Explain: Biodiversity & Evolution KEY
SPRING SEMESTER 2024

INSTRUCTOR:

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Vocabulary / Key Terms/ Concepts	Biodiversity & Evolution Notes
• *Adaptation* • *Anatomical Homology* • *Biogeography*	**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,*

- *Bottleneck Effect*
- *Competition for Resources*
- *Differential Reproductive Success*
- *Directional Selection*
- *Disruptive Selection*
- *Environmental Conditions*
- *Evolution*

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.*

I. Charles Darwin and the Origin of Species

A. 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.

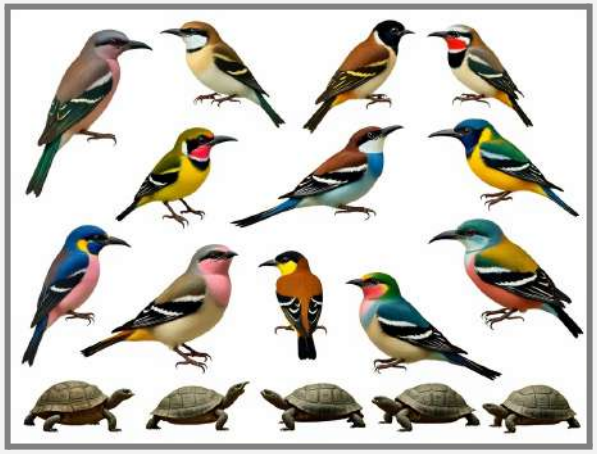
B. The Journey on the HMS Beagle

- 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.

C. Key Discoveries

- *Fossil Record*
- *Gene Flow*
- *Genetic Drift*
- *Genetic Recombination*
- *Gradualism*
- *Inherited Variation*
- *Mutation*
- *Natural Selection*

- **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.



D. 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.

II. 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.

- *Overproduction of Offspring*
- *Punctuated Equilibrium*
- *Speciation*
- *Stabilizing Selection*
- *Stasis*
- *Survival of the Fittest*

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.

III. Evidence of Evolution

A. Fossil Record

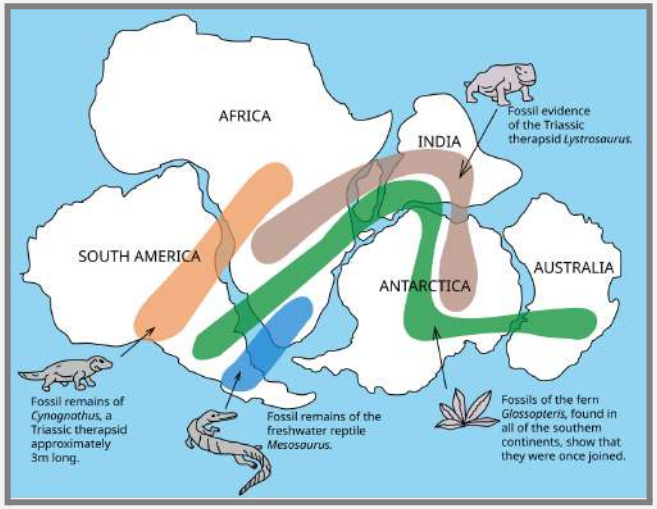
- **Fossils show how species have changed over time.**
  - Fossils in older rocks look very different from modern species.
  - **Intermediate Fossils:** Show links between major groups,

like *Tiktaalik*, which connects fish and amphibians.

- **Law of Superposition**: Older fossils are deeper in the earth while younger fossils appear near the surface

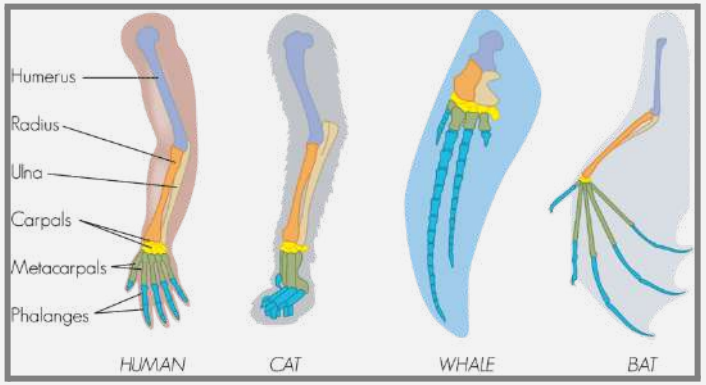
B. Biogeography

- **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.



C. Homologies

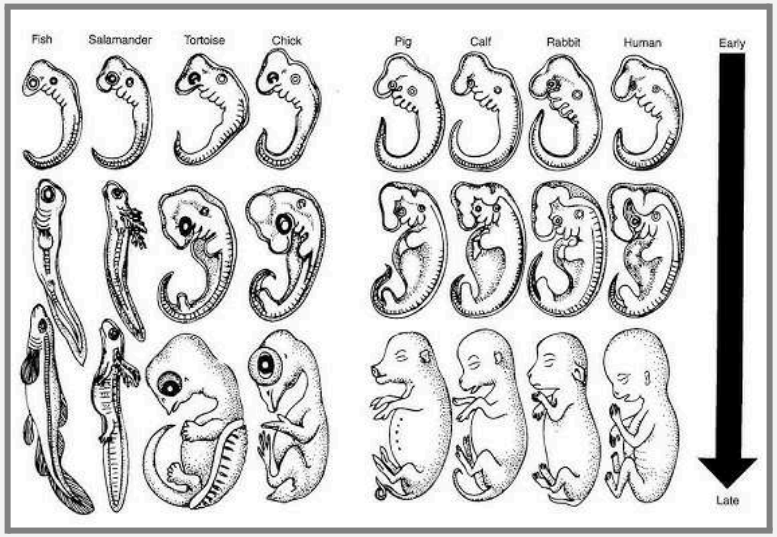
- **Traits shared by species because they came from a common ancestor.**
  1. **Anatomical Homologies:** Similar structures, like the bones in a whale's fin and a human hand.



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

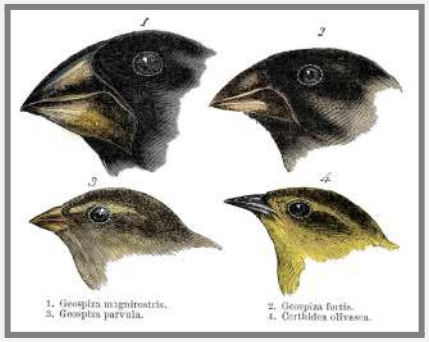
Cytochrome *c* Evolution	
Organism	Number of amino acid differences from humans
Chimpanzee	0
Rhesus monkey	1
Rabbit	9
Cow	10
Pigeon	12
Bullfrog	20
Fruit fly	24
Wheat germ	37
Yeast	42

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



D. Patterns of Evolution

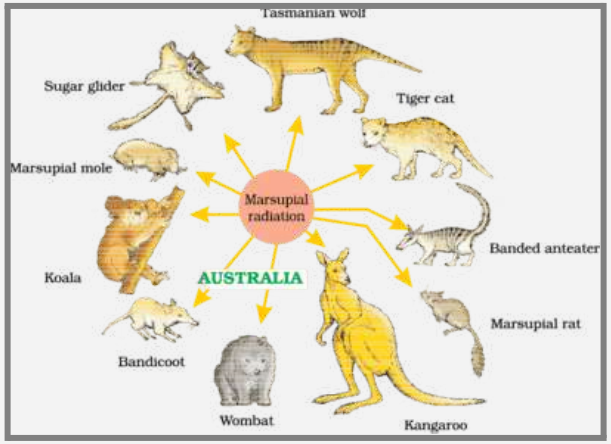
- **Convergent Evolution:** Unrelated species develop similar traits because they live in similar environments.
    - **Example:** Wings of birds and bats.
- **Divergent Evolution:** Related species evolve different traits due to different environments.
    - **Example:** Darwin's finches with varied beak shapes.
- **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.



IV. Natural Selection

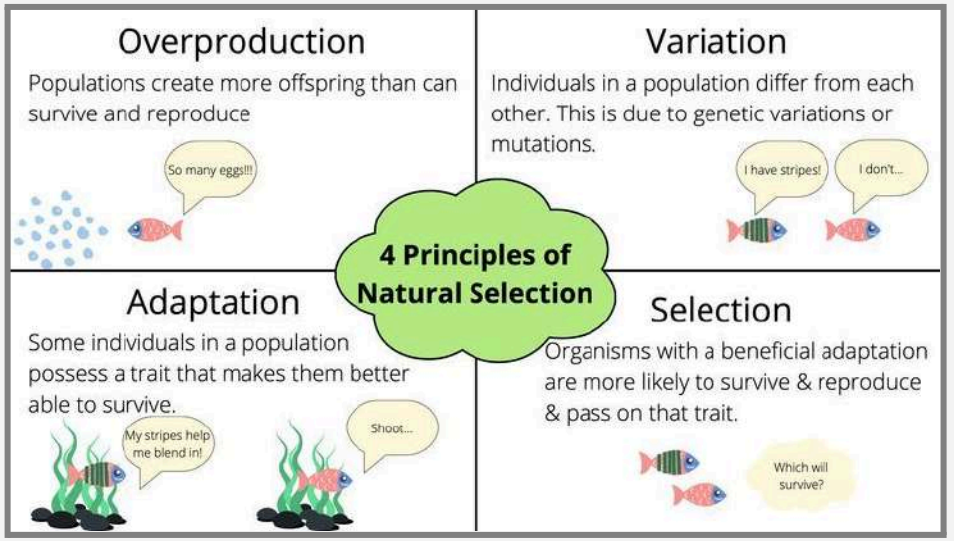
A. Key Concepts

- **Definition: The process where organisms with helpful traits survive and reproduce.**



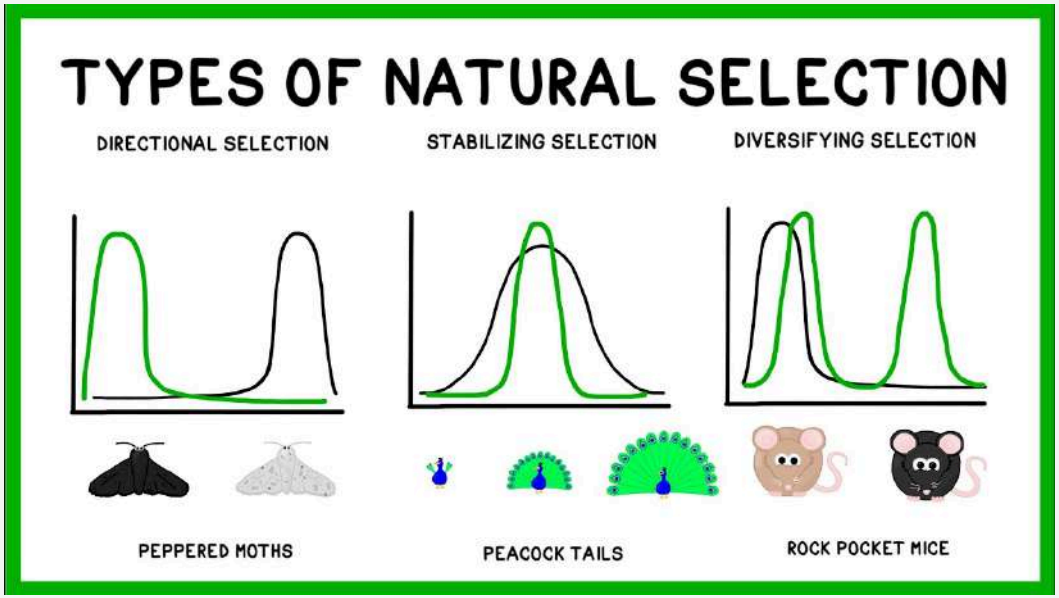
- **Key Elements:**

    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.



B. Types of Selection

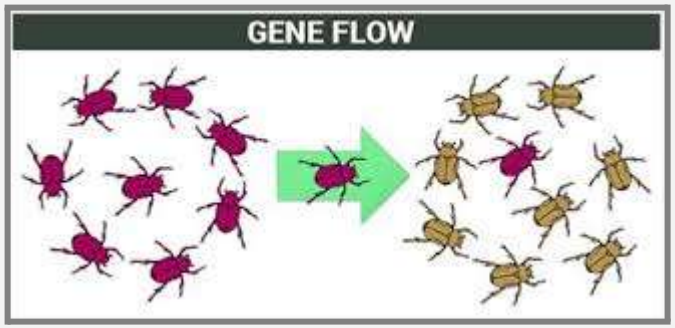
- **Directional Selection:** Favors one extreme trait.
    - **Example:** Giraffes with longer necks.
- **Disruptive Selection:** Favors both extreme traits but not the average.
    - **Example:** Birds with very small or very large beaks.
- **Stabilizing Selection:** Favors average traits and removes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



V. Mechanisms That Drive Evolution

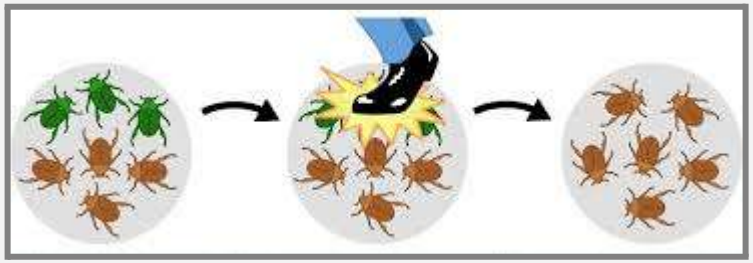
A. Gene Flow

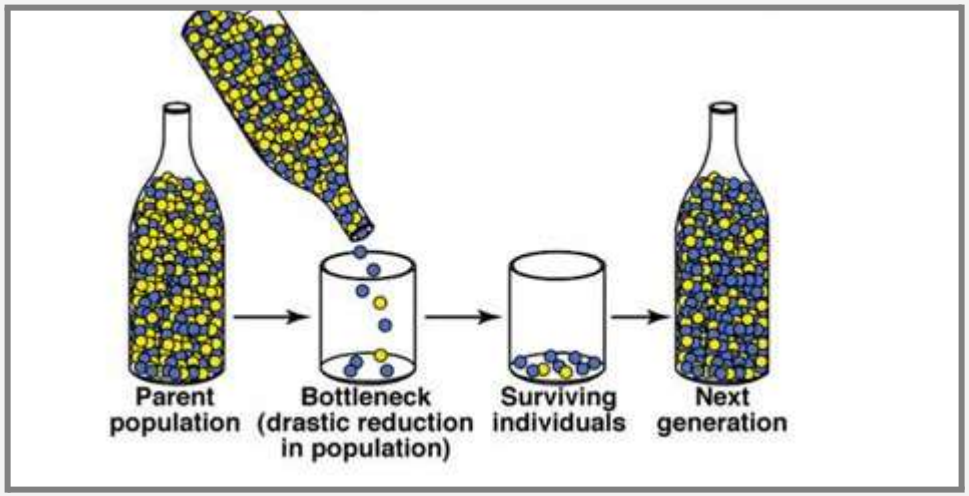
- Movement of genes between populations (e.g., animals migrating and breeding in new areas).



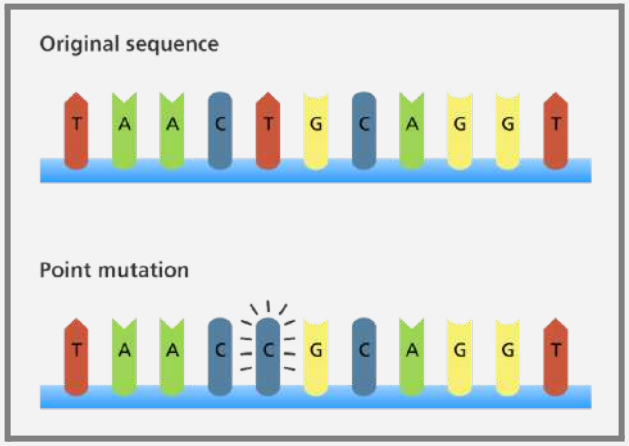
B. Genetic Drift

- Random changes in traits, especially in small populations.
    - **Bottleneck Effect:** Population shrinks, losing genetic diversity (e.g., cheetahs).





- **Founder Effect:** A small group starts a new population with limited traits.



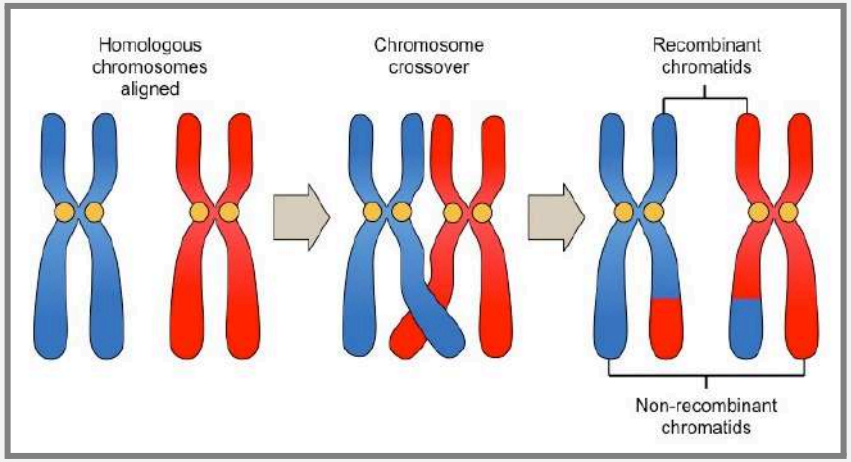
C. Mutations

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

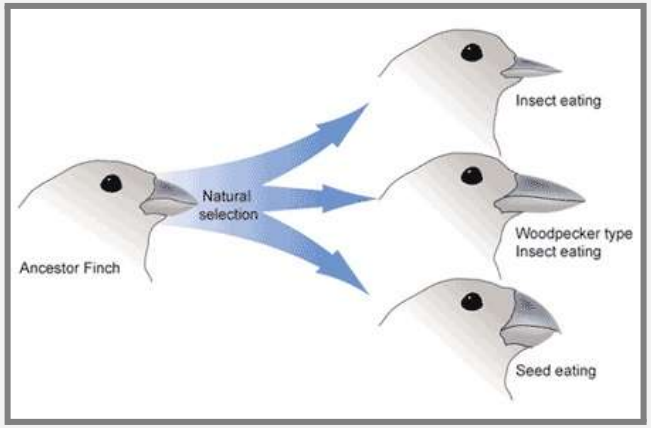
D. Genetic Recombination

- Mixing of genes during reproduction creates new trait combinations.

- **Example**: Crossing Over during prophase I in Meiosis



VI. Speciation



A. Definition

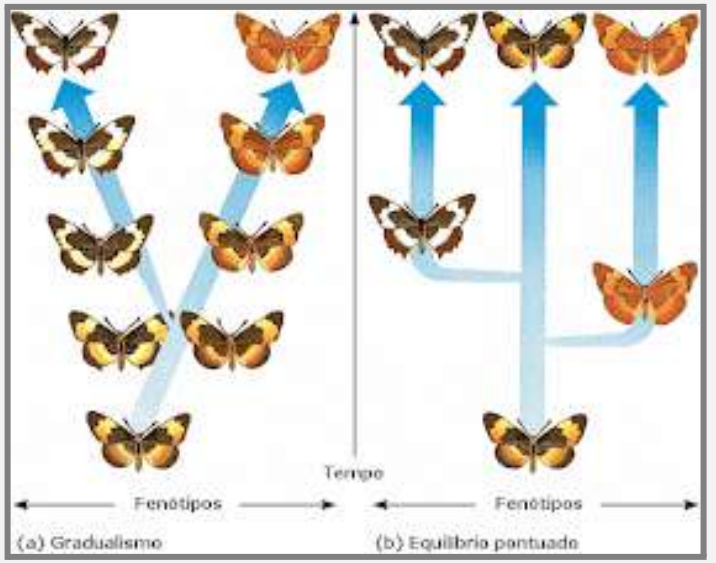
- The formation of new species when populations become isolated and stop interbreeding.

B. Causes

- **Geographic Isolation:** Physical barriers, like mountains or rivers.
- **Behavioral Isolation:** Differences in mating behaviors.

- **Temporal Isolation:** Reproducing at different times.

VII. Rates of Evolution



A. Gradualism

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

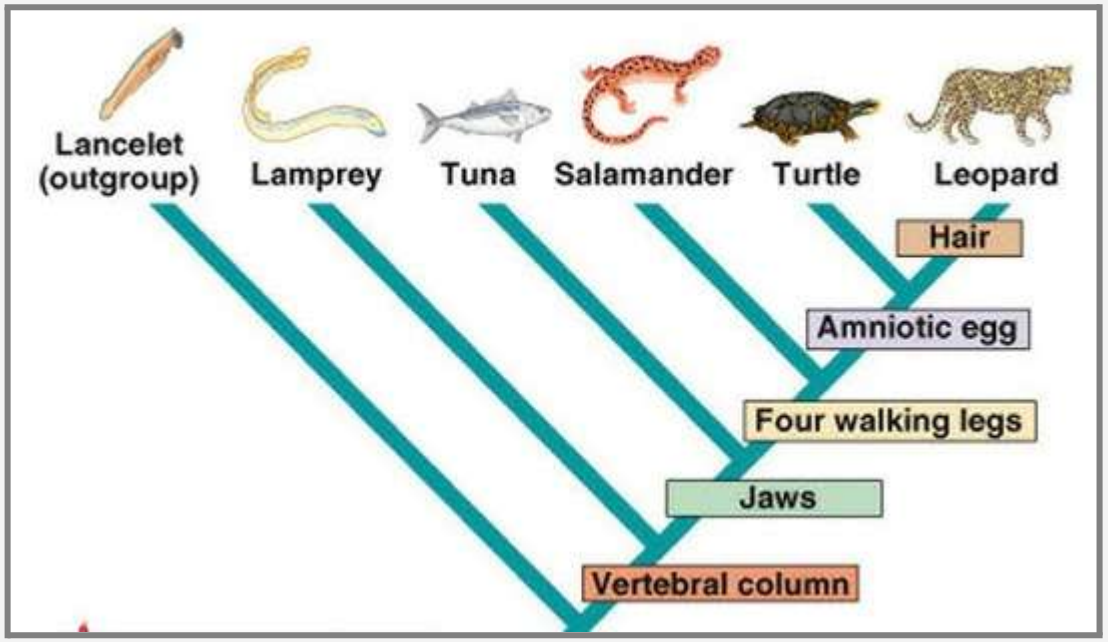
B. Punctuated Equilibrium

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

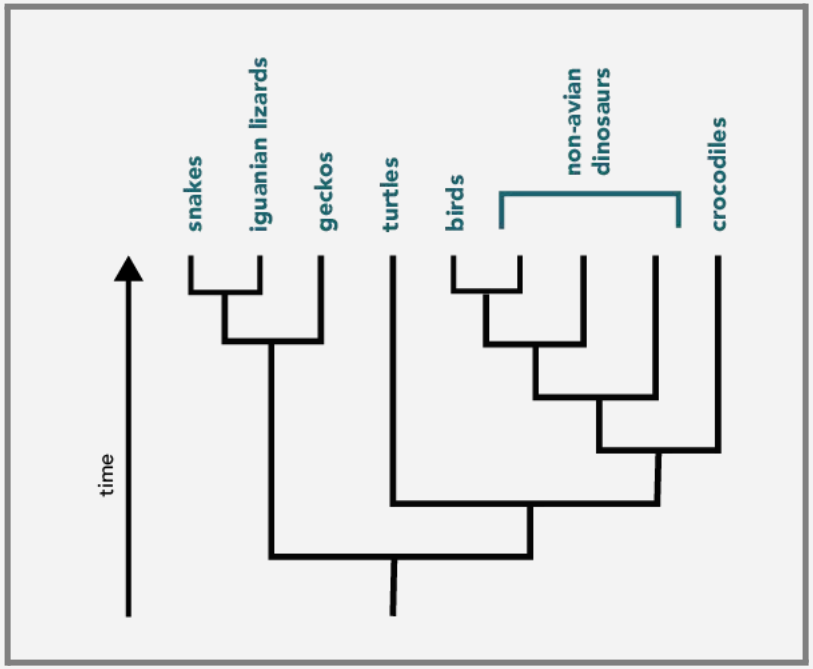
VIII. Cladograms and Phylogenetic Trees

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.

C. Example Diagram

IX. 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.

Notes Summary	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.