divergent evolution o**ccurs when a single **ancestral species diverges** into **multiple new species** in response to **different selective pressures** in their environment.
2. This can lead to the formation of **new species** and the **development** of diverse **ecosystems.**
3. **Examples:**

d) Darwin's finches:

- Darwin's finches are a group of 13 species of finches found on the Galápagos Islands.
- Each species has a unique beak shape that is adapted to its specific food source, which has led to the evolution of different feeding behaviors and niches within the group.



https://image.shutterstock.com/image-vector/divergent-vs-convergent-evolution-ancestors-260nw-2080339300.jpg

Divergent Evolution - Cont'

c) African elephants:

- African elephants are the largest land animals on Earth and are divided into two species, the savanna elephant and the forest elephant.
- These two species have evolved different physical characteristics and behaviors that are adapted to their different habitats.

https://africageographic.com/wp-content/uploads/2019/01/Elephants-3-species.jpg

d) Anole lizards:

- Anole lizards are a group of more than 400 species found throughout the Americas.
- Despite their close evolutionary relationship, different species have evolved different physical characteristics, such as body size and coloration, as a result of selective pressures such as predation and competition.

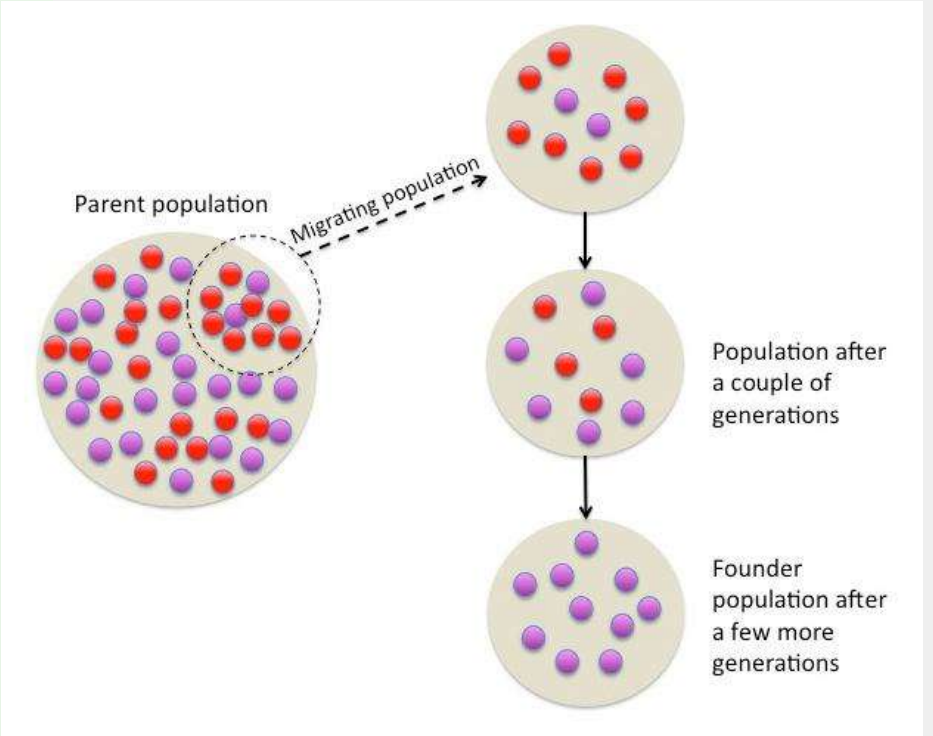
Genetic Drift

D. Genetic Drift

1. **Genetic drift** is the **random fluctuation** of **allele frequencies (gene pool)** in a **population** due to **chance** events**,** such as genetic **mutations** or fluctuations in **population size.**
2. **It can lead to the loss of genetic diversity and the formation of new species.**
3. **Examples:**

d) Founder effect:

- **Occurs when a small group of individuals from a larger population colonizes a new area.**
- Only a subset of the genetic diversity of the original population is brought with them.
- The genetic makeup of the new population may differ significantly from that of the original population due to random sampling of alleles.



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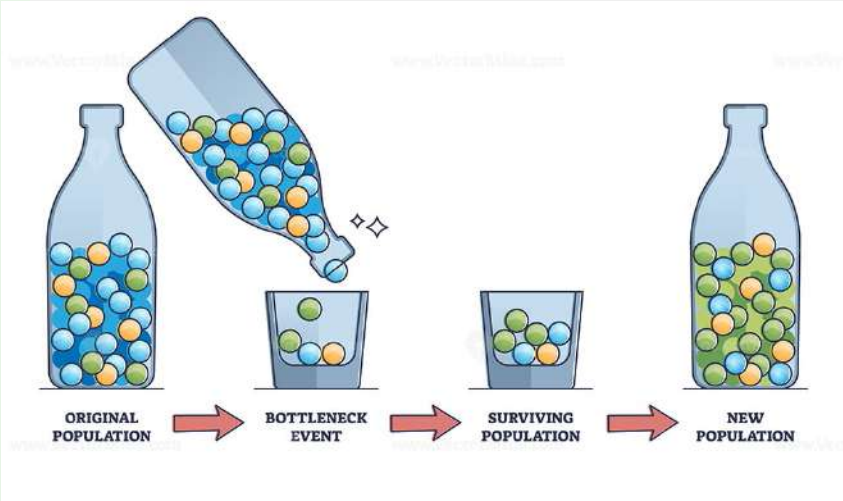
Genetic Drift - Cont'

b) Bottleneck effect:

- **Occurs when a population undergoes a sharp reduction in size due to a catastrophic event.**
- The genetic diversity of the population can be severely reduced.
- Certain alleles may become more or less common in the population due to chance.
- **Example**: **The northern elephant seal.**

c) Genetic isolation:

- **Occurs when populations become geographically isolated from one another.**
- Populations can undergo genetic drift due to differences in selective pressures or random fluctuations in allele frequencies.
- Over time, these differences can lead to the emergence of new species.
- **Example**: **The Galapagos finches.**



https://vectormine.com/wp-content/uploads/Bottleneck_Effect_outline_diagram_2.jpg

Gene Flow

E. Gene Flow

1. **Gene flow** is the **transfer** of **genes** between **different populations** due to **migration** or other means.
2. It can **increase genetic diversity** within a **population** and can **prevent** the formation of **new species.**
3. **Examples:**

d) Migration:

- Occurs when **individuals move** from one **population** to **another** and **breed** with members of the **new** population.
- **Introduces** new **alleles** into the **gene pool** of the population.
- Can **increase** genetic **diversity** and may lead to **new adaptations** in the population.
- **Example: The brown anole lizard in Florida.**

https://s.hdnux.com/photos/01/32/00/04/23593221/3/rawImage.jpg

Gene Flow - Cont'

b) Pollination:

- Occurs when **pollen** from one population of plants is **carried** to **another** population by **wind**, **insects**, or other means.
- Leads to **gene flow** between populations.
- **Introduces** new **alleles** into the **gene pool** of the population.
- Can increase genetic diversity and may lead to the emergence of new species with novel traits.
- **Example: The wild sunflowers of North America.**

c) Human-mediated gene flow:

- Occurs when humans **intentionally** or **unintentionally introduce** new **alleles** into populations of **plants** and **animals** through activities such as **agriculture**, **domestication**, and **transportation**.
- Can lead to gene flow between populations that would not have otherwise occurred.
- Introduces new alleles into the gene pool of the population.
- Can lead to changes in the genetic makeup of the population over time.
- **Example: The domestication of crops such as maize and wheat.**

Mutation

F. Mutation

1. **Mutation** is the process by which **genetic (DNA/RNA)** information is **altered** or **changed**.
2. It can lead to the **development** of new **traits** and the formation of **new species** over time.
3. **Examples:**

d) Antibiotic resistance in bacteria:

- Bacteria can develop resistance to antibiotics through mutations that confer resistance to the drug.
- **Accumulation** of these **mutations** can lead to the **emergence** of **new** strains of **bacteria** that are **resistant** to multiple **antibiotics**.
- **Example: Methicillin-resistant Staphylococcus aureus (MRSA).**

https://upload.wikimedia.org/wikipedia/commons/thumb/a/ab/Antibiotic_sensitivity_and_resistance.jpg/1200px-Antibiotic_sensitivity_and_resistance.jpg

b) The evolution of lactose tolerance in humans:

- The ability to digest lactose into adulthood is due to a mutation in the LCT gene that occurred in humans around 7,000-10,000 years ago.
- This **mutation** allowed **people** who **possessed** it to continue **producing** the **lactase enzyme**, which **breaks** down **lactose**, into adulthood.

Mutation Cont’

c) The evolution of coloration in peppered moths:

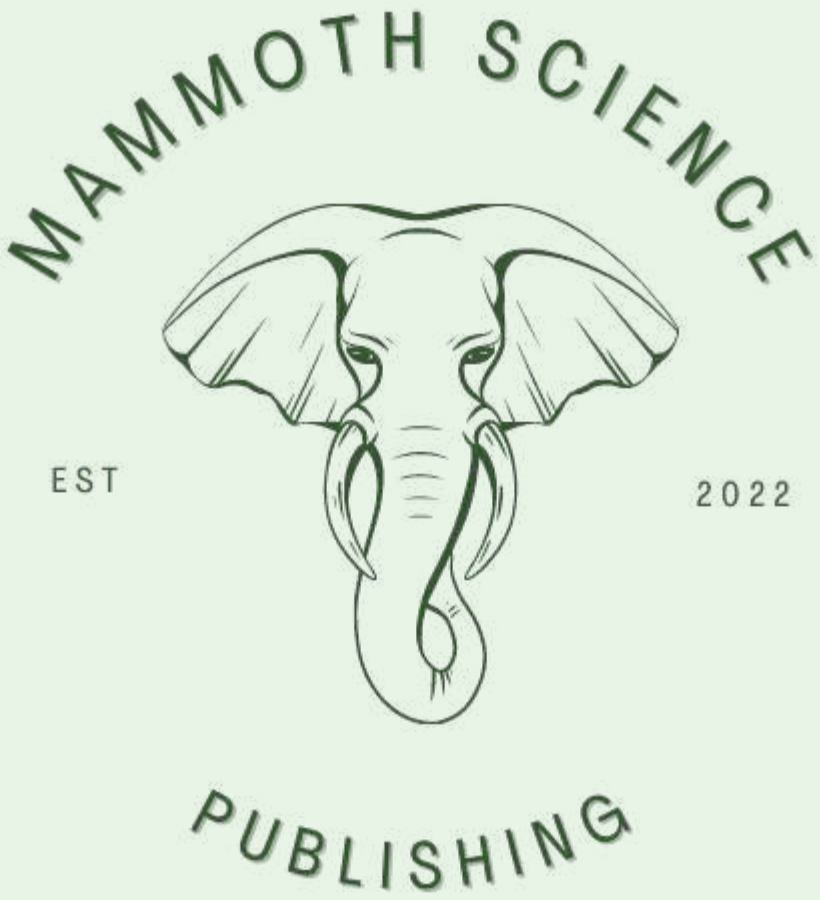
- During the industrial revolution in England, **pollution** caused many of the **trees** that the moths rested on to become **darkened** by soot.
- This led to an **increase** in the **frequency** of **dark-colored moths**, as they were better **camouflaged** on the darkened trees.
- This **adaptation** was due to a **mutation** in a **gene** that **regulates** the production of **pigments** in the moth's wings.

https://askabiologist.asu.edu/sites/default/files/resources/articles/peppered-moths/peppered-moths-large.png

d) The evolution of the arctic fox:

- **Arctic foxes** have **adapted** to their **cold** and snowy environments through a **mutation** in a gene that **regulates** the **expression** of their **fur**.
- In winter, their **fur** turns **white** to blend in with the snow, while in **summer** it turns **brown** to blend in with the tundra.
- This **adaptation** allows them to **avoid predation** and **hunt** more **effectively**.

https://cdn.britannica.com/64/5864-050-88E958F1/phase-White-Arctic-fox-summer-coat.jpg



Thank you!

Do you have any questions?

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