EVOLUTION AND CLASSIFICATION

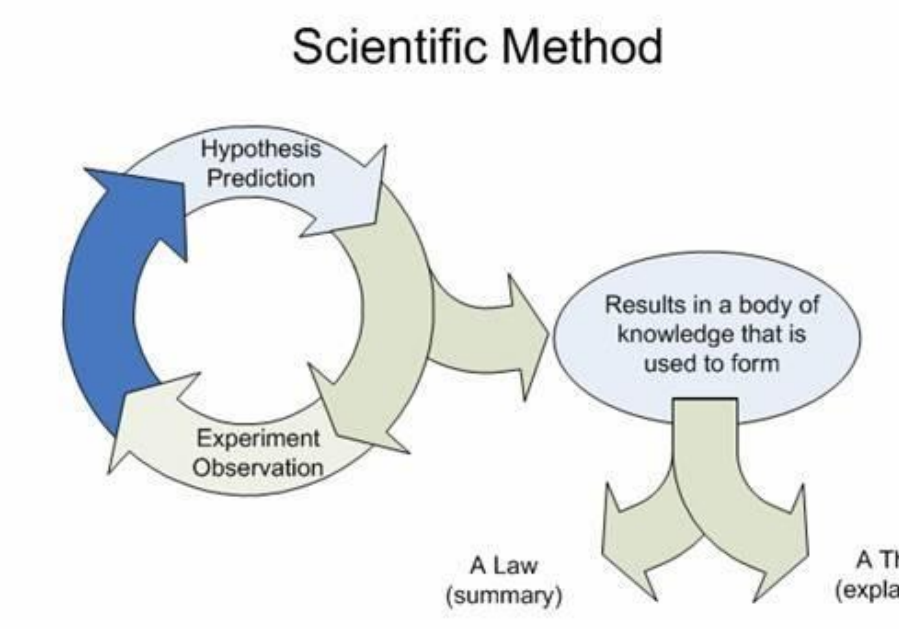
Unit 8

TOPIC 2

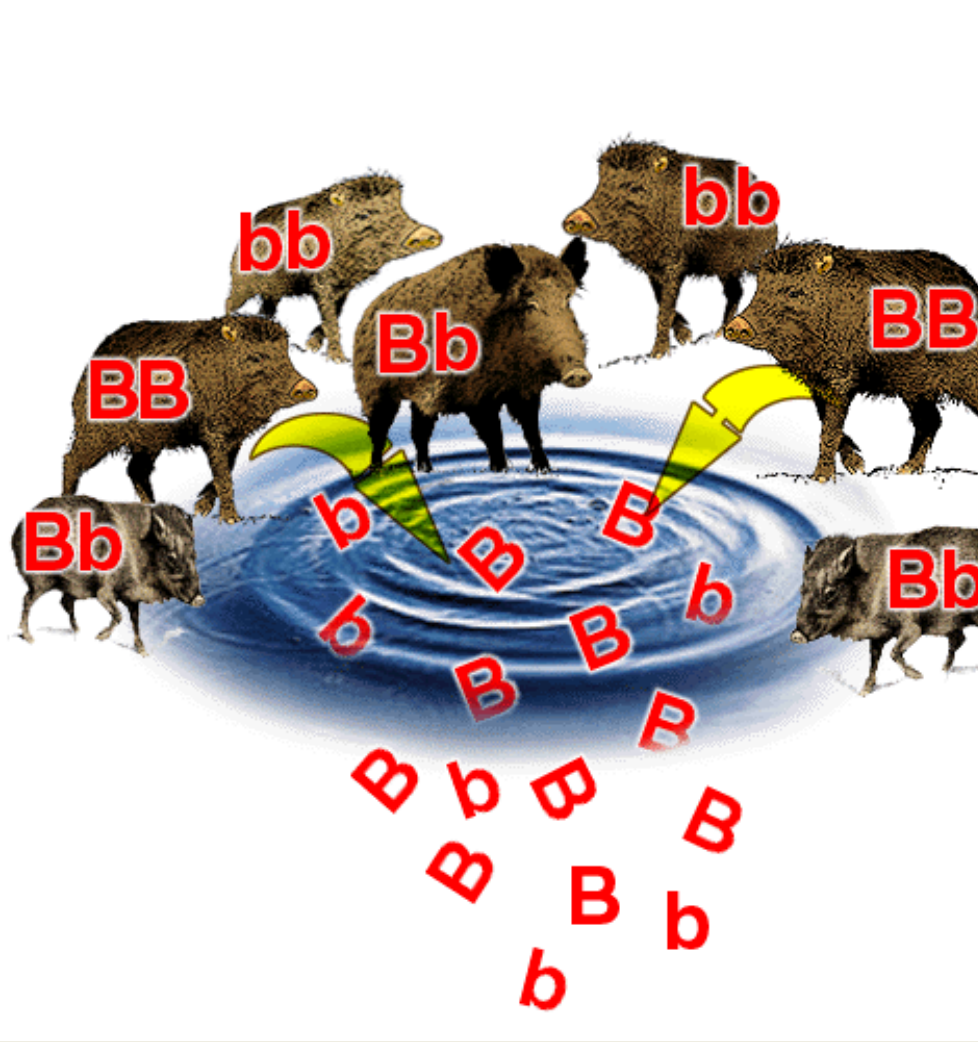
evolution

Revisiting Vocabulary

- Inference: interpretation based on prior knowledge/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
  - *About the natural world*
  - *Lots of evidence in support*
- Law: a statement based on repeated experimental observations
  - *Always applies under the same conditions*



- Evolution is a change in a population of species over a period of time
  - *Genotypic v. phenotypic changes*
- Evolution acts on populations, not individuals
  - *A population is a group of individuals of the same species in an area (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*
- Microevolution: small scale (molecular)
  - *Seen in living populations*
- Macroevolution: large scale (speciation)
  - *Seen in the fossil record*



Scientists of Evolution

Jean Baptiste Lamarck (1744-1829)

Acquired Traits

- Theory of use and disuse
  - *If an organ is used, it becomes stronger and better developed*
  - *If an organ is not used, it becomes weaker and withers away*
- Believed an organism acquires traits based on need/experience, not from genes

Charles Darwin (1809-1882)

Natural Selection

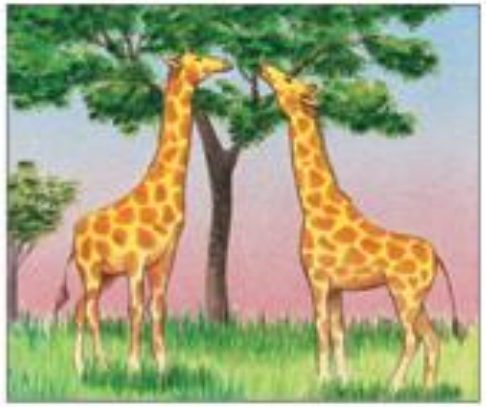
Descent by Modification

- Nature will select the organisms that have variation that allow them to better survive (survival of the fittest)
- Found that species vary locally/globally/over time
- Studied finches and other animals in the Galapagos while on board the HMS Beagle (naturalist on voyage)

Giraffe Necks

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

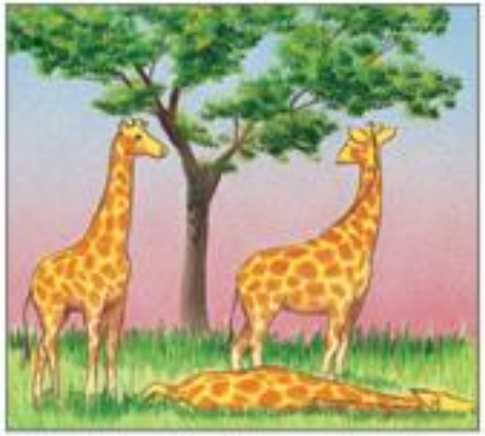
Their offspring had longer necks that they stretched to reach food.



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

a. Lamarck's proposal

Early giraffes probably had necks of various lengths.

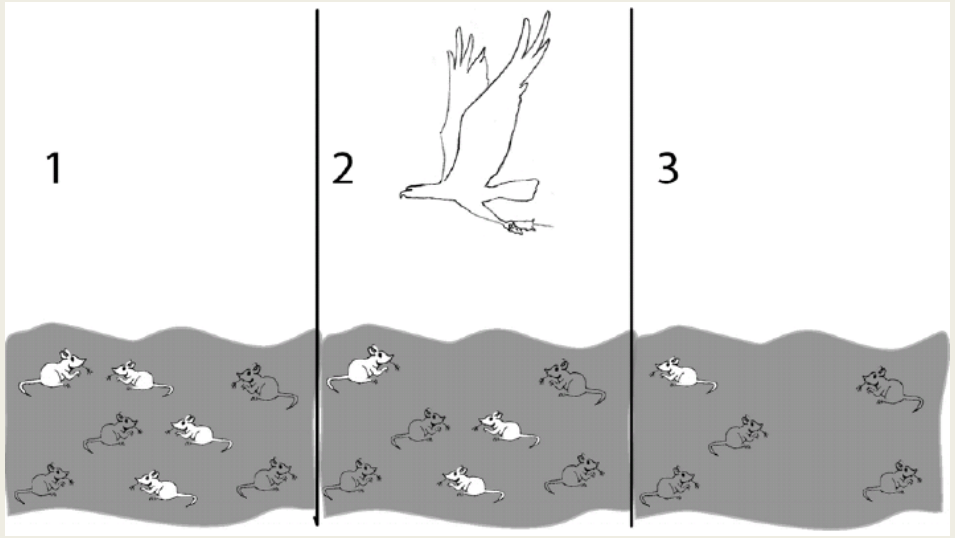


Natural selection due to competition led to survival of the longer-necked giraffes and their offspring.

Eventually, only long-necked giraffes survived the competition.

b. Darwin's theory

Darwin's Theory



1) There is variation in every population
2) Some variations are favorable
   (these organisms live and can reproduce, the others die)
3) More young are produced in each generation than can survive
   (overproduction)
4) There is competition for resources (food, water, shelter, space)
   (struggle for existence)
5) Those that are successful go on to reproduce
6) Overtime, small changes accumulate in a population because the best traits continue to be passed on

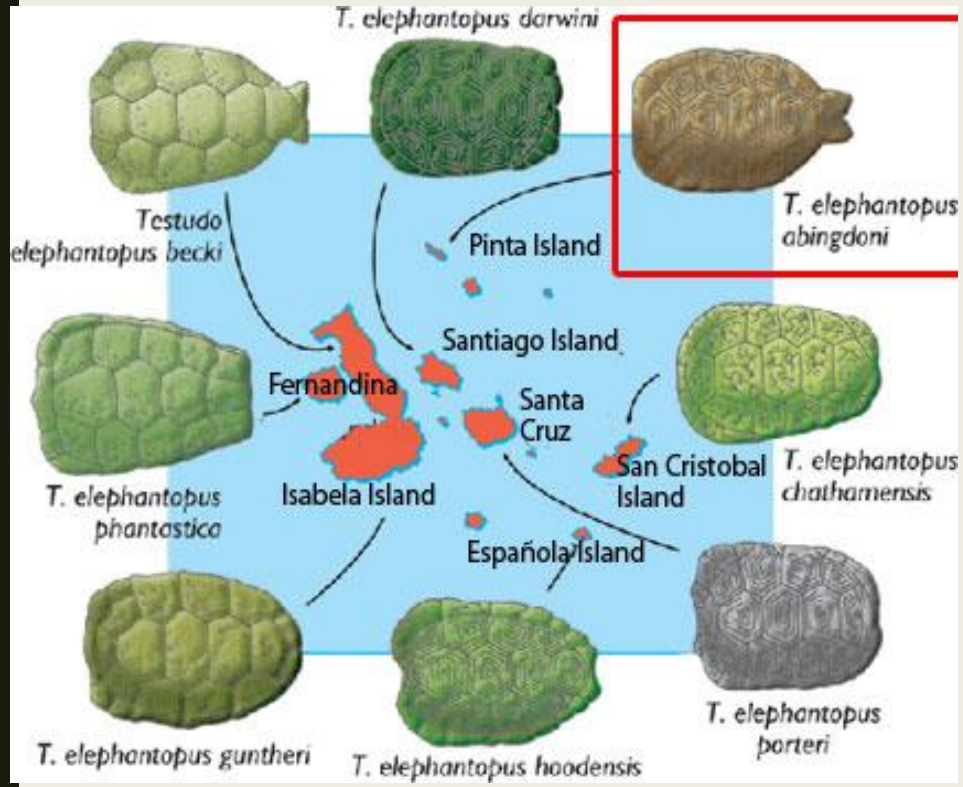
Natural Selection?

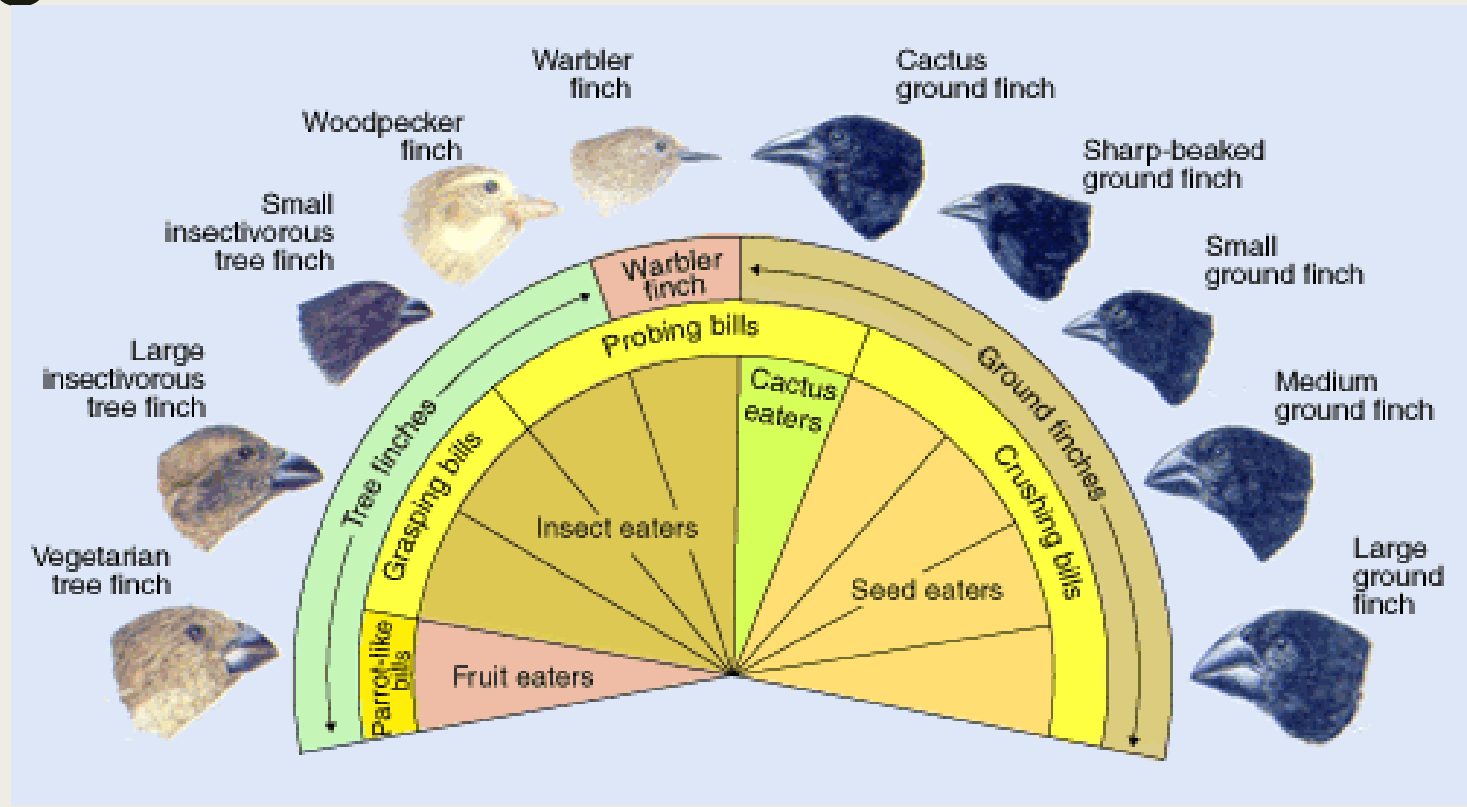
- What leads to these changes?
  - *Random mutations*
    - Organisms w/ shorter generation times have higher mutation rates & so evolve quicker than animals w/ longer generation times

Examples:

- Industrial Revolution vs. Peppered Moth
- Darwin's Finches

Darwin's Studies





- Turtle shells and finch beaks
  - *Beak shape is related to food type*

Evidence of Evolution

- Fossils
  - *Trace of long-dead organism found in layers of sedimentary rock; minerals replace tissue*
- Comparative anatomy
  - *Compare structures in modern organisms with ancient organisms (homologous, analogous, and vestigial structures)*
- Comparative embryology
  - *Finding similarities in embryos; organisms with a recent ancestor have more similar embryos*
- Comparative biochemistry
  - *Finding similarities in protein and DNA sequences (the fewer differences, the more closely related two organisms are)*

Memory trick

FAME summarizes the evidence that evolution has occurred:

- F – **fossil** evidence (remains of ancient organisms)
- A – **anatomical** structures (body parts)
- M – **molecular** evidence (DNA/RNA/ATP)
- E – **embryological** (embryos look similar from one species to the next)

Fossils

(tell us age, diet, habitat, lifestyle)

Types of Fossils

- **Mold** = imprint in rock
- **Cast** = a mold filled with hard minerals

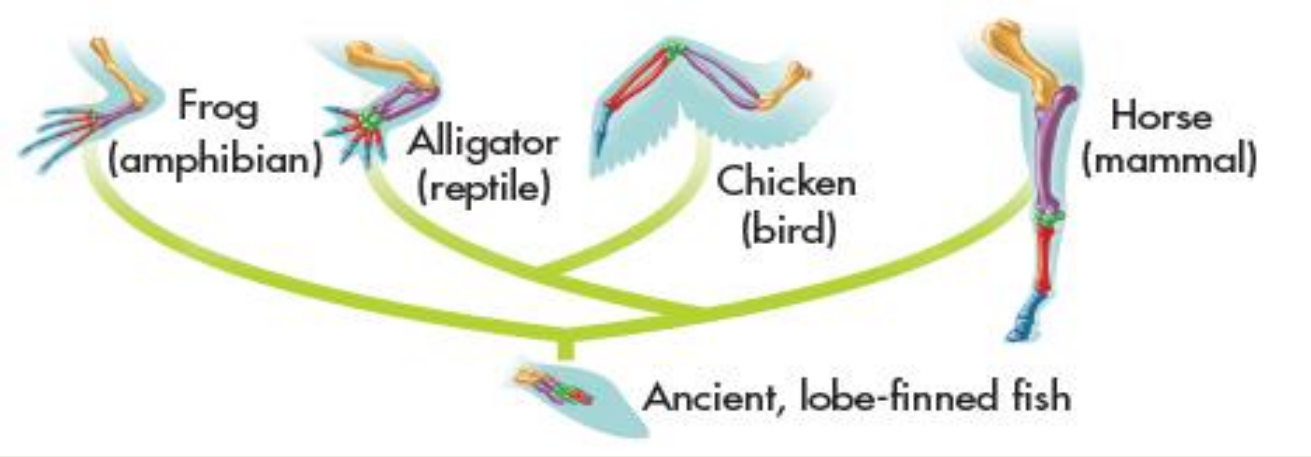
- **Trace Fossils** = signs of life (footprints, burrowing, etc.)

- **Resin Fossils** = organisms that have been preserved nearly perfectly in plant resin (amber)

- **“Living Fossils”** = any living species that is nearly identical to species previously known only from fossils

II: Anatomy: Homologous Structures (divergent evolution)

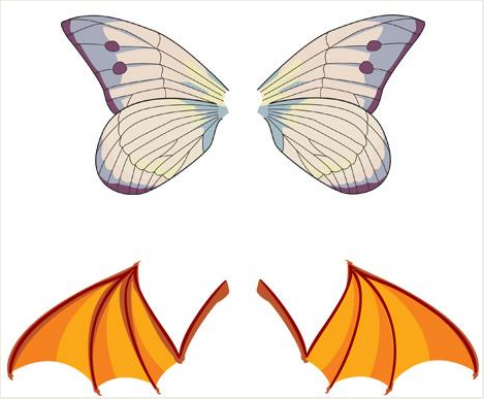
- Darwin proposed that animals with similar structures evolved from a **common ancestor** with a basic version of that structure.
- Structures that are shared by related species and that have been inherited from a common ancestor are called ***homologous structures*.**
- ***Homologous structures* are similar in structure** because they develop from same tissues early in development
  - *may or may not* ***have different functions.***



II: Anatomy: Analogous Structures (convergent evolution)

Fig. 9.5. Analogous order

- The clue to common descent is common structure, not common function. A bird's wing and a horse's front limb have different functions but similar structures (homologous structures).
- Body parts that share a common function, but not structure, are called analogous structures. Analogous structures are used for the same purpose but are not due to a common ancestor. The wing of a bee and the wing of a bird are analogous structures.



Homology or Analogy?

Shark

- skeleton made of cartilage
- use gills to get oxygen from the water in which they swim
- don't nurse their young
- don't have hair

Dolphin

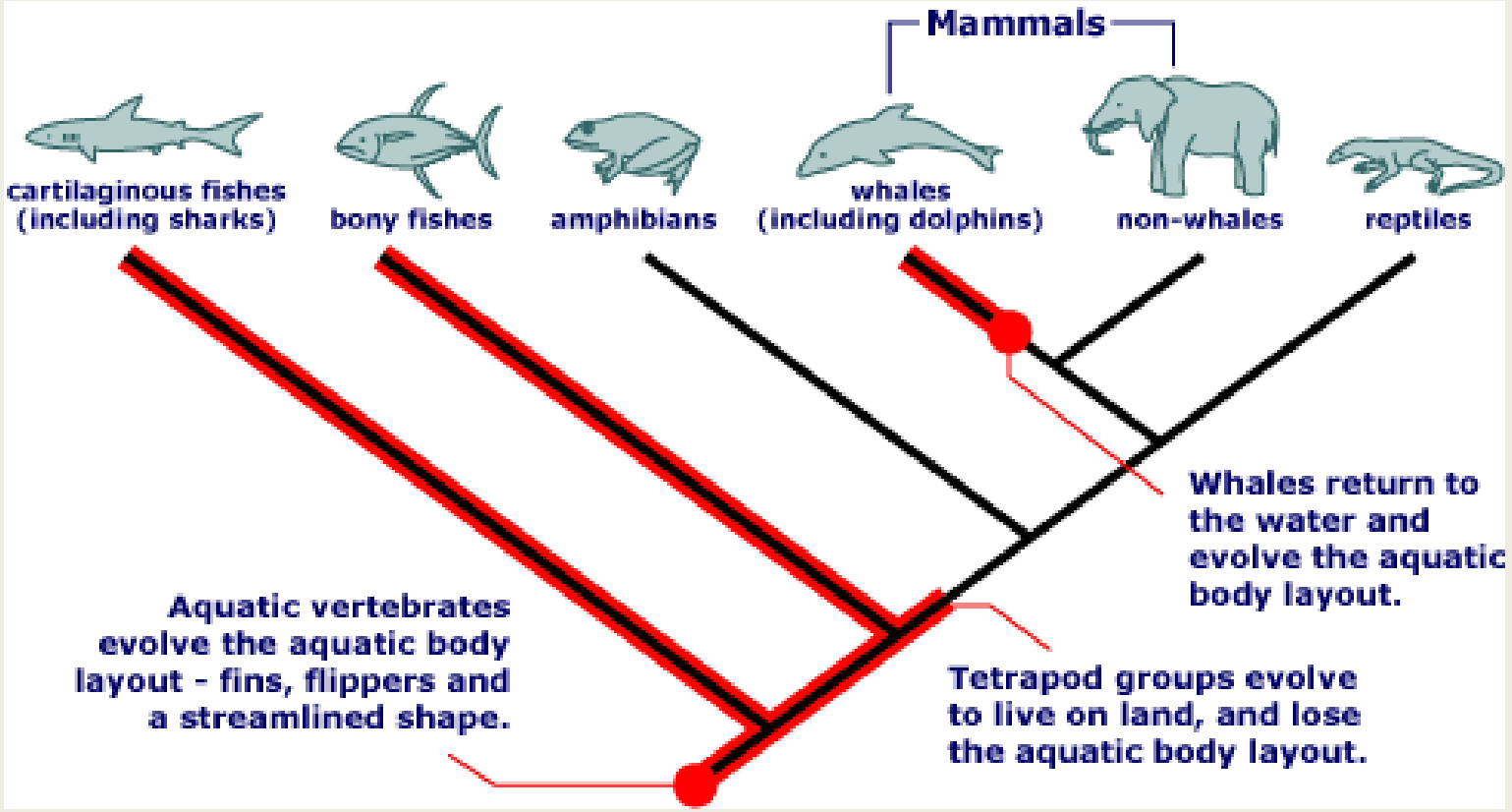
•skeleton made of bone

•go to the surface and breathe atmospheric air in through their blowholes

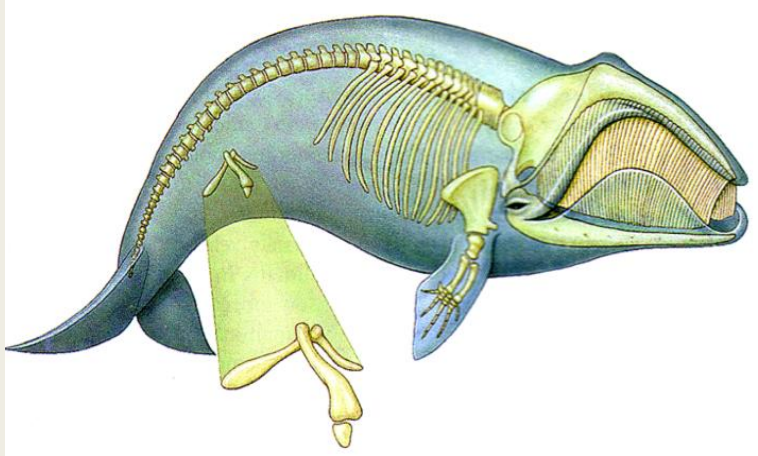
•do nurse their young

•they are born with hair around their "noses"

Analogy- convergent evolution!
Sharks and dolphins evolved their adaptations separately!



II: Anatomy: Vestigial Structures



- Not all homologous structures have important functions.
- **Vestigial structures** are inherited from ancestors, but have lost much or all of their original function due to different selection pressures acting on the descendant.
  - *The hipbones of bottlenose dolphins are vestigial structures. In their ancestors, hipbones played a role in terrestrial locomotion. However, as the dolphin lineage adapted to life at sea, this function was lost.*
  - *The human tailbone and appendix are vestigial structures.*

III: Embryology

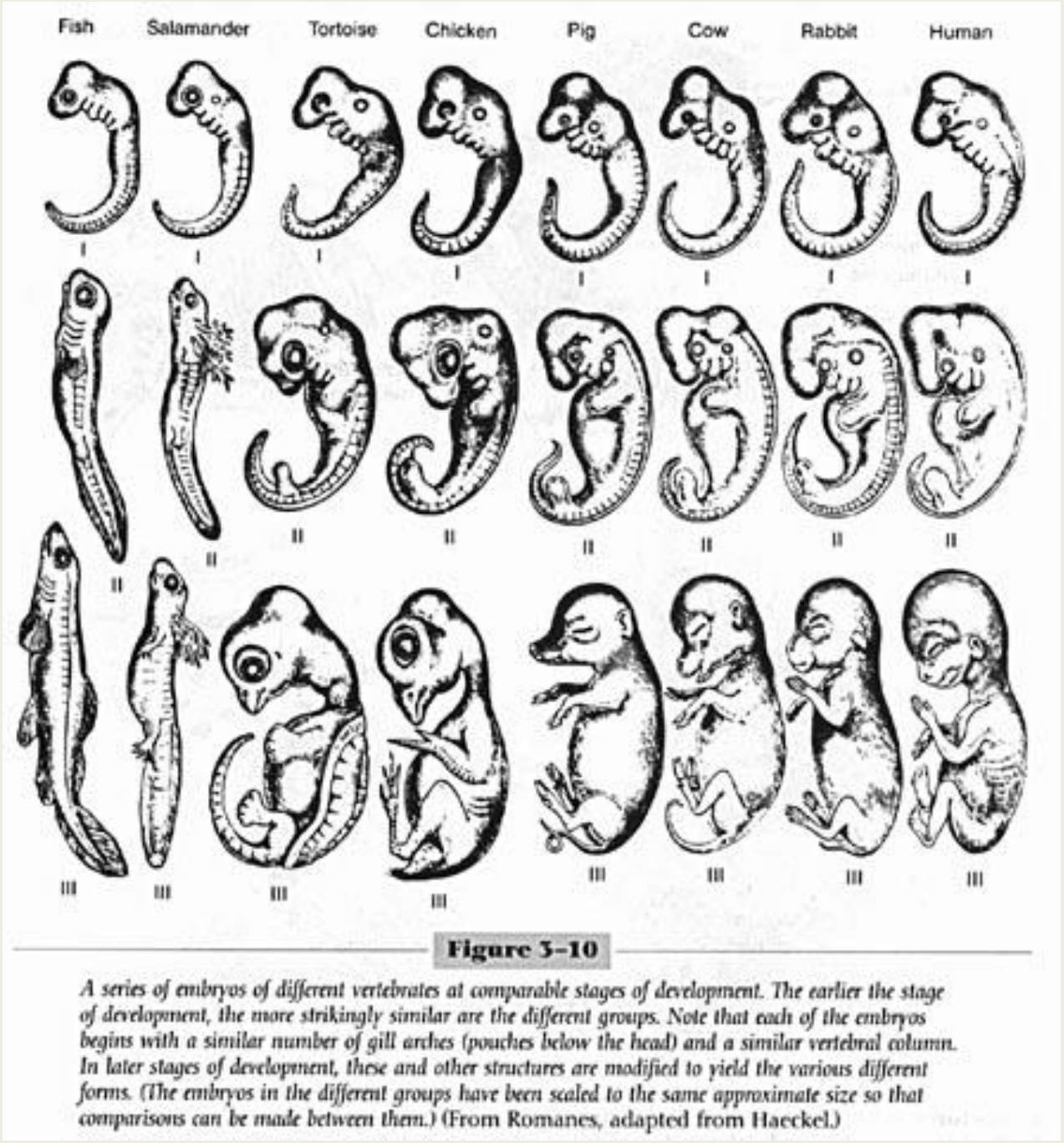
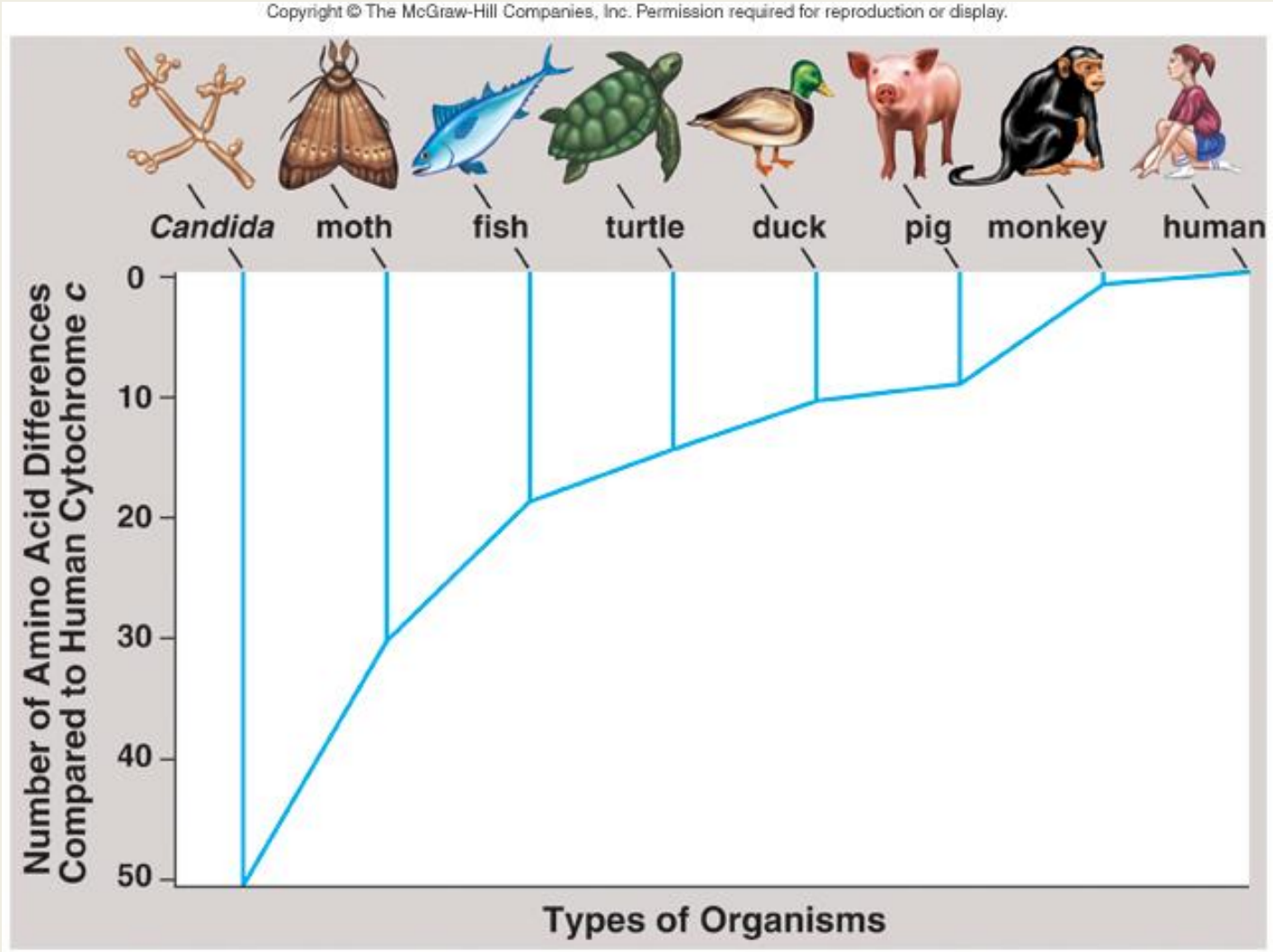


Figure 3–10

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.)

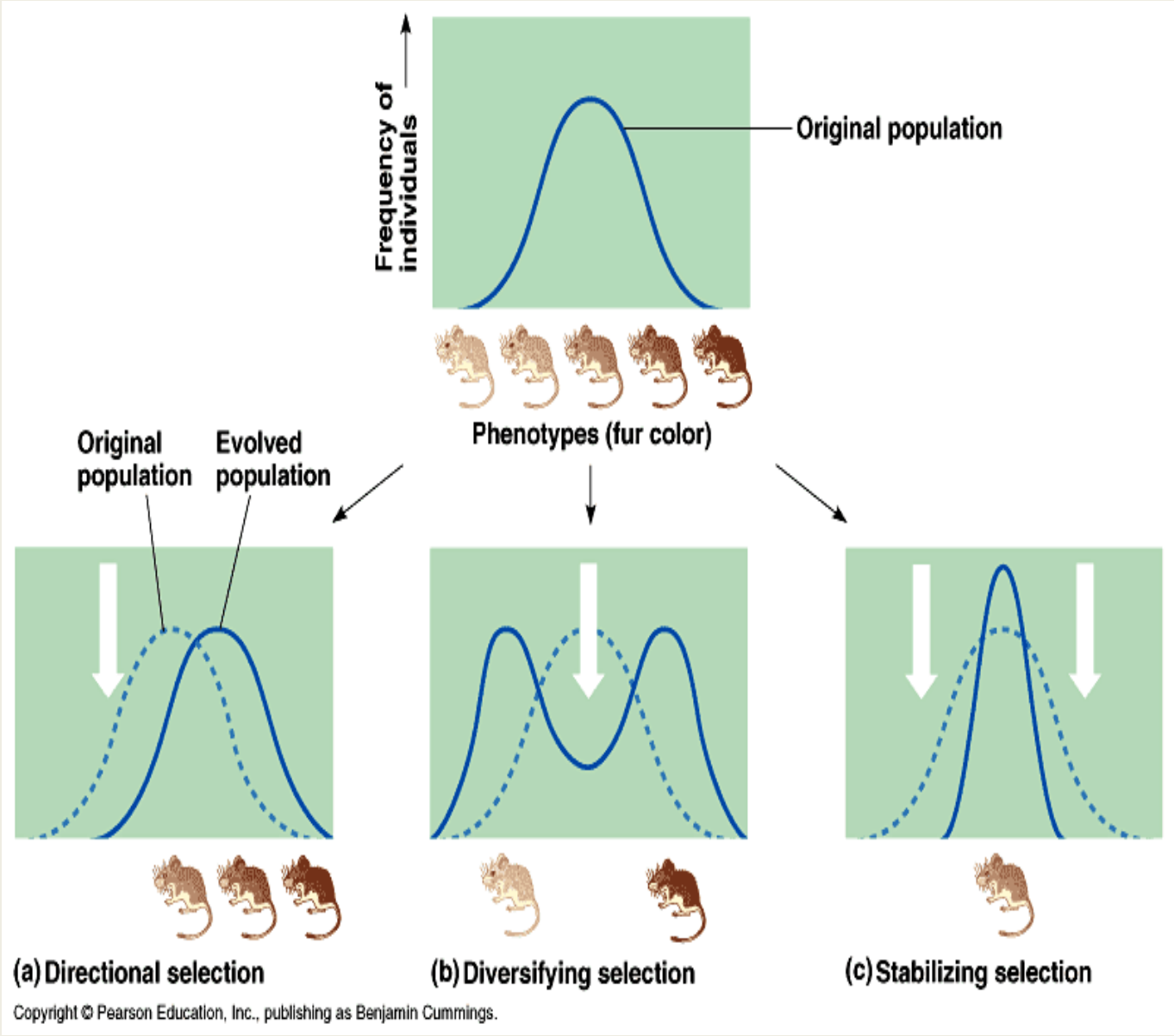
IV: Biochemistry

- Universal genetic code – organisms use the same triplet code and the same 20 amino acids in proteins
- All organisms have certain organic molecules in common.
  1. *Hemoglobin - carries oxygen in blood*
  2. *Cytochrome c - protein for cell respiration found in almost all living cells*
  3. *HOX genes – control development*

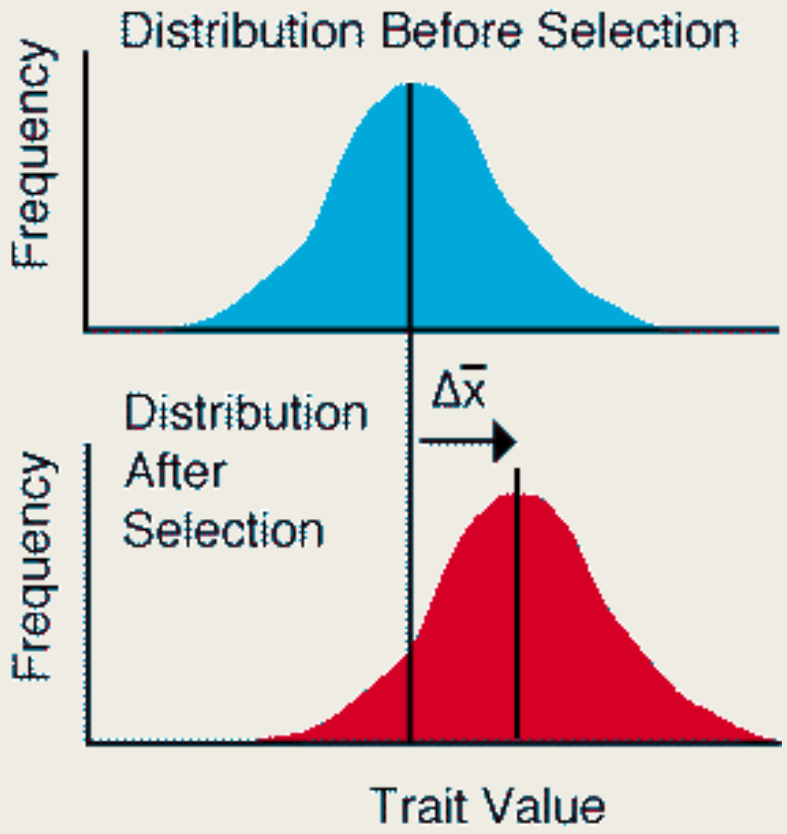


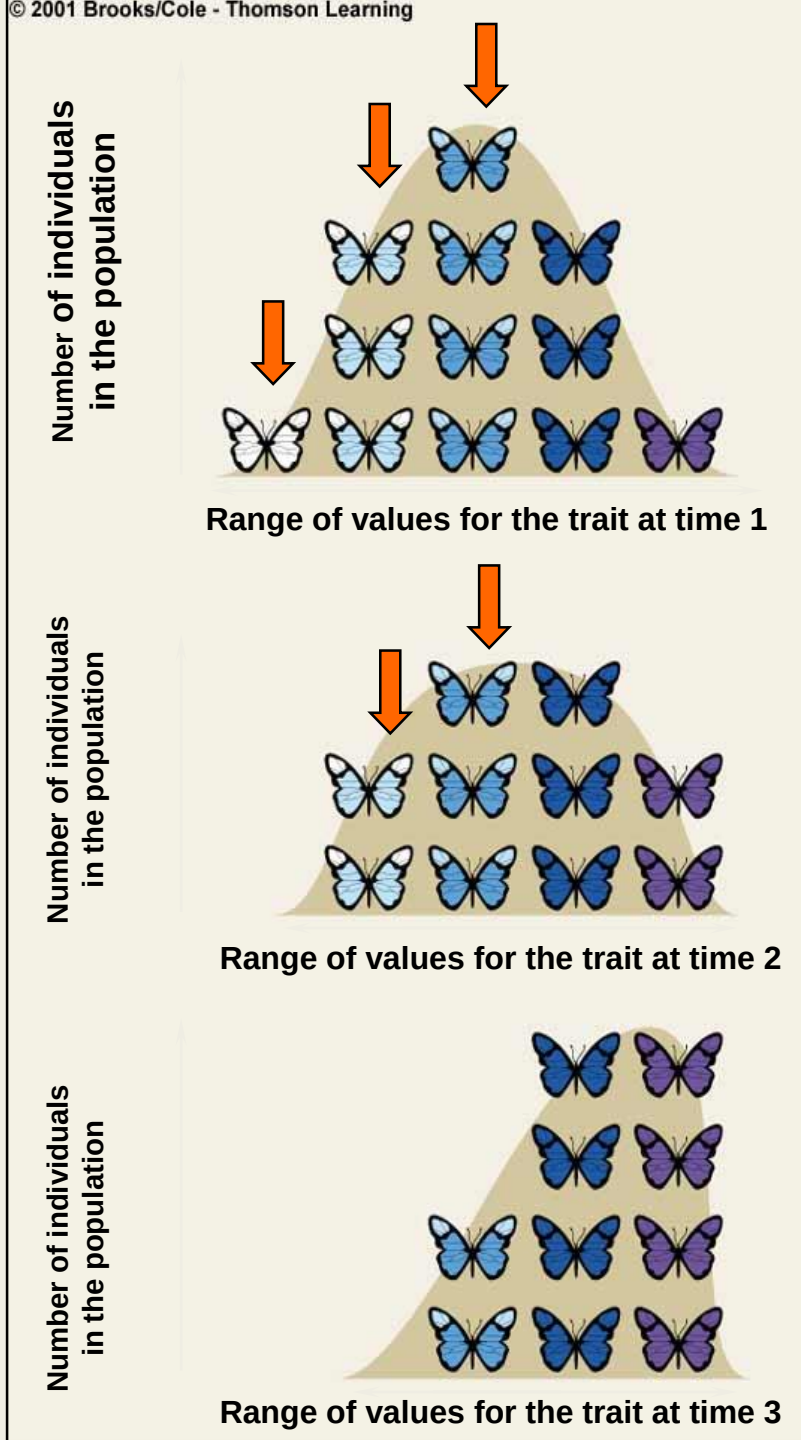
Types of natural selection

- Stabilizing
- Directional
- **Disruptive**
  - *Aka diversifying*
- sexual



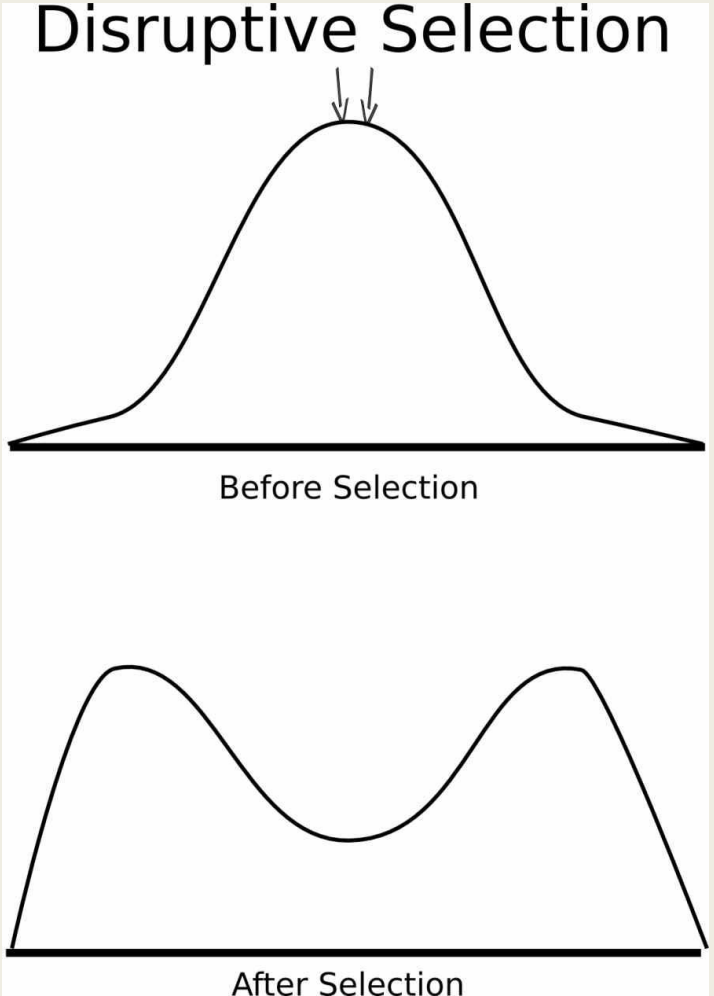
1. **Directional Selection**
   - *Individuals at one end of the curve have higher fitness than those in the middle or at the other end.*
   - *(Example: Large beak size in finches.)*

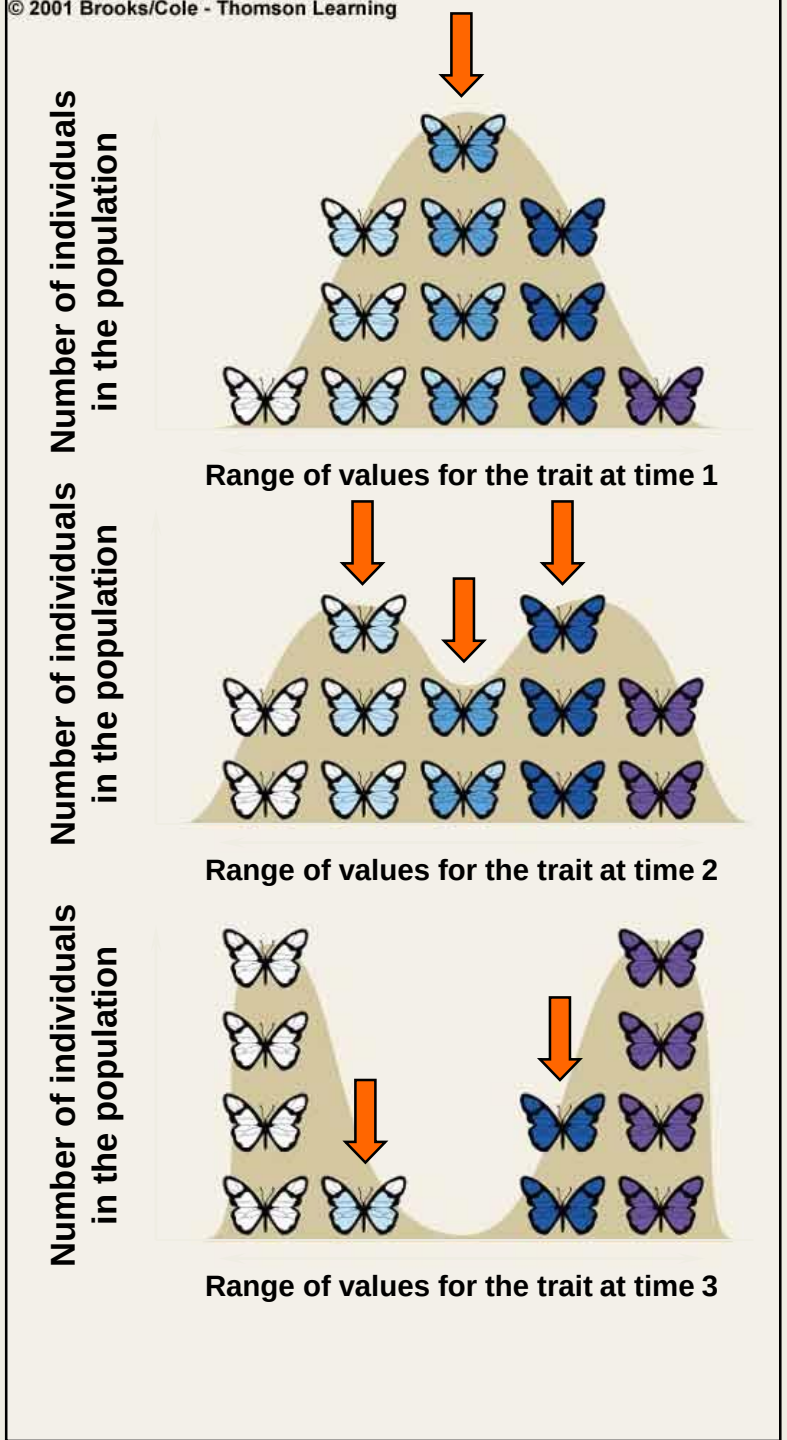




2. Disruptive Selection

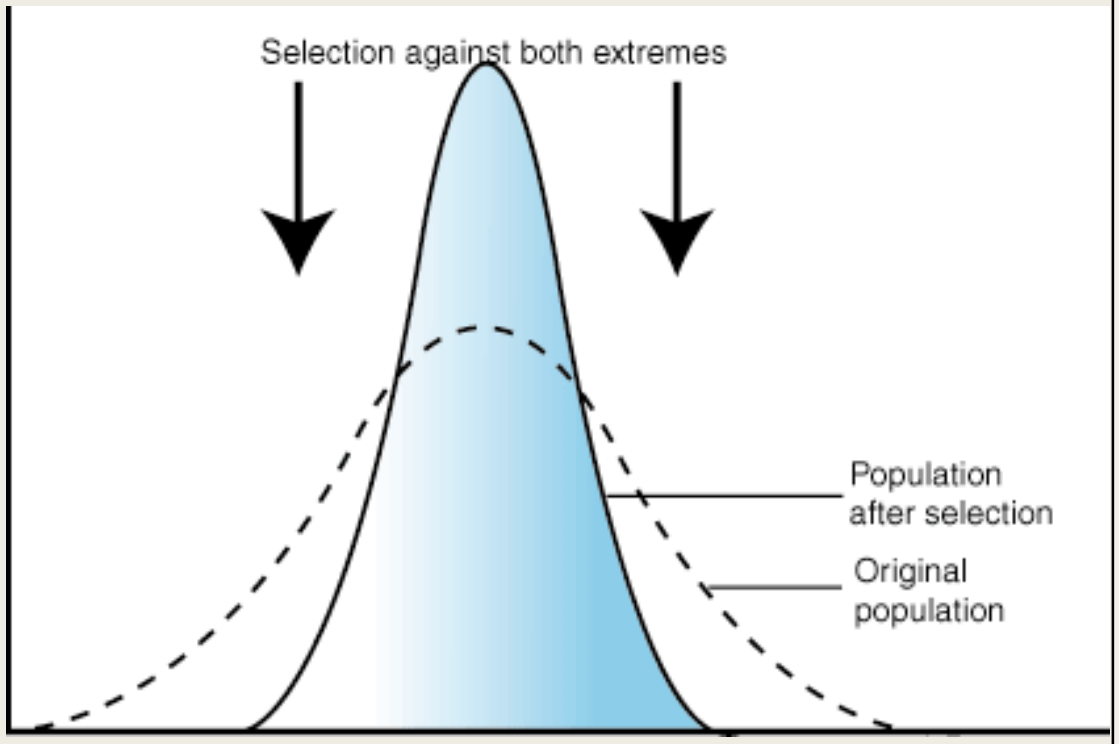
- *Individuals at the upper and lower ends of the curve have higher fitness than those near the middle.*
- *Creates two different phenotypes.*

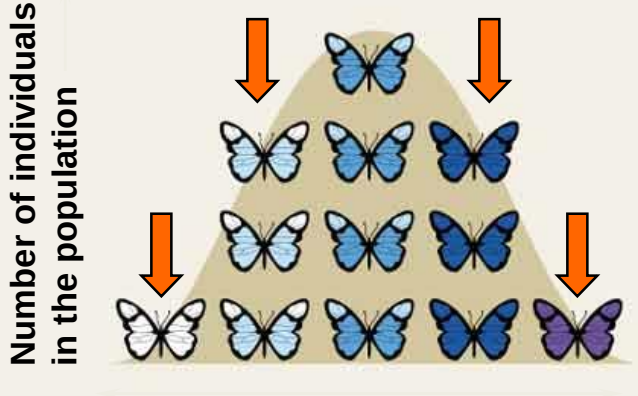




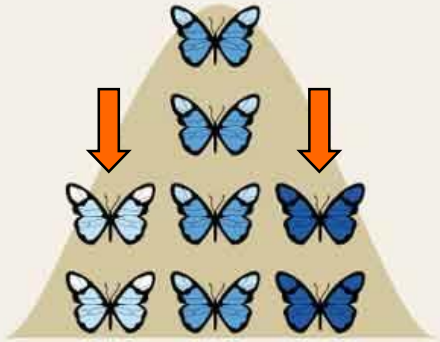
3. Stabilizing Selection

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

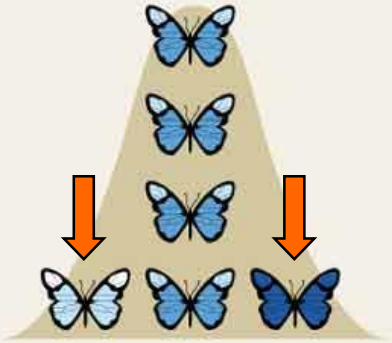




Range of values for the trait at time 1



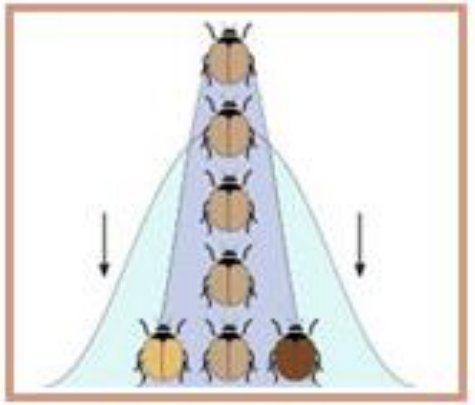
Range of values for the trait at time 2



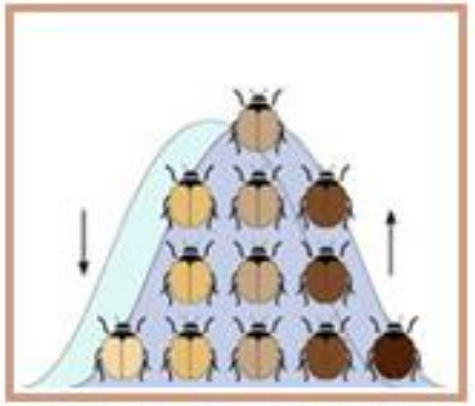
Range of values for the trait at time 3

Three Types of Natural Selection

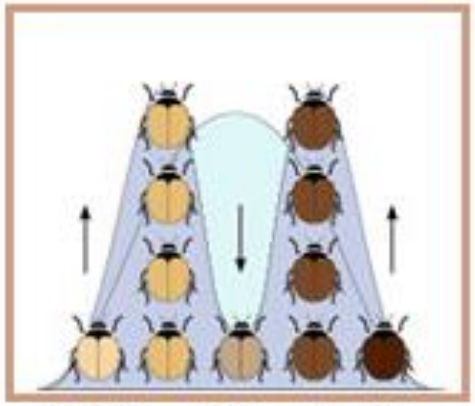
Which type of selection could lead to one species splitting up into 2 separate species? Why?



(b) Stabilizing selection



(c) Directional selection



(d) Disruptive selection

Sexual Selection

- Females choose males based on certain traits
- Males with these traits have higher fitness
  - *Reproductive success*

Artificial Selection

- To find an explanation for change in nature, Darwin studied change produced by **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 – **selective breeding.**
  - *For example, farmers would select for breeding only trees that produced the largest fruit or cows that produced the most milk.*
- Over time, this **selective breeding** would produce trees with even bigger fruit and cows that gave even more milk.
- **Artificial Selection** = humans "select" certain characteristics in plants, dogs, etc., that they find favorable

V. When does evolution create new species? - Speciation

- First off, how do we define a species?
- **Morphological Species Concept** – internal and external structures are used to group organisms into species
- **Biological Species Concept**– defines a species as a population of organisms that can successfully interbreed

V. Speciation

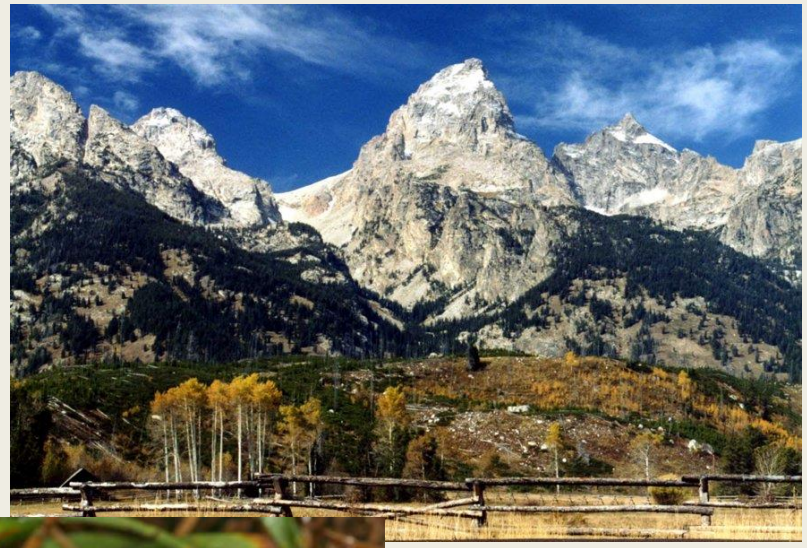
- **Speciation =** formation of a new species

- **Reasons for Speciation**

  1) Geographic Isolation

  2) Reproductive Isolation
     -prezygotic (before fertilization)

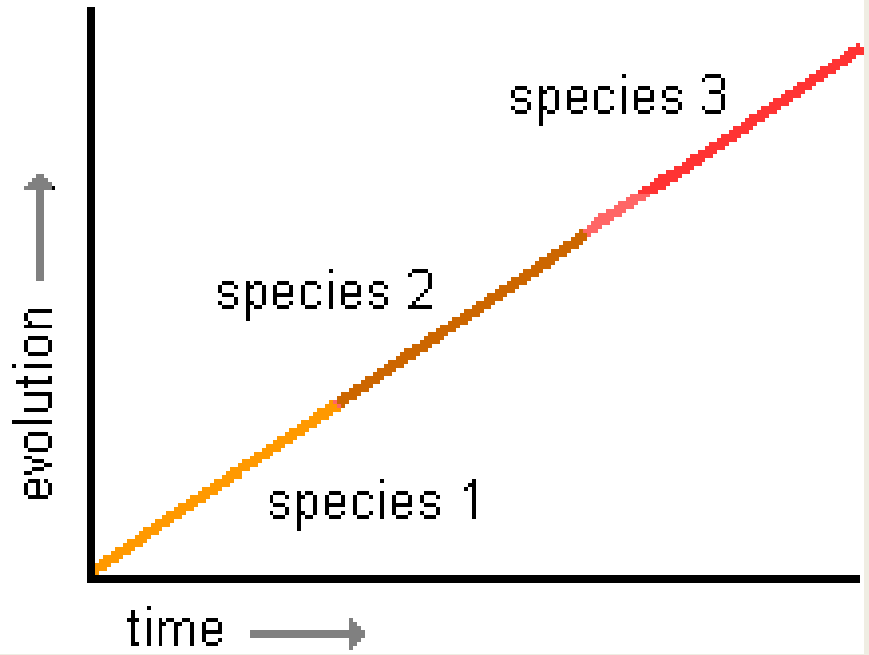
     -postzygotic (after fertilization)



V. Speciation

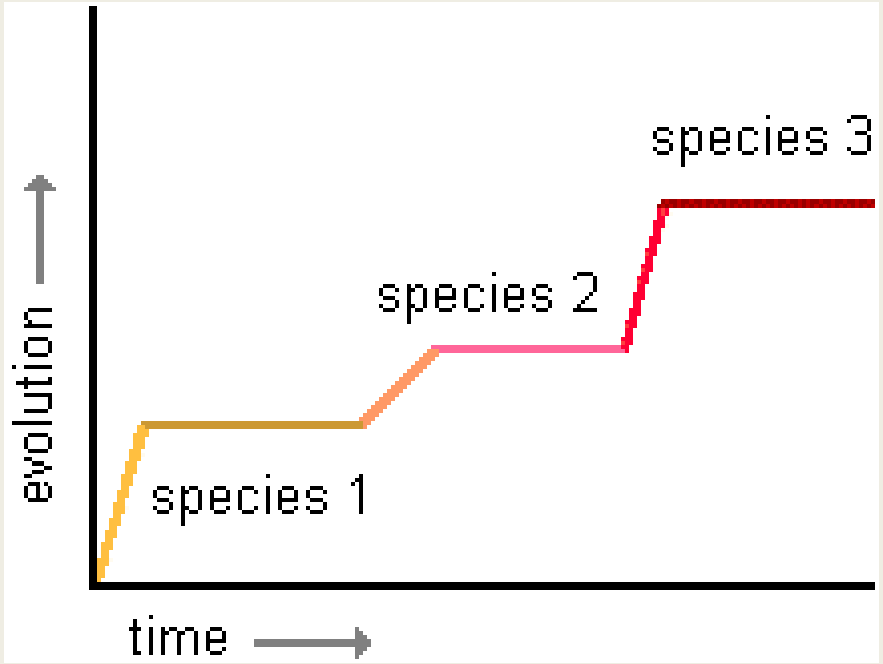
There are two models of speciation, or how populations change over time

Model #1: Gradualism (change happens slowly, and new species are made at a constant rate)

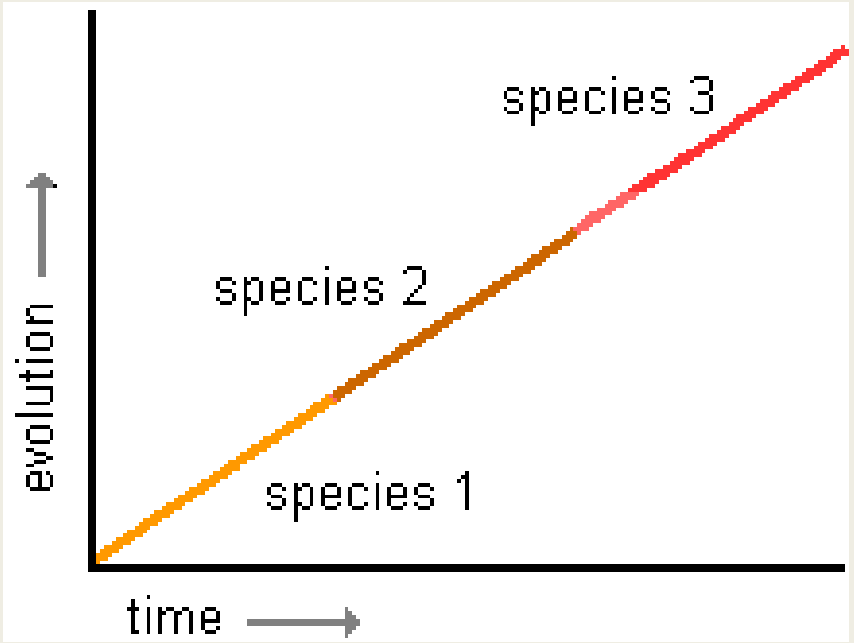


Model #2: Punctuated Equilibrium (there are times of little or no change followed by times of rapid change – often due to major changes in the environment)

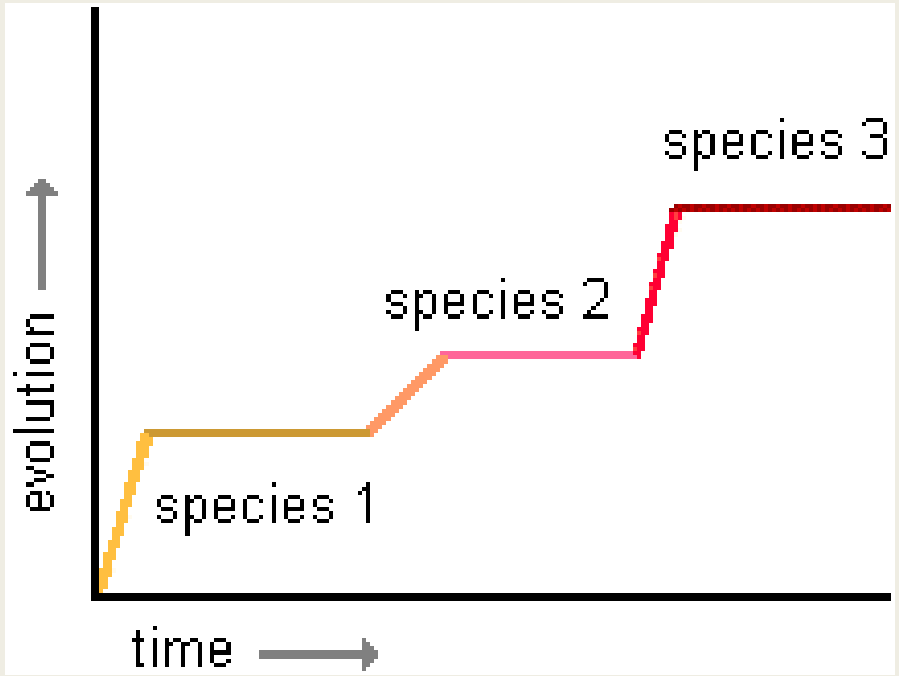
Stephen Jay Gould came up with this model!



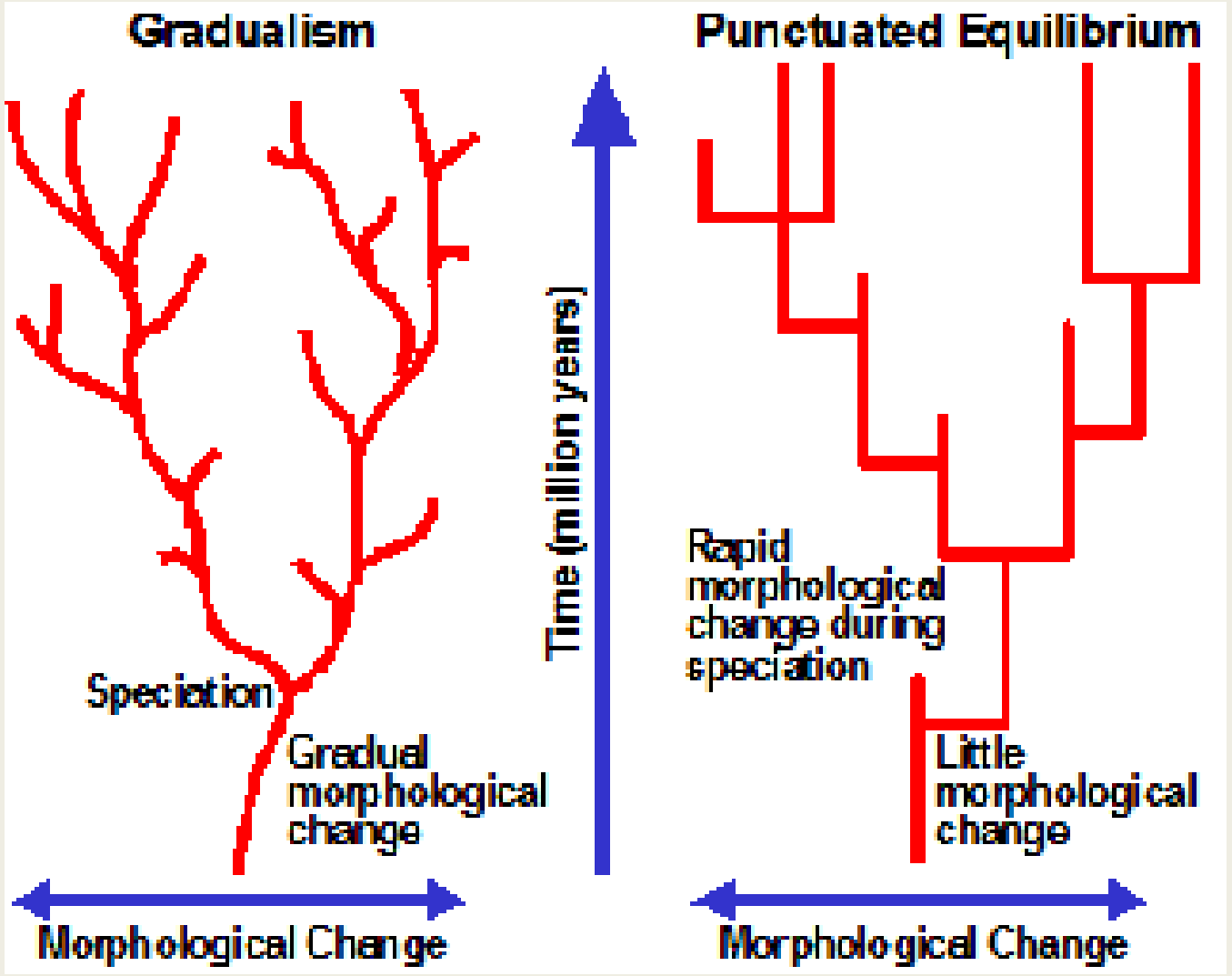
Gradualism



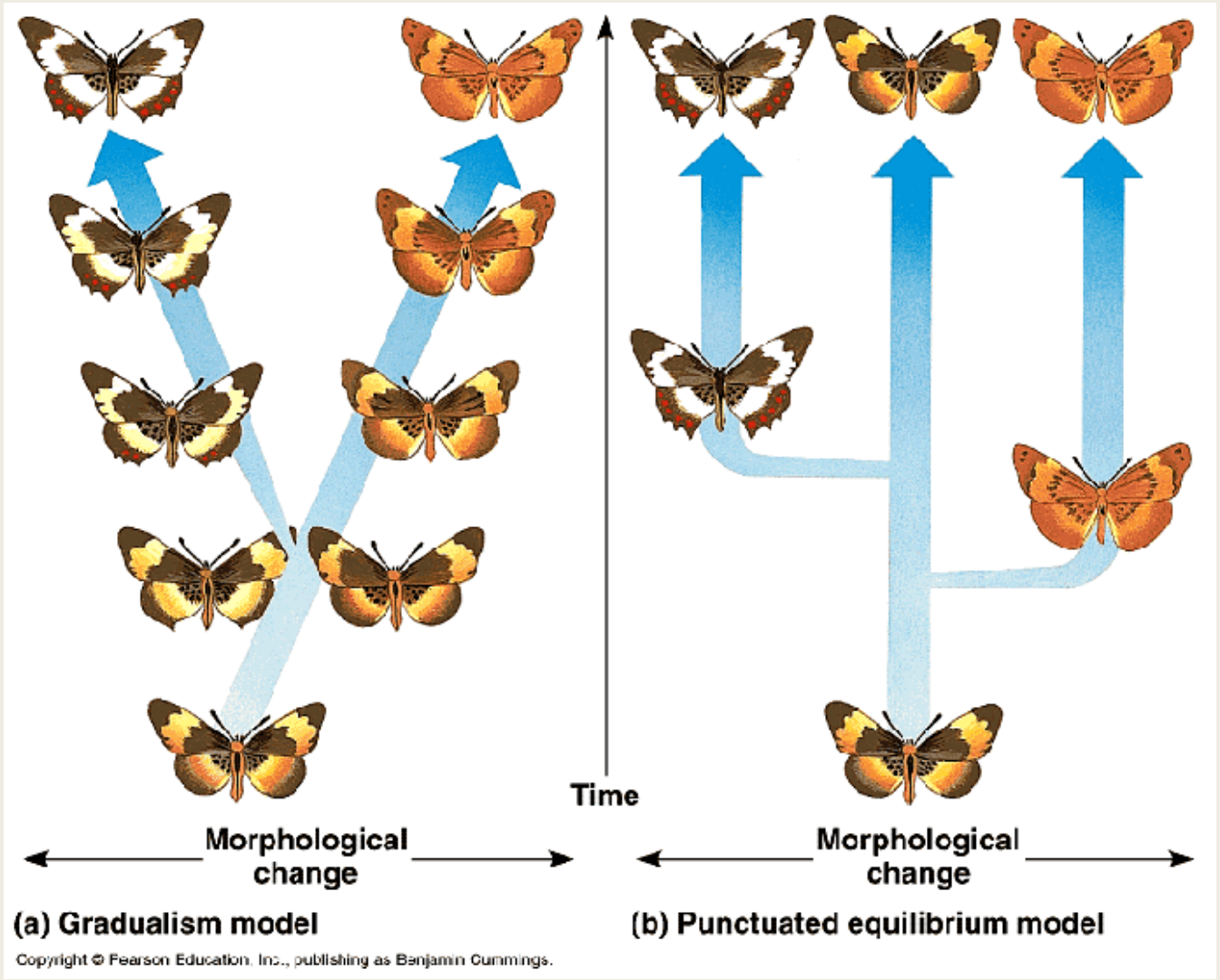
Punctuated Equilibrium



Another Way of Looking at It!



And yet another way of looking at it!



VI. Patterns of Evolution

A) Coevolution = change of two or more species in response to one another

(Ex: predator/prey relationships)

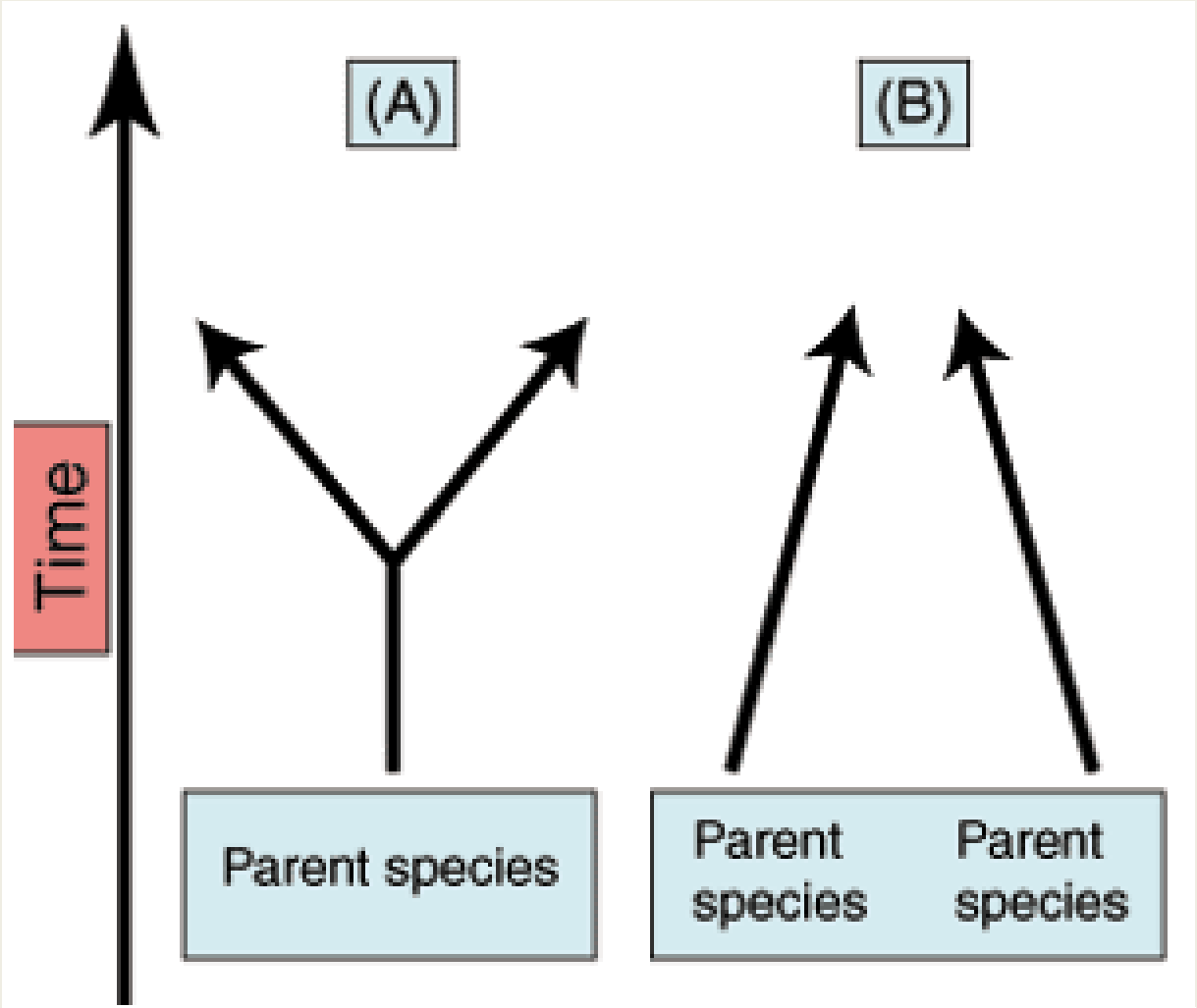
Orchid Fly

Snails + Crabs

VI. Patterns of Evolution

B) Convergent Evolution = organisms with different ancestors become very similar due to environment (Ex: sharks and dolphins)

C) Divergent Evolution = two or more related populations/species become different (Ex: Darwin's finches)

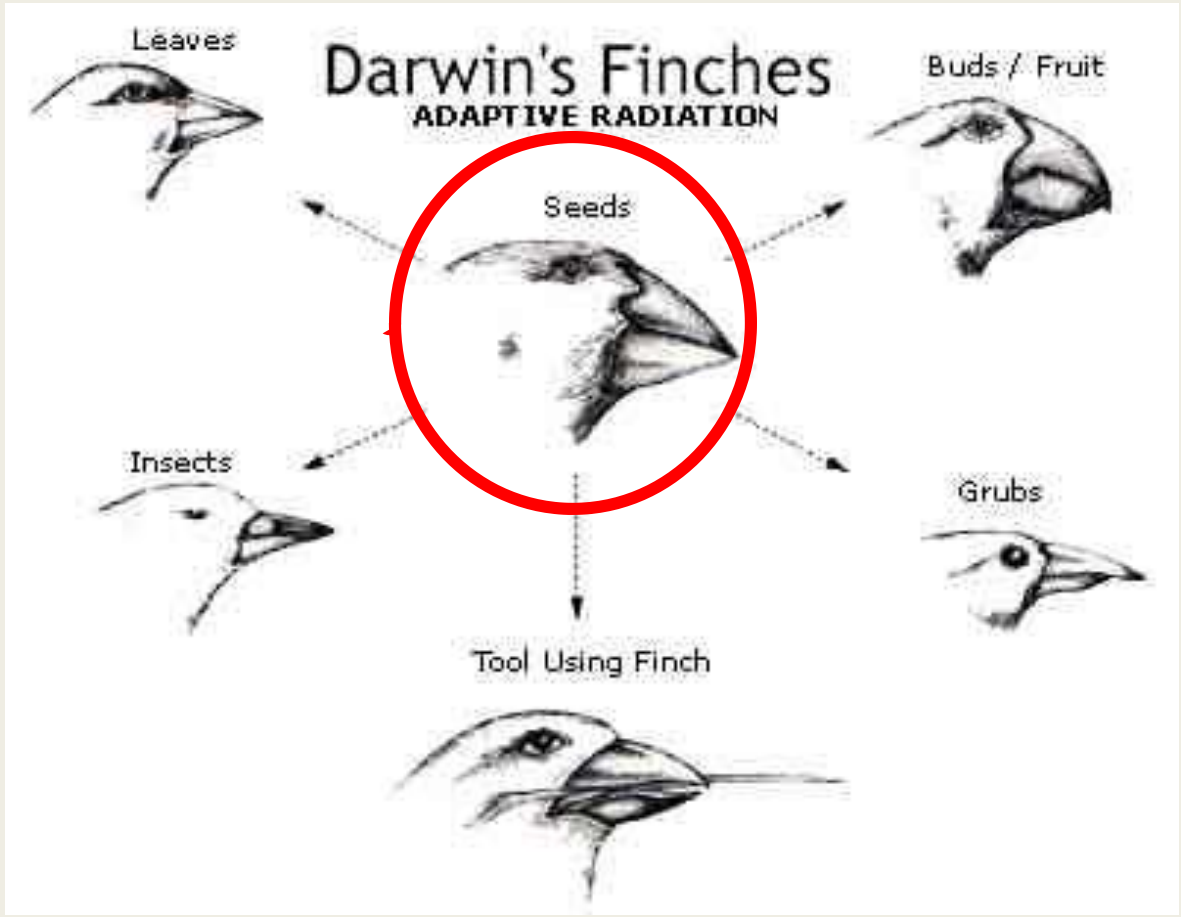


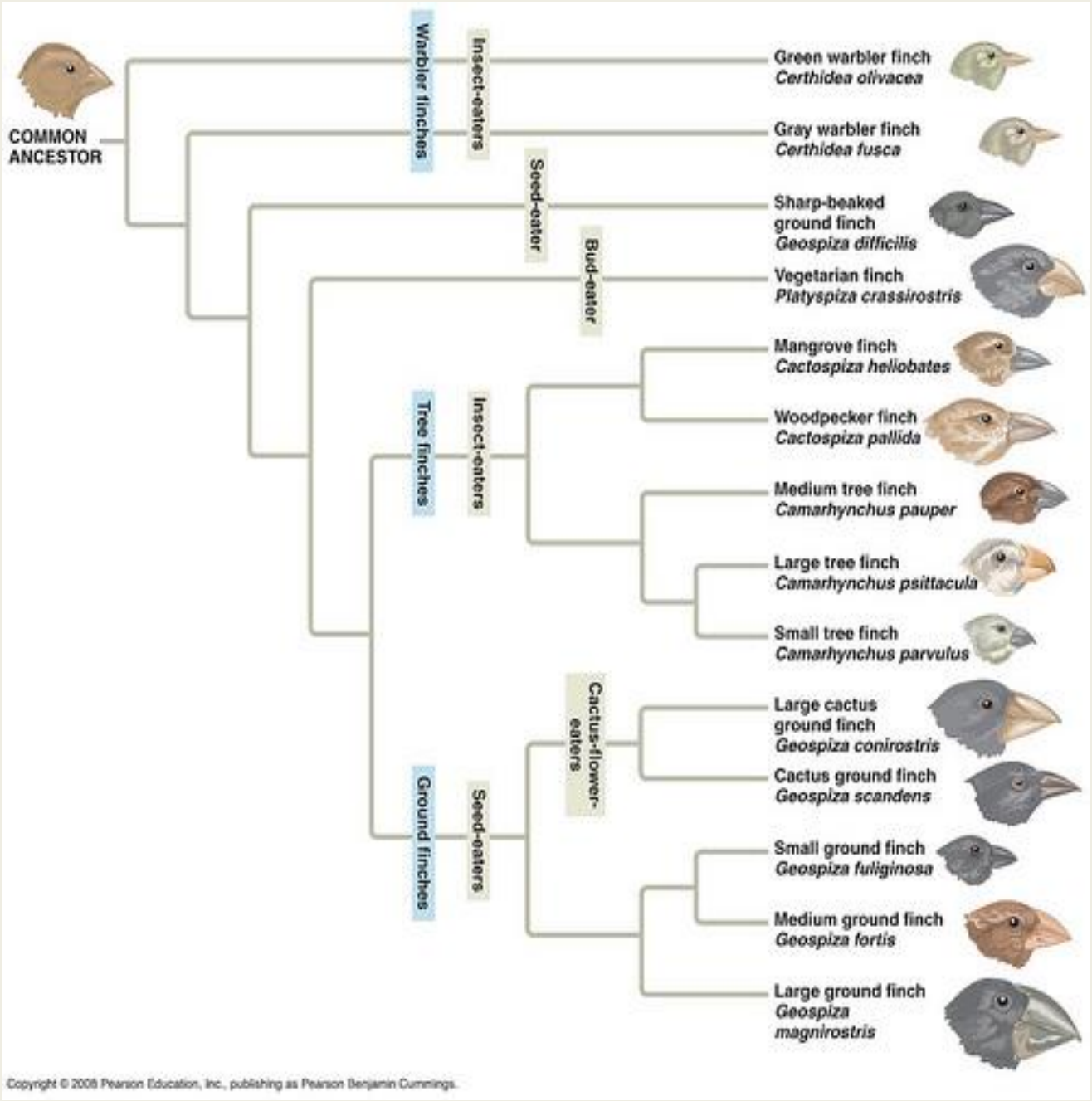
Divergent Evolution

Convergent Evolution

VI. Patterns of Evolution

*D) **Adaptive Radiation*** = an extreme form of divergent evolution where many related species evolve from a single ancestor species



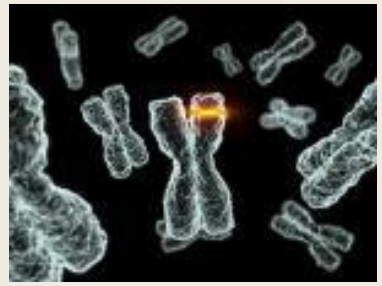


Mechanisms of Change

1. Mutation
   - A change in the DNA sequence.

   (1 in 100,000) leads to new traits.

   Some traits will be advantageous to the species.



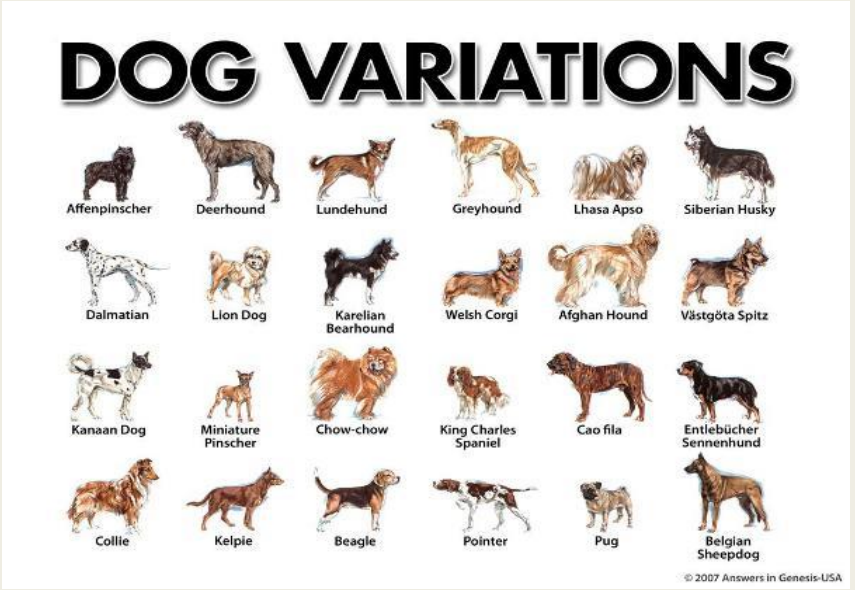
2. Migration
   - Movement of individuals form

   one population into another.
   - Can alter the genetic

   characteristics of a population.

Mechanisms of Change

3. Nonrandom Mating- controls the genes
   - When individuals mate with one another more or less frequently: **example inbreeding**.
4. Selection
   - Artificial Selection – individuals breed organisms for specific traits.
   - Natural Selection - environment dictates Which traits are needed to survive.



Mechanisms of Change

5. Genetic Drift
   - Random loss of alleles. Small population a person does not reproduce.
     - Founder effect – one or a few individuals migrate and become an isolated population with distinct genotypes.
       - The population splits due to migration events
     - Bottle neck – restrictions in genetic variability due to flooding or natural disasters.
       - The population splits due to natural disasters

Speciation
(How do we get a new species?)

- Usually involves successive change
  - Local populations of a species become isolated and more specialized (adapted)
  - Natural selection acts to keep them specialized (different from the larger population)
- Convergent Evolution v. Divergent Evolution

- Populations of a species *must* become <u>reproductively isolated</u> in order to develop into new species.

Variations vs. Adaptations

- **Variations** – differences that exist within a population that may have no effect on fitness
  - *Ex: length of your thumb*

- **Adaptations** – a variation that **all** members of a population have inherited because that trait improves fitness
  - *Ex: an opposable thumbs*

Sources of variation

- Sources of variation:
  - ***Mutations*** *– individual genes change*
    - Ex: ATC → AGC
  - ***Events during meiosis*** *– during meiosis, chromosomes get mixed up (crossing over) in making eggs & sperm*
  - ***Random fusion of gametes*** *– which sperm fertilizes which egg – determined by chance*