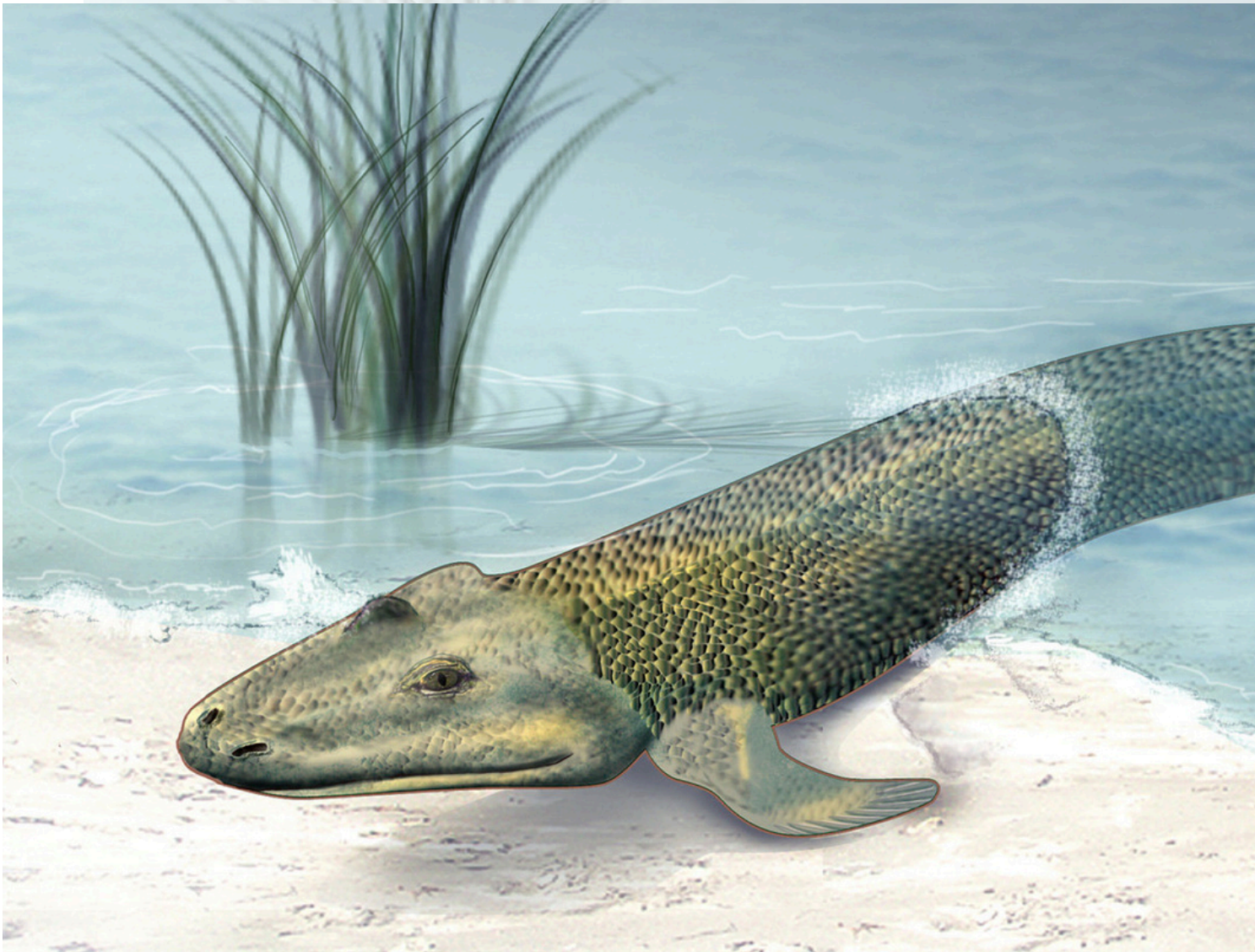
CHAPTER 1 I MODULE 1

EVOLUTION

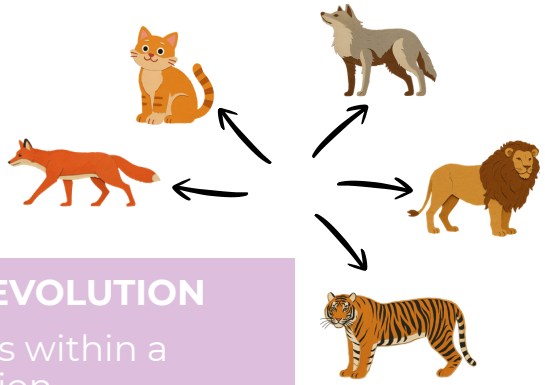


MODULE 1

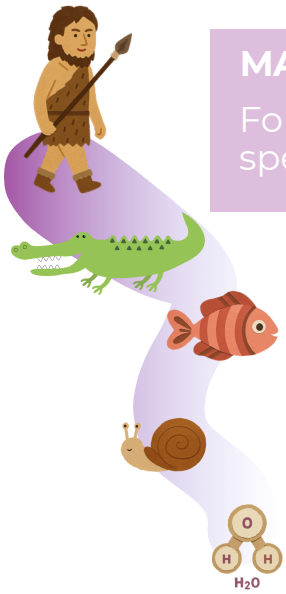
EVOLUTION

What is Evolution?
- Evolution is the change in the **genes of a population** on Earth over time.

Microevolution happens on a small scale (within same species).
Macroevolution happens on a scale that transcends the boundaries of a single species (converting to other species).



MICROEVOLUTION
Changes within a population



MACROEVOLUTION
Formation of new species

Evidence for evolution?
- The theory of evolution by natural selection is now widely accepted by the scientific community due to its being supported by a great deal of evidence
- Evidence for evolution comes from **extant organisms** (living species), **extinct organisms** (fossils), and **comparisons of molecular, morphological**, and **genetic data**

Six areas of scientific study that provide evidence for evolution.
1. Fossil record
2. Comparative anatomy
3. Comparative biochemistry
4. Comparative embryology
5. Molecular biology
6. Biogeography

REMEMBER
Individuals never evolve; only **populations** evolve.

What is a Population?
consists of all the members of one species in one place.

Species: a group capable of interbreeding and exchanging genetic information to **produce viable, fertile offspring**

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EVOLUTION

Fossil Record
fossil record reveals the existence of species that have become extinct or have evolved into other species. The fossil record shows that:

- 99% of all organisms that ever lived on **Earth are now extinct.**
- The age of fossils can be determined using **radioactive isotopes** to date the fossils or by studying the age of the layers where the fossils are found, Through studies of radioactive dating and half-life, we know that Earth is about **4.6 billion years old.**
- **Prokaryotic** cells are the oldest fossils and were the first organisms to develop on Earth.
- Paleontologists have discovered many **transitional fossils** that link older extinct fossils to modern species.

What is a transitional Fossil?
a fossil that demonstrates a transitional form of two **separate species.** The traits of both the species that came before it and the species that came after it can be present in the transitional fossil.

- E.g. transitional fossils like **Archaeopteryx**, a bird-like dinosaur fossil which provides a **bridge between dinosaurs and current-day birds**

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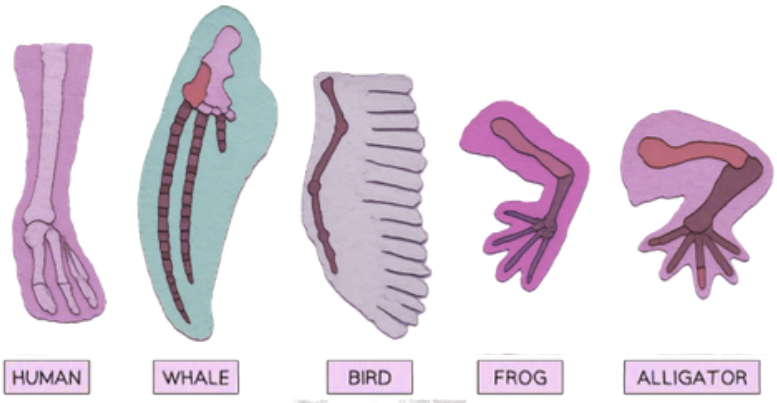
EVOLUTION

Comparative Anatomy

→ Organisms that have similar anatomical structures are related to each other and share a common ancestor.

Morphological homologies

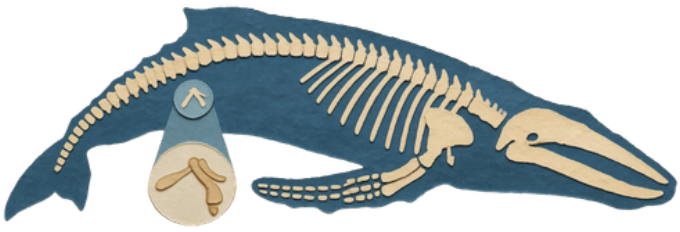
1. **Homologous structures:** are similar structures which have different functionalities despite common ancestry; The presence of homologous structure is evidence of common ancestry → divergent evolution.



The bone structure of the pentadactyl limb of a human, whale, bird, frog, and alligator; they all have the same basic layout despite having evolved for different functions

SAME STRUCTURE ✓
DIFFERENT FUNCTION ✗

2. **Vestigial structure:** are evidence that the anatomy of animals has evolved.




COCCYX


APPENDIX


WISDOM TEETH

VESTIGIAL STRUCTURES

3. **Analogous structures:** are evidence of convergent evolution.

SAME FUNCTION ✓
DIFFERENT STRUCTURE ✗

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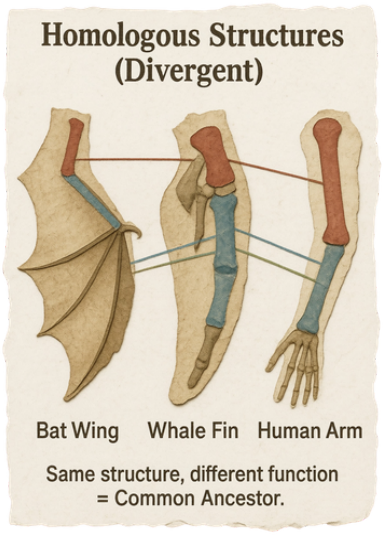
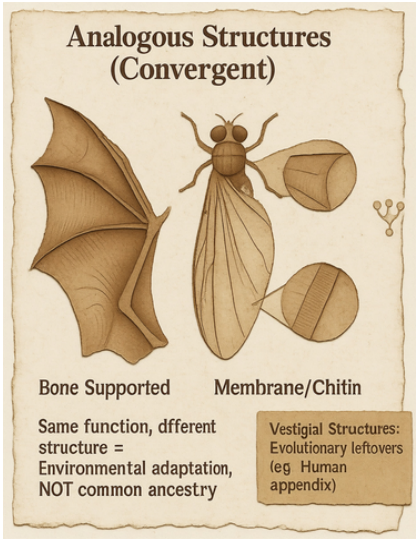
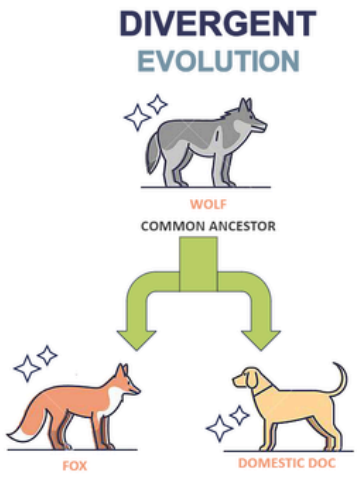
EVOLUTION

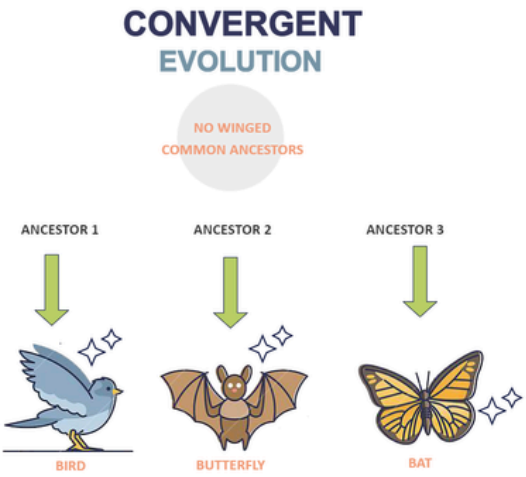
Q: WHAT IS THE DIFFERENCE BETWEEN HOMOLOGOUS & ANALOGOUS STRUCTURES?







Same ancestry [Divergent ancestry]



Different ancestry [Convergent evolution]

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EVOLUTION

Comparative Biochemistry

COMMON ANCESTOR = COMMON BIOCHEMICAL PATHWAYS.

The more closely related organisms are to each other, the more similar their biochemistry is. Humans and mice are both mammals. This close relationship is the reason medical researchers can test new medicines on mice and extrapolate the results to humans.

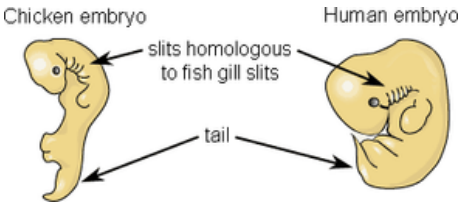
Species	Sequence of Amino Acids in the Same Part of the Hemoglobin Molecules
Human	Lys–Glu–His–Iso
Horse	Arg–Lys–His–Lys
Gorilla	Lys–Glu–His–Lys
Chimpanzee	Lys–Glu–His–Iso
Zebra	Arg–Lys–His–Arg

Comparative Embryology

Closely related organisms go through **similar stages** in their **embryonic development** because they evolved from a common ancestor.

→ all vertebrate embryos go through a stage in which they have gill pouches in the sides of their throats.

- In fish, the **gill pouches develop into gills.**
- In humans, they **develop into eustachian tubes** that connect the middle ear with the throat.



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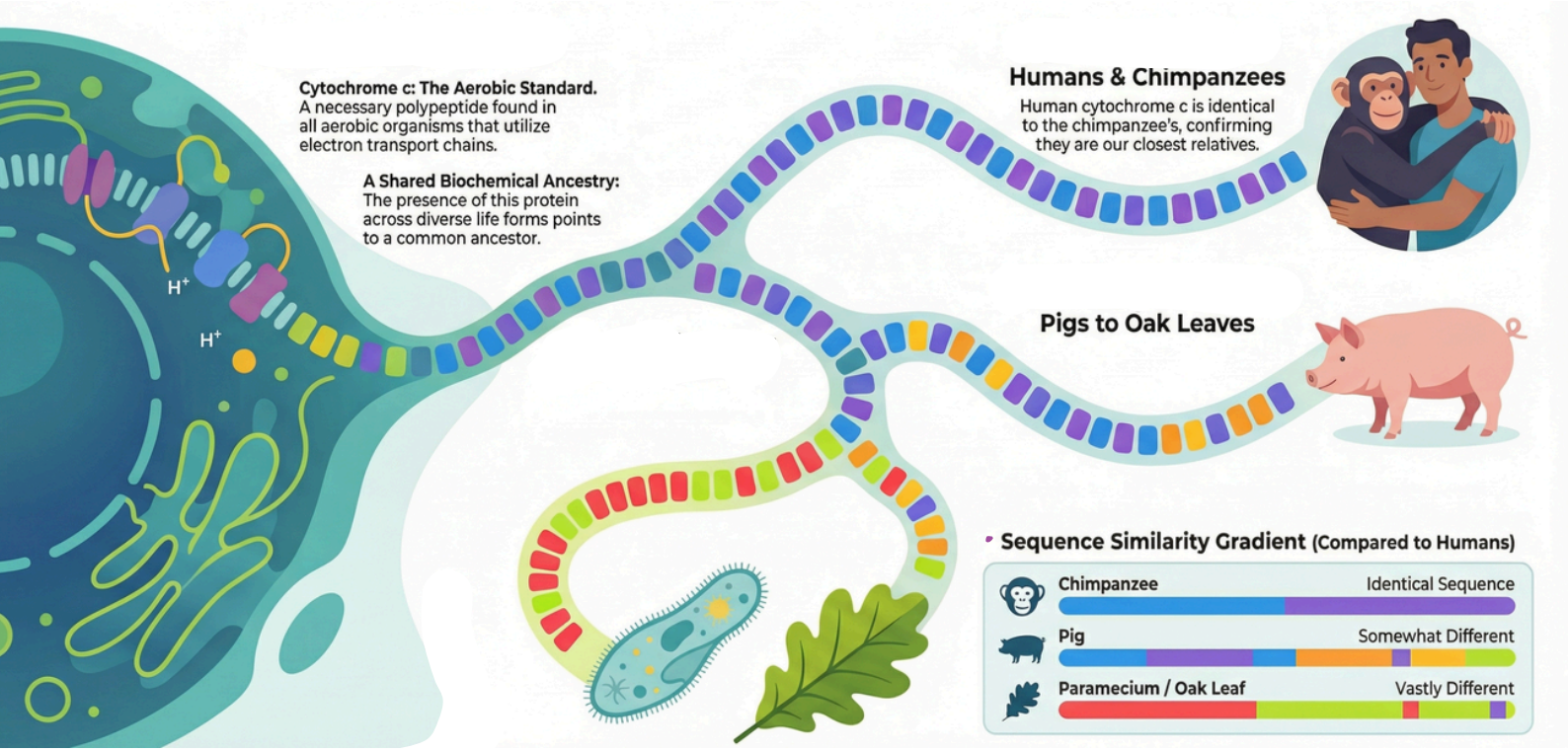
Molecular Biology

A comparison of the amino acid sequence of cytochrome c among different organisms shows which are most closely related.

→ The cytochrome *c* in human cells is identical to that of our closest relative, the chimpanzee, but differs somewhat from that of a pig and is vastly different from the cytochrome *c* found in paramecia or in oak leaves.



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EVOLUTION

Biogeography

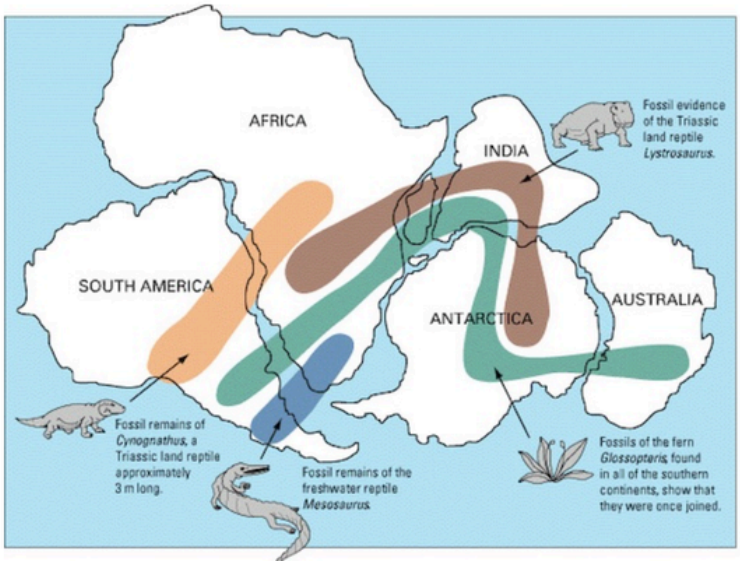
The geographic distribution of organisms on Earth follows patterns that are explained by **evolution**, in combination with the movement of tectonic plates over geological time.

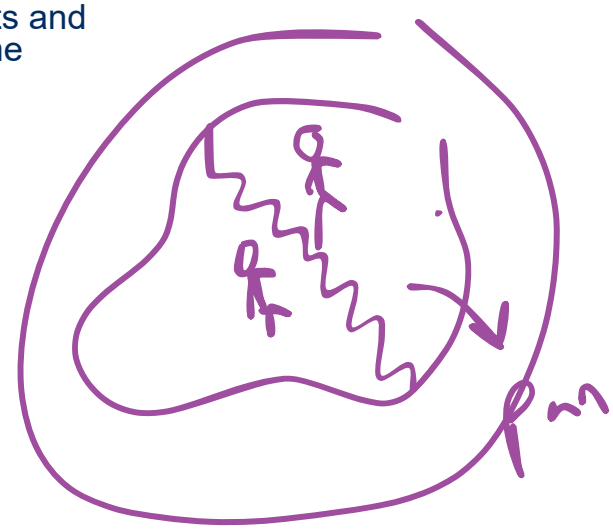
→ For example, broad groupings of organisms that had already evolved before the breakup of the supercontinent Pangaea (about 200 million years ago) tend to be distributed worldwide.

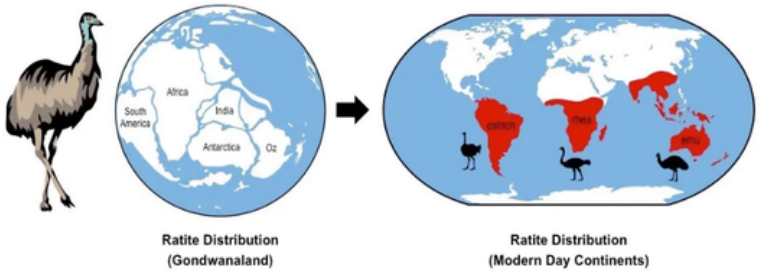
In contrast, broad groupings that evolved after the breakup tend to appear uniquely in smaller regions of Earth.

What is the theory of continental drift?
The theory of continental drift states that about 250 million years ago, the continents were locked together in a single **supercontinent known as Pangaea**

Movement of tectonic plates reshapes continents and alters ecosystem distribution over geological time







Different species came from the same ancient continent → Pangaea

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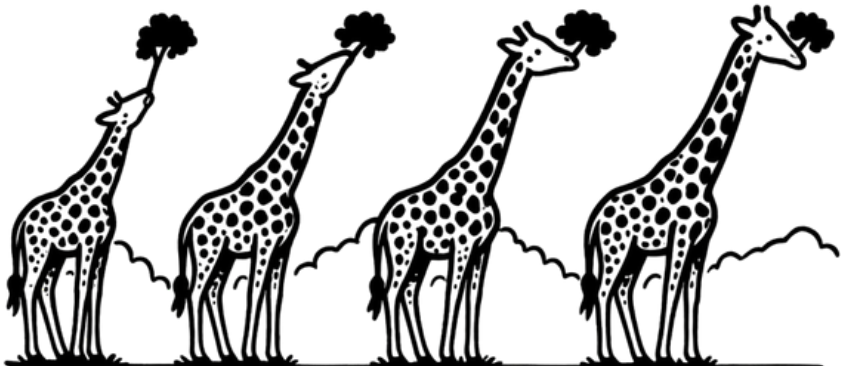
EVOLUTION

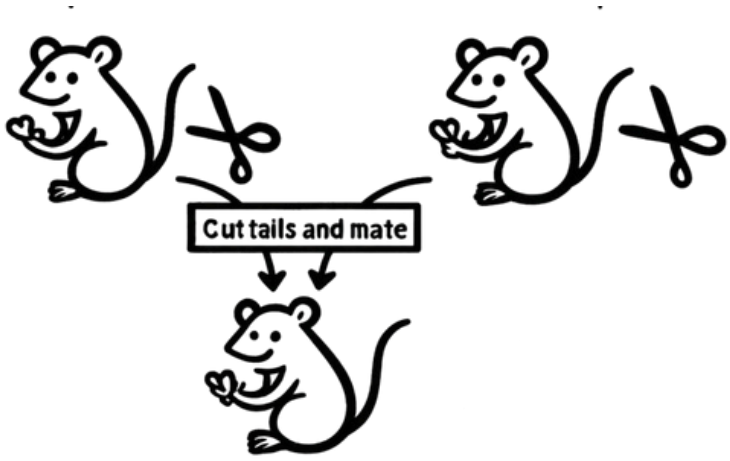
Use and disuse

Lamarck theory relied on ideas of inheritance of acquired characteristics
He states that individual organisms change in response to environment.



As giraffe developed a long neck to eat leaves of tall acacia tree and pass that acquired trait of elongated neck to their offspring

Weismann disapprove this theory by cutting tails of 22 generations of mice, but he found that size of tails in subsequent generations was not affected



MODULE 1

EVOLUTION

DARWIN'S THEORY OF NATURAL SELECTION

- **Over production** : population tend to grow exponentially, till it over populate and exceed their resources
- **Variation** : Living organisms differ in size, color, strength, etc.. → Some individuals have more favorable variations

→ **Variation** is the **raw material of natural selection**

- **Struggle for existence** : living organisms compete for food, water, space, and other requirements in environment
- **Survival of the fittest :** degree of fittest is measured by ability of an individual to survive and reproduce

→ Best fit individuals survive and pass on their traits to their offspring

EVOLUTION IS

the idea that species change and give rise to new species over extended periods of time and that all species can trace their descent to a common ancestor.

NATURAL SELECTION IS

the mechanism that Darwin proposed to explain how evolution takes place and why organisms are typically adapted, or well-suited, to their environments and roles.

↳ natural selection is that organisms with heritable traits that help them **survive and reproduce**

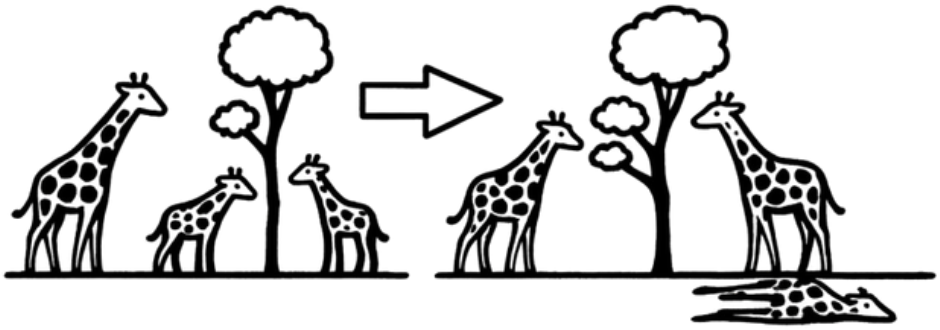
MODULE 1

EVOLUTION

Cases of natural selection

1- Giraffe and long neck

Ancestral giraffes were short-necked, however neck length varied individually
→ Giraffe population used to compete for limited food, tall neck individuals had better chance of survival than short neck giraffes



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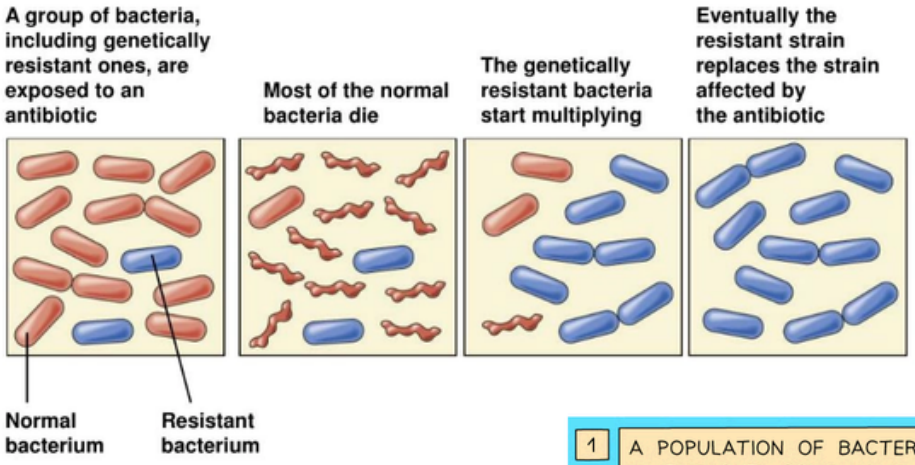
EVOLUTION

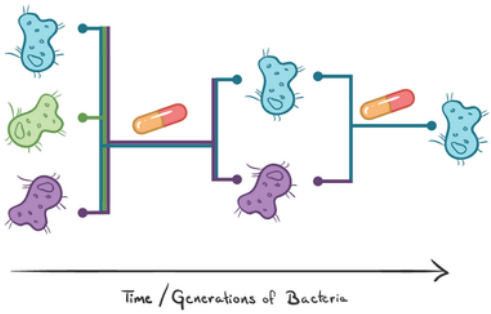
Cases of natural selection

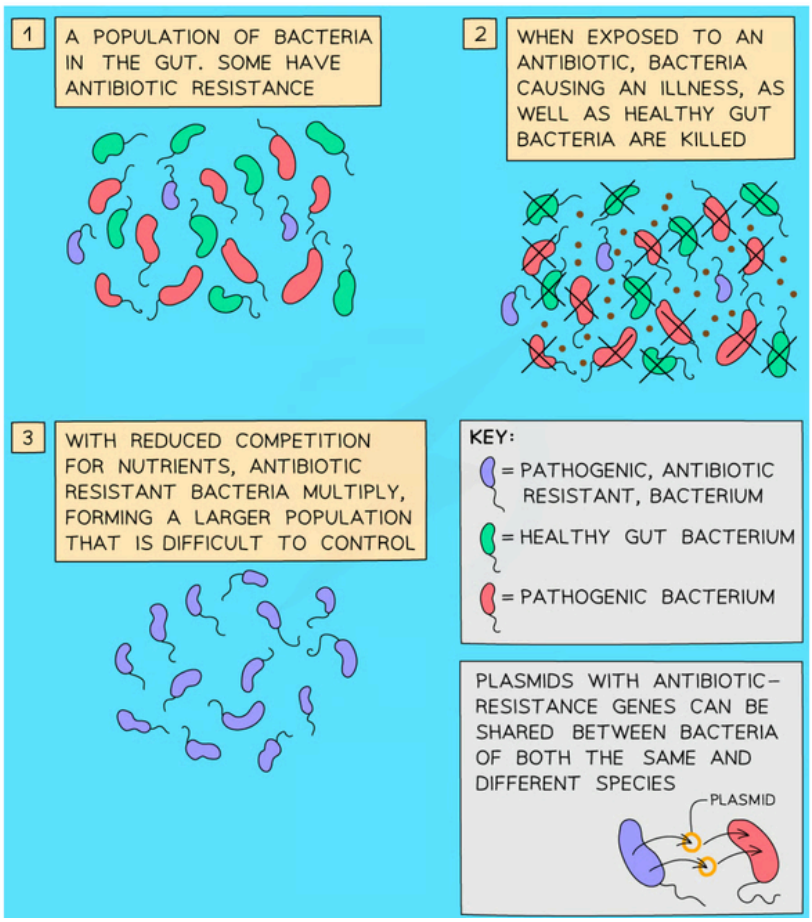
2- Drug resistance [IMP.]

Antibiotic only kill susceptible bacteria, while resistant individuals survive to reproduce



Did antibiotic develop Resistant strain? ❌
Acquired? ❌
Developed resistance? ❌
Frequency of resistant bacteria increase ✅





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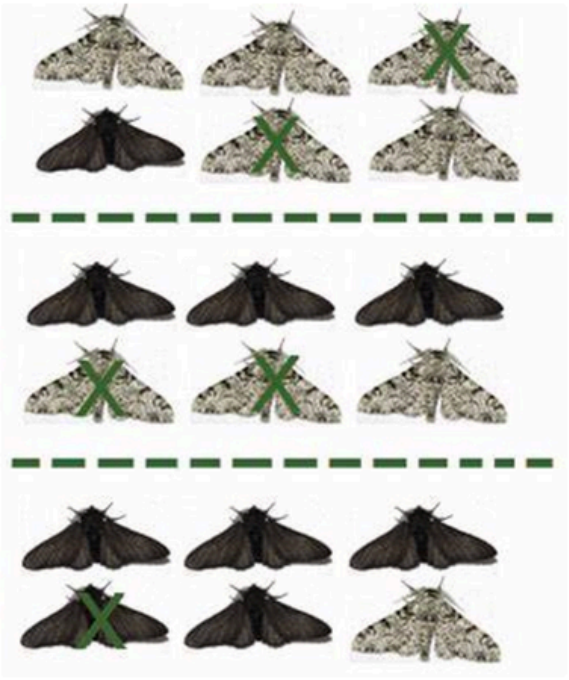
Cases of natural selection

3- Peppered Moth color



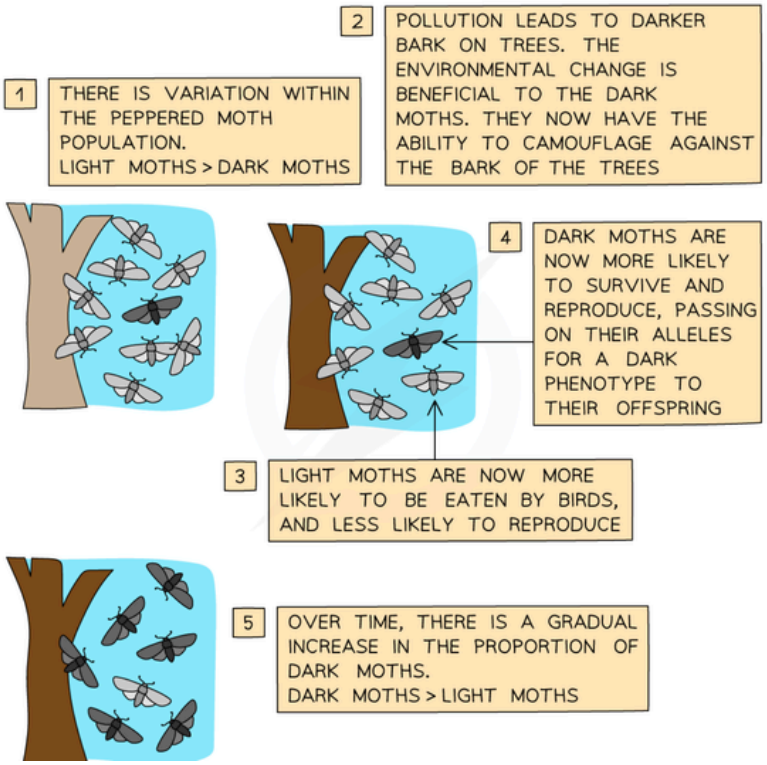
With increasing industrialization, smoke and soot polluted the environment, making all plants and rocks black

Until 1800 in England → Most peppered moths were light colored, and dark individuals were rarely found.

In 1950, all moths were black → few light colored were found

Before industrial revolution, white moths were camouflaged, while dark moths were easy prey for predators.

After the environment darkened by pollution, dark moths were camouflaged and had selective advantage



MODULE 1
EVOLUTION

Types of Natural selection

There are three basic ways that natural selection can influence distribution of phenotypes for polygenic traits in a population.

1. **Stabilizing selection: intermediate phenotypes** are **more fit** than extreme ones.

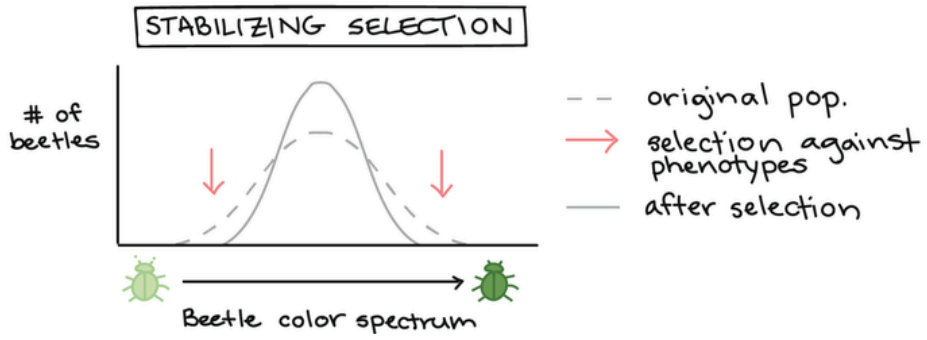
→ For example, **medium-green beetles** might be the **best camouflaged**, and thus survive best, on a forest floor covered by medium-green plants. Stabilizing selection tends to narrow the curve.

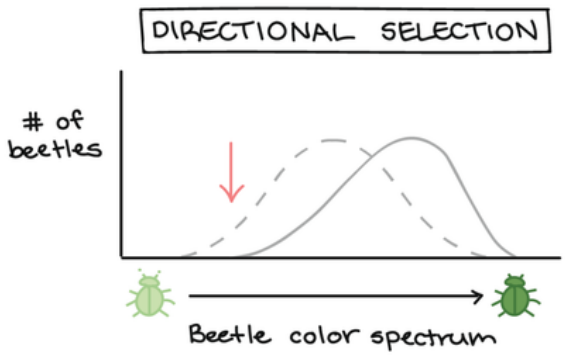
2. **Directional selection: One extreme phenotype** is **more fit** than all the other phenotypes.

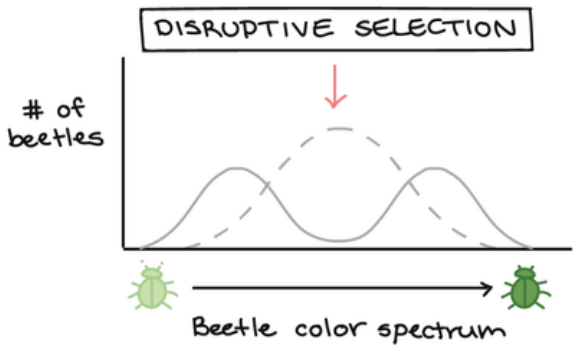
→ For example, if the beetle population moves into a new environment with **dark soil** and vegetation, the **dark green beetles** might be better hidden and survive better than medium or light beetles. Directional selection shifts the curve towards the favorable phenotype.

3. **Disruptive selection: [diversifying selection] Both extreme phenotypes** are **more fit** than those in the middle.

→ For example, if the beetles move into a new environment with patches o**f light-green moss and dark-green shrubs,** both light and dark beetles might be better hidden (and survive better) than medium-green beetles. **Diversifying selection makes multiple peaks in the curve**







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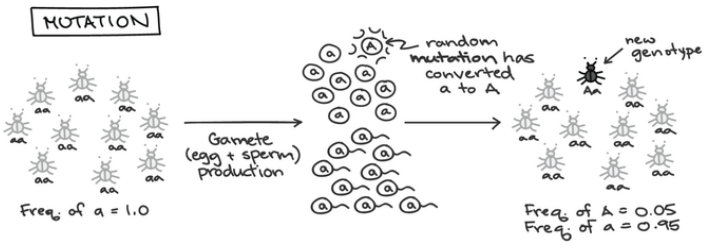
EVOLUTION

Evolution is defined as a change in the frequency of alleles (versions of a gene) in a population over time.

Causes of variation in population

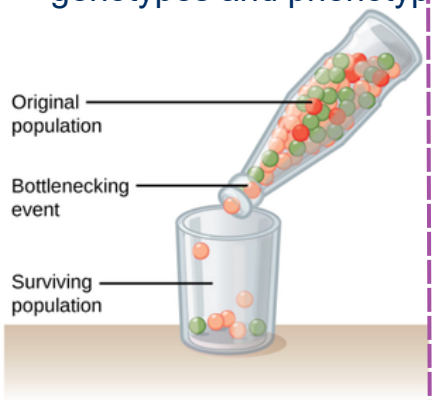
Mutation : change in genetic material and the raw material for variation that is the raw material for evolution



Genetic drift : **Change** in **gene pool** due to chance, it's divided into two types:

A. Bottle Neck effect : Natural disasters such as fire, earthquake, and flood.
→ Reduce size of population, resulting in loss of genetic variation especially in **small population**

B. Founder effect : Reduction **in genetic variation**, result when a small subset of large population is used to **establishing new colony [Migrating]**
→ The new population may be very different from the original population, both in terms of its genotypes and phenotypes



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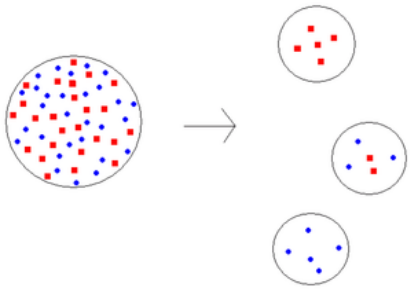
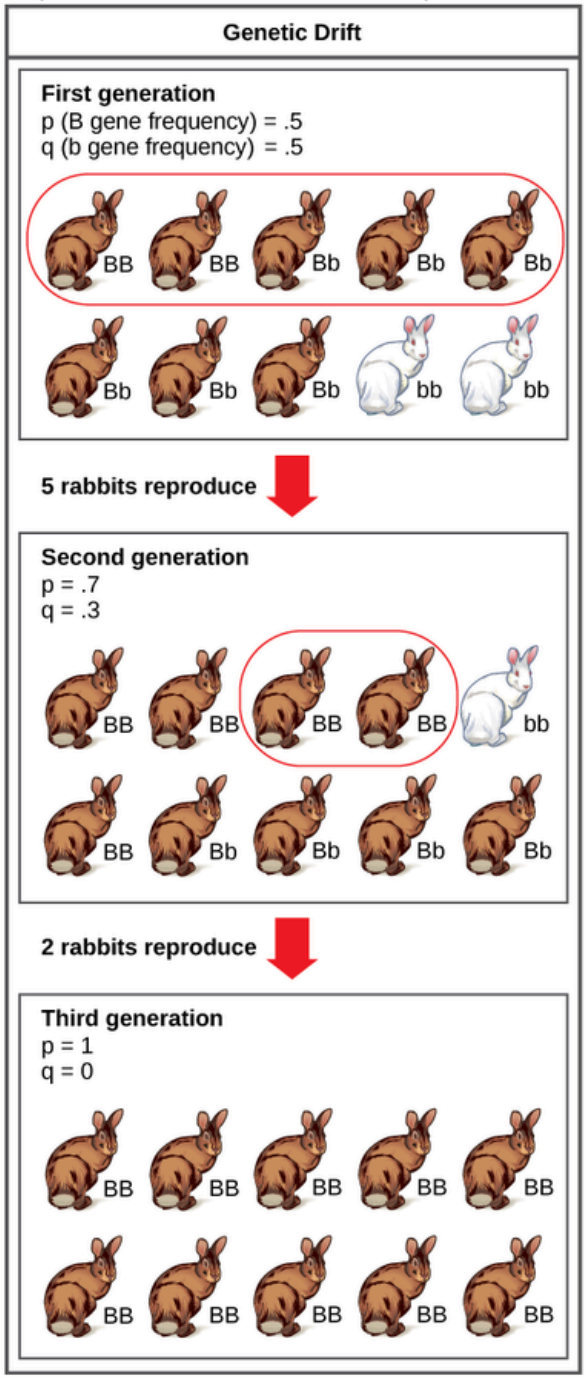


Image credit: "Founder effect." by qz10, public domain.



BOTTLE NECK EFFECT

when the size of a population is severely reduced.

FOUNDER EFFECT

a small group of individuals breaks off from a larger population to establish a colony.

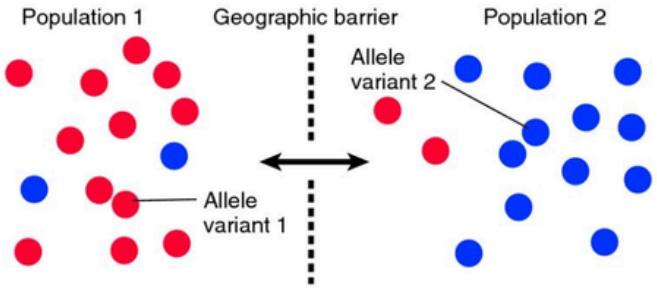
MODULE 1

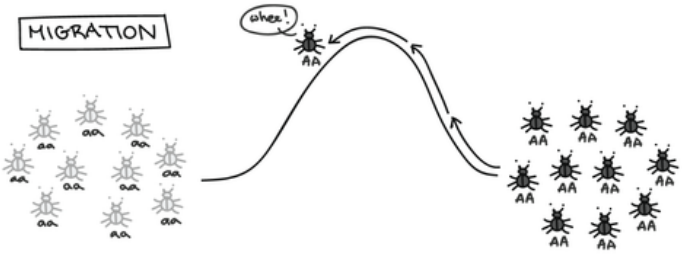
EVOLUTION

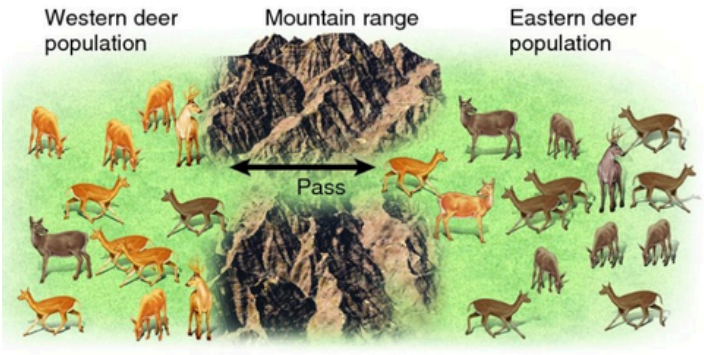
Causes of variation in population

Gene Flow : Movement of alleles into or out of population
It occurs as a result of migration of fertile individuals or gametes between populations

→ For example , pollen carried by wind across mountain between two valleys

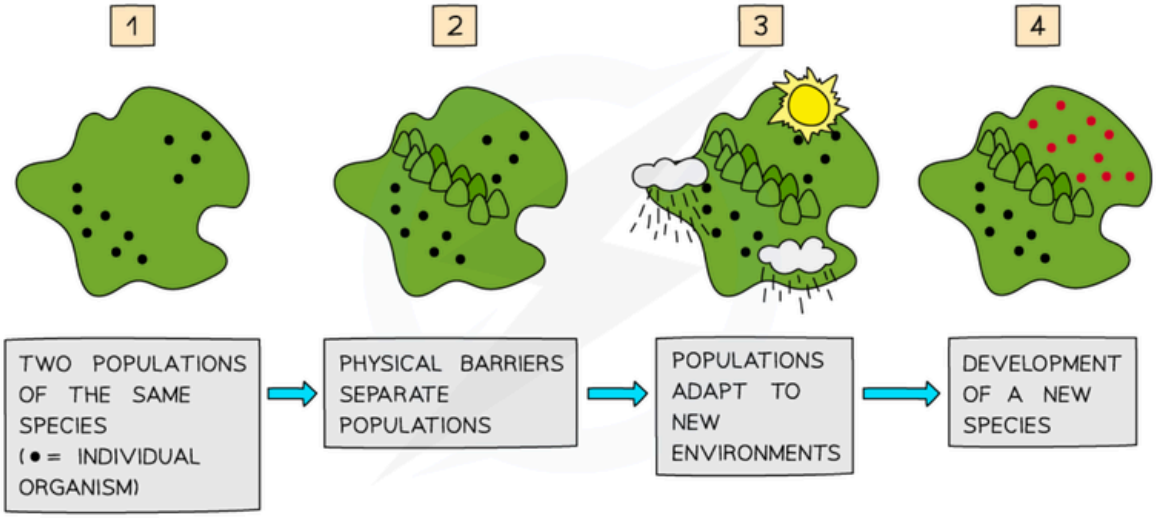






Reproductive Isolation and speciation

Speciation is the process by which new species form.
It occurs when groups in a species become reproductively isolated



MODULE 1

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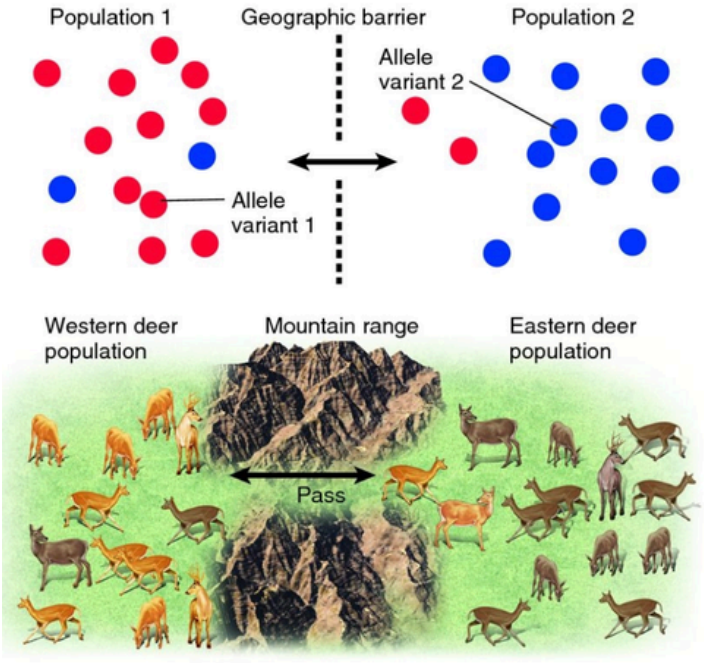

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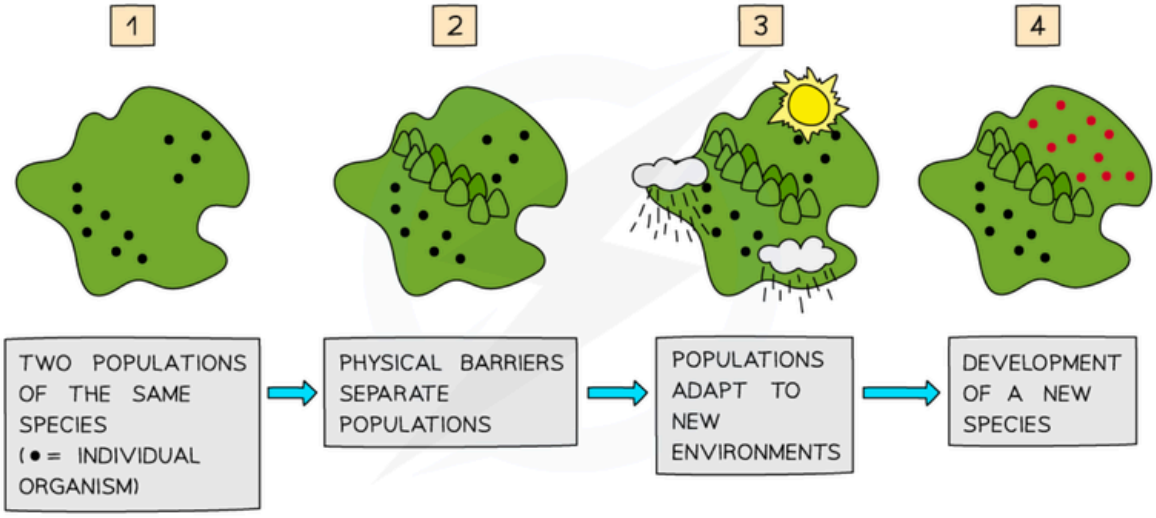
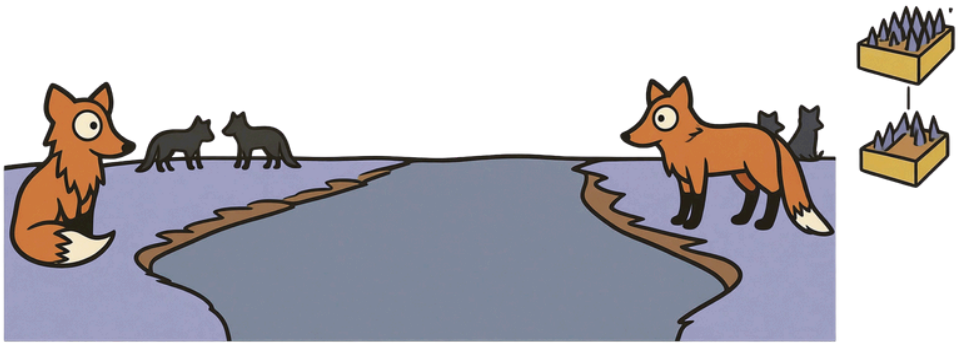


1. **Geographic isolation**

Occurs when species are separated by mountains, canyons, rivers or glaciers. That cause isolation between species



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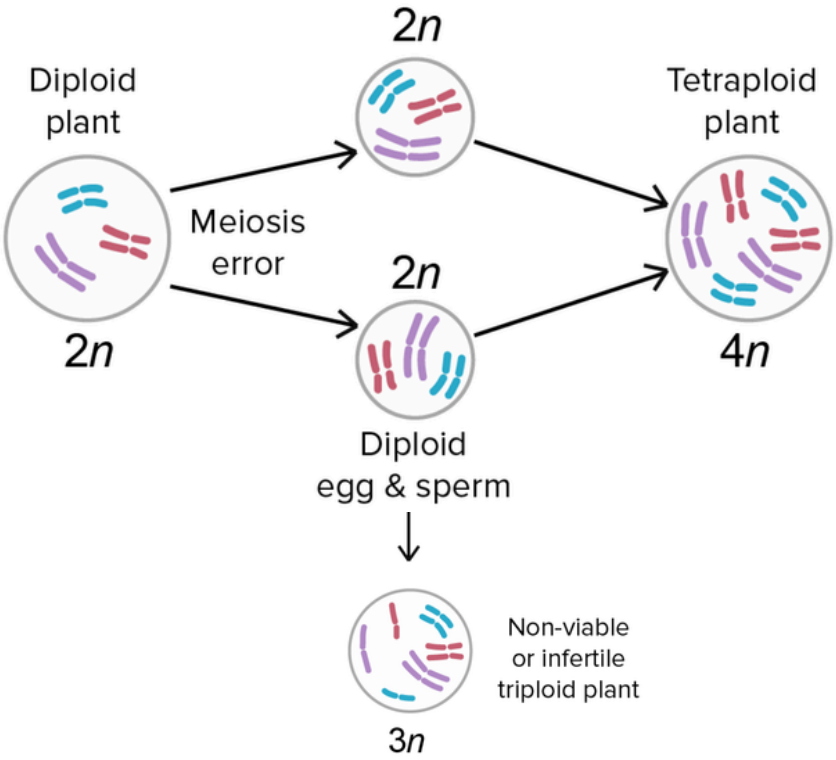
EVOLUTION

2. **Polyploidy**
is the condition of having more than two full sets of chromosomes → **Many flowering plants**, and majority of ferns are polyploid

Polyploid organisms cannot breed with organisms that are not polyploid and isolated from them



3. **Temporal Isolation**
individuals of different species do not mate because they are sexually active at different times of the day or in different seasons

MODULE 1
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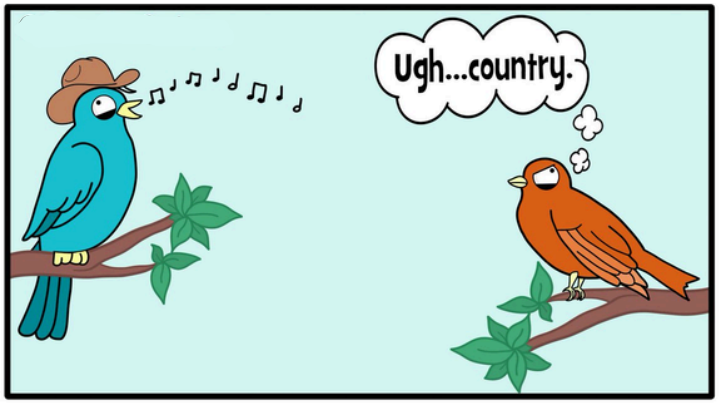
4. **Habitat isolation**

Occurs when different habitat lowers the probability of mating between individuals

5. **Behavioral isolation**

It occurs when population begin to develop different behaviors that are not preferred by members in another population



MODULE 1

EVOLUTION

Patterns of evolution

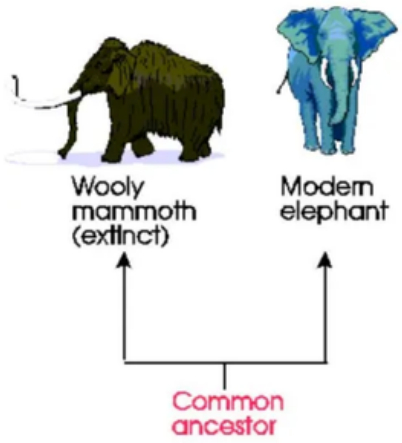
Coevolution

it is the evolutionary change in interacting populations over time
→ For example, pollinator-plant relationship [mutualism]

honey bees that lives on nectar of flower, flower has tripping mechanism that arches stamens [male part] over bee and dust it with pollen. Some of bees rub off into pistil [female part] of another flower

Parallel Evolution

It is similar development of a trait in distinct species that are not closely related, but share similar original trait in response to similar evolutionary pressure



MODULE 1

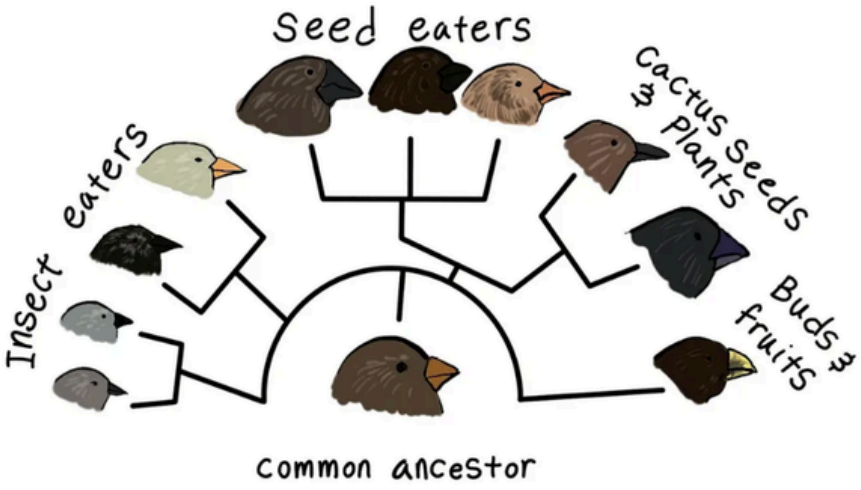
EVOLUTION

Patterns of evolution

Adaptive Radiation

Emergence of numerous species from a **single common ancestor**
Darwin discovered 14 species of Finches each filling a different niche. They all evolved from single ancestral species

Adaptive radiation: a single species rapidly adapts to fill available niches in an environment.



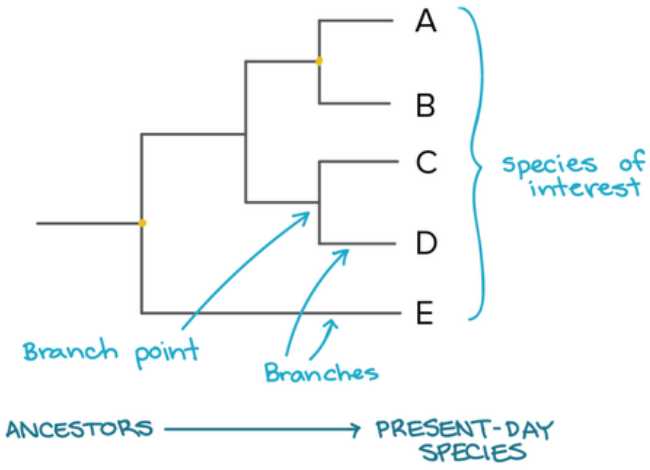
MODULE 1

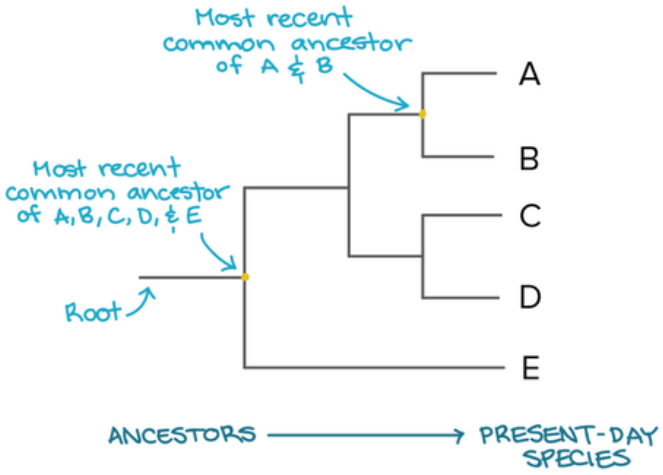
EVOLUTION

Patterns of evolution

The Phylogenetic tree [phylogeny or evolutionary tree]

branching diagram or a tree showing the evolutionary relationships among various biological species or other entities based upon similarities and differences in their physical or genetic characteristics





Two species are **more related** if they have a more recent common ancestor, and less related if they have a less recent common ancestor.

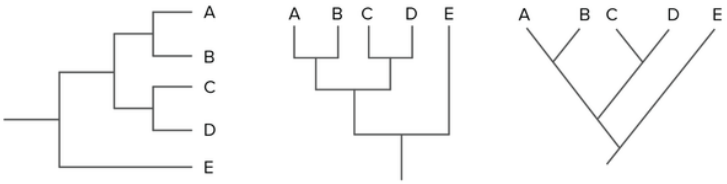
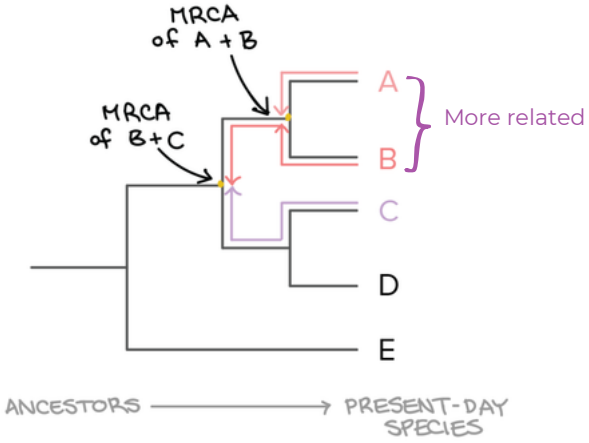
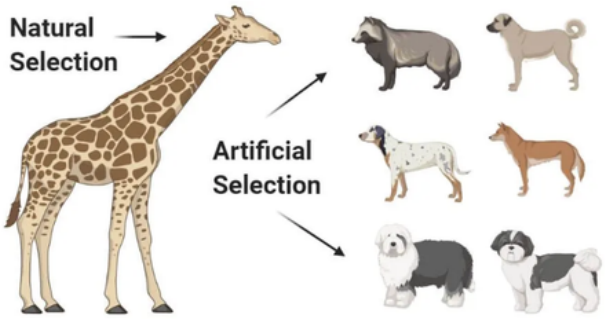


Image modified from *Taxonomy and phylogeny: Figure 2* by Robert Bear et al., CC BY 4.0





MODULE 1

EVOLUTION

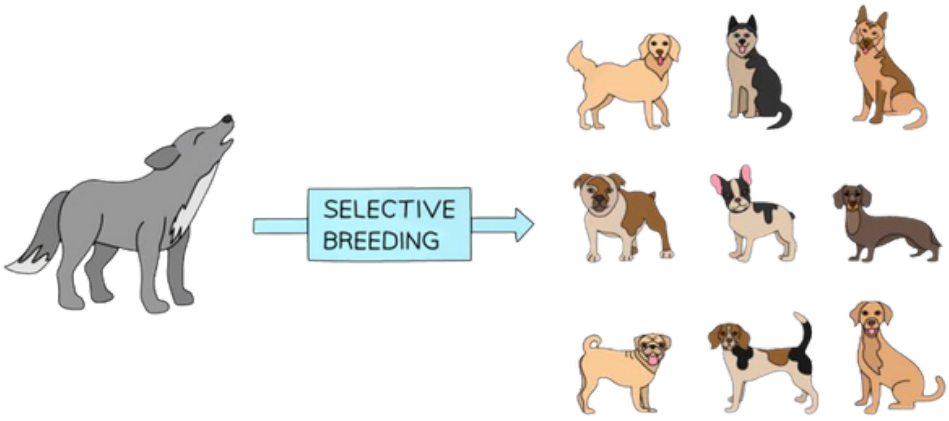
Types of diversity

Genetic diversity: Diversity of genes within a species

Biodiversity Hotspot: is a biogeographic region that is both significant reservoir of biodiversity and threatened with destruction by them

Species diversity: Diversity among species in an ecosystem

Artificial Selection [selective breeding]: The identification by humans of desirable traits in plants and animals, and the steps taken to enhance and perpetuate those traits in future generations



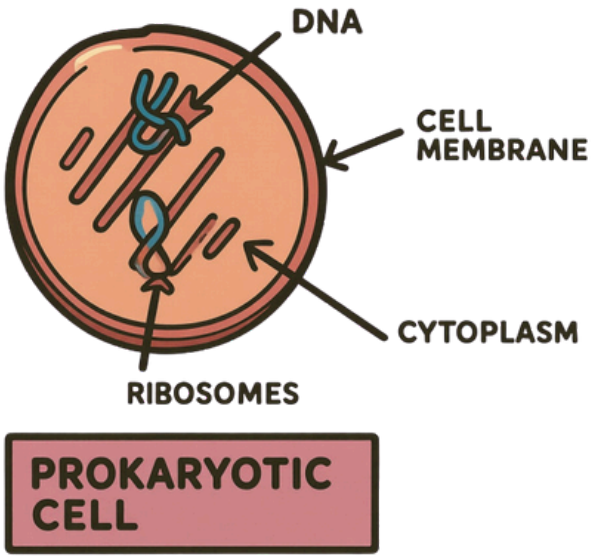
MODULE 1

EVOLUTION

Theories of Evolution

Heterotroph Hypothesis

First cells were Anaerobic Prokaryote Heterotrophic and would have fed on organic molecules that had been made without cells



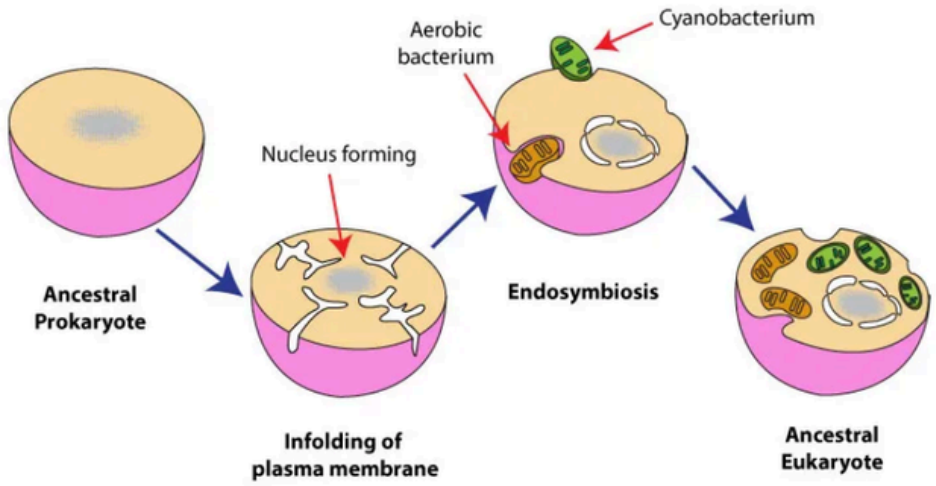
MODULE 1

EVOLUTION

Theories of Evolution

Theory of Endosymbiosis

Organelles such as chloroplasts and mitochondria were free-living prokaryotes which lived symbiotically within larger heterotrophic prokaryotic cells, forming modern day eukaryotic cells



1. Prokaryotic cell 2. Cyanobacterium has chlorophyl go through photosynthesis and produce oxygen 3. aerobic bacterium takes oxygen and use respiration to make energy 4.Finally cell have Nuclues, Mitochondria, Chloroplast→ becomes Eukaryotic cell

→ Earth is about 4.6 billion years old

→ Life started in water

→ First prokaryotic cell evolved about 3.5 billion years ago , prokaryotic cells evolved to eukaryotic cell about 1.5 billion years ago

→ Cambrian explosion part of the Palaeozoic era happened 540 million years ago, when most of the major groups of animal first apeared in Fossil record

MODULE 1

EVOLUTION

Theories of Evolution

Several characters enabled animals & plants to move to land :

In Animals:

1 Appearance of lungs
2 Appearance of limbs to move out
3 Skin to keep animals from dehydration
4 Internal fertilization
5 Hard shell to protect them

In Plants:

1 Roots anchor plants in soil to absor water
2 Vascular tissue to trasport water upward
3 Waxy substance protects leaves from dehydration
4 seeds have hard coat to protect embryo and its food

Oparin-Haldane Hypothesis

Oparin-Haldane suggests that life arose gradually from inorganic molecules, with "building blocks" like amino acids forming first and then combining to make complex polymers

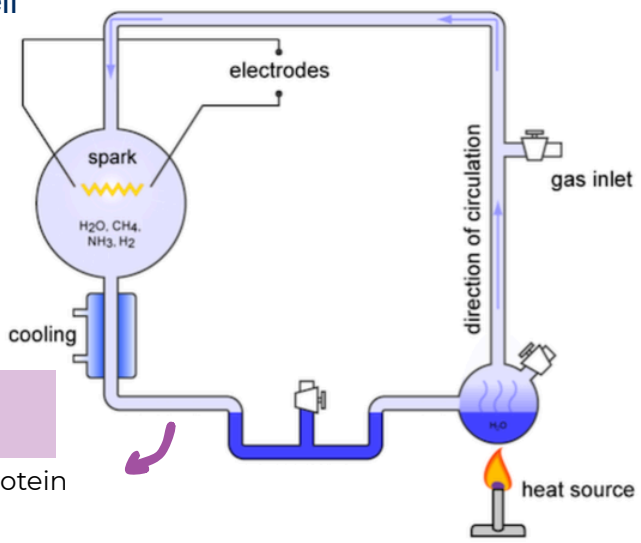
Miller-Urey Experiment

In 1953, Stanley Miller and Harold Urey did an experiment to test Oparin and Haldane's ideas. They found that organic molecules could be spontaneously produced under reducing conditions thought to resemble those of early Earth.

Ancient environment consisted of **CH4 [methane], NH3 [ammonia], H2O and H2, but lack free oxygen**

intense heat, lightning, and U.V. radiation in primitive atmosphere provided energy for chemical reactions that produced first cell

Urey and Miller are scientists mimic this early atmosphere to determine how first molecules and early life devoloped



FIRST ORGANIC COMPOUND

Amino Acids OR Protein

MODULE 1

EVOLUTION

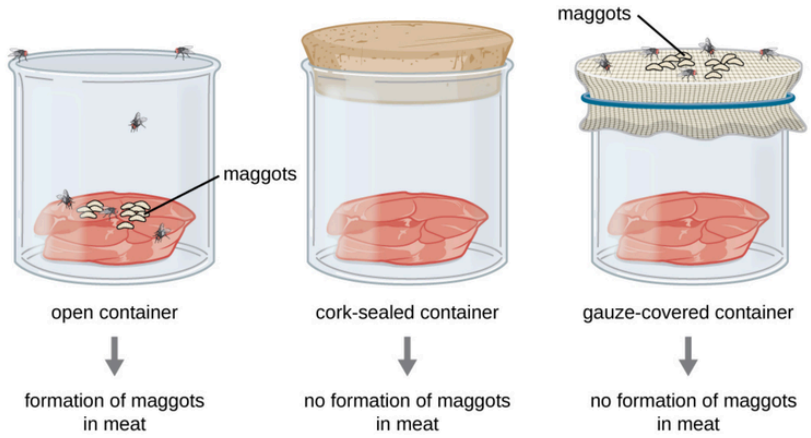
Theories of Evolution

Spontaneous generation

Theory of spontaneous generation held that living creatures could arise from non-living matter

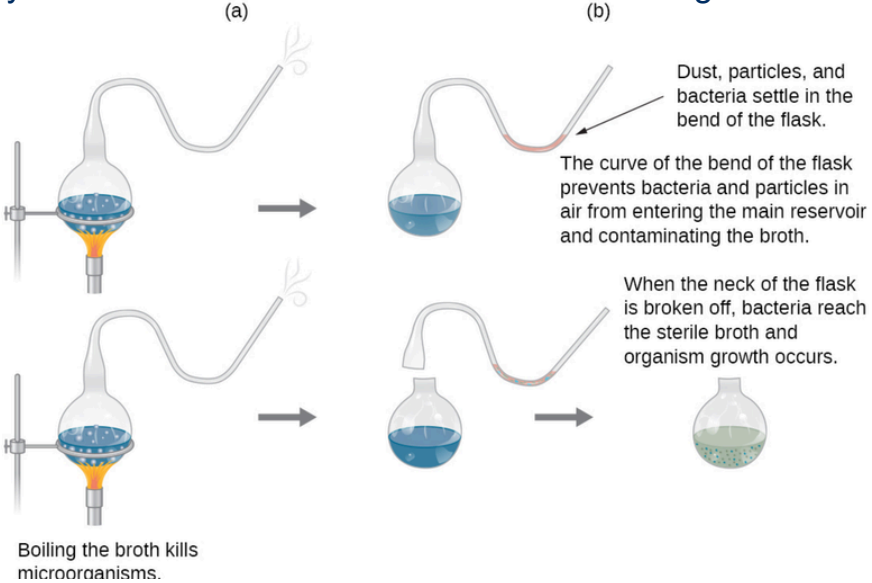
Francesco Redi concluded that if flies laid eggs on the meat in the open jar caused the maggots

→ If the flies could not lay eggs on the meat in the covered jar, no maggots were produced
Redi proved that decaying meat did not produce maggots



Louis Pasteur boiled a meat broth in a swan neck flask

The band in the neck of the flask prevented falling microbes from reaching the broth
Only bottle with broken neck will show microbial growth from the air



MODULE 1

EVOLUTION

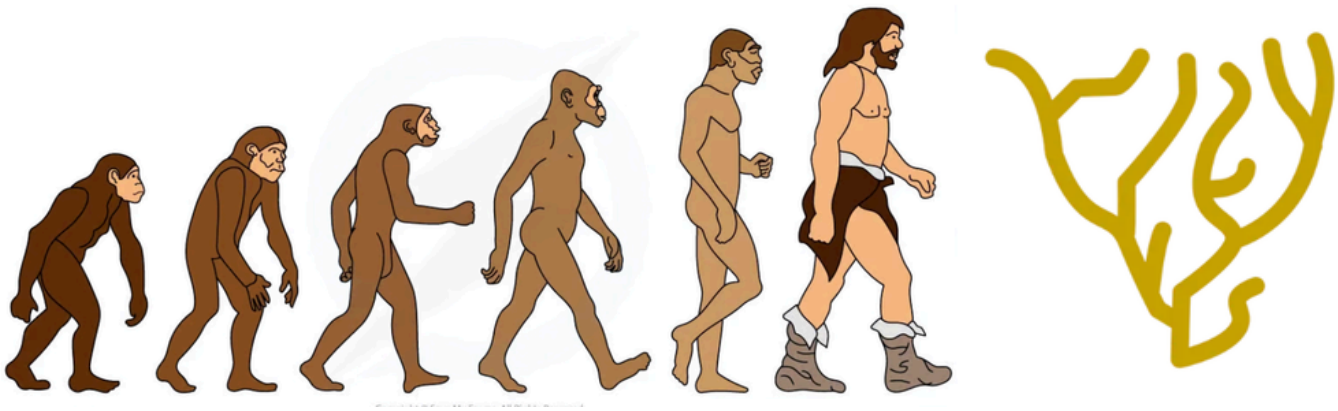
Theories of Evolution

Gradualism

Scientists abandoned this theory because transitional fossils are rarely found.

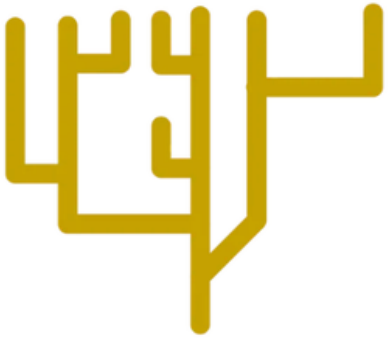
Gradualism is the name given to speciation that occurs gradually through the accumulation of small changes over time
→ Big changes occur by accumulation of many small ones

Charles Darwin states that organisms descend from a common ancestor gradually



Punctuated equilibrium

Stephen Gould and Niles eldridge proposed that new species arise suddenly after long period of stasis
→ Fossil record confirms this model



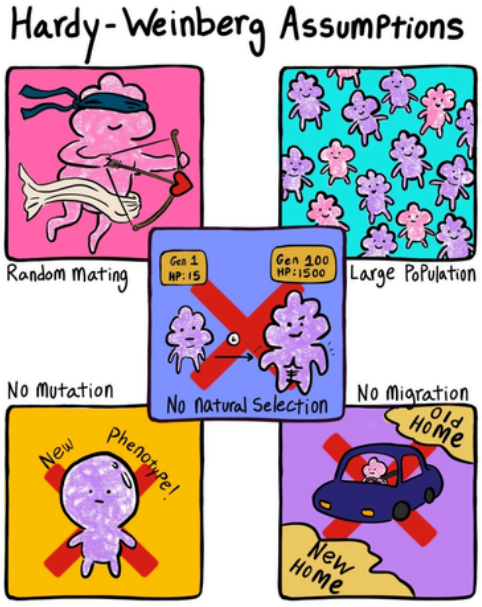
MODULE 1

EVOLUTION

Population stability

Hardy-Weinberg equilibrium

Principle stating that the allele frequency in a population will remain constant [no evolution] from one generation to the next , in presence of some factor such as :



1. Population must be **VERY LARGE**
2. Population must be **ISOLATED**
3. **NO** Mutation
4. Mating must be **RANDOM**
5. **NO** genetic drift
6. **NO** Natural selection