Biodiversity & Evolution

Life Science Explorations: Biology for Diverse Learners

Student Expectations

- **Identify** evidence of common ancestry from the fossil record, biogeography, and homologies (anatomical, molecular, developmental).
- **Describe** different rates of evolutionary change, such as gradualism, abrupt appearance, and stasis.
- **Explain** how natural selection affects populations rather than individuals.
- **List** the key elements of natural selection: inherited variation, overproduction of offspring, competition for resources, and differential reproductive success.
- **Recognize** how natural selection can lead to the formation of new species (speciation).
- **Define** evolutionary mechanisms beyond natural selection, including genetic drift, gene flow, mutation, and genetic recombination.
- **Summarize** the process of evolution, including factors like population growth potential, genetic variation, competition, and survival of the fittest.
- **Identify** the impacts of changing environmental conditions on species, such as increases in population, speciation, and extinction.

The Father of Evolutionary Thought

I. Charles Darwin and the Origin of Species

B. Who Was Charles Darwin?

- A **naturalist** and **biologist** who developed the theory of evolution by natural selection.
- Published *"On the **Origin of Species**"* in 1859, explaining how species change over time.

C. The Journey on the HMS Beagle

- Darwin traveled around the world from 1831–1836 on the **HMS Beagle**.
- Visited places like the **Galápagos** Islands, South America, and Australia.
- Observed and collected plants, animals, and fossils.

Key Discoveries

A. Key Discoveries

- **Adaptations:** Traits that help organisms survive in their environment.
    - *Finches on the Galápagos Islands: Beak shapes varied depending on the type of food available.*
    - *Tortoises: Shell shapes were different based on the island's environment.*
- **Fossil Evidence:** Fossils of extinct animals resembled living species.

B. Early Theories

- **Common Descent:** All species share a **common ancestor**.
- **Natural Selection:** Organisms with traits that help them **survive** **reproduce** more, passing those traits to their **offspring**.

Charles Darwin - A Summary

1. What inspired Charles Darwin to study plants and animals in new places?
2. How did Darwin use his observations of the finches to explain his ideas about nature?
3. Why do you think the Galápagos Islands were important for Darwin's discoveries?
4. What does "natural selection" mean, and how does it help animals survive?
5. If you could ask Darwin one question about his journey, what would it be?

Turn and Talk...

Theories on the Origin of Life

A. Abiogenesis (Origins of Life)

- Life arose from non-living matter over 3.5 billion years ago.
- Miller-Urey Experiment (1953): Simulated early Earth conditions and produced amino acids, key building blocks of life.

B. Endosymbiotic Theory

- Explains how complex cells (**eukaryotes**) evolved from simple cells (**prokaryotes**).
- **Key Idea:** Larger cells engulfed smaller ones, which became **organelles** like **mitochondria** and **chloroplasts**.
- **Evidence**:
    - Mitochondria and chloroplasts have their own **DNA**, similar to **bacteria**.
    - They reproduce **independently** within cells.

Endosymbiosis- A Summary

1. **What is the endosymbiotic theory, and how does it explain where mitochondria and chloroplasts came from?**
2. **Why do scientists think mitochondria and chloroplasts were once free-living organisms?**
3. **What evidence supports the idea that mitochondria and chloroplasts were part of a symbiotic relationship?**
4. **How do mitochondria and chloroplasts help cells survive today?**
5. **Why is it important to learn about how cells may have evolved in the past?**

Turn and Talk...

Evidence of Evolution

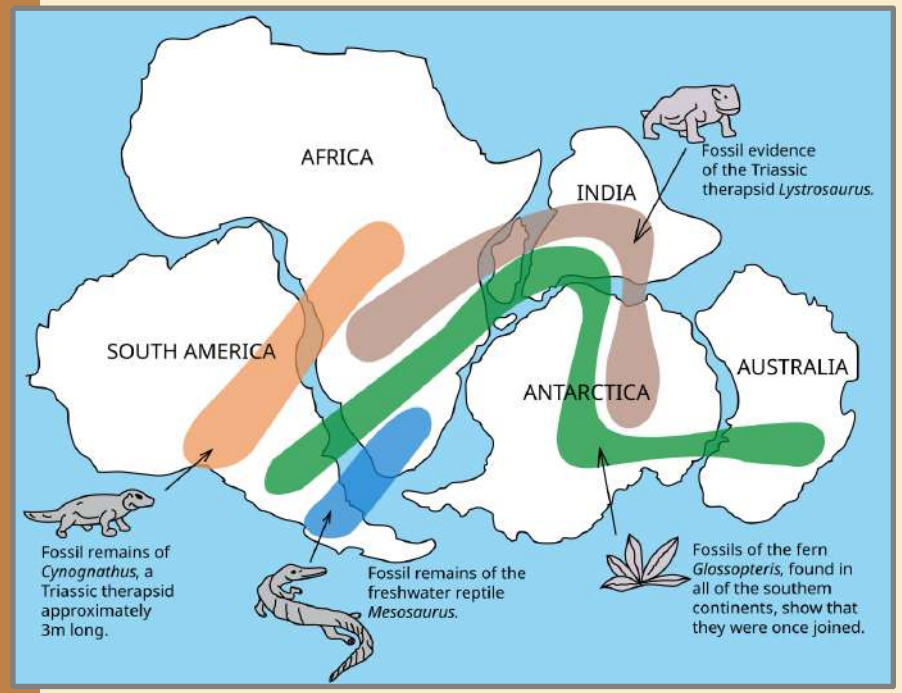
A. Fossil Record

- **Fossils show how species have changed over time.**
  - **Fossils** in older rocks look very different from modern species.
  - **Intermediate Fossils:** Show **links** between major **groups**, like *Tiktaalik*, which connects fish and amphibians.
  - **Law of Superposition**: **Older** fossils are **deeper** in the earth while **younger** fossils appear near the **surface**

Biogeography

B. Biogeography

- **Study of where species live and how they got there.**
  - **Example:** Marsupials like kangaroos in Australia suggest **common ancestry** due to geographic isolation.
  - **Endemic Species:** Found only in **specific** places, like finches on the Galápagos.

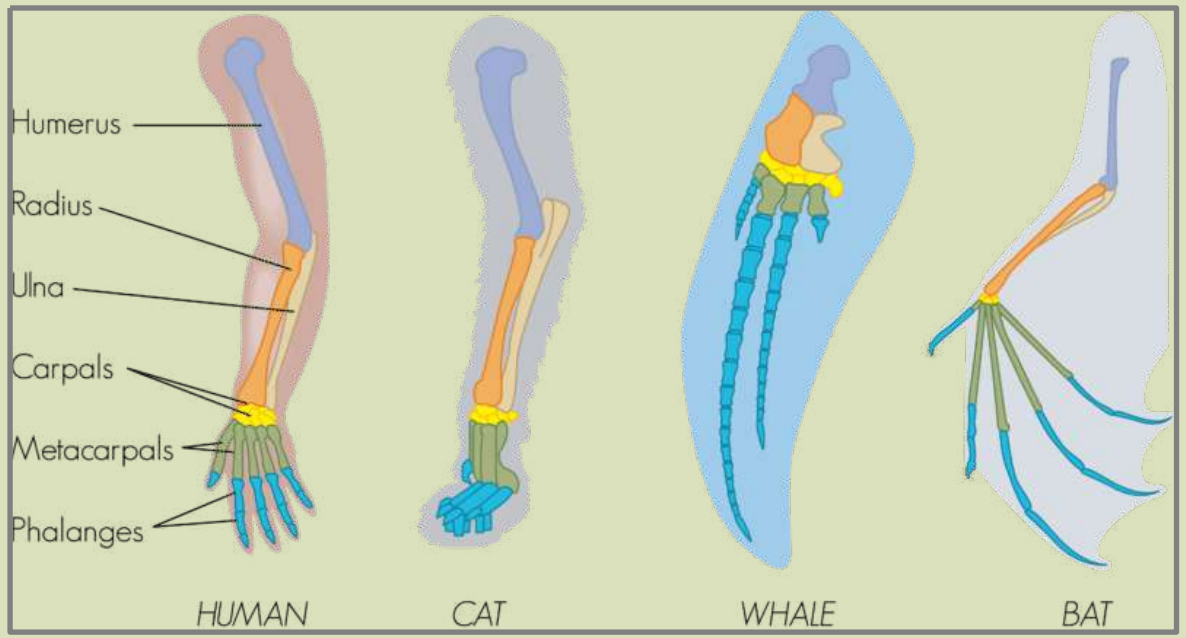


Homologies

C. Homologies

- **Traits shared by species because they came from a common ancestor.**

1. **Anatomical Homologies: Similar structures**, like the bones in a whale's fin and a human hand - **Common Ancestry**
2. **Analogous Structures**: **Different structures**, **similar functions**, like the wings of insects, bats, and birds - **No Commonality**
3. **Vestigial Structures**: **non-use**, what your **ancestors** used - appendix, wisdom teeth



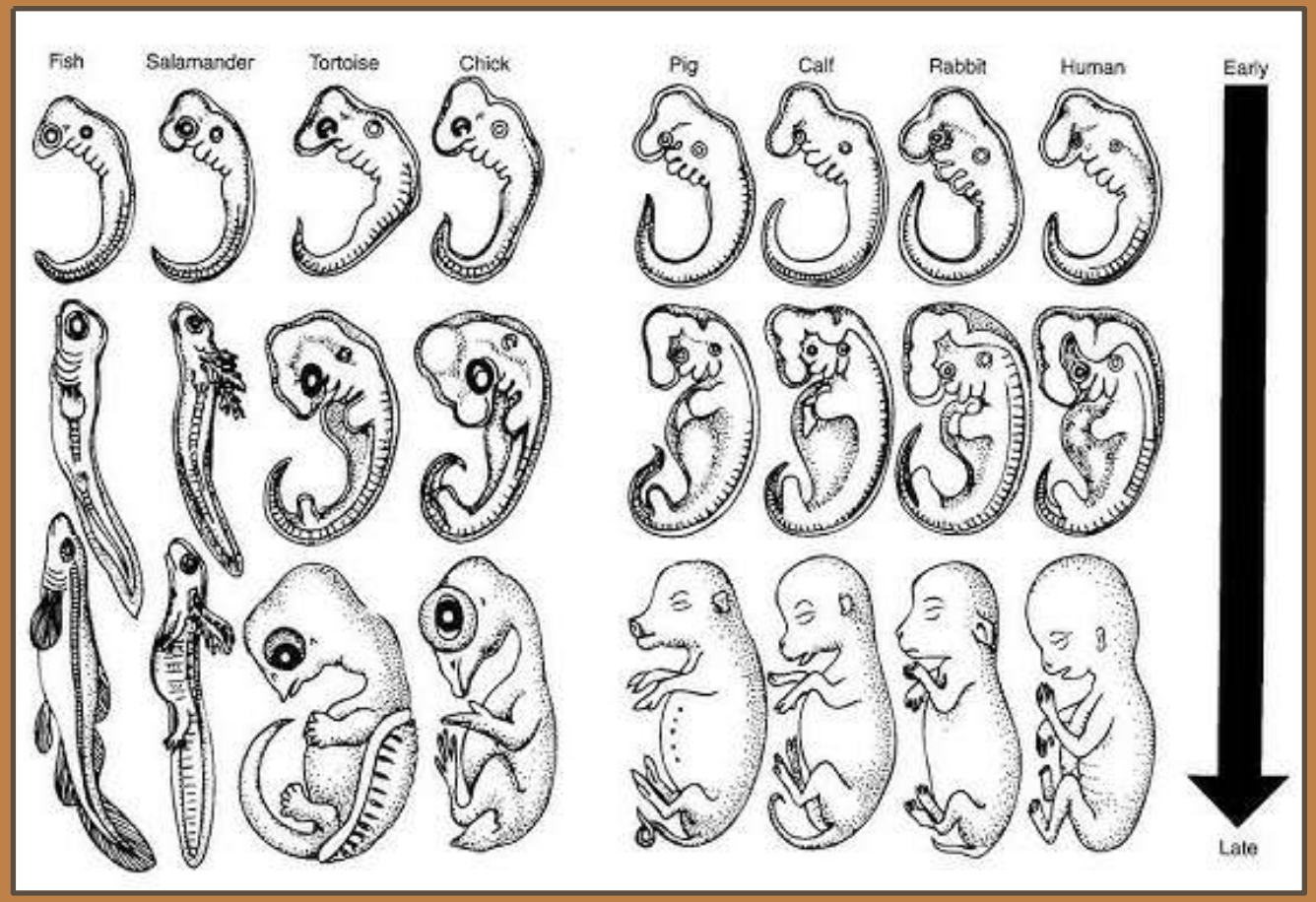
Molecular Homologies

2. **Molecular Homologies:**

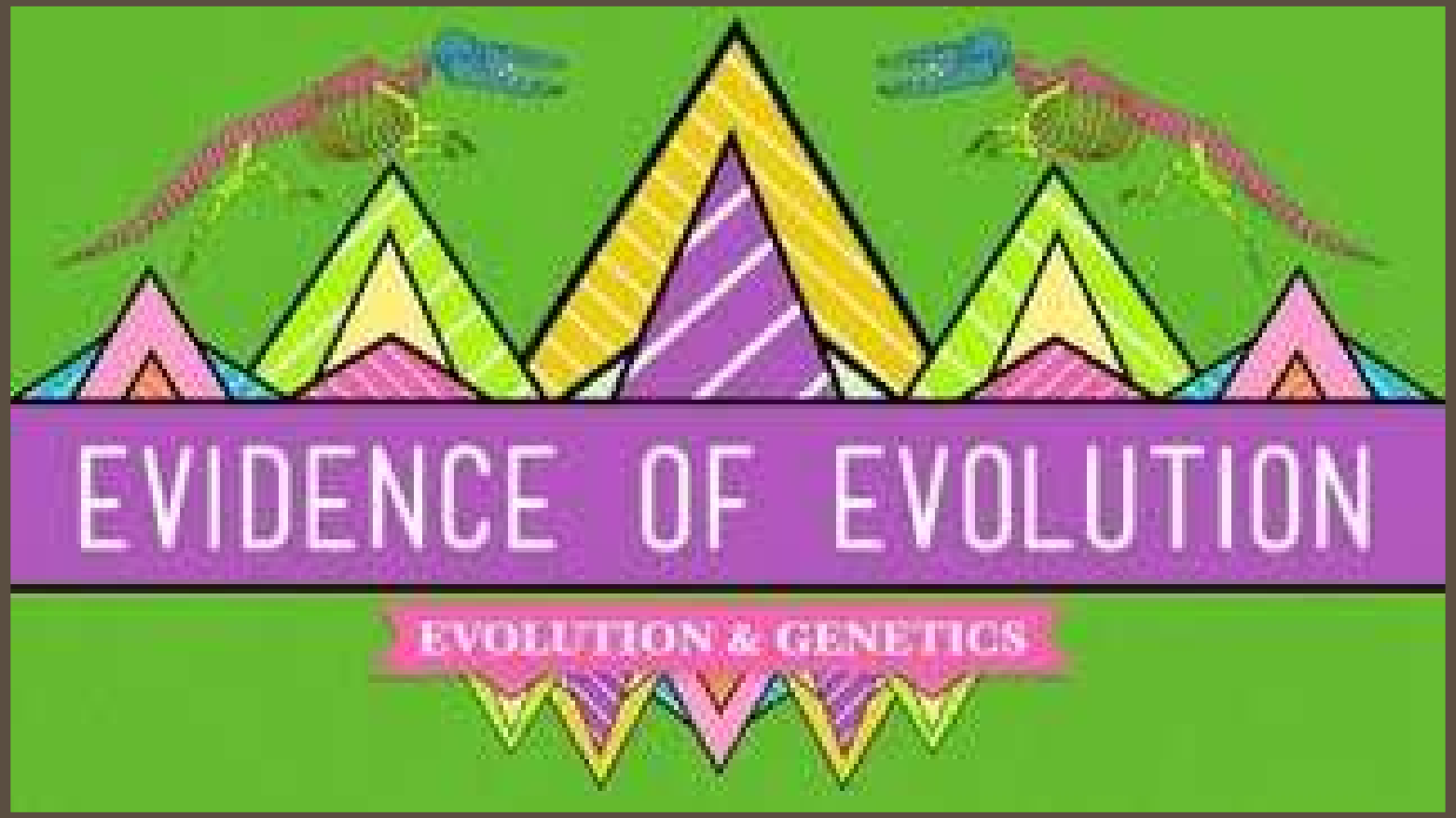
   Similar DNA or **proteins** (e.g., fewer differences in cytochrome c in closely related species).

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

Developmental Homologies



3. **Developmental Homologies: Embryos** of different animals (e.g., humans and chickens) look **similar** during early stages.



Evidences For Evolution - A Summary

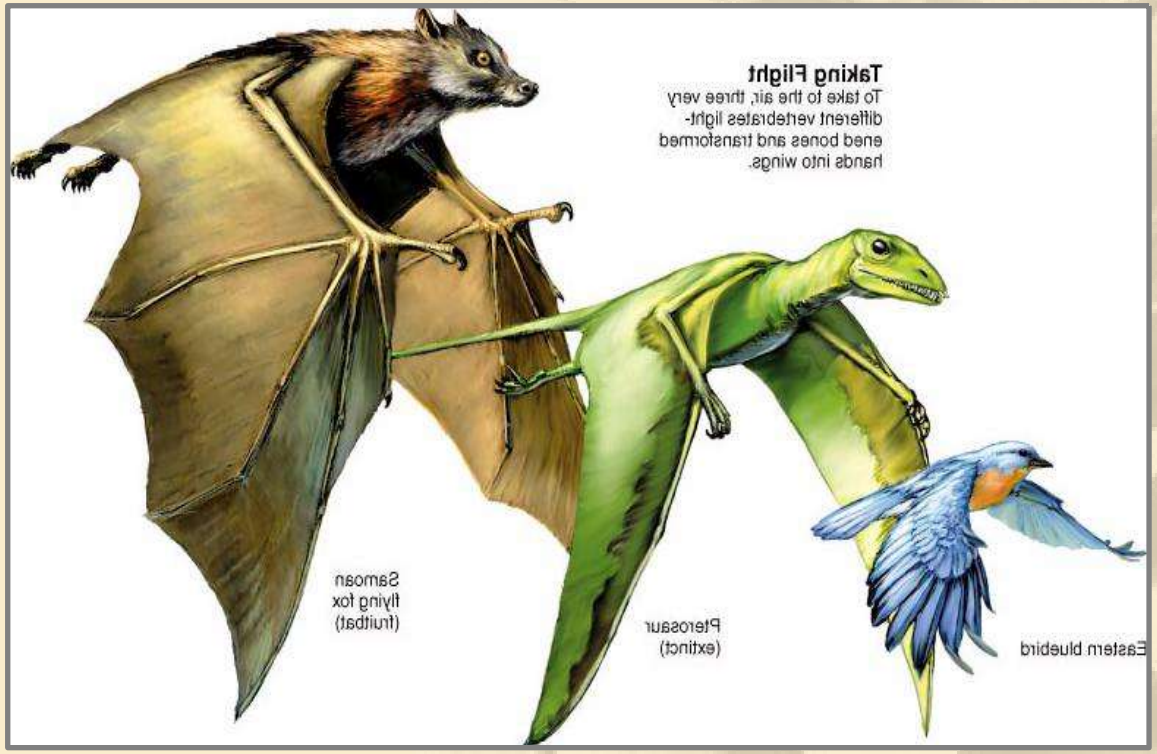
1. What are some examples of evidence scientists use to show that evolution has happened?
2. How do fossils help scientists learn about animals and plants from the past?
3. Why are homologous structures, like similar bones in different animals, important for understanding evolution?
4. What do embryos of different animals tell us about how species are related?
5. How does DNA evidence help prove that different species share a common ancestor?

Turn and Talk...

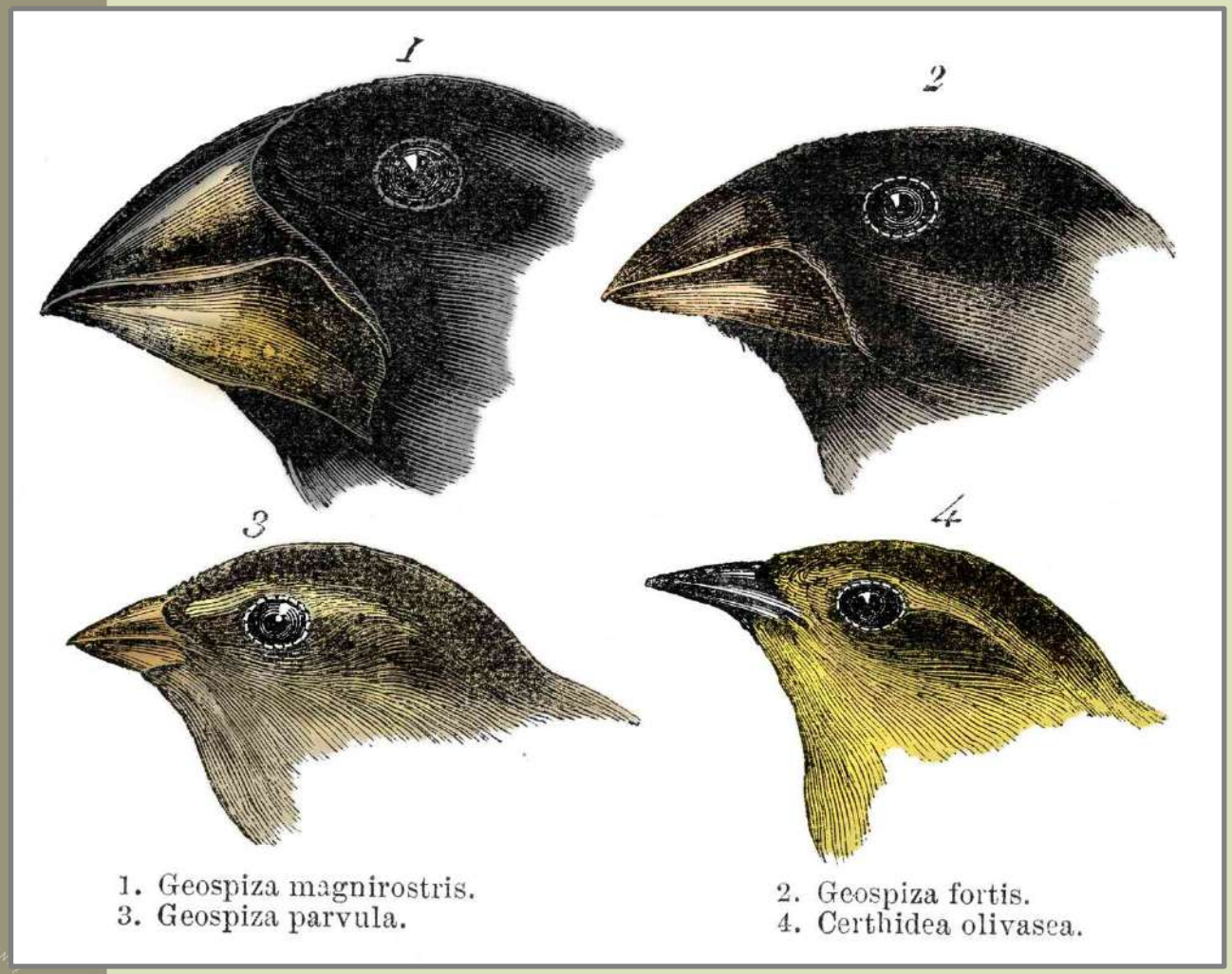
Patterns of Evolution

D. Patterns of Evolution

- **Convergent Evolution:** Unrelated species develop similar traits because they live in similar environments.
    - **Example:** Wings of birds and bats.



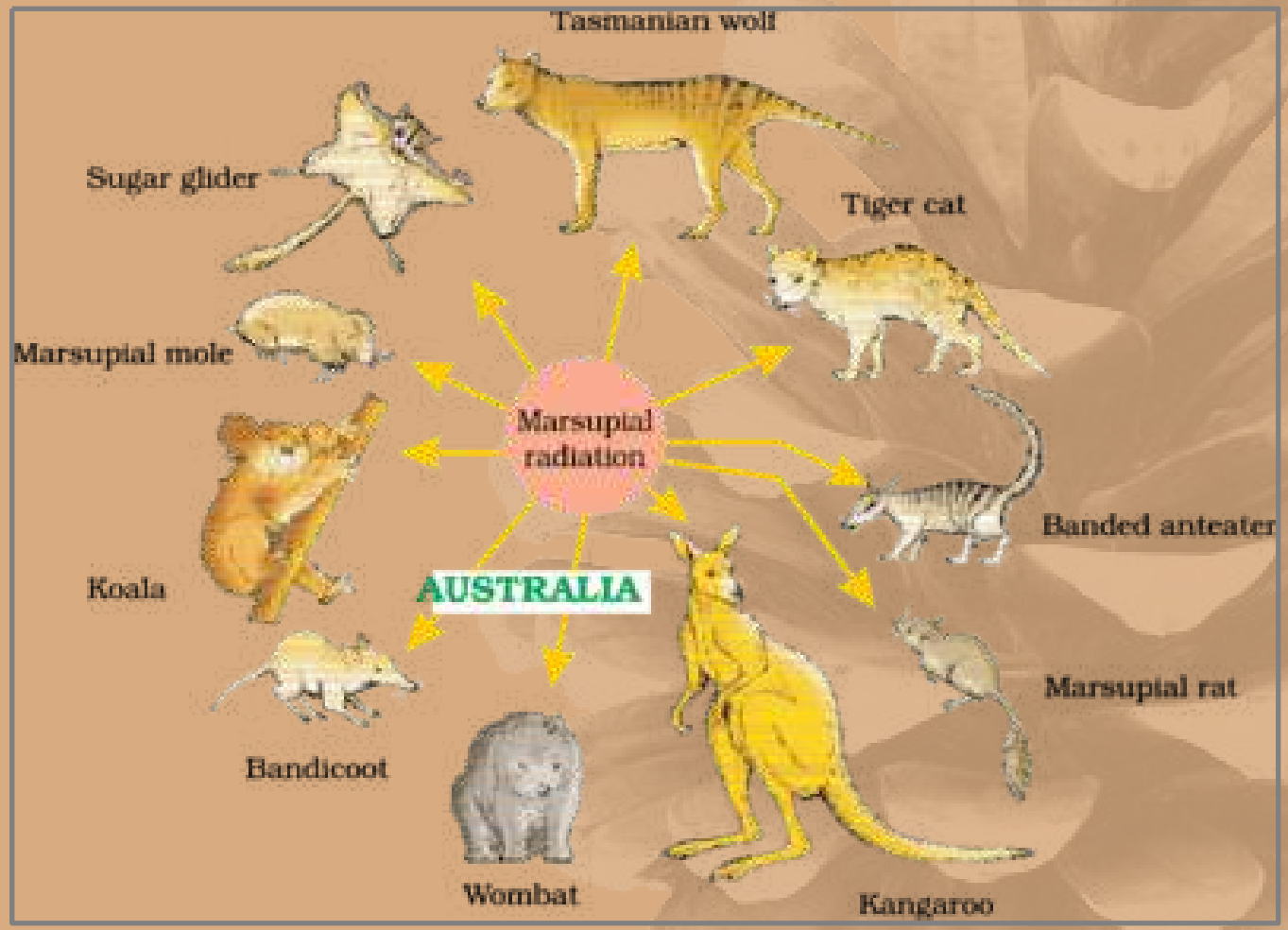
Patterns of Evolution

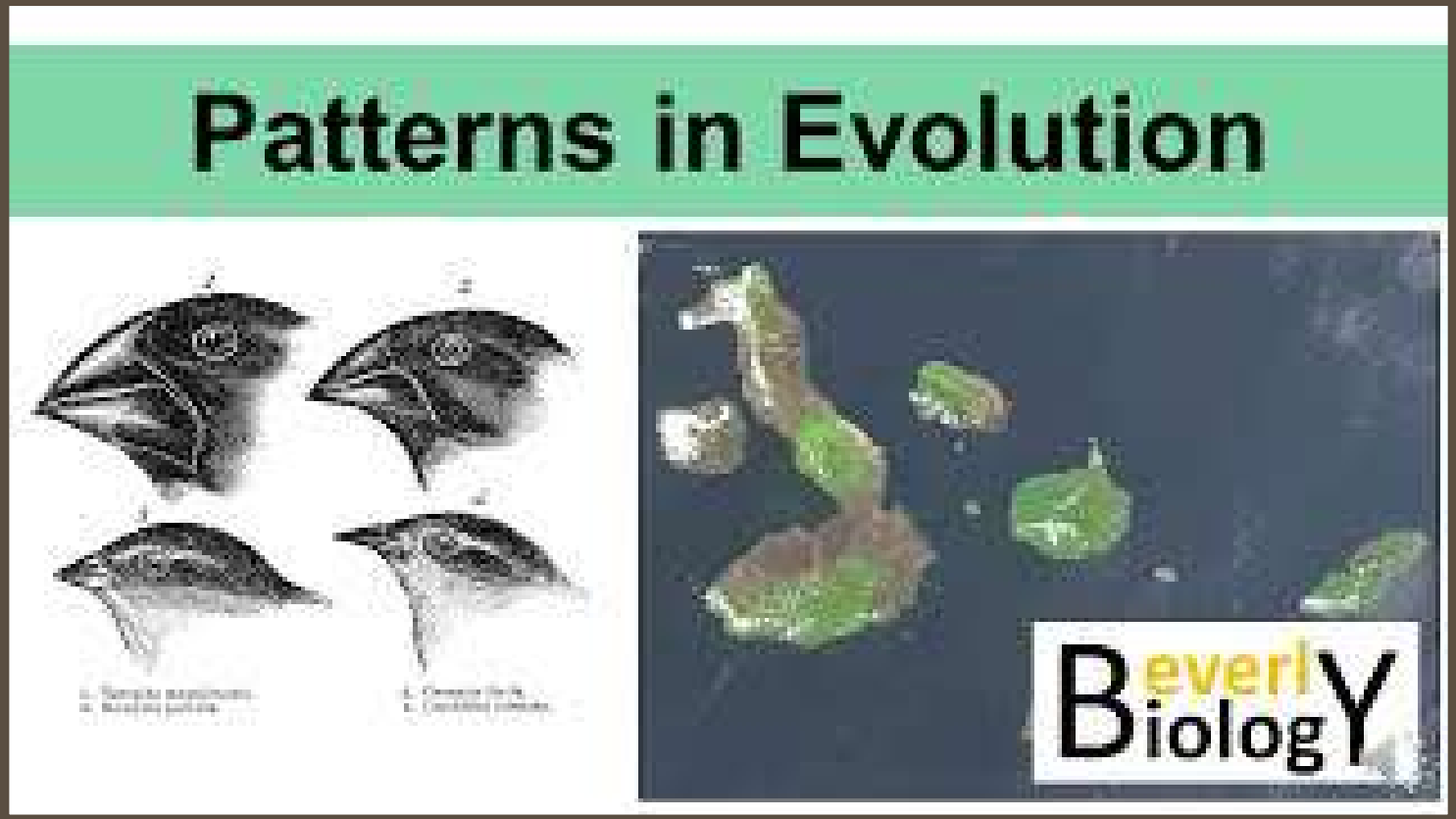


- **Divergent Evolution:** Related species evolve different traits due to different environments.
  - **Example:** Darwin's finches with varied beak shapes.

Patterns of Evolution

- **Adaptive Radiation:** One species evolves into many to fill different roles in an environment.
    - **Example: Australian Marsupials –** Different marsupial species evolved to fill ecological roles similar to placental mammals found elsewhere.



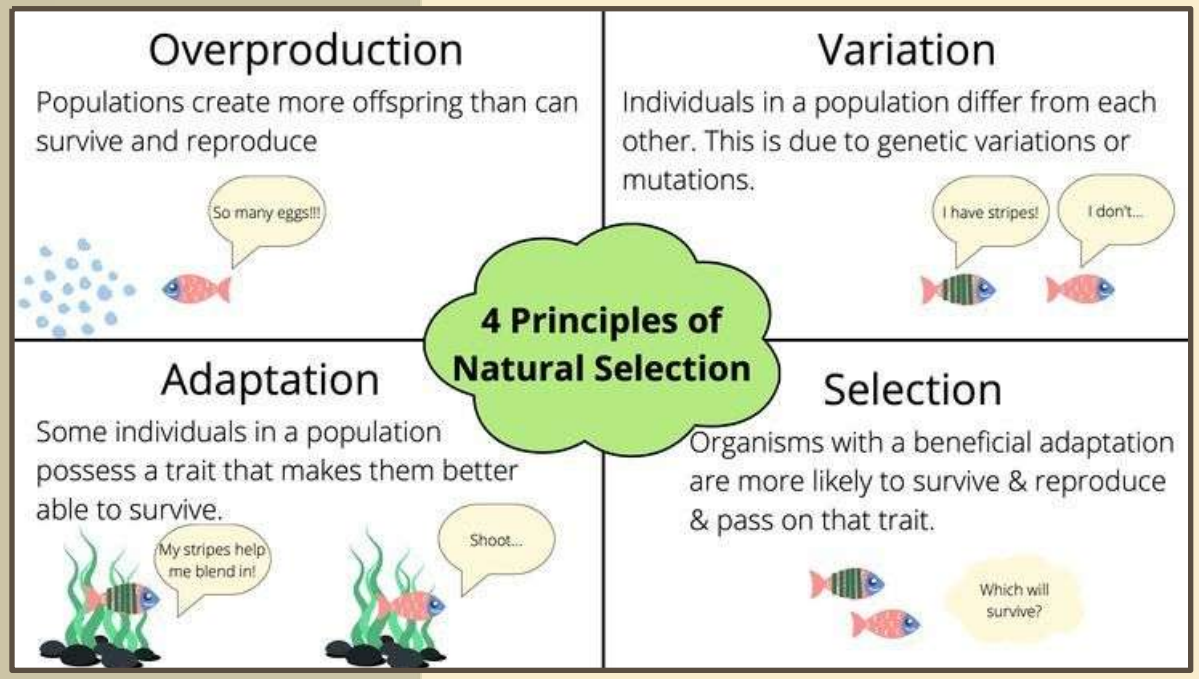


Patterns in Evolution - A Summary

1. What is the difference between divergent and convergent evolution? Can you give an example of each?
2. How does coevolution show how species can depend on each other to survive?
3. Why do you think extinction is a natural part of evolution, and what might cause it to happen faster?
4. What is the difference between gradualism and punctuated equilibrium, and which one do you think explains most changes in nature?
5. Can you think of a real-life example that shows one of the patterns of evolution, like coevolution or convergent evolution?

Turn and Talk...

Natural Selection



IV. Natural Selection

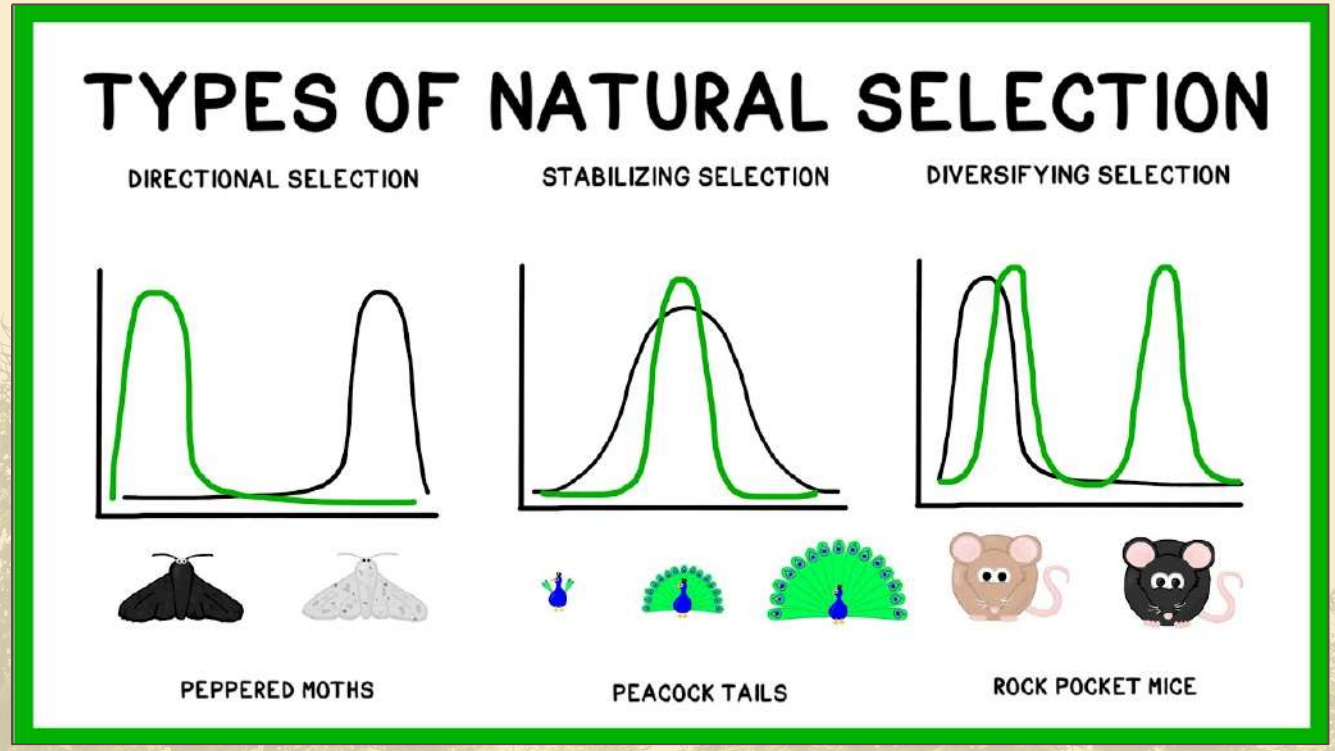
A. Key Concepts

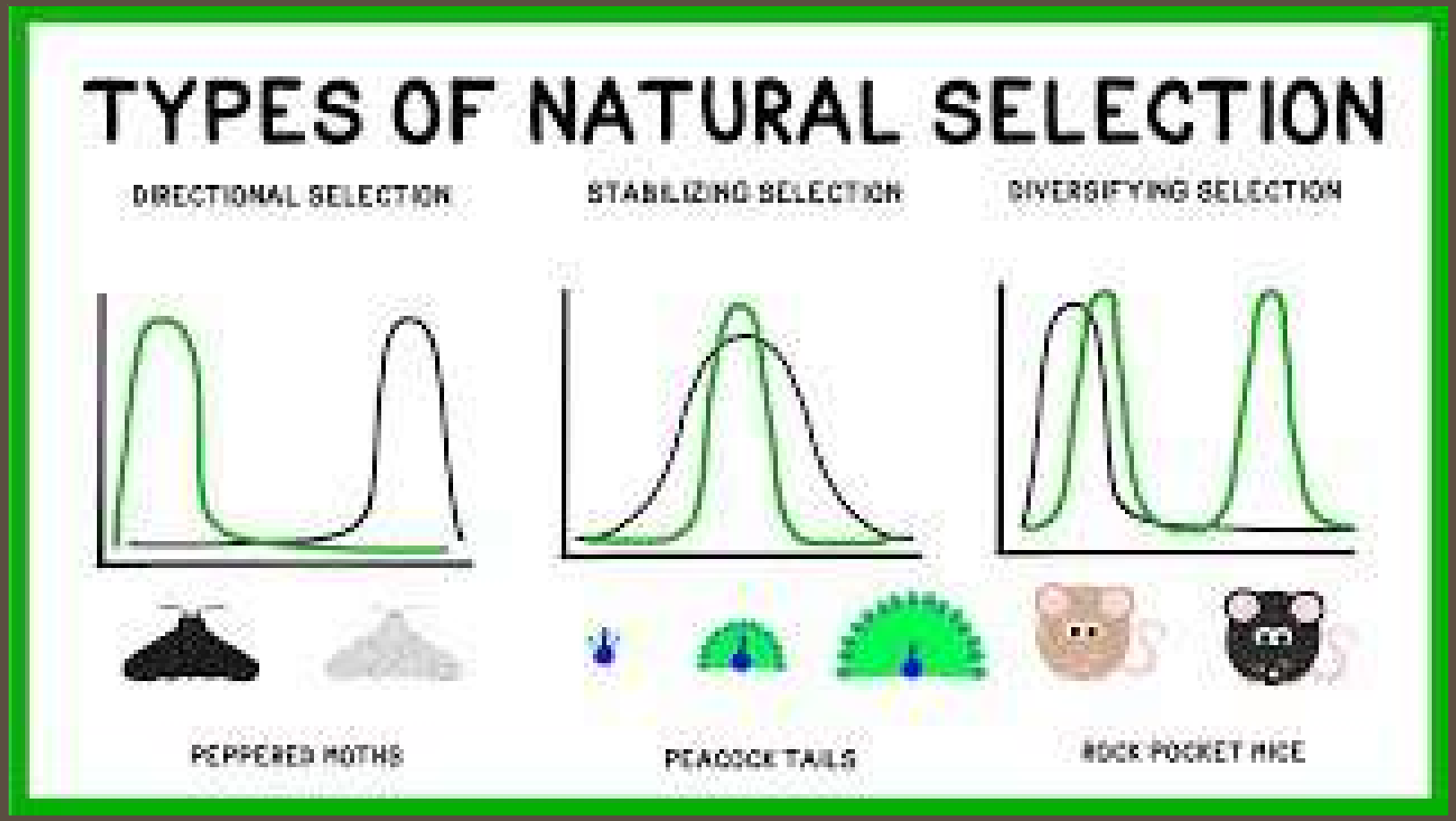
- **Definition: The process where organisms with helpful traits survive and reproduce.**
- **Key Elements:**
  1. **Inherited Variation:** Traits are passed from parents to offspring.
  2. **Overproduction of Offspring:** More offspring are born than can survive.
  3. **Competition for Resources:** Organisms struggle for food, water, and space.
  4. **Differential Reproductive Success:** Organisms with the best traits have more babies.

Selection Types

B. Types of Selection

- **Directional Selection:** Favors **one extreme** trait.
  - **Example:** Giraffes with longer necks.
- **Disruptive Selection:** Favors **both extreme** traits but not the average.
  - **Example:** Birds with very small or very large beaks.
- **Stabilizing Selection:** Favors **average** traits and removes extremes.
  - **Example:** Human baby birth weights.





Natural Selection - A Summary

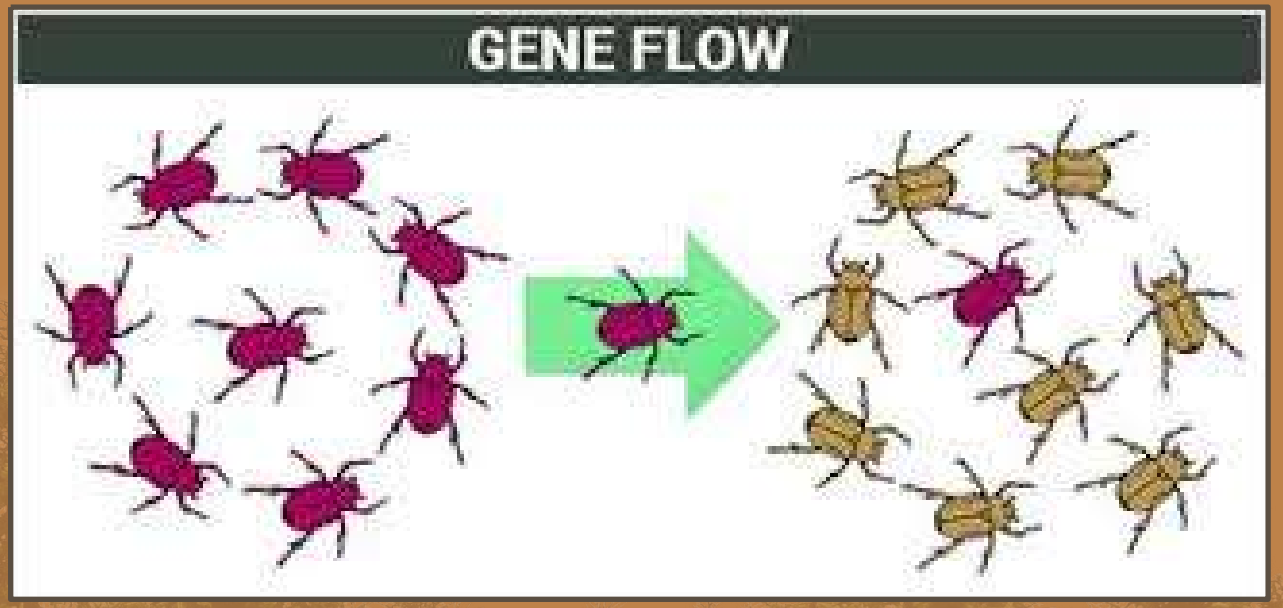
1. What are the four main parts of natural selection, and why are they important for evolution?
2. How do inherited traits help some animals survive better than others?
3. Why is it important for a species to have variation in its population?
4. What happens over time when a helpful trait becomes more common in a population?
5. Can you think of an example from nature where a species has changed because of natural selection?

Turn and Talk...

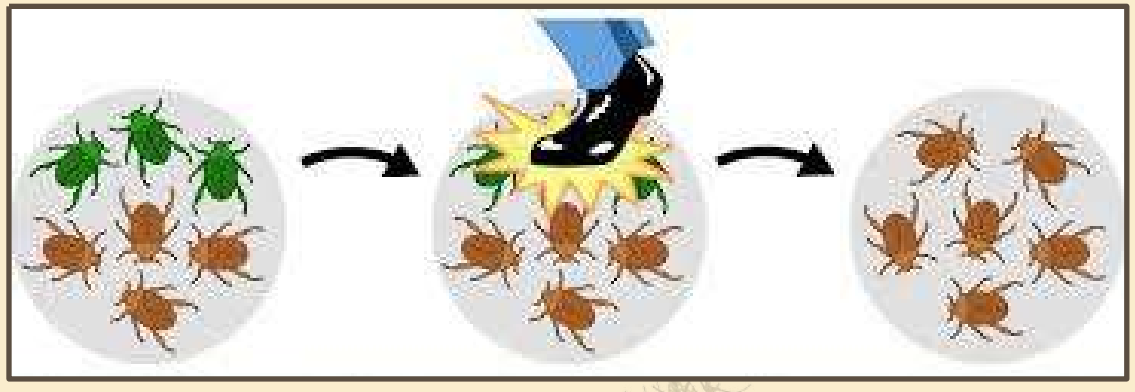
Mechanisms That Drive Evolution

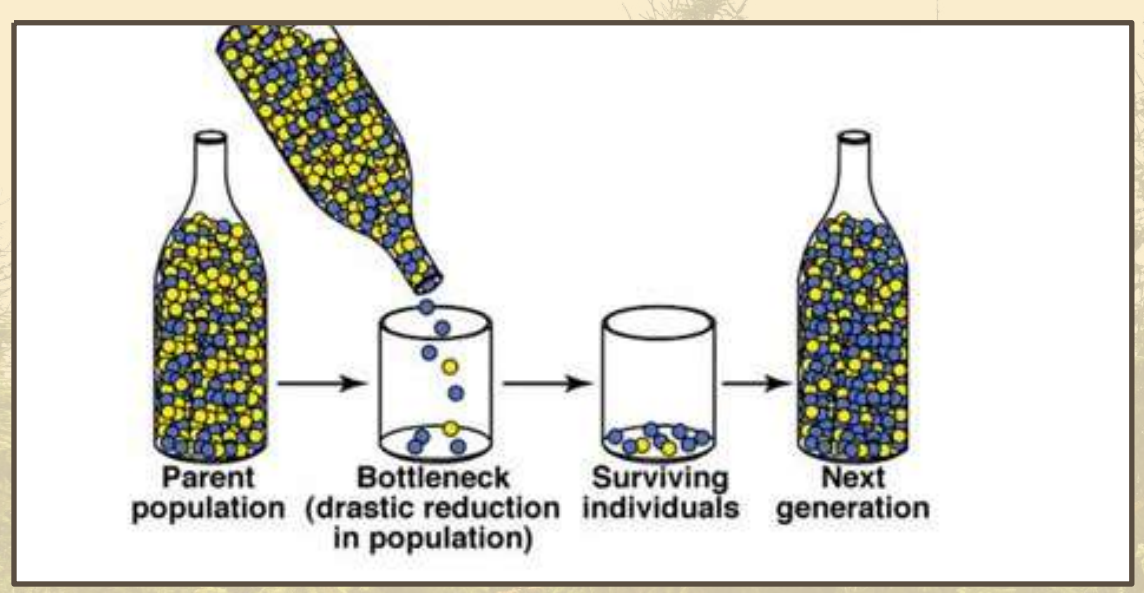
A. Gene Flow

- **Movement** of **genes** between populations (e.g., animals migrating and breeding in new areas).



Mechanisms That Drive Evolution





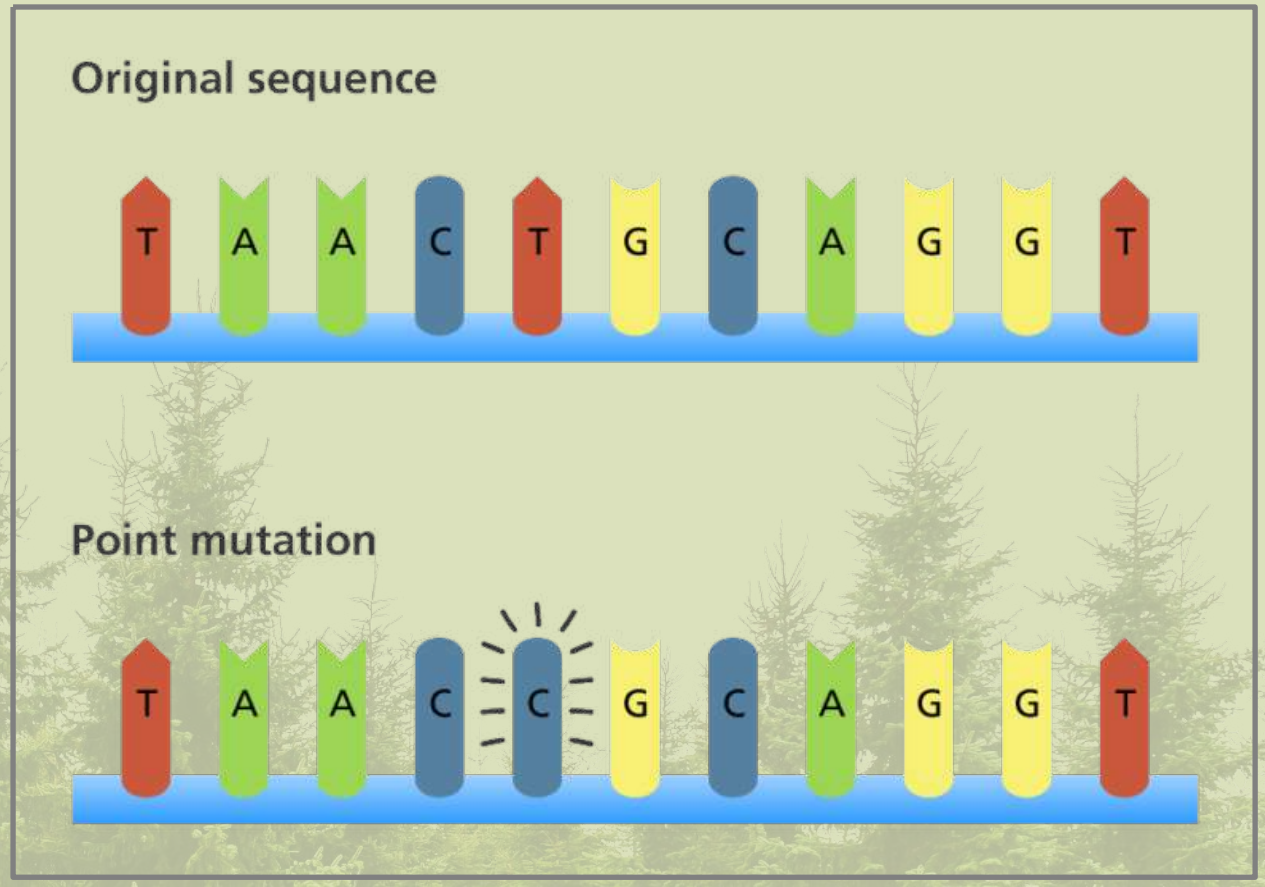
B. Genetic Drift

- **Random changes** in traits, especially in small populations. The **disappearance** of **genes** from a population
  - **Bottleneck Effect:** Population **shrinks**, **losing** genetic **diversity** (e.g., cheetahs)
  - **Founder Effect:** A small group starts a new population with limited traits.

Mechanisms That Drive Evolution

C. Mutations

- Changes in DNA introduce new traits.
    - **Example:** A **mutation** in fur color can help animals blend into their environment.



Mechanisms That Drive Evolution

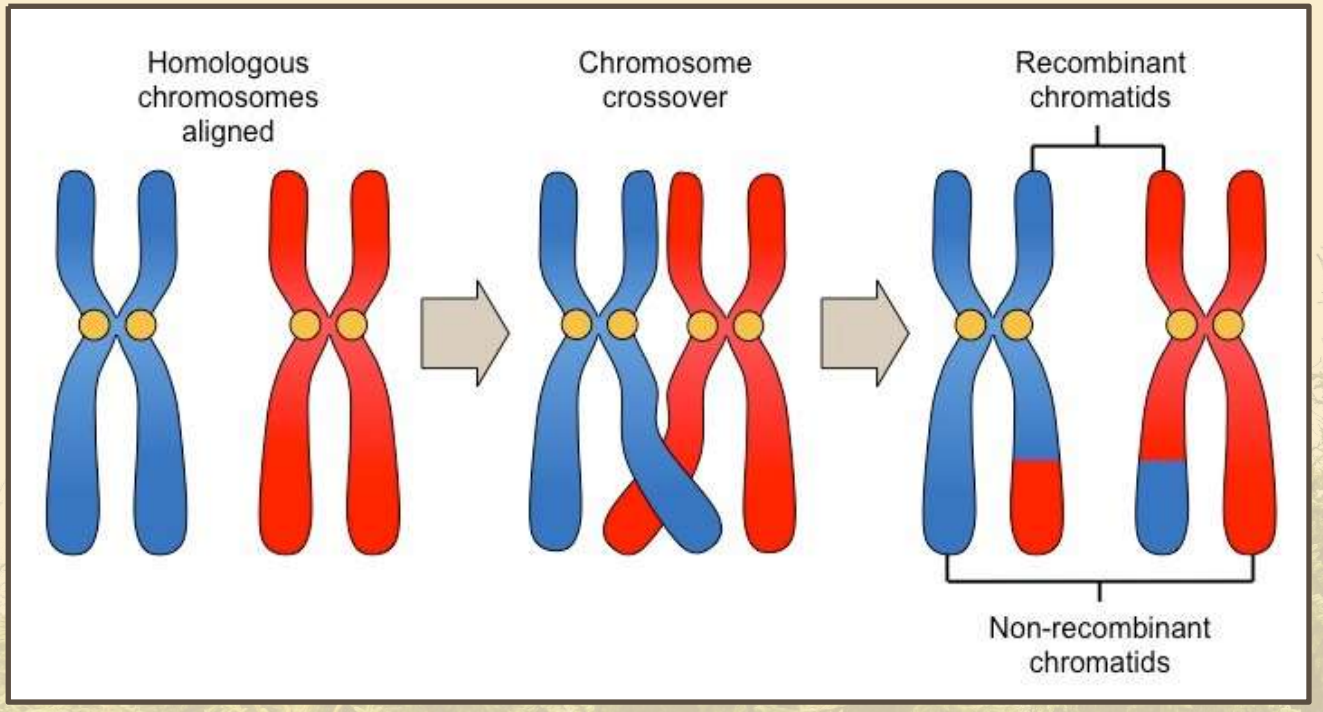
D. Sexual Selection

- A type of natural selection where certain traits increase an individual's chances of attracting a mate and reproducing.
  - Focuses on traits that help with mating success, not just survival.
    - **Two Main Types:**
      - **Intrasexual Selection**
        - Competition within the **same sex** (usually males) for access to mates.
        - **Example**: Male deer fighting with antlers.
      - **Intersexual Selection**
        - **Mate choice** — individuals (usually females) select mates based on traits.
        - **Example**: Female peacocks choosing males with the most colorful tails.

Mechanisms That Drive Evolution

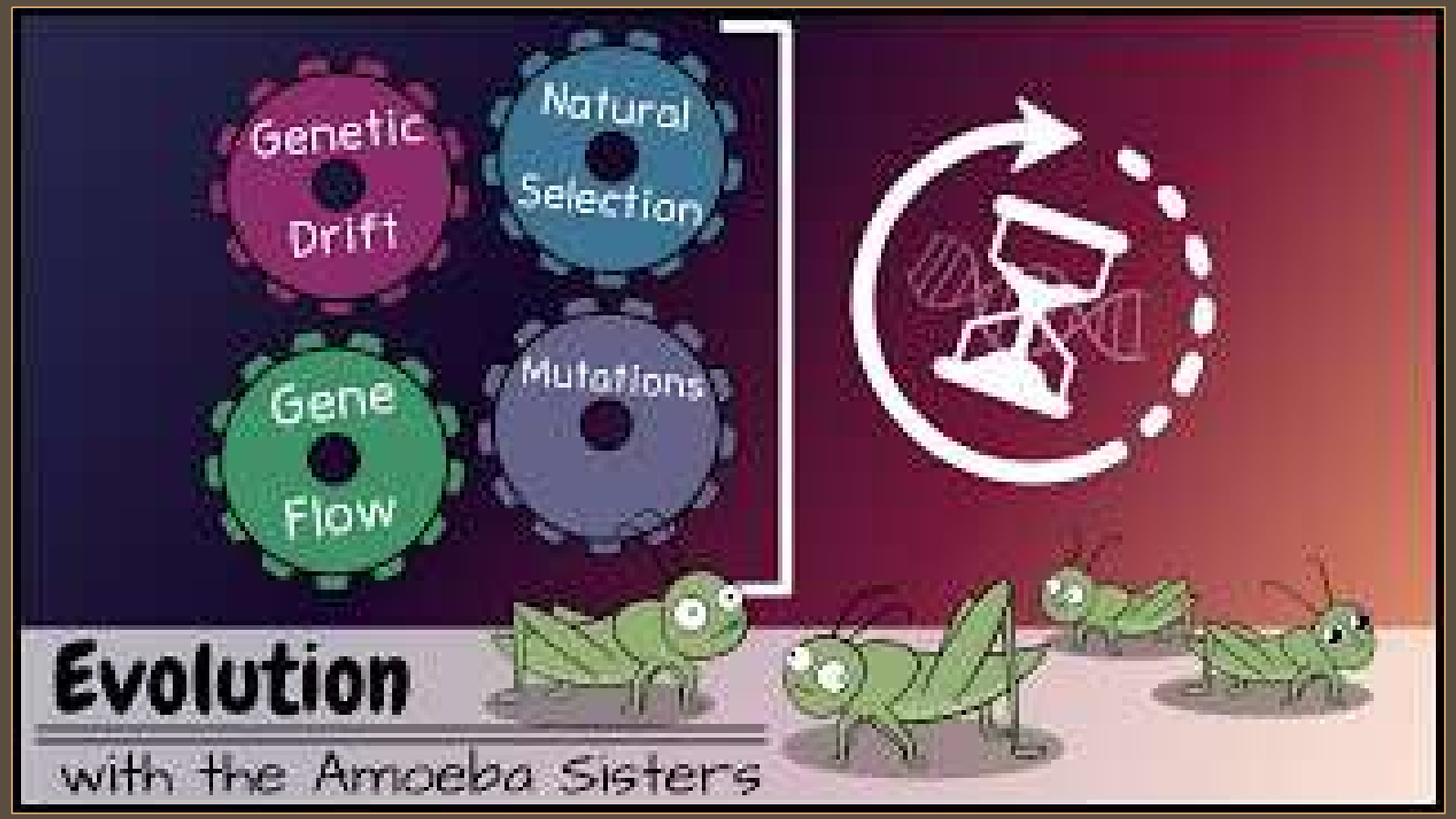
- **Mating Patterns: Random vs. Non-Random Mating**
  - **Random Mating**
    - Mates pair by chance.
    - No preference for specific traits.
    - All individuals have equal chances of reproducing.
    - Example: Wind-pollinated plants.
  - **Non-Random Mating**
    - **Mates** are chosen **based** on **specific** traits.
    - Includes sexual selection and other behaviors.
    - **Leads** to **changes** in **allele frequency** over time (evolution).
    - **Example**: Female birds choosing brighter males.

Mechanisms That Drive Evolution



E. Genetic Recombination

- **Mixing** of **genes** during reproduction creates new trait combinations.
  - **Example**: **Crossing Over** during prophase I in Meiosis



Mechanisms - Natural Selection - A Summary

1. How do mutations create new traits, and why are they important for natural selection?
2. What role does genetic recombination play in making populations more diverse?
3. How can a trait that starts as a random mutation become common in a population?
4. Why is it helpful for populations to have a lot of genetic variation?
5. Can you think of an example where a mutation or recombination might help a species survive in a changing environment?

Turn and Talk...

Speciation

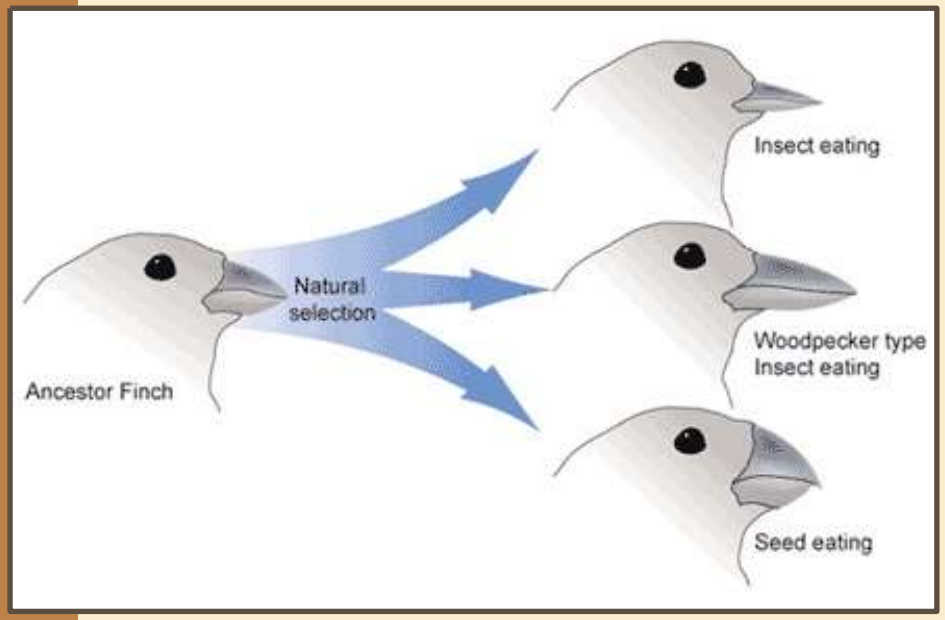
VI. Speciation

A. Definition

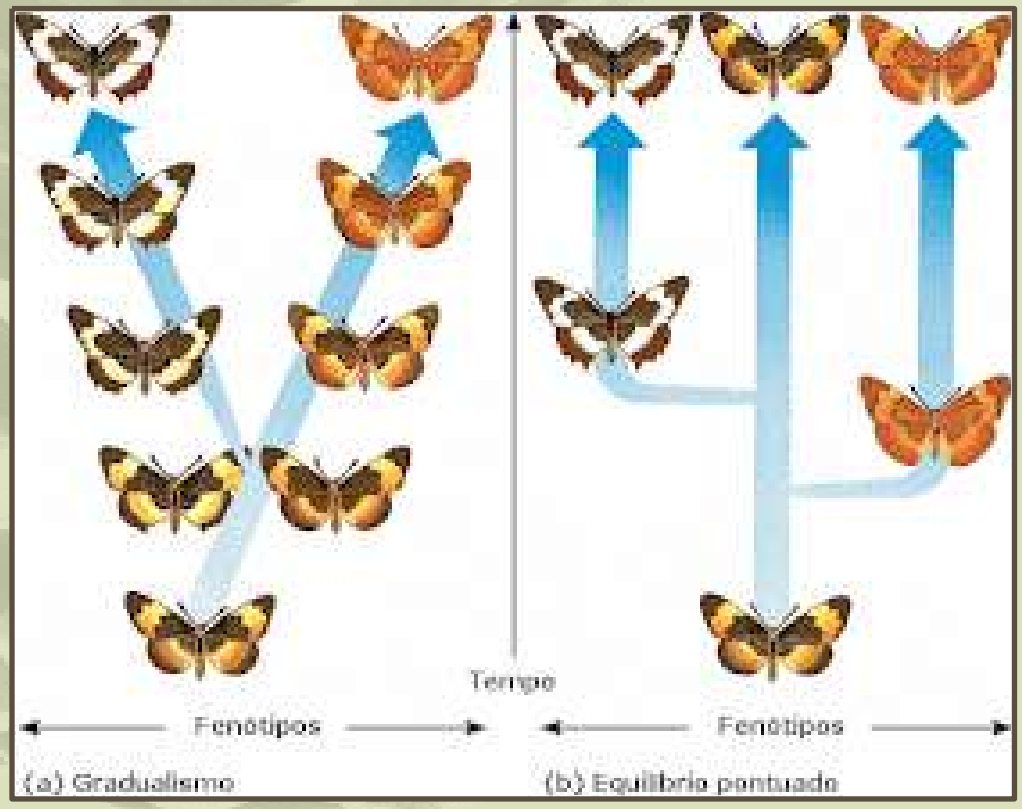
- The **formation** of new **species** when **populations** become **isolated** and stop interbreeding.

B. Causes

- **Geographic Isolation: Physical** barriers, like mountains or rivers.
- **Behavioral Isolation:** Differences in **mating** behaviors.
- **Temporal Isolation:** Reproducing at different **times**.



Rates of Evolution



VII.Rates of Evolution

A. Gradualism

- Evolution happens **slowly** over a long time.
    - Fossil evidence shows continuous, small changes.

B. Punctuated Equilibrium

- Evolution happens in **bursts** with **long periods** of no **change** (stasis).
    - Triggered by sudden environmental changes or mutations.

Evolution Rates - A Summary

1. What is catastrophism, and how does it explain sudden changes in Earth's history?
2. How does gradualism describe the way changes happen over a long period of time?
3. What makes punctuated equilibrium different from gradualism?
4. How might a natural disaster, like a volcanic eruption, fit into the idea of catastrophism?
5. Can you think of an example in nature that could show gradual change and one that might show sudden change?

Turn and Talk...

Cladograms and Phylogenetic Trees

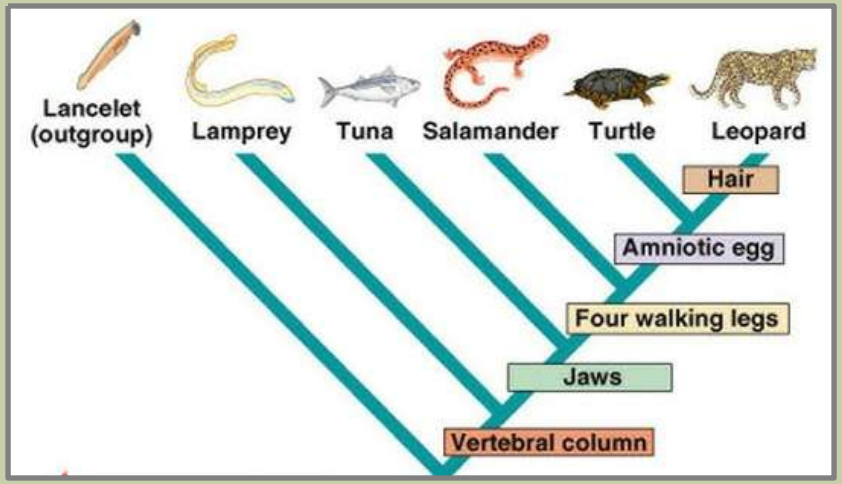
VIII.Cladograms and Phylogenetic Trees

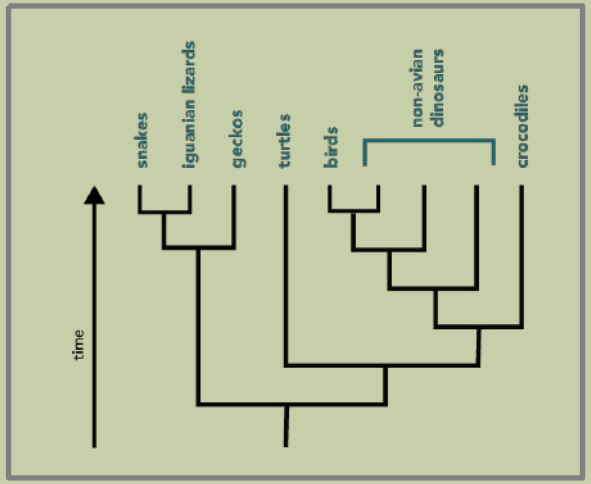
A. Definitions

- **Cladogram:** Shows **relationships** based on **shared** traits.
- **Phylogenetic Tree:** Shows **evolutionary relationships**, often with **time** included.

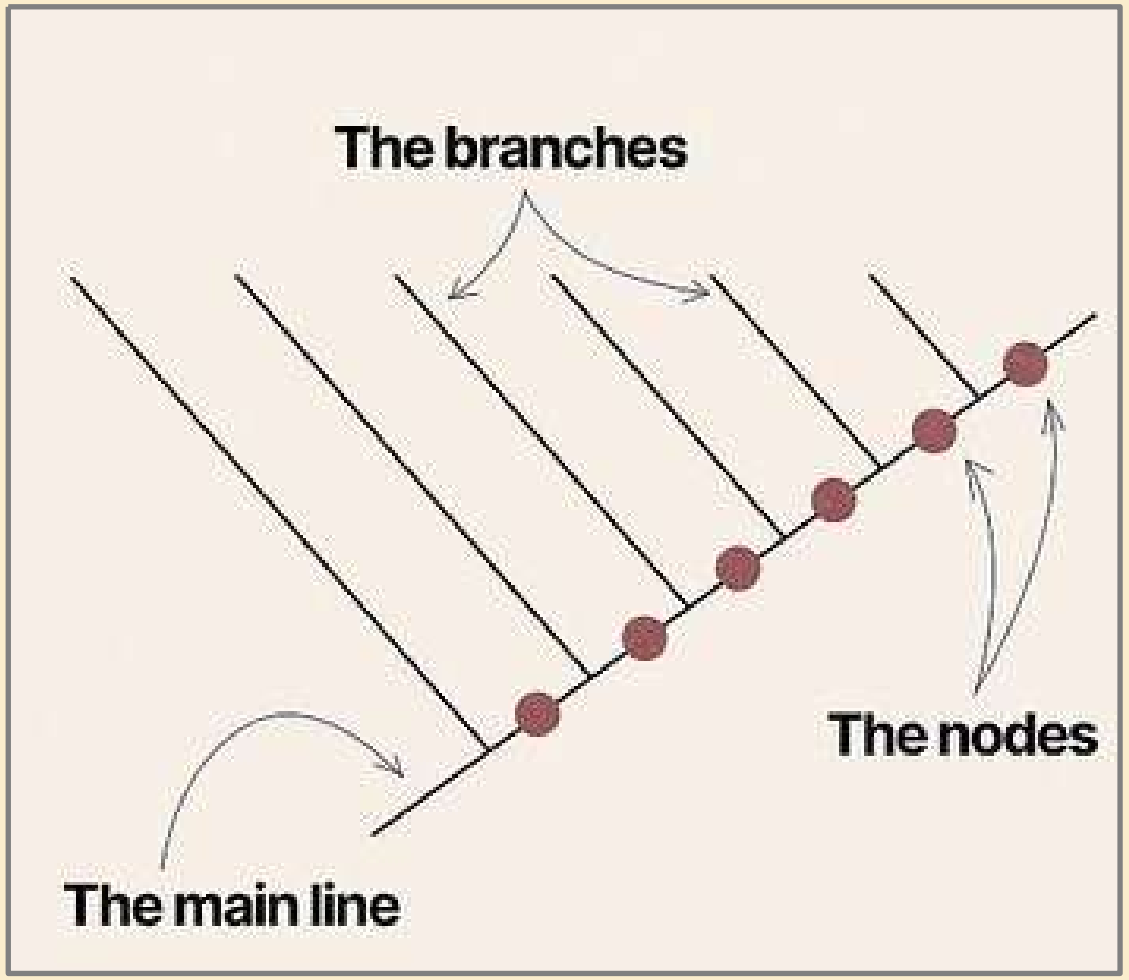
B. How to Read

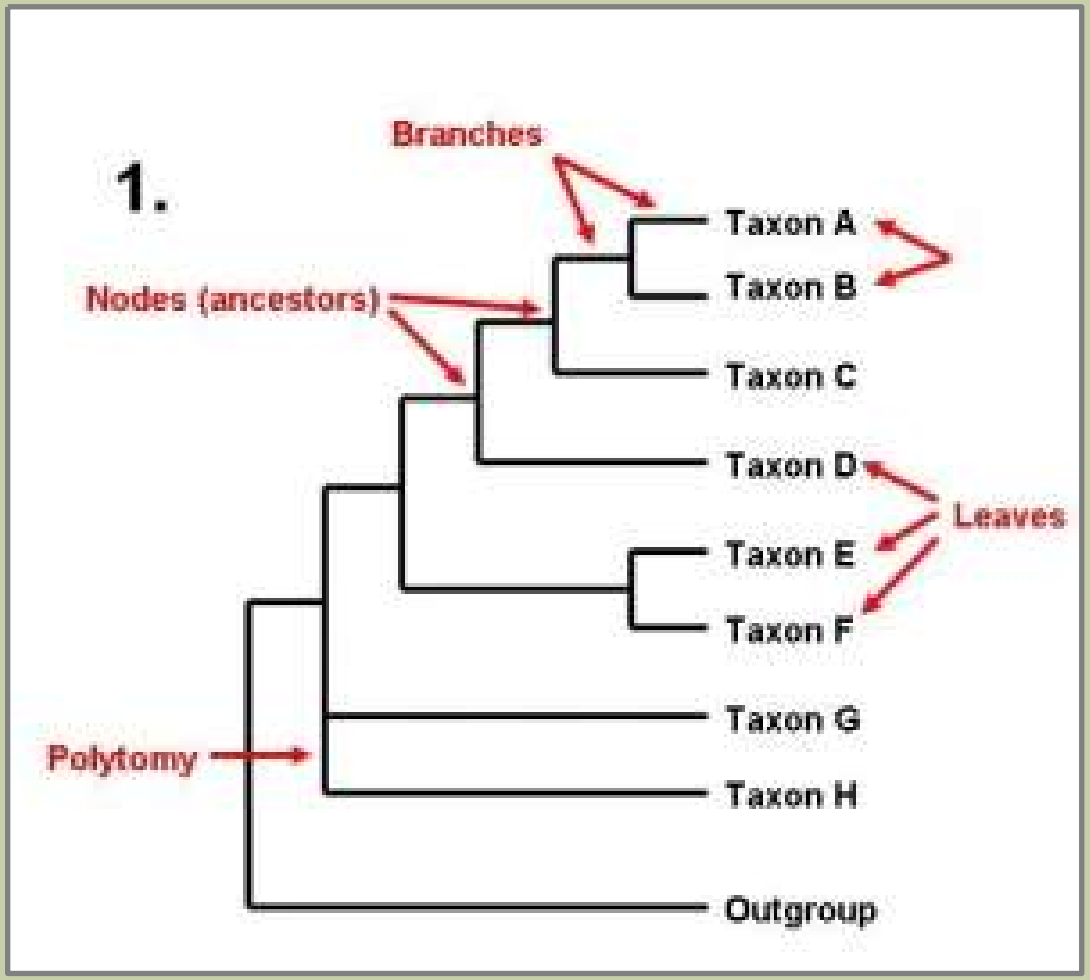
- **Nodes:** Represent **common ancestors**.
- **Branches:** Show **evolutionary paths**.
- **Example:**
  - Species closer on the tree share a more recent ancestor.
  - Longer branches indicate more evolutionary change or time.





Cladograms and Phylogenetic Trees





Environmental Changes and Evolution

A. Population Changes

- Favorable conditions lead to population growth.
- Unfavorable conditions can lead to extinction.

B. Speciation

- New species form when environments change and populations adapt.

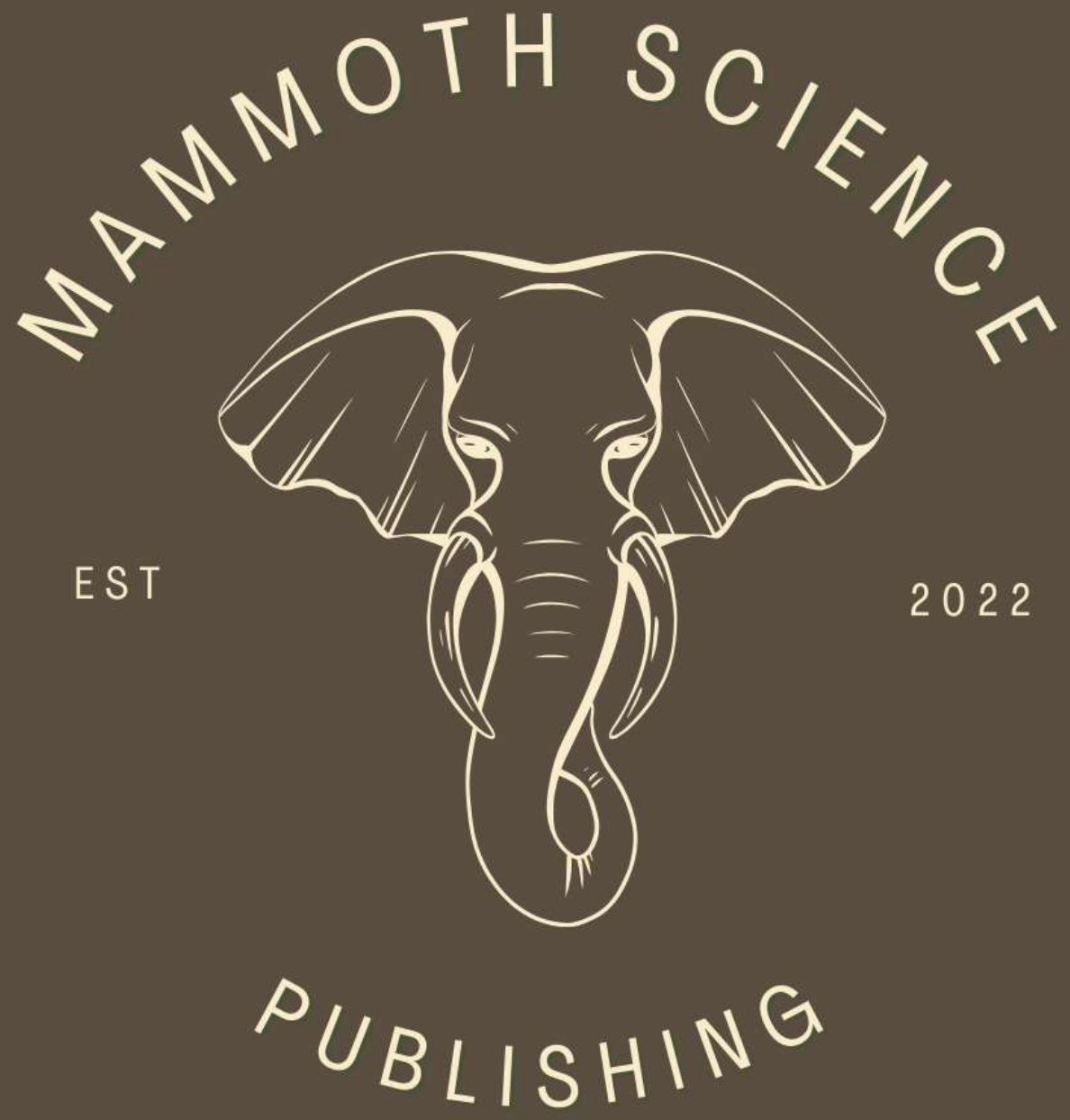
C. **Extinction**

- Rapid changes, like habitat destruction, can eliminate species unable to adapt.

Summary

The Significance of Biodiversity and Evolution

Life on Earth is constantly changing through processes that shape species over time. Evolution explains how living organisms are connected through common ancestry, with evidence found in fossils, geographical distribution, and similarities in structures, DNA, and development. Traits that help organisms survive and reproduce, called adaptations, play a key role in natural selection, where favorable traits become more common in populations. Changes can happen gradually or in sudden bursts, leading to the formation of new species. Life's origins are linked to early chemical processes and the development of complex cells through cooperation between simpler ones. Understanding evolutionary relationships helps explain how species are connected and adapt to changing environments.



Thank you for Listening...

If you have any questions, please contact your instructor. We are always looking for any feedback to make these presentations better.

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