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.

How does genetic variation among organisms affect survival and reproduction?

REVISITING VOCABULARY

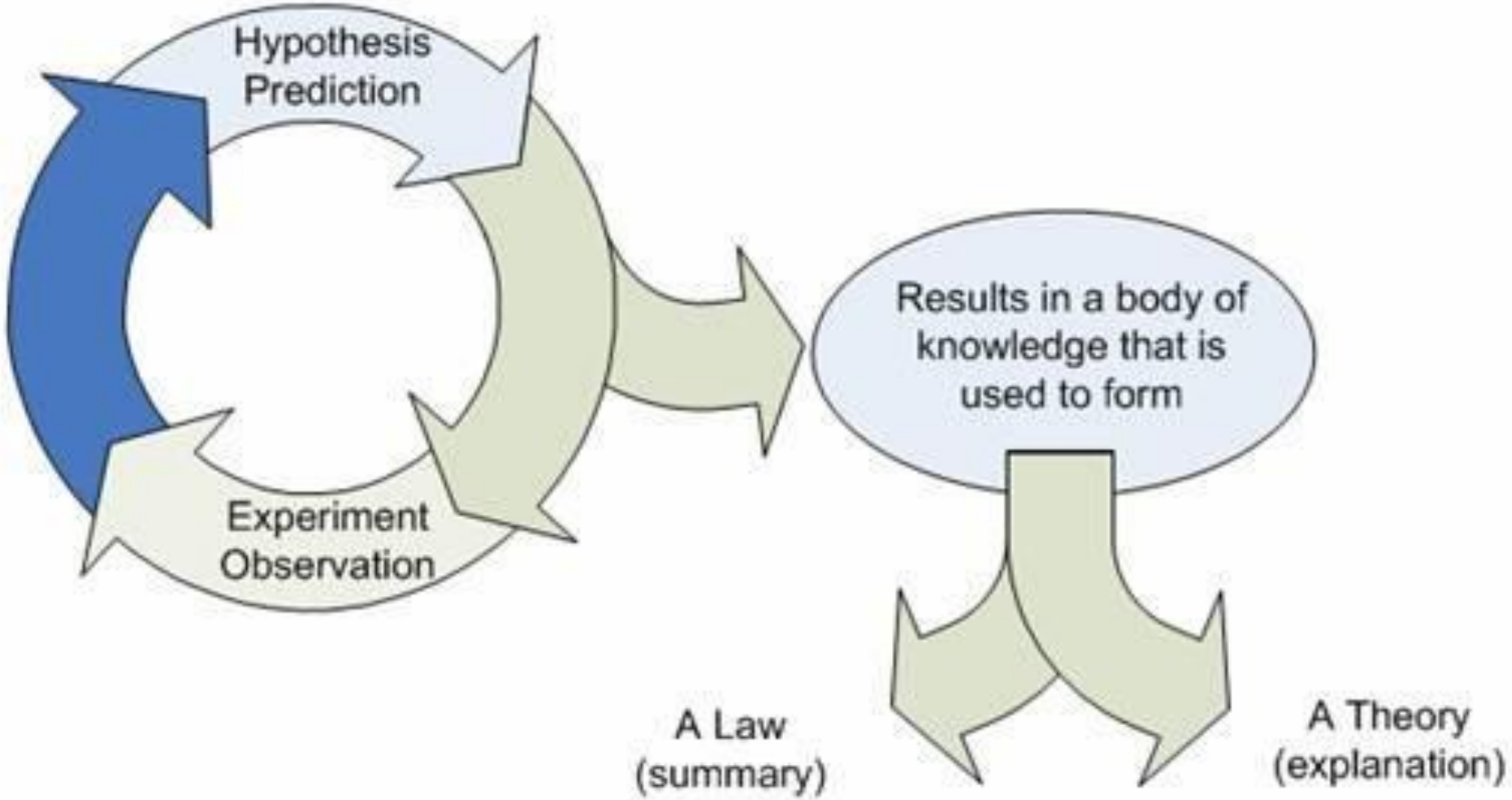
Inference: An interpretation based on prior knowledge and experience

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

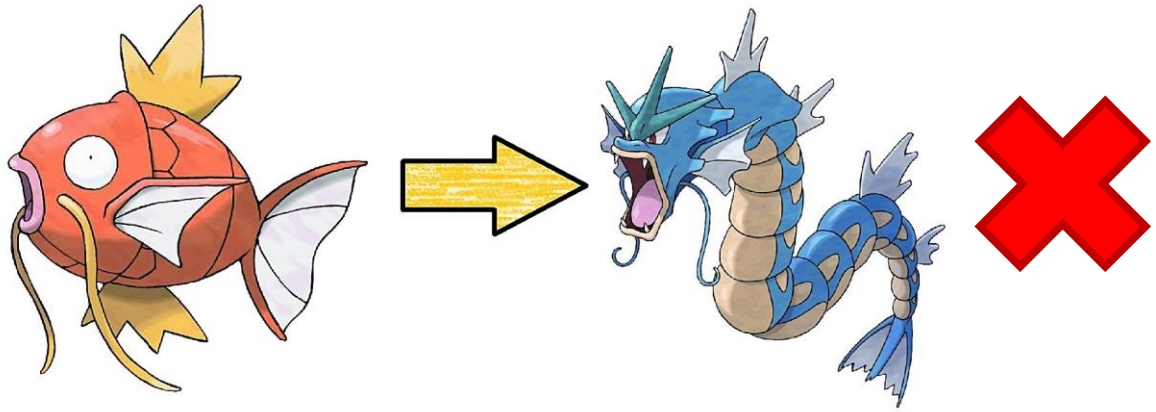
Scientific Method



WHAT IS EVOLUTION?

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

It acts on populations, not individuals



It can occur at one of two levels:

- <u>Microevolution</u>: small scale (molecular) → Seen in living populations
- <u>Macroevolution</u>: large scale (speciation) → Seen in the fossil record


IN-PROGRESS
POKEMON
NOTE: GYARADOS NOT TO SCALE

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

THINK ABOUT IT

A husband and a wife exercise regularly at the gym build up their muscles, and then later have a baby.

Will the big muscles be passed on to their child?

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**

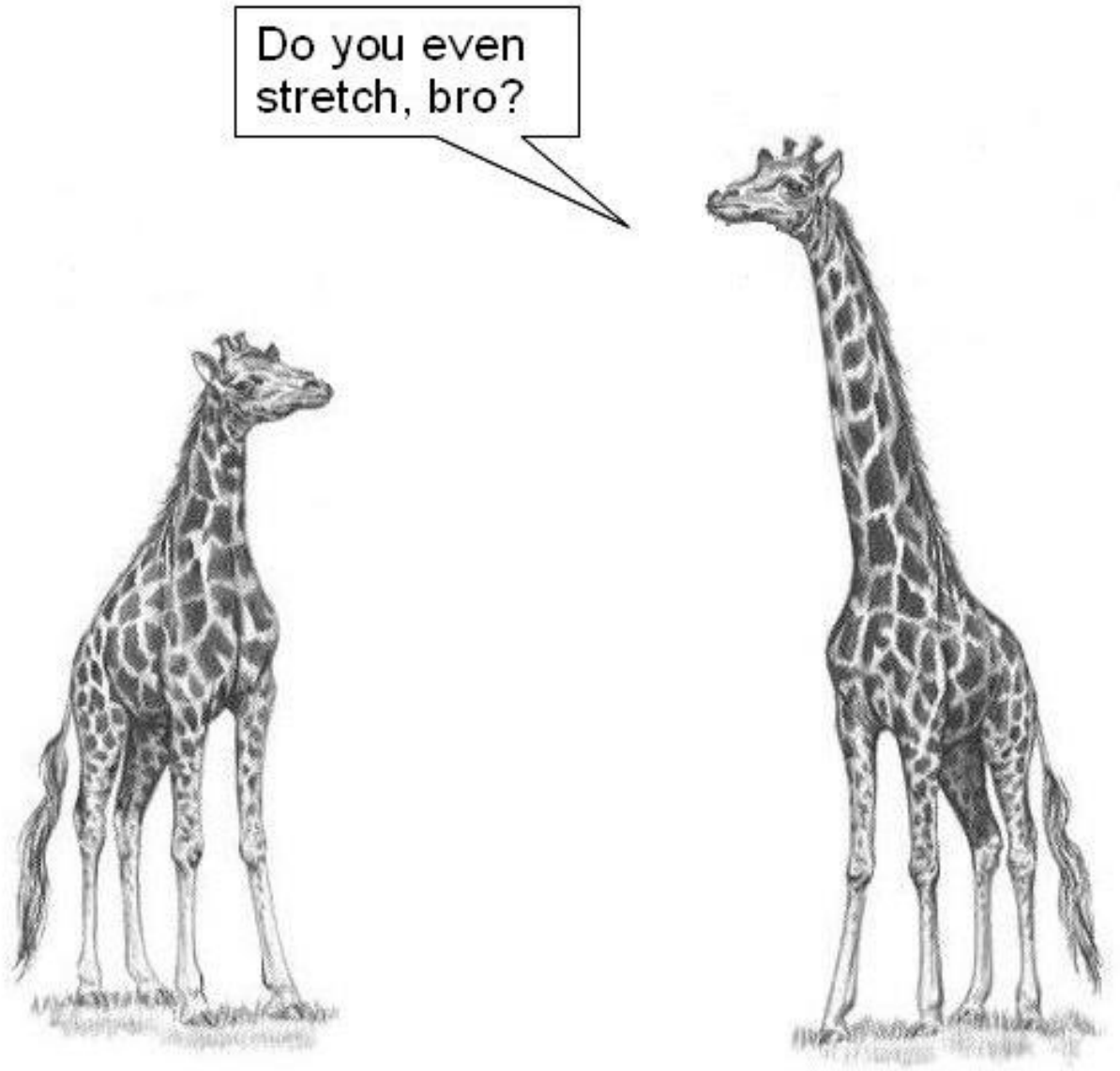
THEORY OF USE AND DISUSE

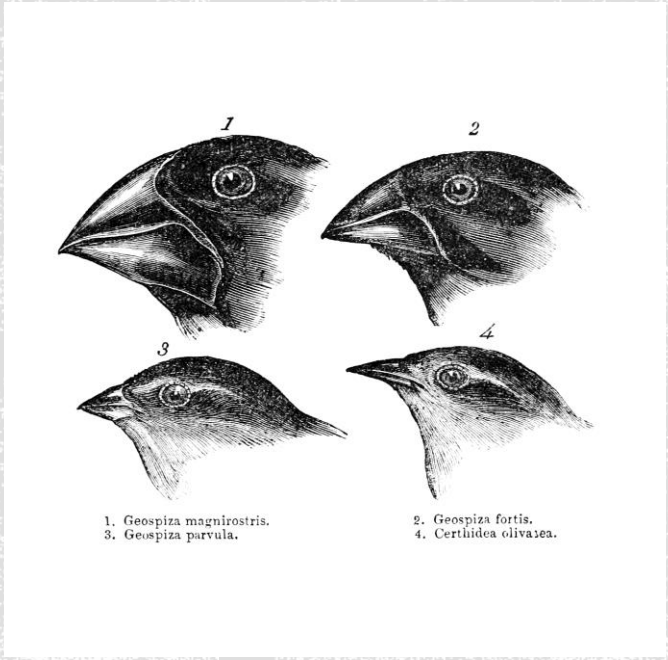
Early giraffes probably had short necks that they stretched to reach food.

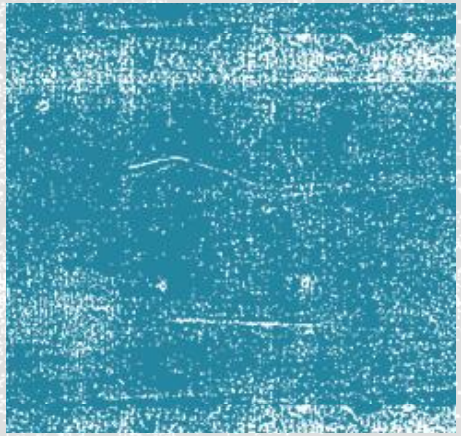
Their offspring had longer necks that they stretched to reach food.

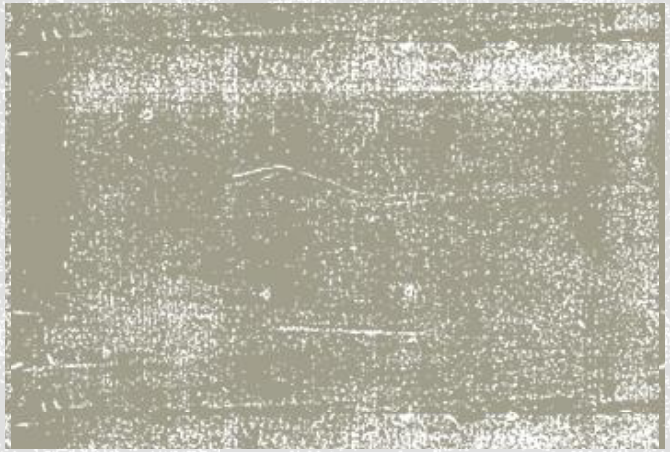
Eventually, the continued stretching of the neck resulted in today's giraffe.

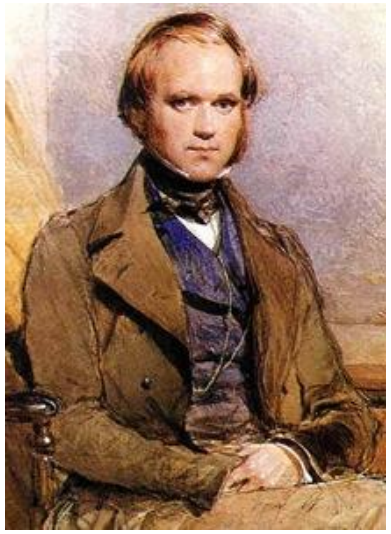
a. Lamarck's proposal


Do you even stretch, bro?









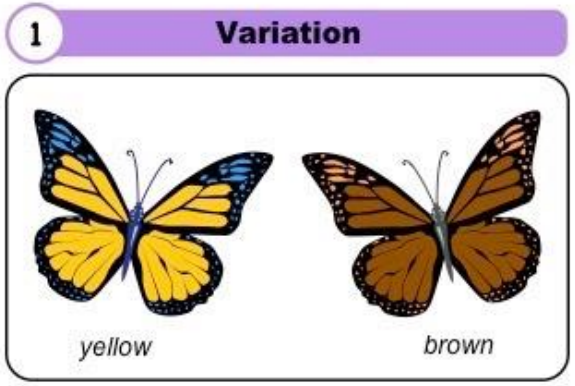
CHARLES DARWIN (1809-1882)

From his voyage on board the HMS Beagle, he found that species vary locally, globally, and over times

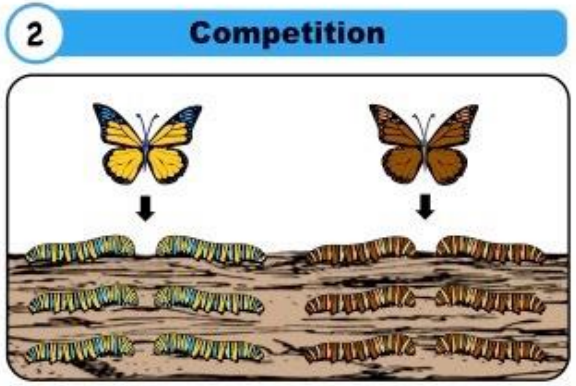
His most well-known studies involved finches and other animals in the Galapagos Islands

- 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**

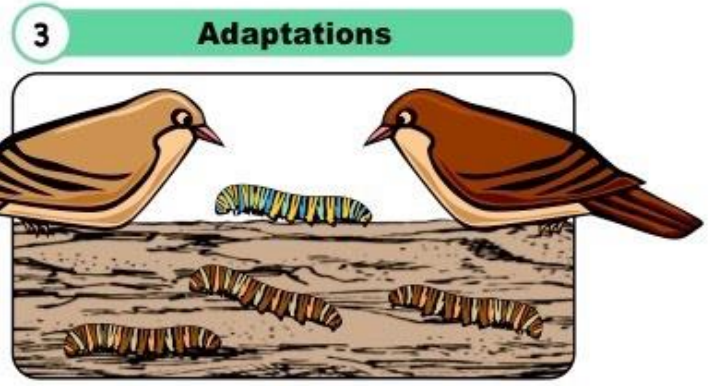
THEORY OF NATURAL SELECTION



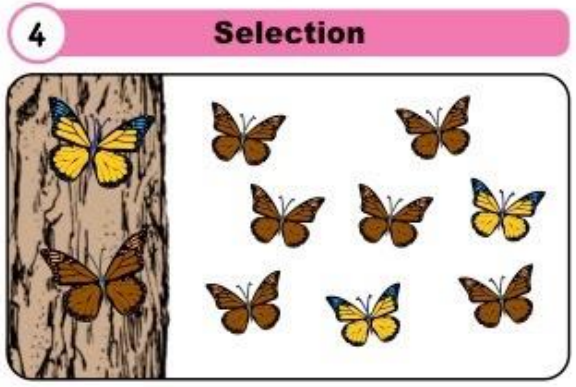
There is genetic variation within a population which can be inherited



Overproduction of offspring leads to competition for survival



Individuals with beneficial adaptations are more likely to survive to pass on their genes



Over many generations, there is a change in allele frequency (evolution)

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

Natural Selection Mnemonic

The key components to the process of natural selection are:

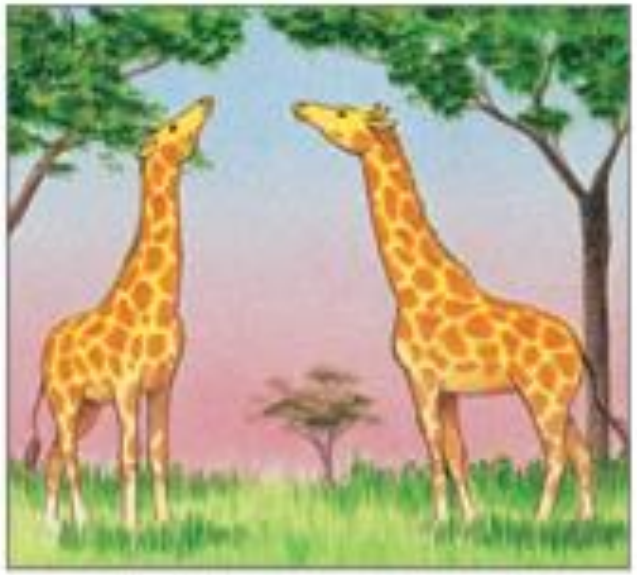
- **Inherited variation** exists within the population
- **Competition** results from an overproduction of offspring
- **Environmental pressures** lead to differential reproduction
- **Adaptations** which benefit survival are selected for
- **Genotype frequency** changes across generations
- **Evolution** occurs within the population

Mnemonic: ICE AGE

NATURAL SELECTION IN GIRAFFES

Early giraffes probably had necks of various lengths.

Natural selection due to competition led to survival of the longer-necked giraffes and their offspring.



Eventually, only long-necked giraffes survived the competition.

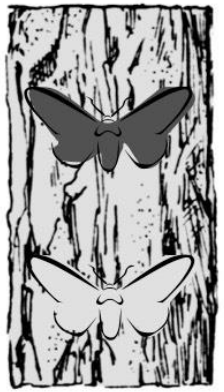
b. Darwin's theory

WHAT CAN LEAD TO VARIATION?

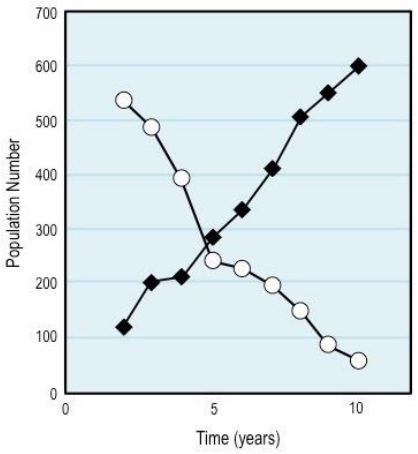
Random mutation: Organisms with shorter generation times → higher mutation rates compared to organisms with longer generation times

Unpolluted Environment

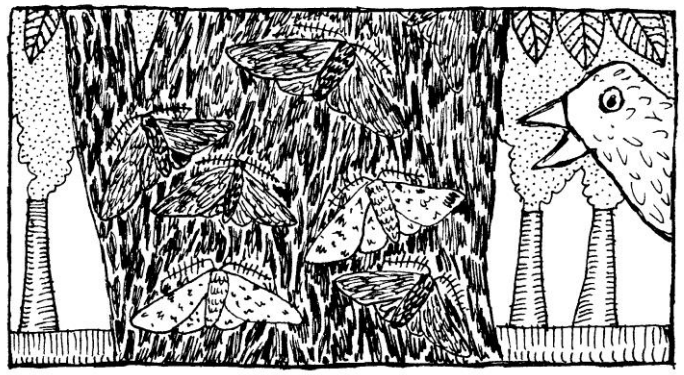
Polluted Environment



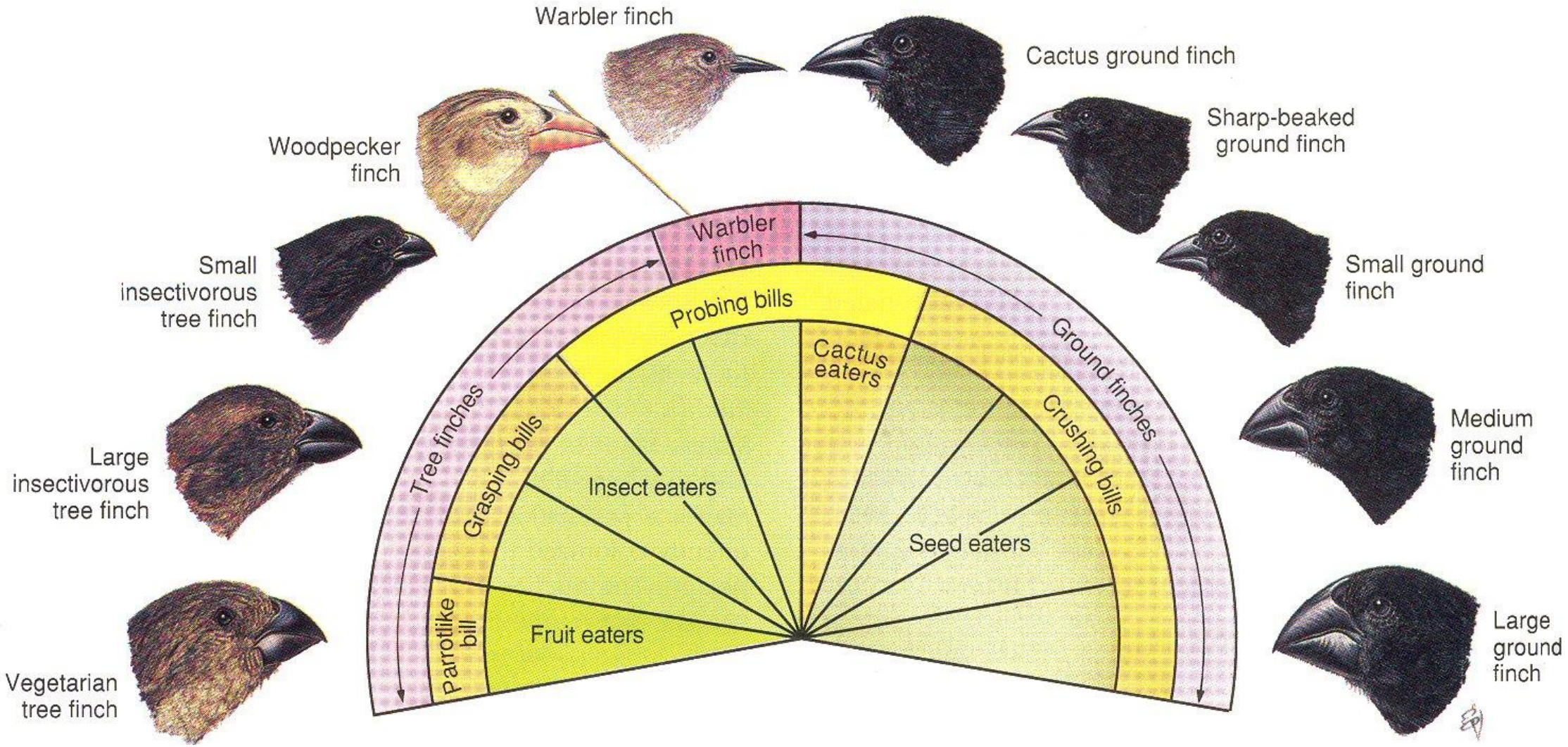
Pre-Industrial Revolution

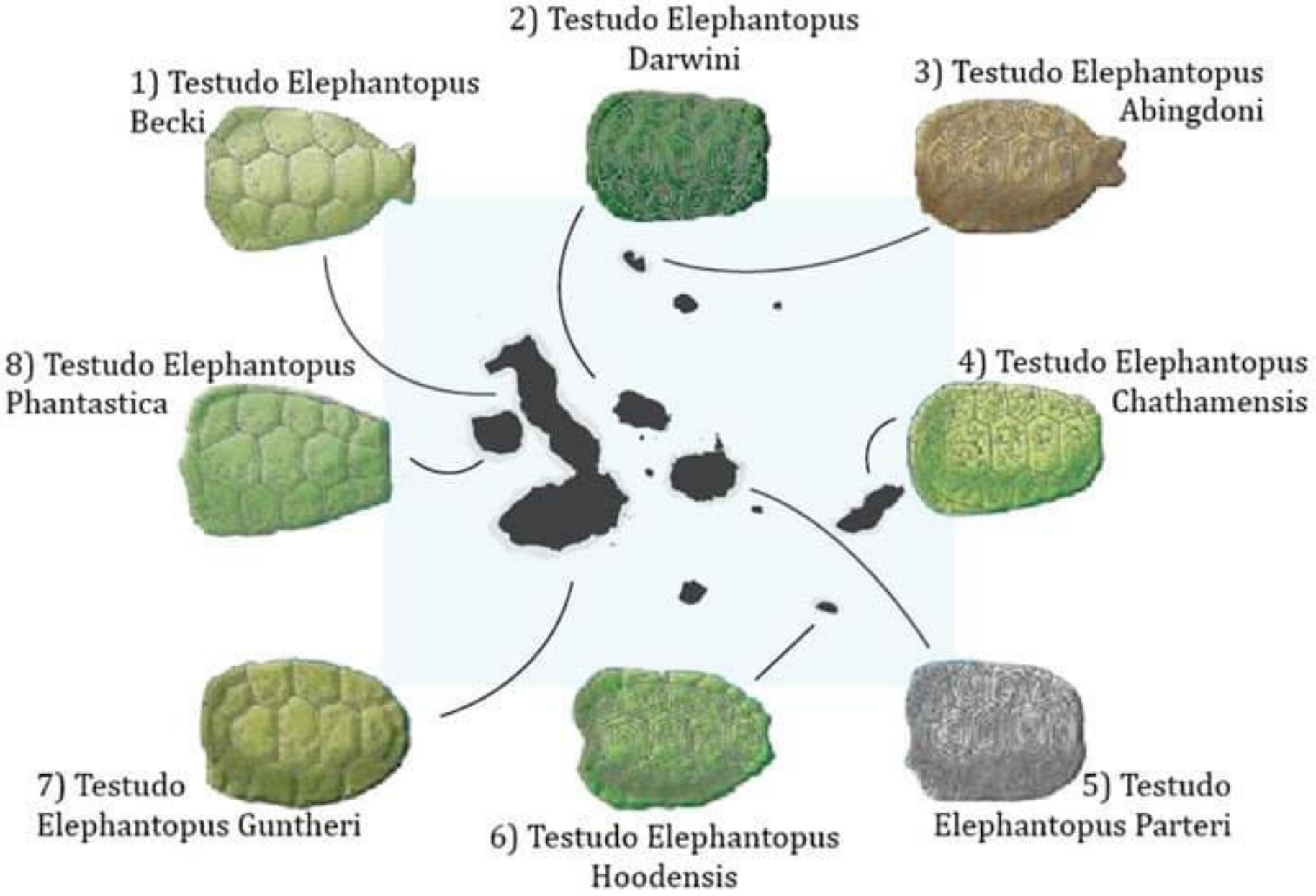


Post-Industrial Revolution



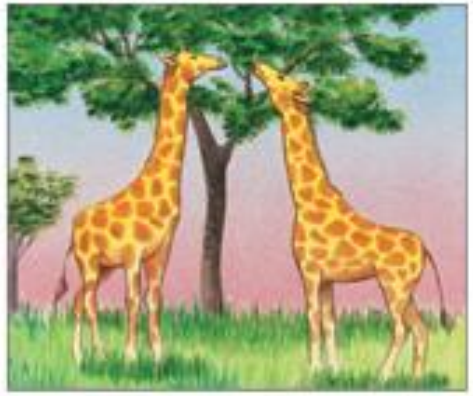
DARWIN'S FINCHES




2) Testudo Elephantopus Darwini
1) Testudo Elephantopus Becki
3) Testudo Elephantopus Abingdoni
8) Testudo Elephantopus Phantastica
4) Testudo Elephantopus Chathamensis
7) Testudo Elephantopus Guntheri
6) Testudo Elephantopus Hoodensis
5) Testudo Elephantopus Parteri

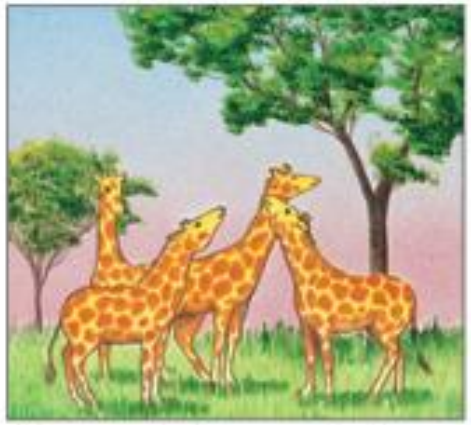
Early giraffes probably had short necks that they stretched to reach food.

Their offspring had longer necks that they stretched to reach food.



Eventually, the continued stretching of the neck resulted in today's giraffe.

a. Lamarck's proposal



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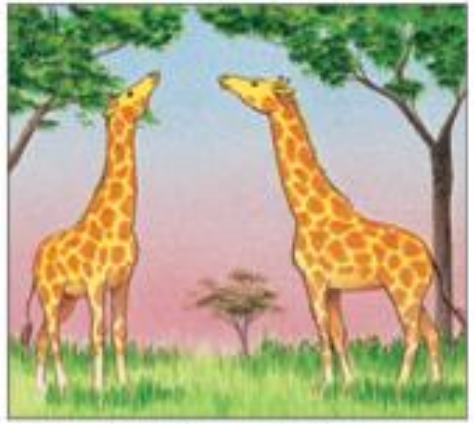


Eventually, only long-necked giraffes survived the competition.

b. Darwin's theory

SCIENTISTS OF EVOLUTION

Jean Baptiste Lamarck (1744-1829)

Organisms acquired traits based on need/experience, not from genes

Use and Disuse

Inheritance of Acquired Characteristics

Charles Darwin (1809-1882)

Nature will select the organisms that have variation that allow them to better survive (survival of the fittest)

Natural Selection

Descent by Modification

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.

CREATE A VENN DIAGRAM

Create a Venn diagram that compares and contrasts Lamarck's and Darwin's theory on evolution.

Then using complete sentences, respond to the following question:

How did Lamarck influence Darwin's thinking?

TOPIC 2 LEARNING TARGETS

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

EVIDENCE OF EVOLUTION

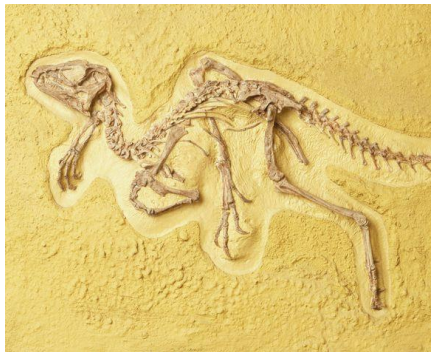
Evidence Mnemonic: **FAME**

Fossil

Anatomical

Molecular

Embryological



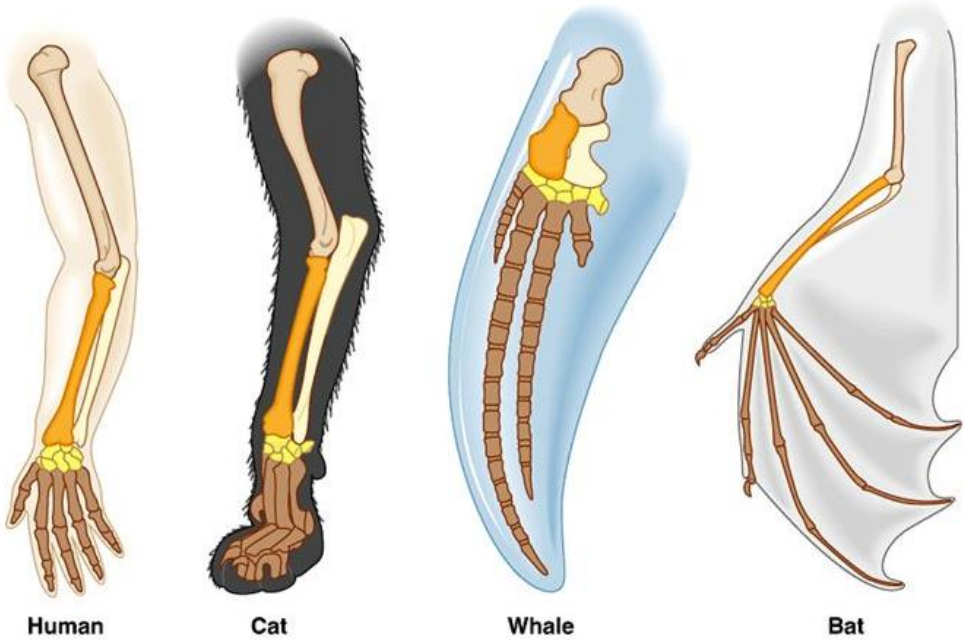
FOSSIL EVIDENCE

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?



ANATOMICAL EVIDENCE

Evidences found from comparing structures in modern organisms with ancient organisms

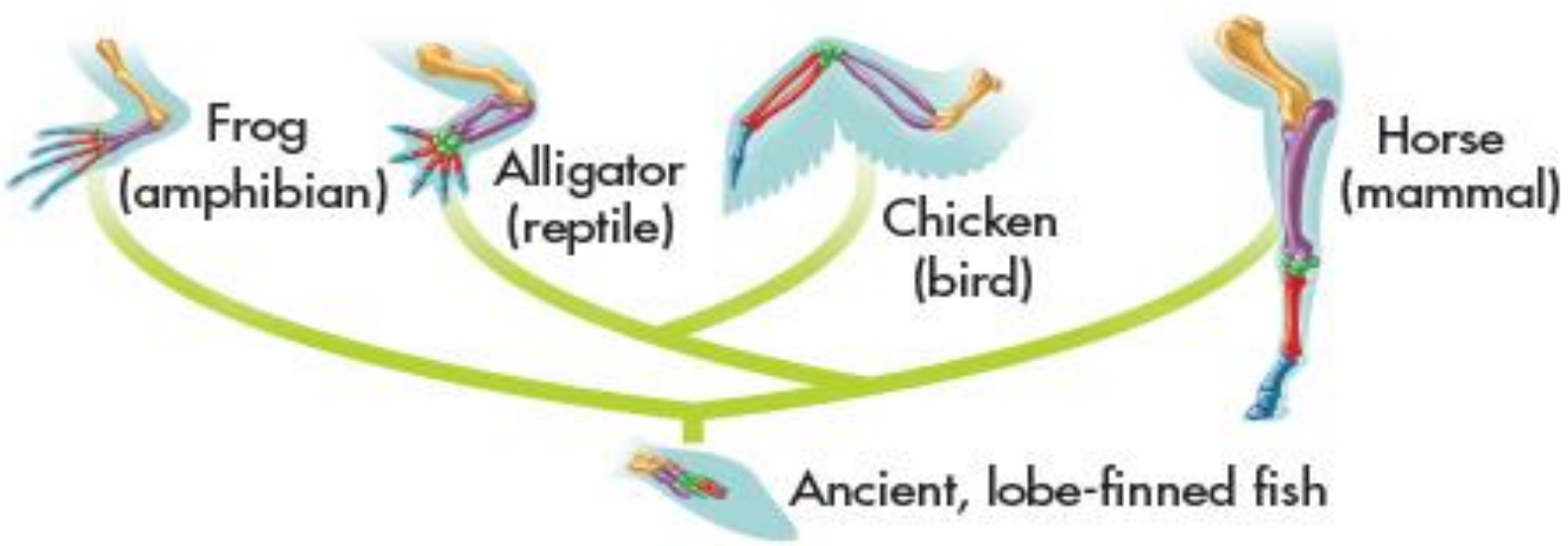
Three types of structures

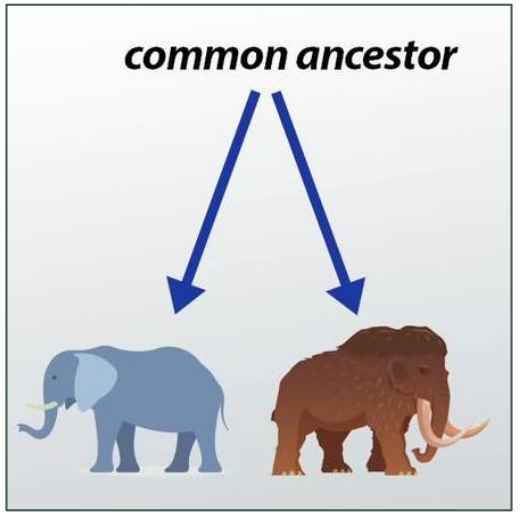
- Homologous: Structures that are shared by related species and that have been inherited from a common ancestor
- Analogous: Structures that share a common function, but are different in structure
- Vestigial: Structures that are inherited from ancestors, but have lost most of their original function 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.

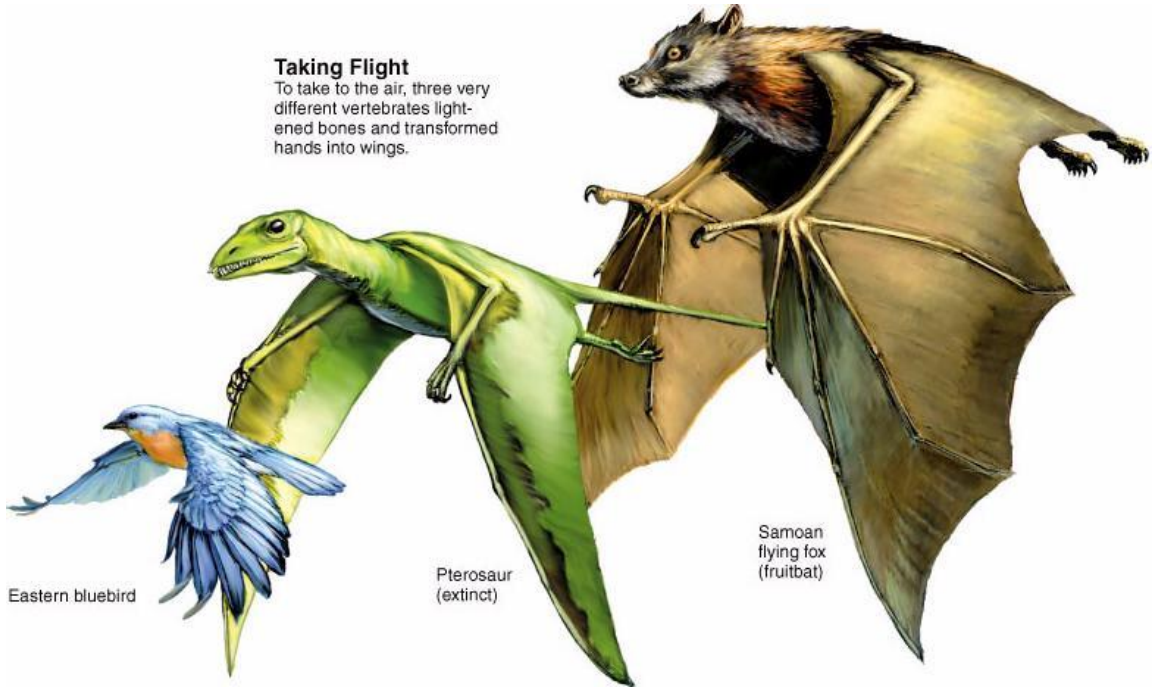


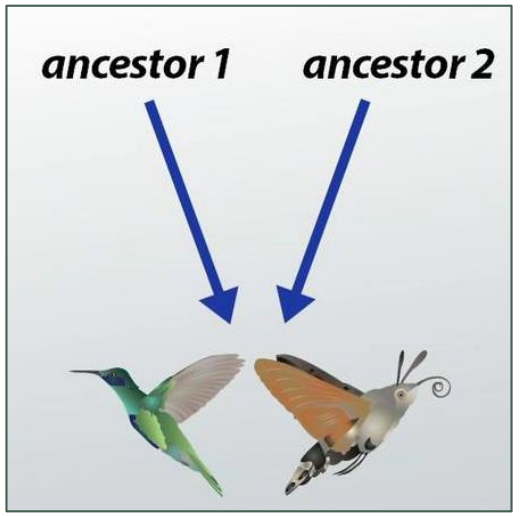


ANALOGOUS STRUCTURES

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.

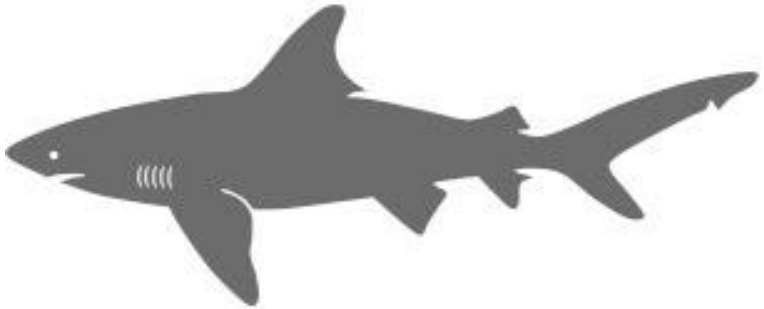


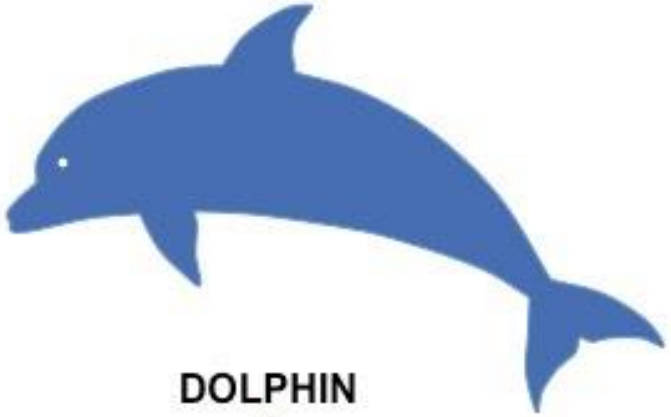


HOMOLOGOUS OR ANALOGOUS?

CONVERGENT EVOLUTION

Streamlined Shape due to Aquatic Environment (Shared Selection Pressure)





SHARK

DOLPHIN

PUMA

CHONDRICHTHYES

- Cartilaginous Skeleton
- Gills
- Scale Denticles in Skin

MAMMALIA

- Bony skeleton
- Lungs
- Mammary Glands

VERTEBRATA

- Vertebrae
- Cranium
- Tri-Partite brain

DIVERGENT EVOLUTION

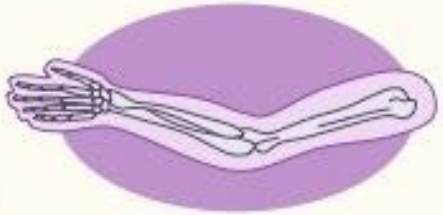
Branching of Vertebrata into Mammalia and Chondrichthyes

Homologous Structures

Lizard

Bird

Human



Whale

Similar structure / Different Function

Analogous Structures

Whale

Turtle

Fish

Penguin

Different structure / Similar Function

Digging

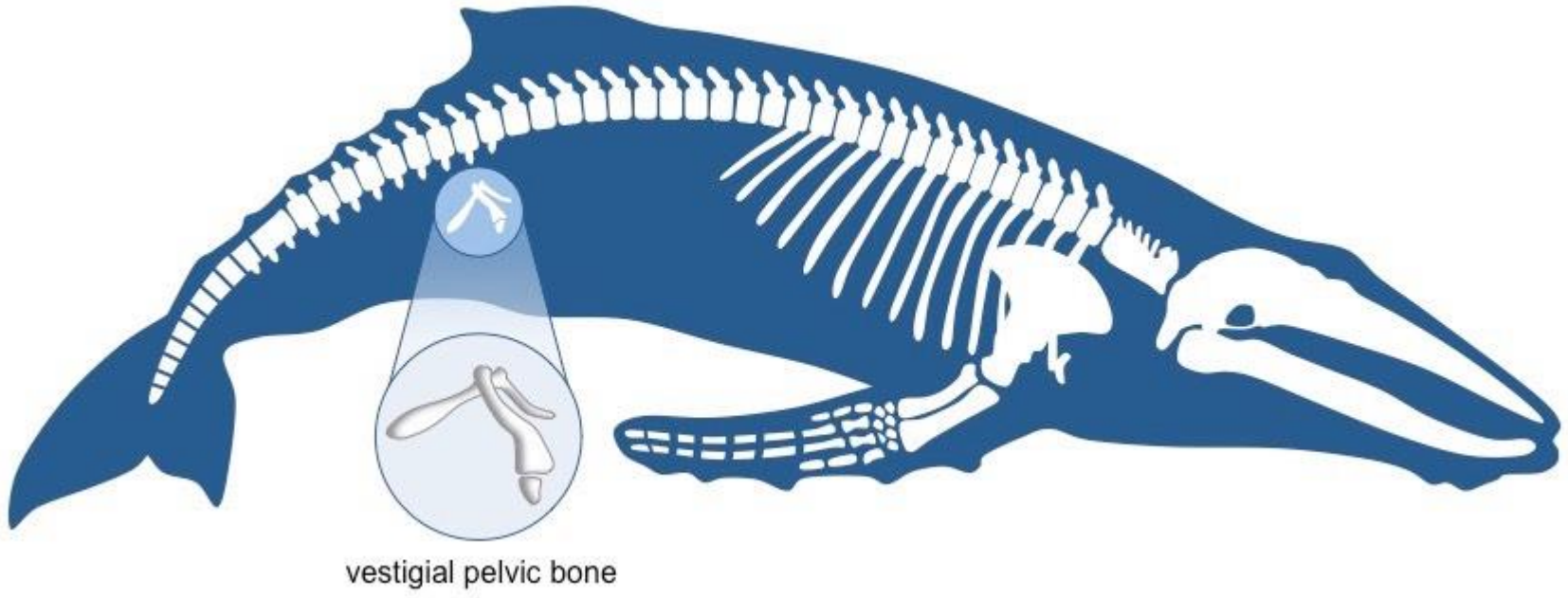
Flying

Grasping

Swimming

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.



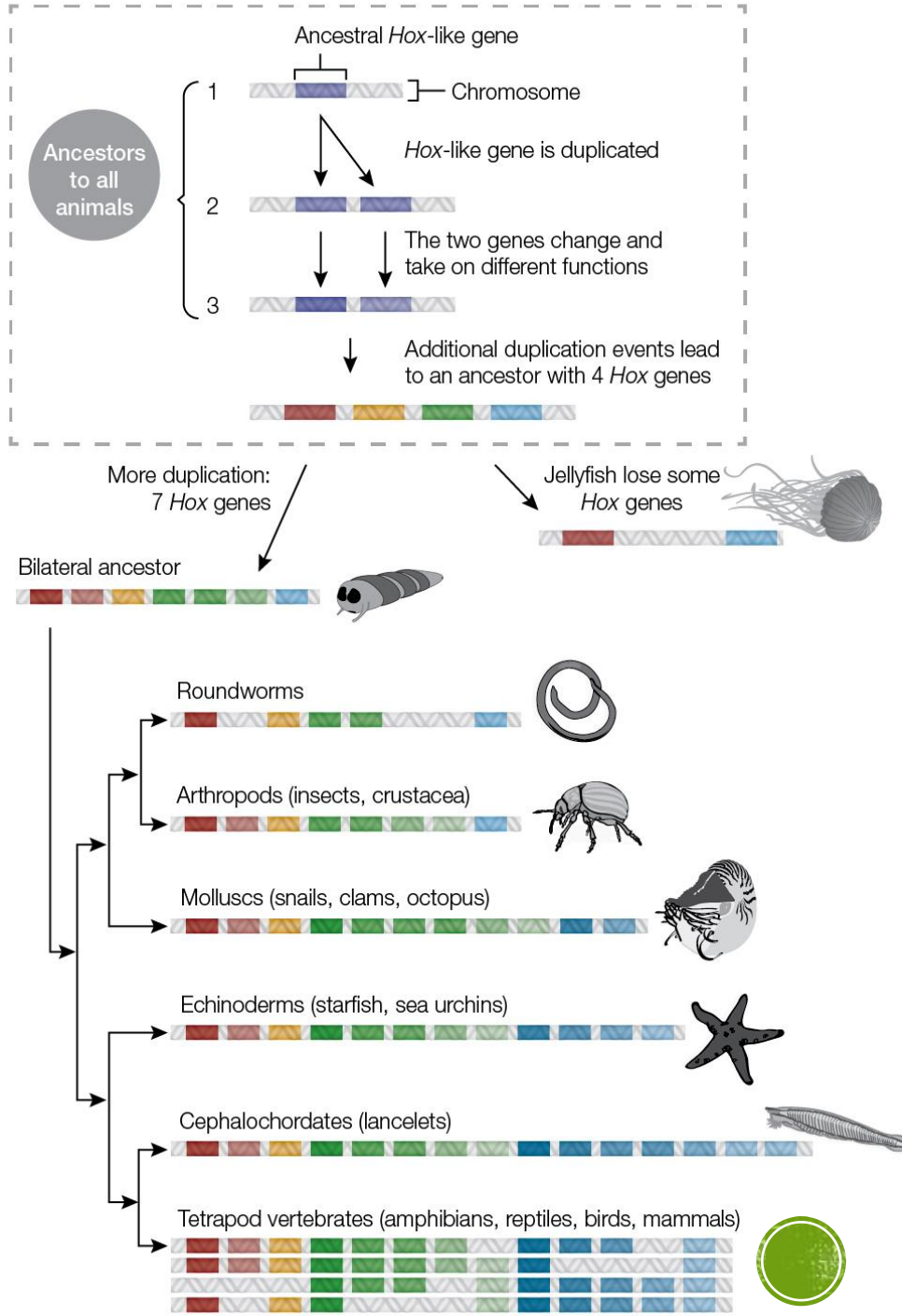
MOLECULAR EVIDENCE

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.



Molecular Evidence

The DNA sequences of whales and ungulates are very similar, as demonstrated by the DNA fragments below.

Hippopotamus	TCC TGGCA GTCCA GTGGT
Humpback whale	CCC TGGCA GTGCA GTGCT

Where are these two organisms different in this DNA sequence?

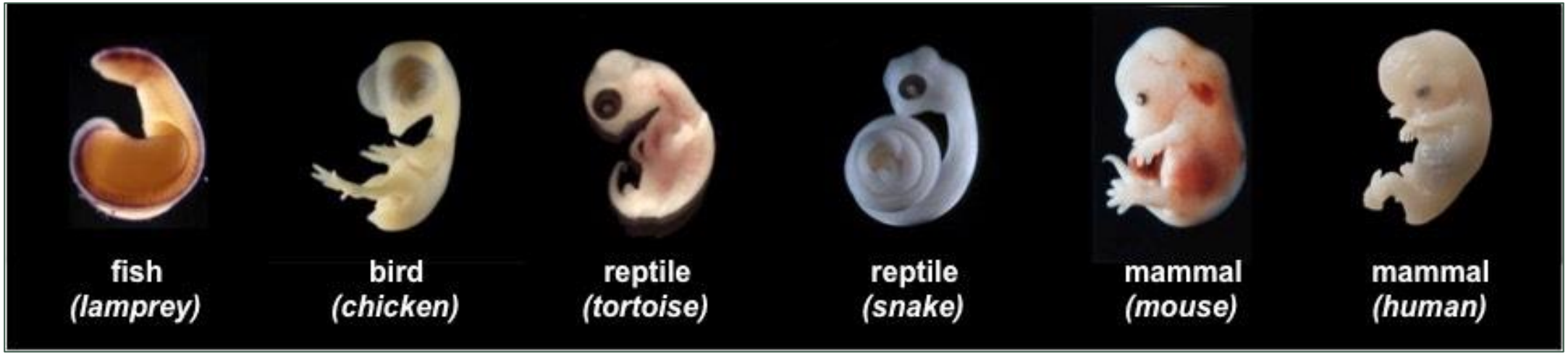
Cytochrome *c* Evolution

Organism	Number of amino acid differences from humans
Chimpanzee	0
Rhesus monkey	1
Rabbit	9
Cow	10
Pigeon	12
Bullfrog	20
Fruit fly	24
Wheat germ	37
Yeast	42

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



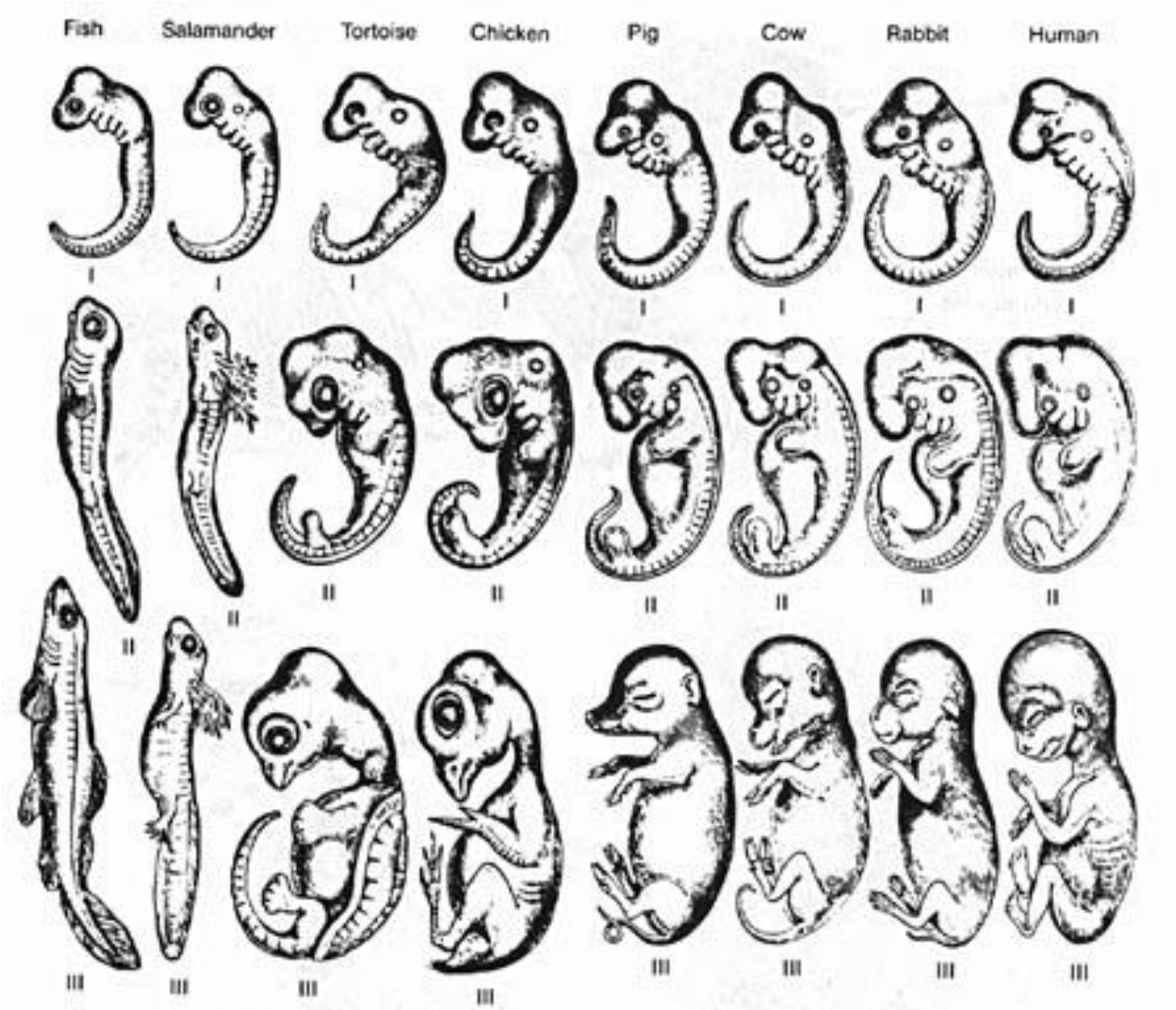
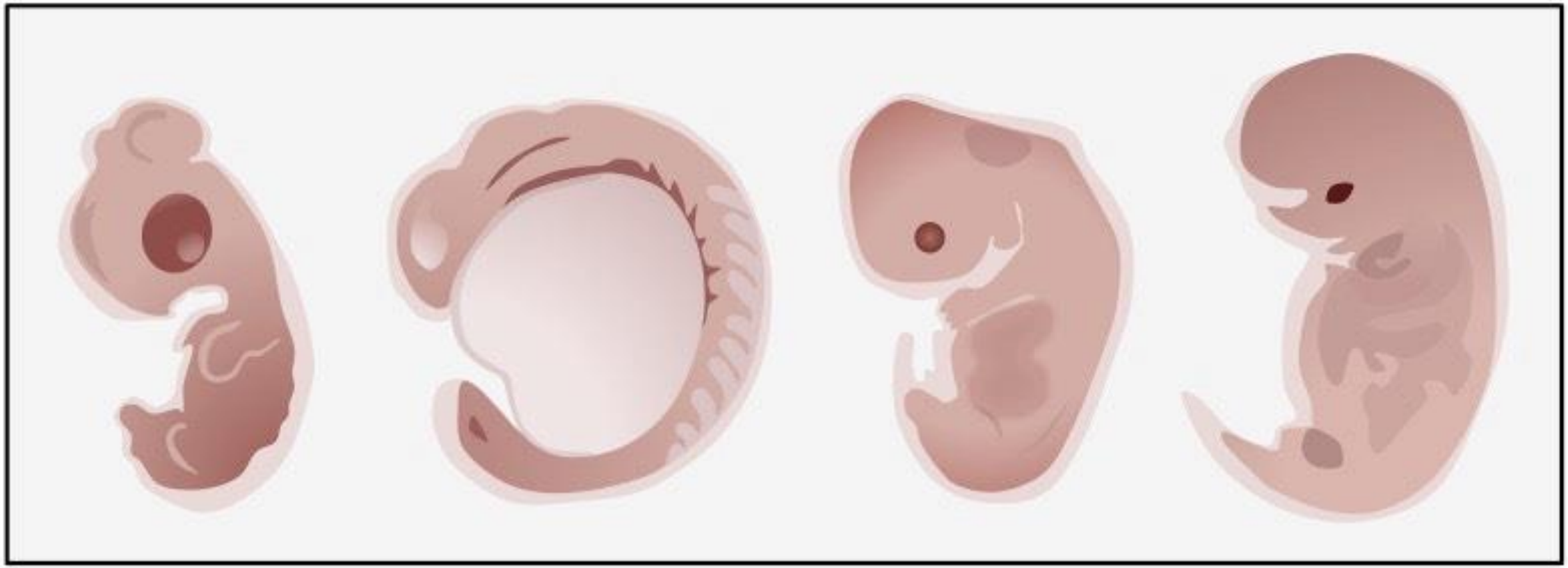


Figure 3–10

A series of embryos of different vertebrates at comparable stages of development. The earlier the stage of development, the more strikingly similar are the different groups. Note that each of the embryos begins with a similar number of gill arches (pouches below the head) and a similar vertebral column. In later stages of development, these and other structures are modified to yield the various different forms. (The embryos in the different groups have been scaled to the same approximate size so that comparisons can be made between them.) (From Romanes, adapted from Haeckel.)

GUESS THE EMBRYO!



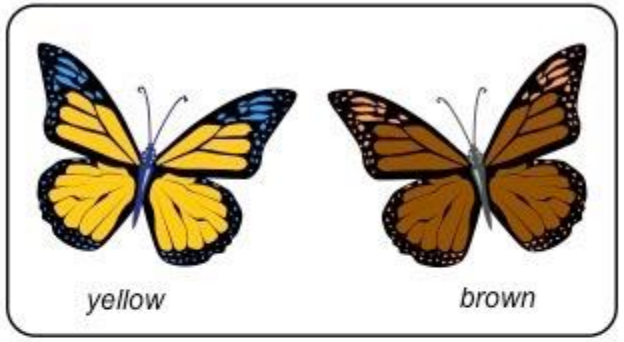
THE ANSWERS

TOPIC 2 LEARNING TARGETS

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

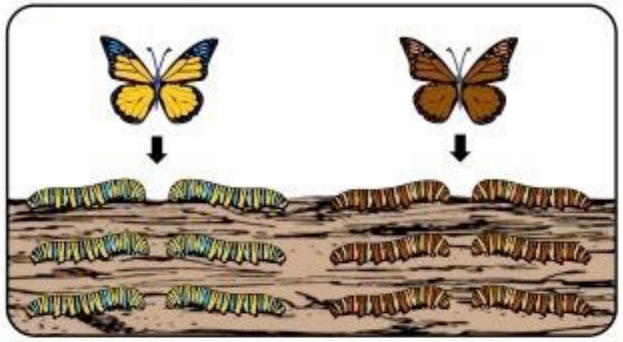
THEORY OF NATURAL SELECTION

1 Variation



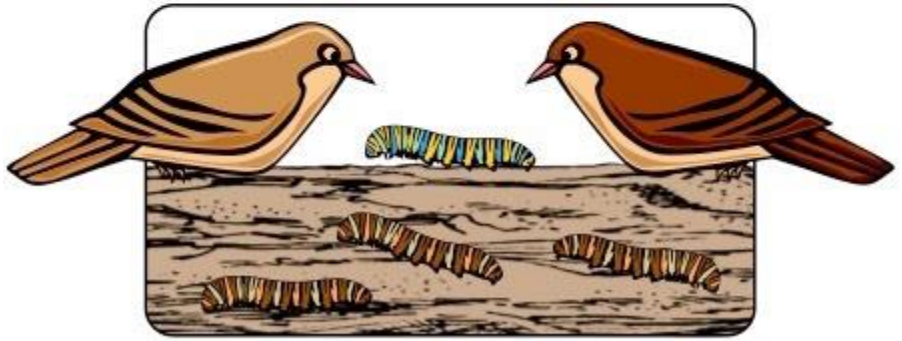
There is genetic variation within a population which can be inherited

2 Competition



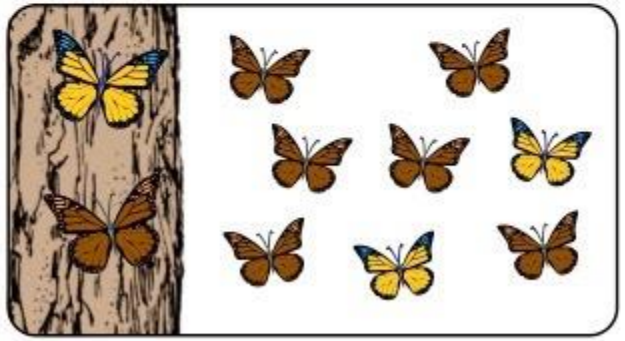
Overproduction of offspring leads to competition for survival

3 Adaptations



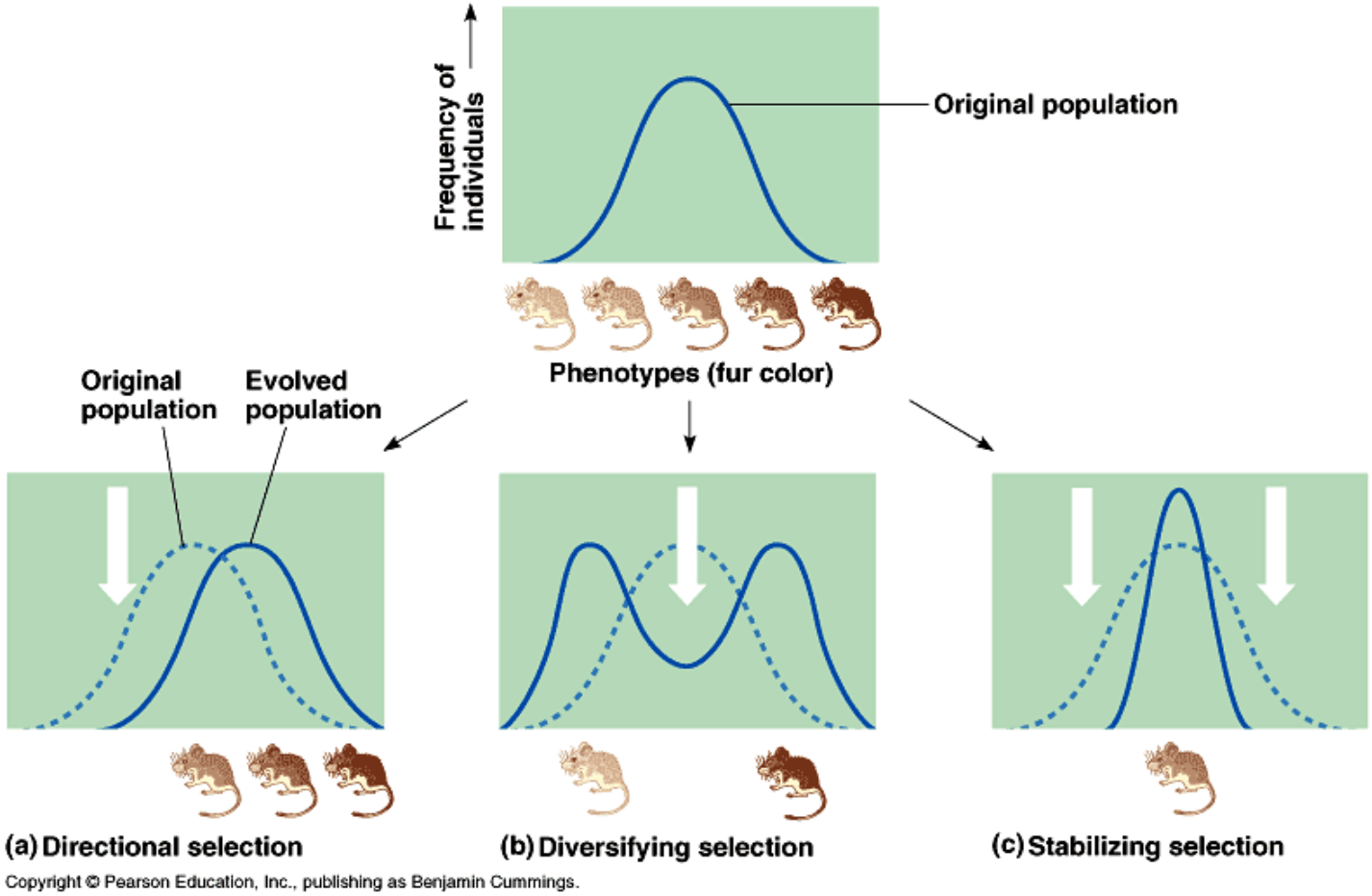
Individuals with beneficial adaptations are more likely to survive to pass on their genes

4 Selection



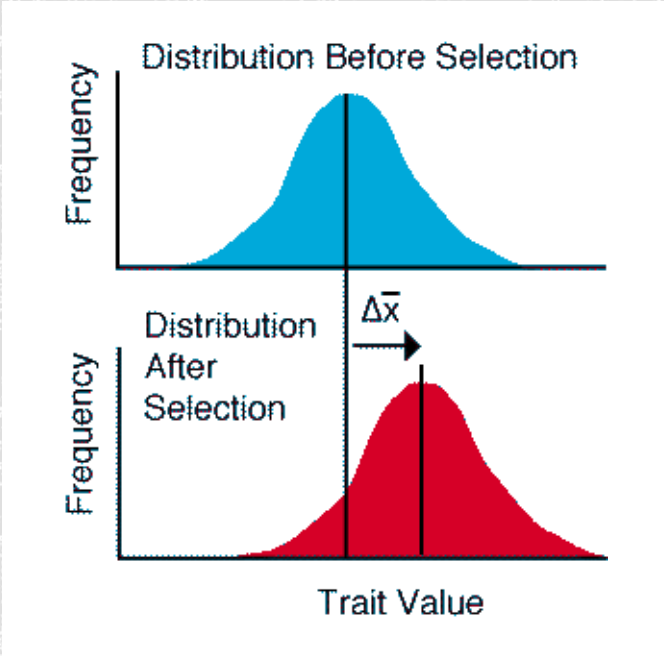
Over many generations, there is a change in allele frequency (evolution)

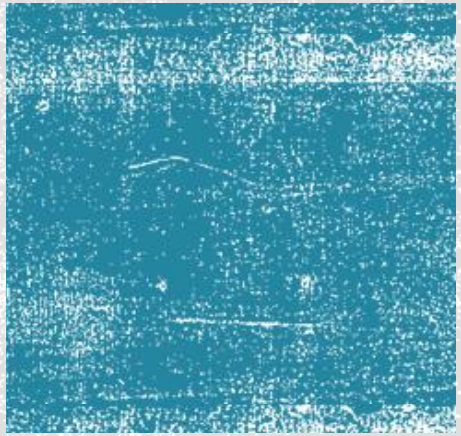
NATURAL SELECTION

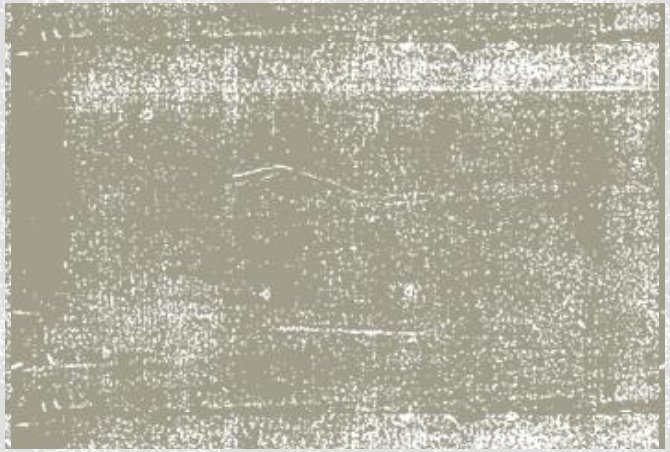


There are three types of natural selection.

- Directional
- Disruptive/diversifying
- Stabilizing

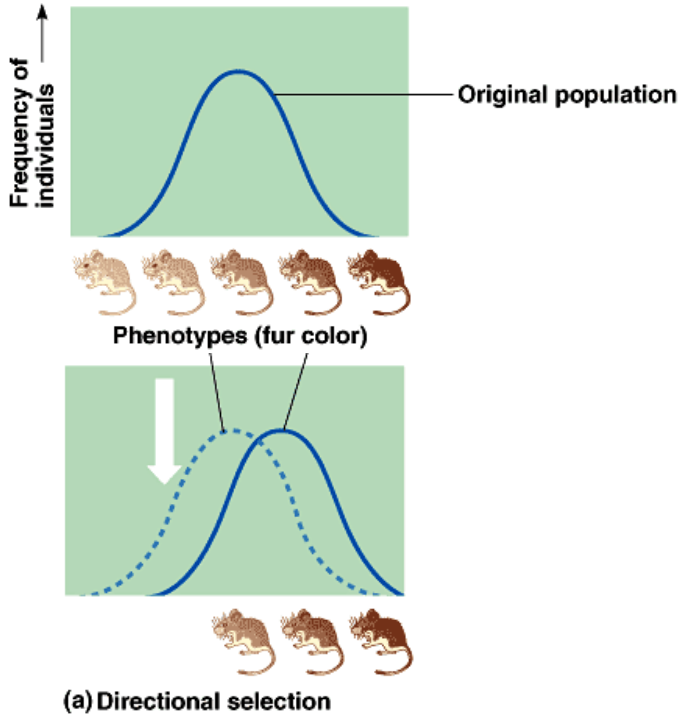


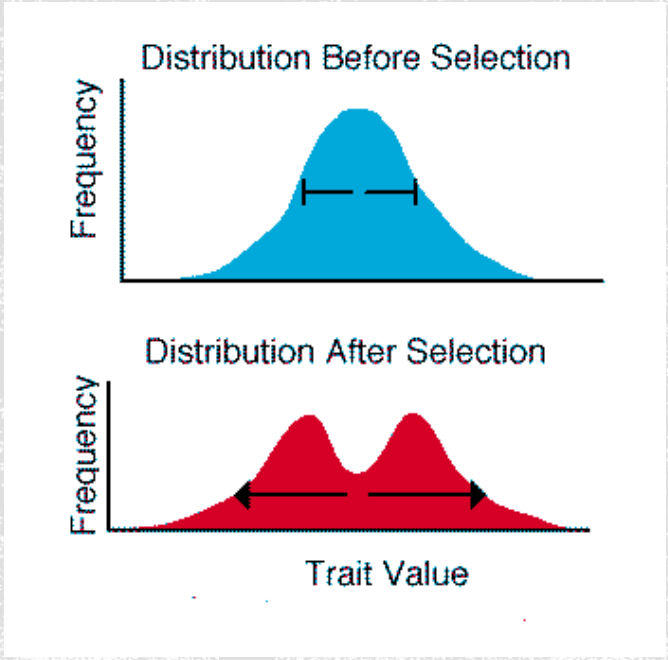


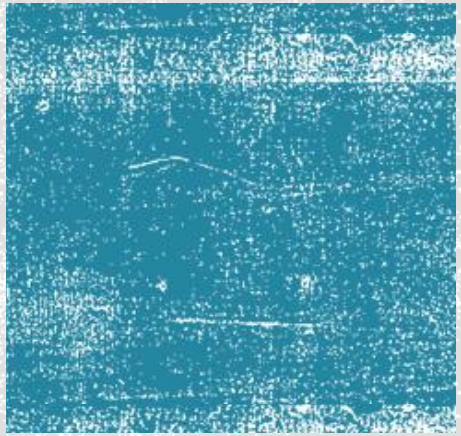


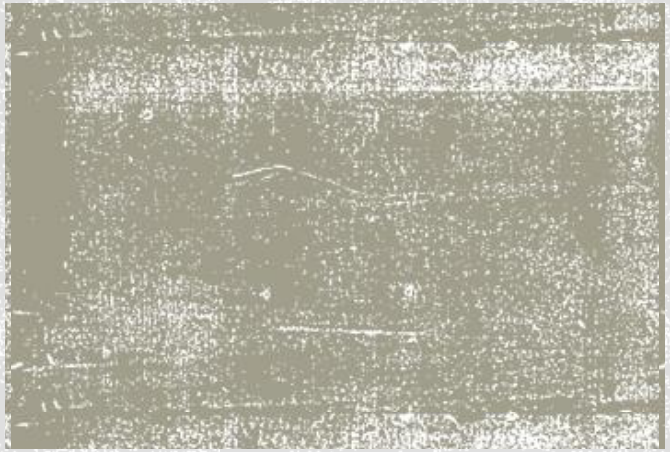
DIRECTIONAL SELECTION

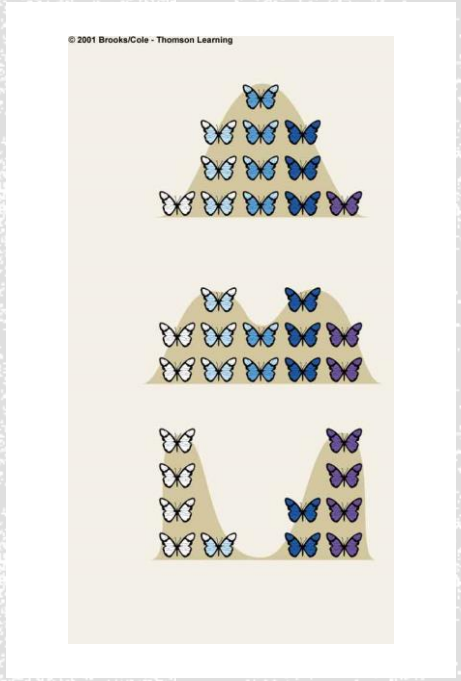
Individuals at one end of the curve have higher fitness than those in the middle or at the other end of the curve.





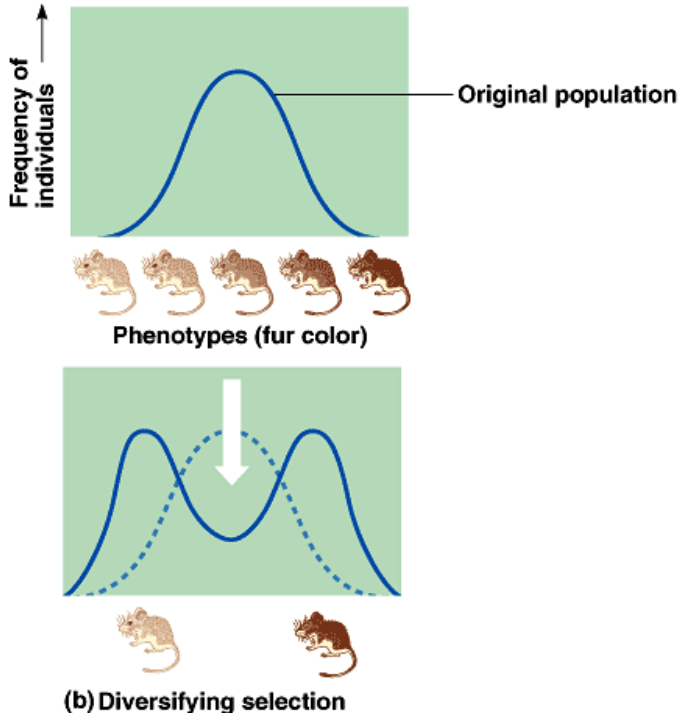


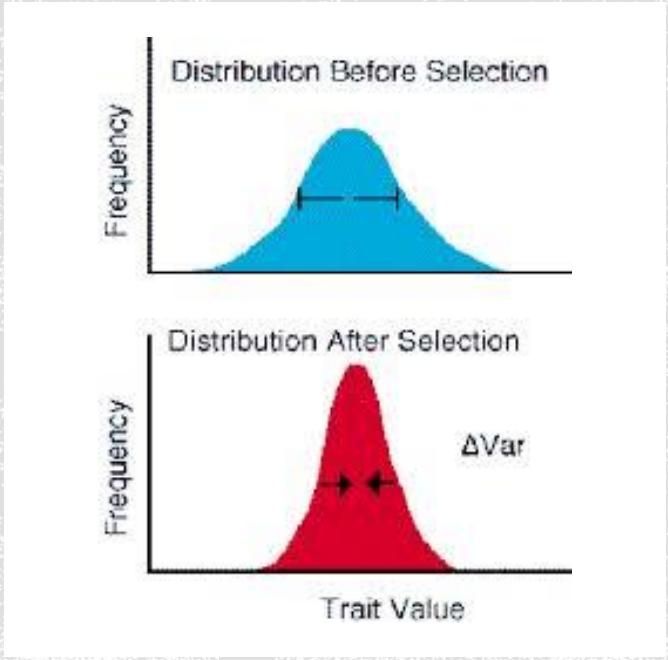


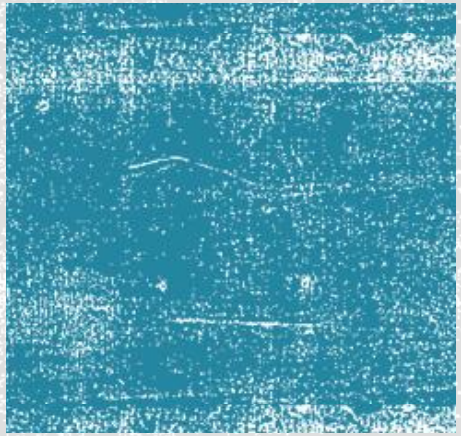


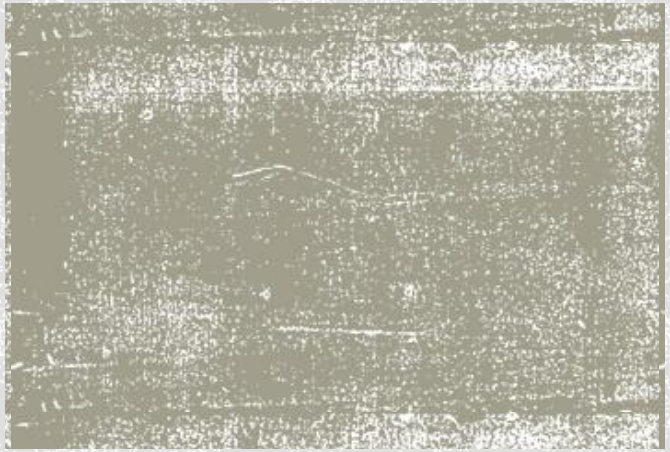
DISRUPTIVE/DIVERSIFYING SELECTION

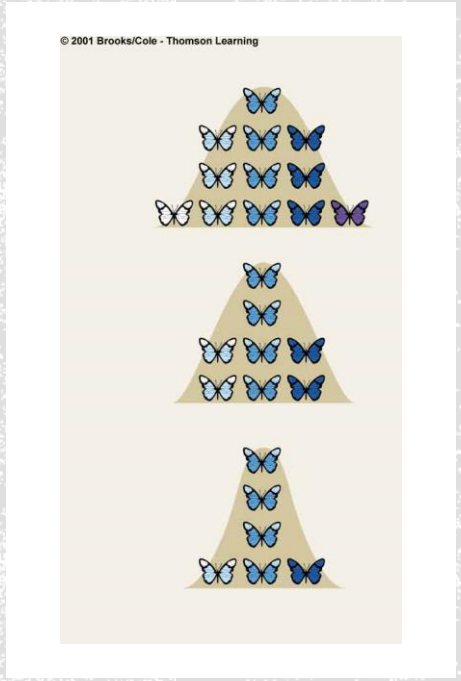
Individuals at the upper and lower ends of the curve have higher fitness than those near the middle – this creates two different phenotypes.





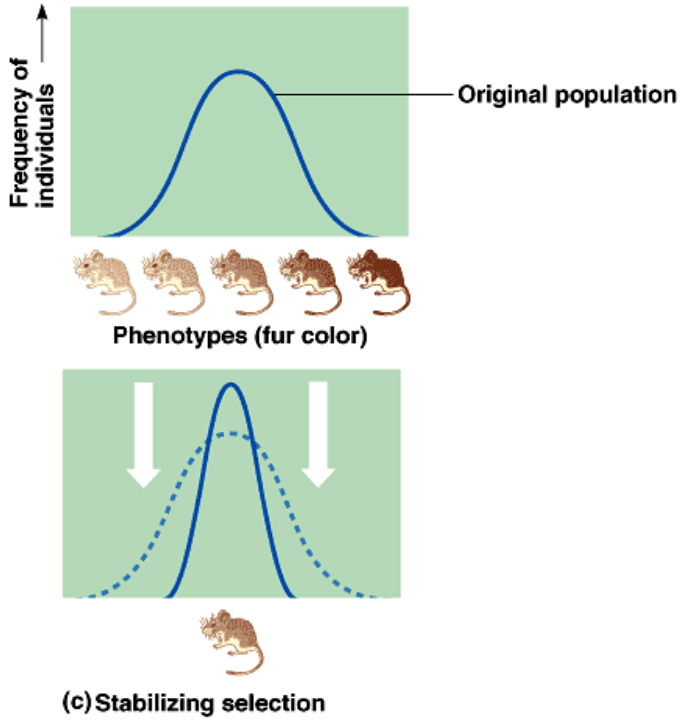






STABILIZING SELECTION

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



SEXUAL SELECTION

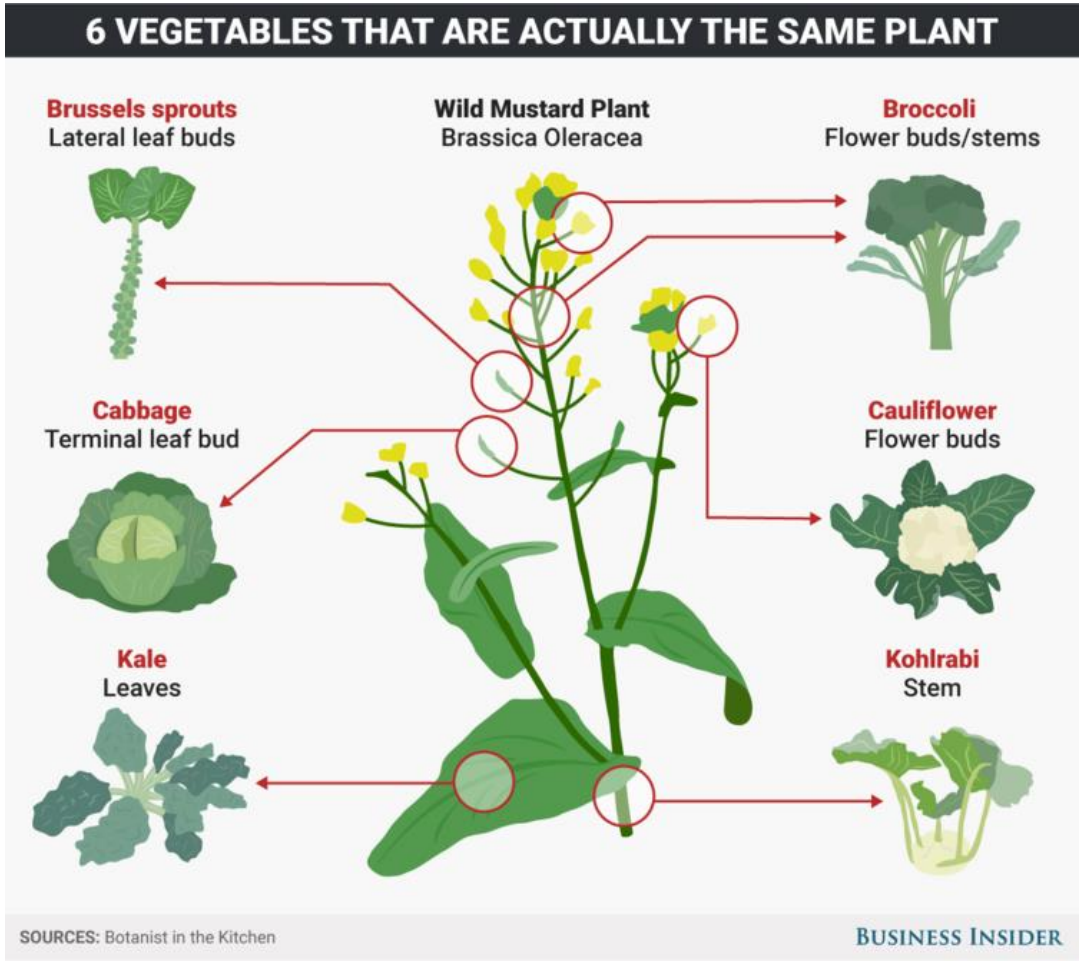
A process by which females choose males for mating based on certain traits.

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 or reproductive success?



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)?

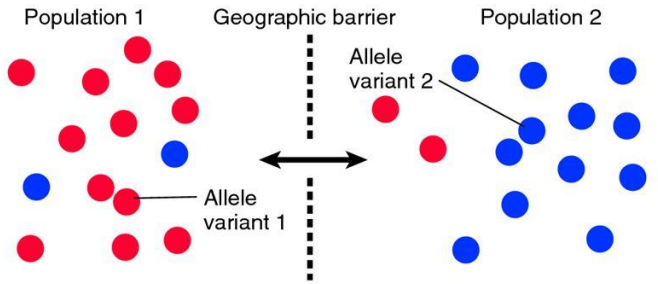
In order to answer this question, we must first define what a species is.

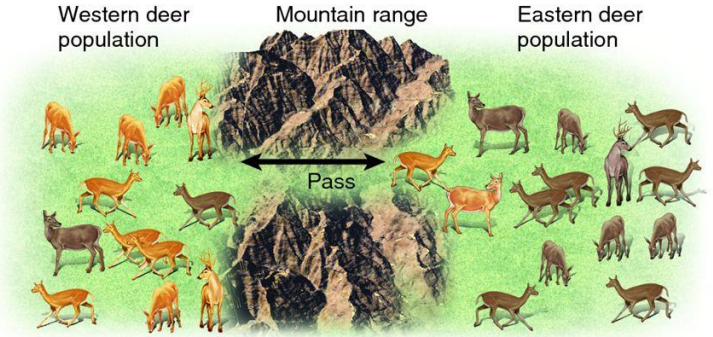
There are two different concepts of a species.

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.

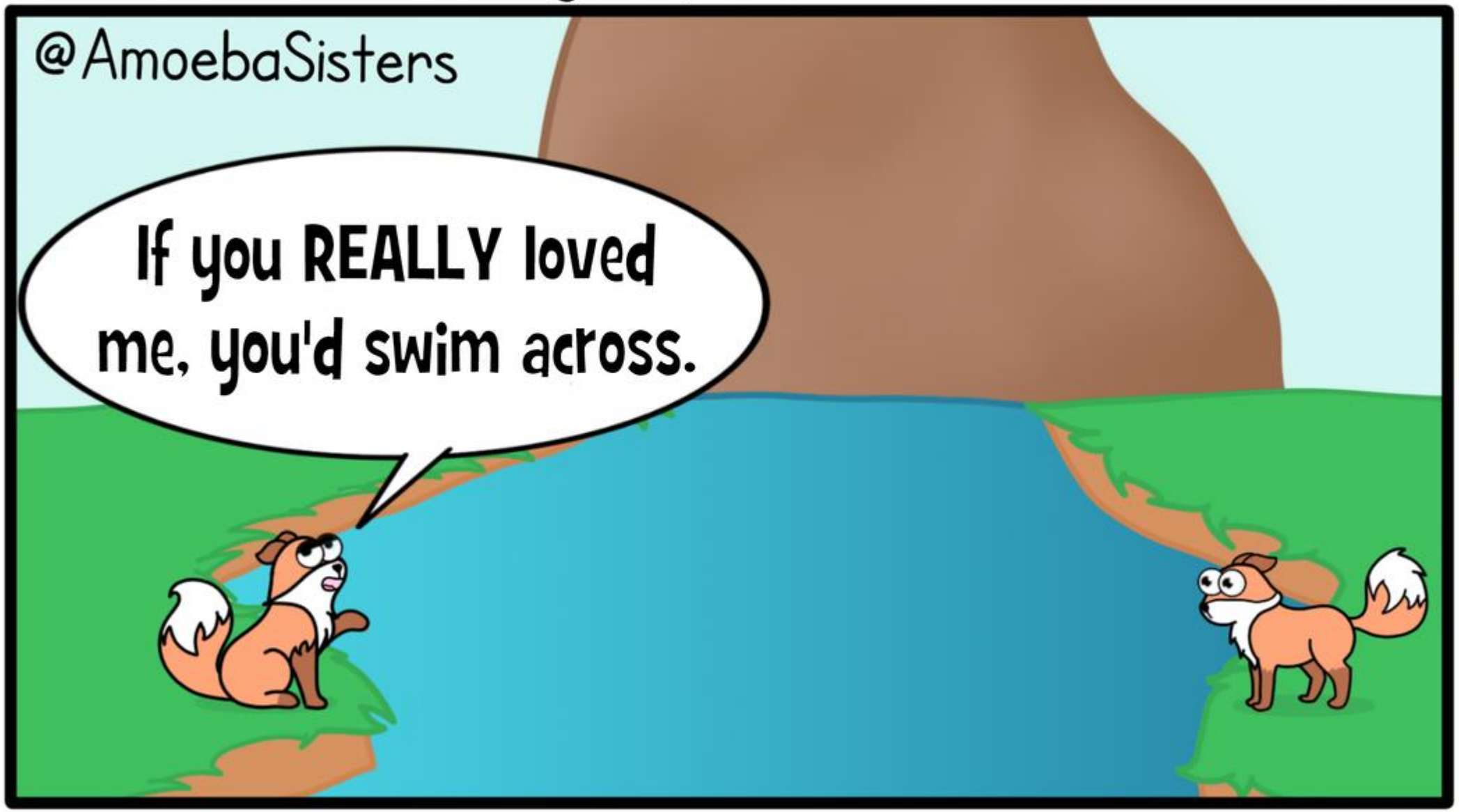




There are two main causes for speciation.

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

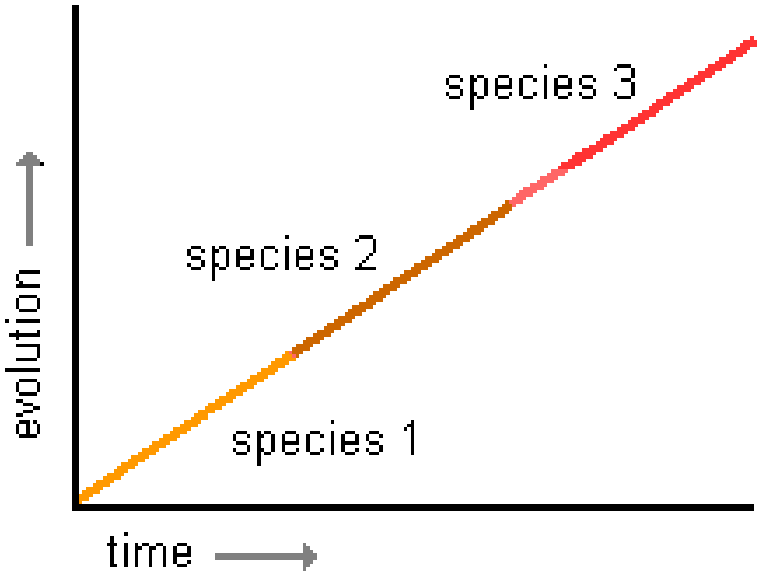
Geographic Isolation



MODELS OF SPECIATION

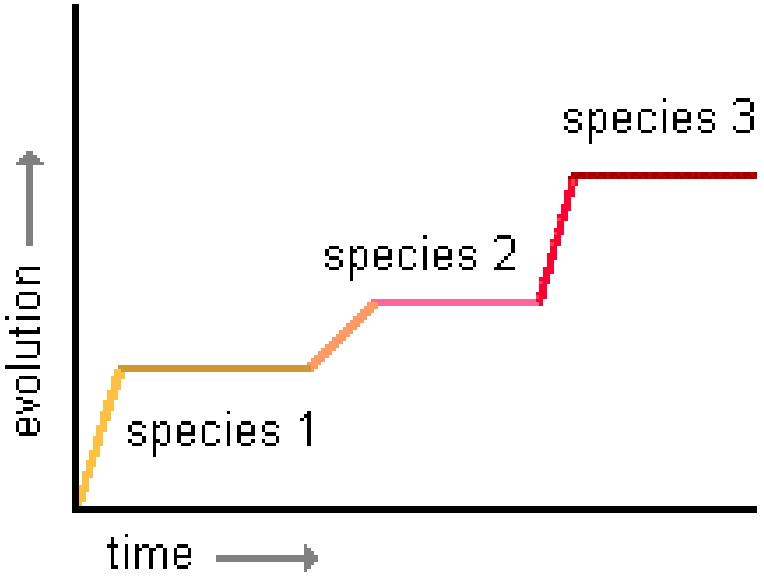
Gradualism

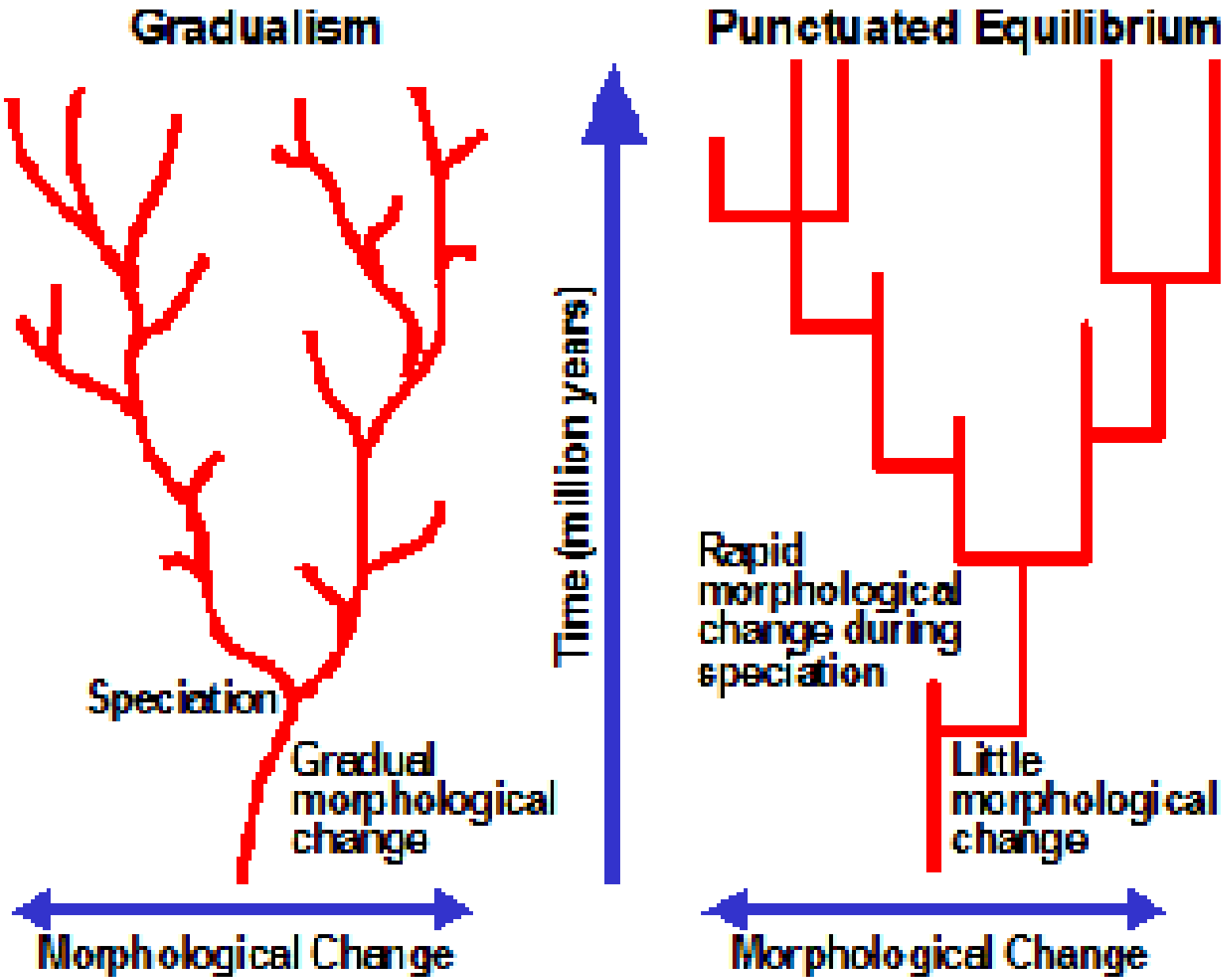
Change occurs slowly and at a constant rate

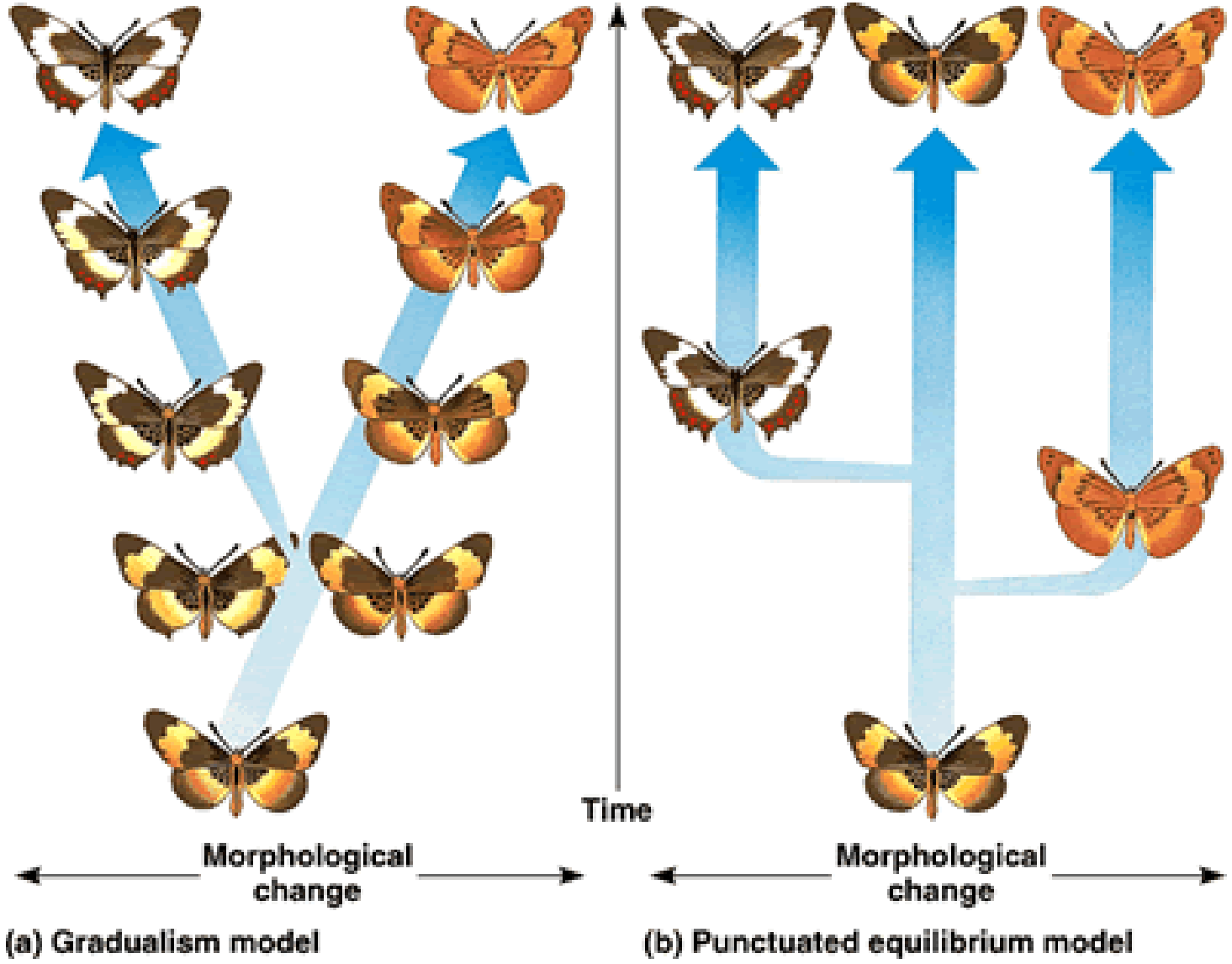


Punctuated Equilibrium

Little or no change is followed by rapid change (often due to major changes in the environment)



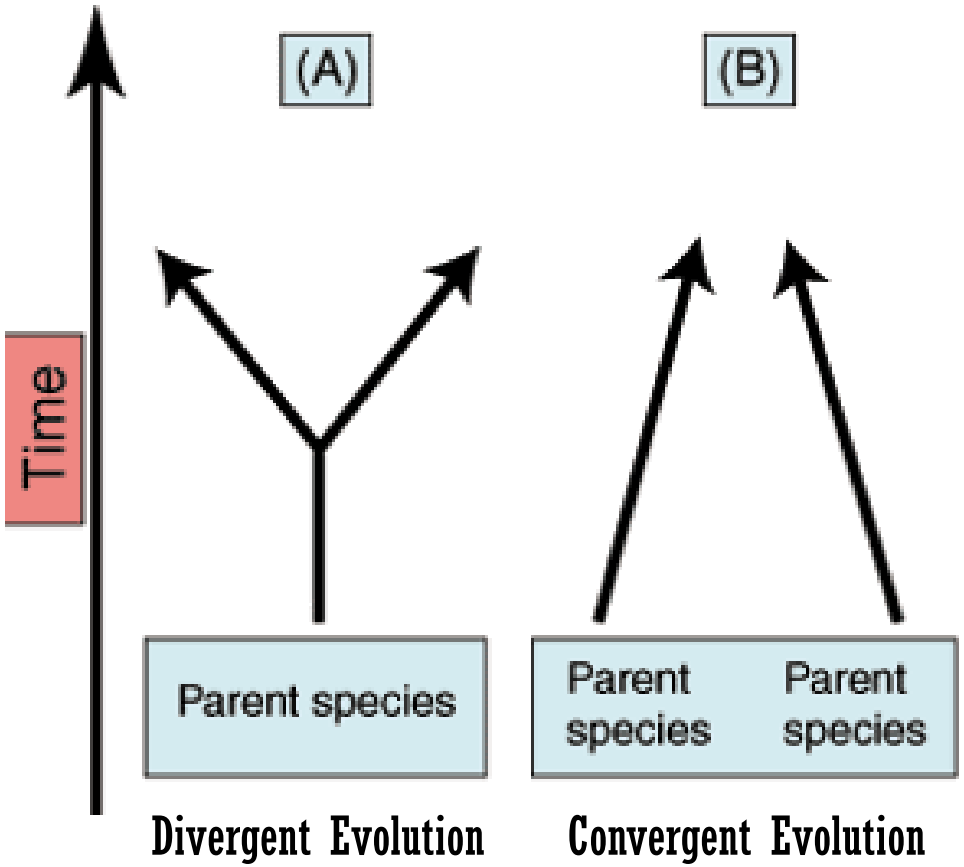

Gradualism
Punctuated Equilibrium
Time (million years)
Speciation
Gradual morphological change
Rapid morphological change during speciation
Little morphological change
Morphological Change
Morphological Change


Time
Morphological change
Morphological change
(a) Gradualism model
(b) Punctuated equilibrium model

PATTERNS OF EVOLUTION

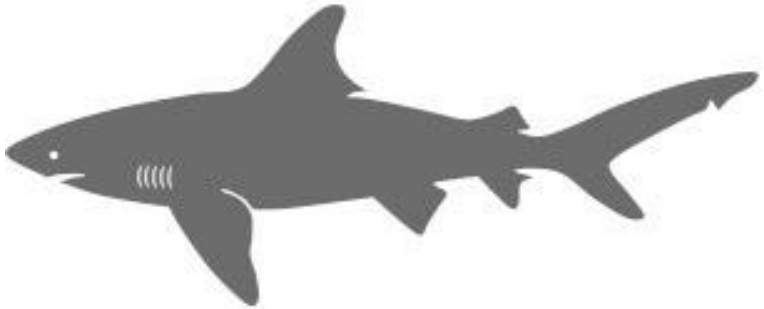
- Divergent evolution: Two or more related populations/species become different (Example: Darwin's finches)
- Convergent evolution: Organisms with different ancestors become very similar due to environmental factors (Example: Sharks and dolphins)
- Coevolution: Change of two or more species in response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

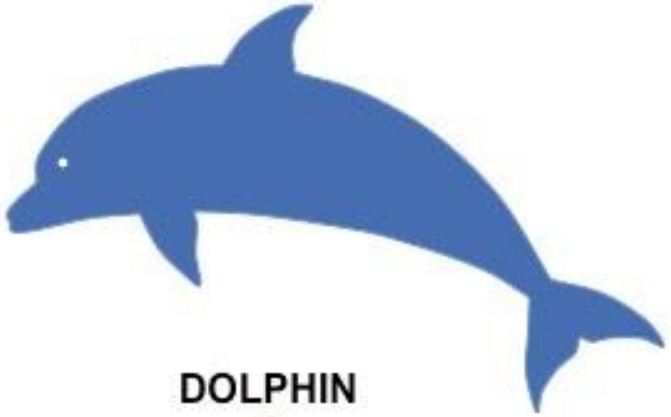
DIVERGENT AND CONVERGENT EVOLUTION



CONVERGENT EVOLUTION

Streamlined Shape due to Aquatic Environment (Shared Selection Pressure)





SHARK

DOLPHIN

PUMA

CHONDRICHTHYES

- Cartilaginous Skeleton
- Gills
- Scale Denticles in Skin

MAMMALIA

- Bony skeleton
- Lungs
- Mammary Glands

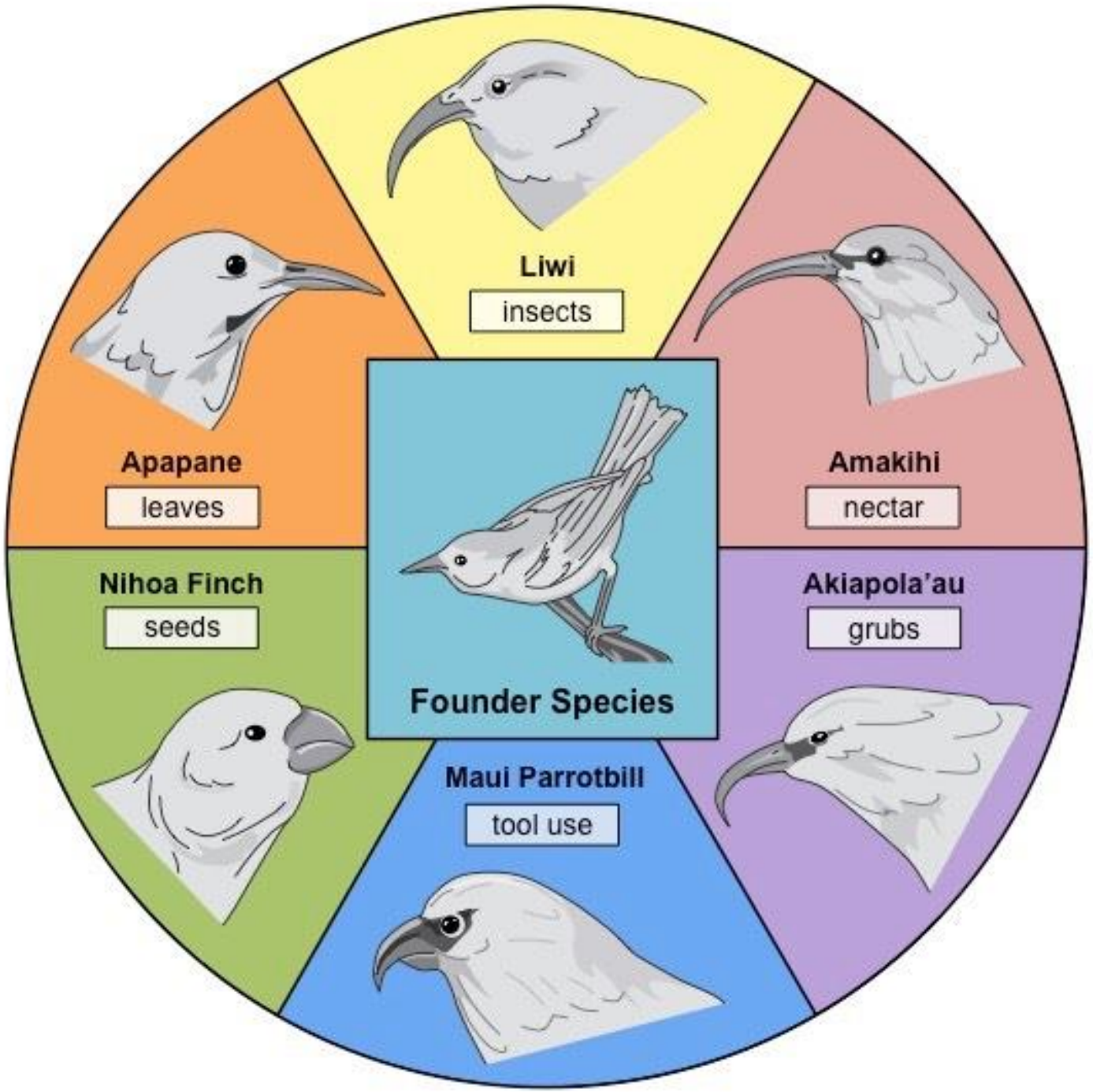
VERTEBRATA

- Vertebrae
- Cranium
- Tri-Partite brain

DIVERGENT EVOLUTION

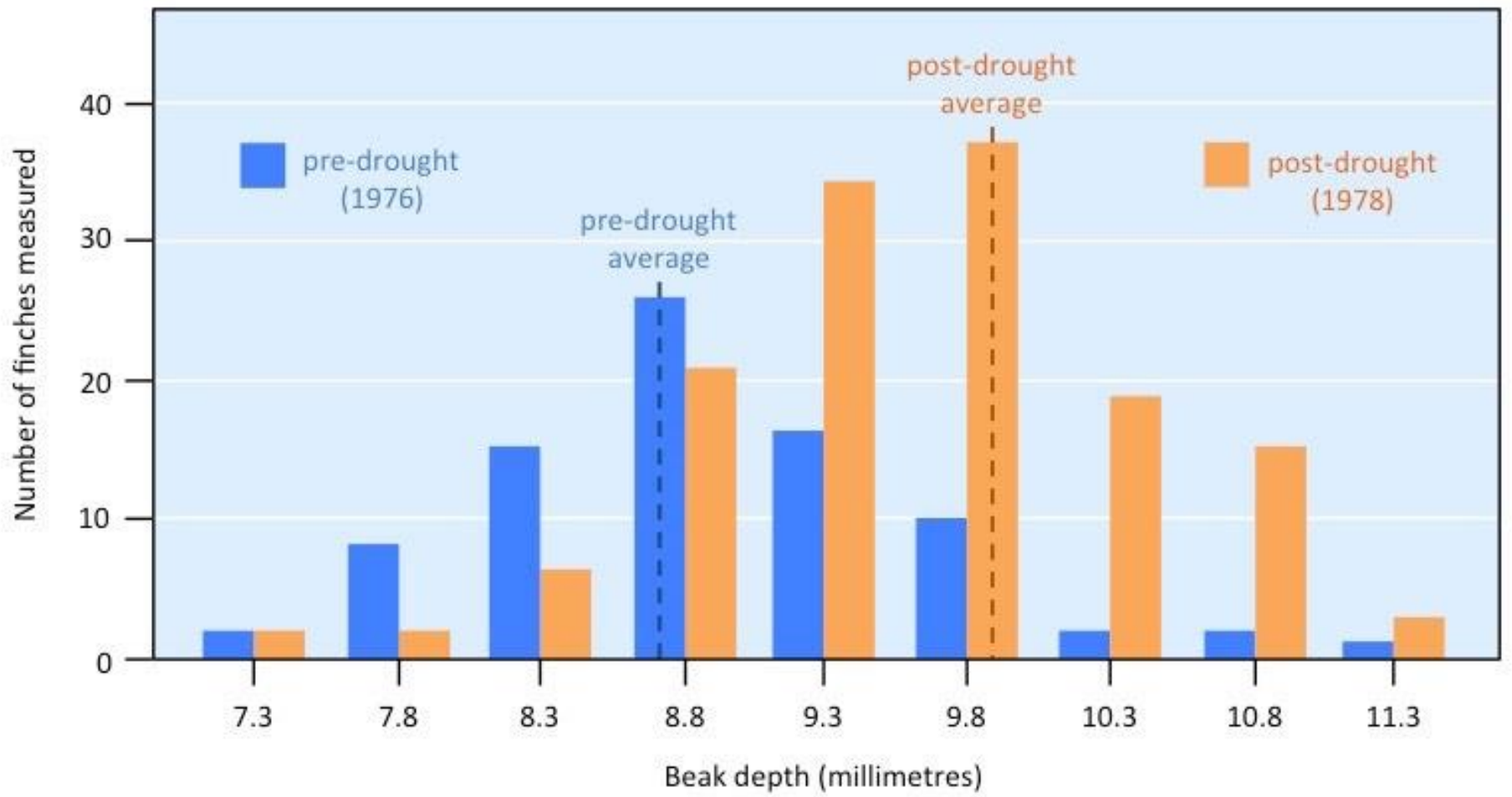
Branching of Vertebrata into Mammalia and Chondrichthyes

COEVOLUTION



ADAPTIVE RADIATION

Hypothesis: Dry conditions produce larger seeds and may affect beak size in finches due to natural selection



Looking at our data, what can we conclude about dry conditions affect on beak size?

CREATE A GRAPHIC ORGANIZER

Create a graphic organizer that shows:

- The three different types of natural selection
- The two models for speciation
- Divergent evolution vs. convergent evolution

MECHANISMS OF VARIATION

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

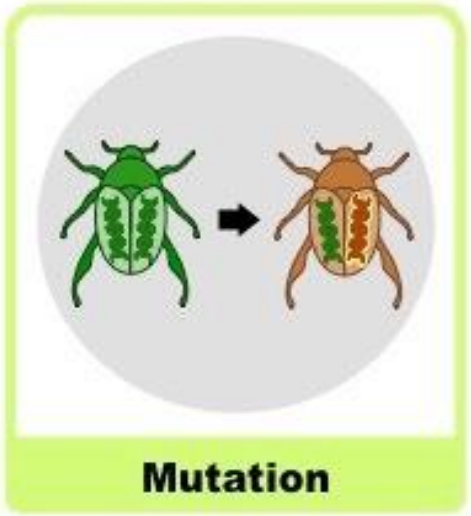
- Mutation: A change in the genetic composition of an organism due to alterations in DNA base sequence. It can lead to a new trait that may be advantageous to have.
- Sexual reproduction (nonrandom mating): Introduce new gene combinations in offspring via random mating and meiotic divisions
- Gene flow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

MECHANISMS OF CHANGE

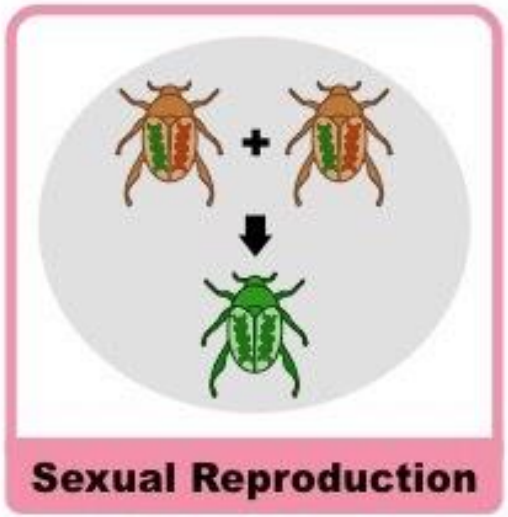
There are two main mechanisms for change which will reduce biodiversity within a population.

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

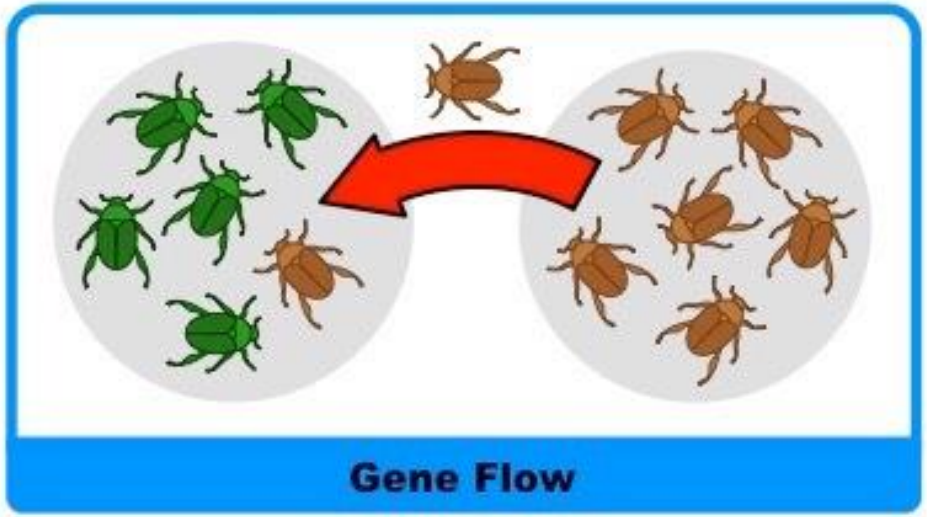
Mechanisms of Variation:



Mutation

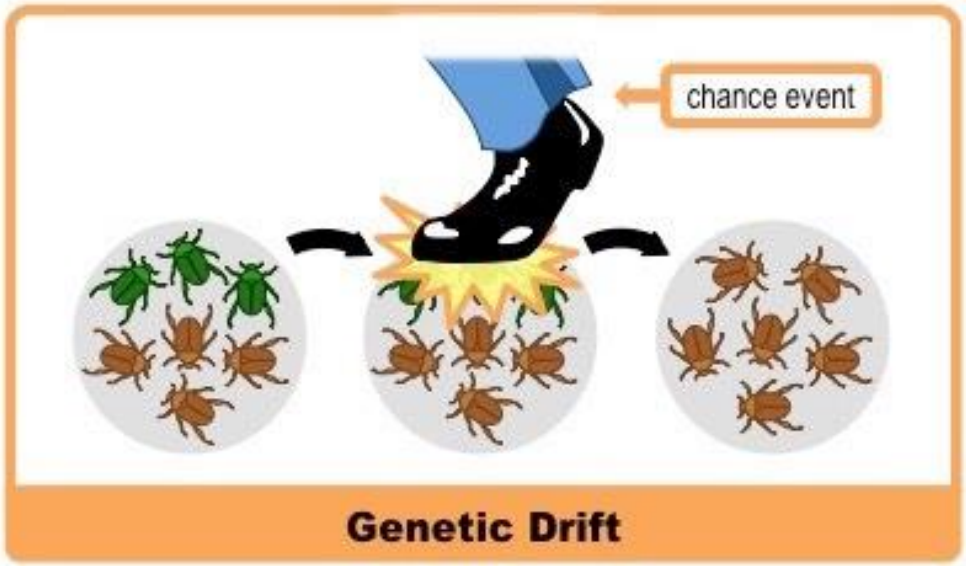


Sexual Reproduction

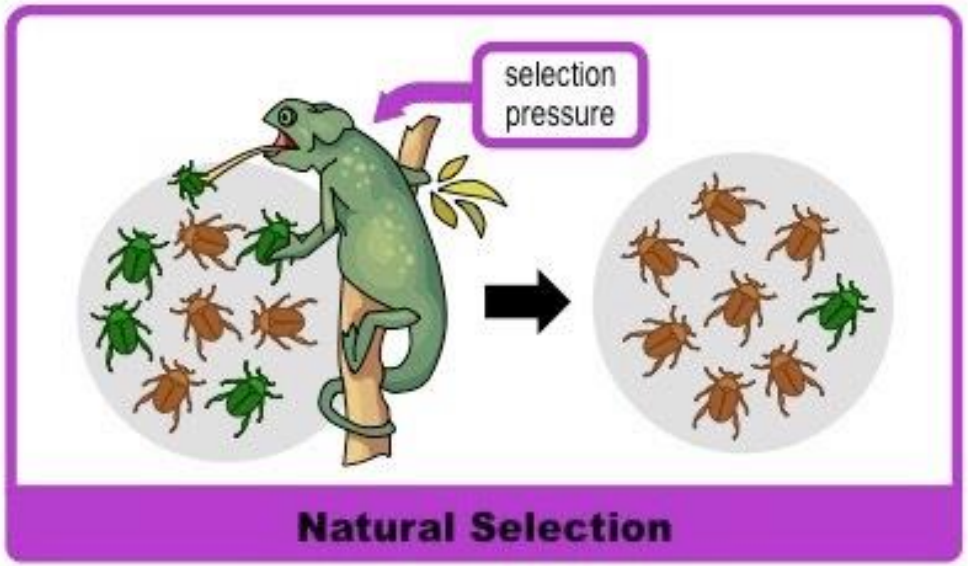


Gene Flow

Mechanisms of Change:



Genetic Drift



Natural Selection

SPECIATION

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

VARIATIONS VS. ADAPTATIONS

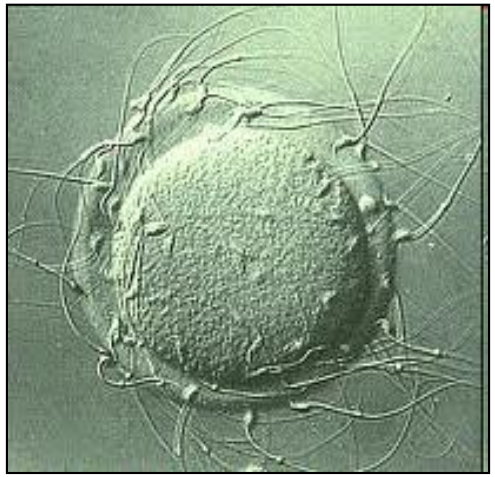
Variations

Differences that exist within a population that may have no effect on fitness

Example: Length of your thumbs

Causes for variation:

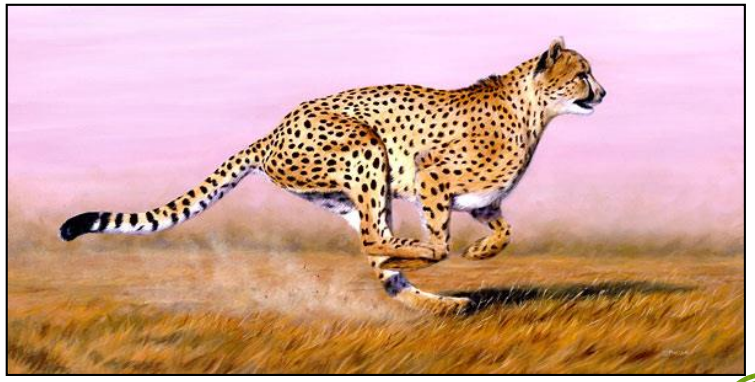
- Mutation (ATC→AGC)
- Events during meiosis (crossing over)
- Random fusion of gametes (which sperm fertilizes which egg)



Adaptations

A variation that all members of a population have inherited because that trait improves fitness

Example: Opposable thumbs



TOPIC 2 LEARNING TARGETS

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