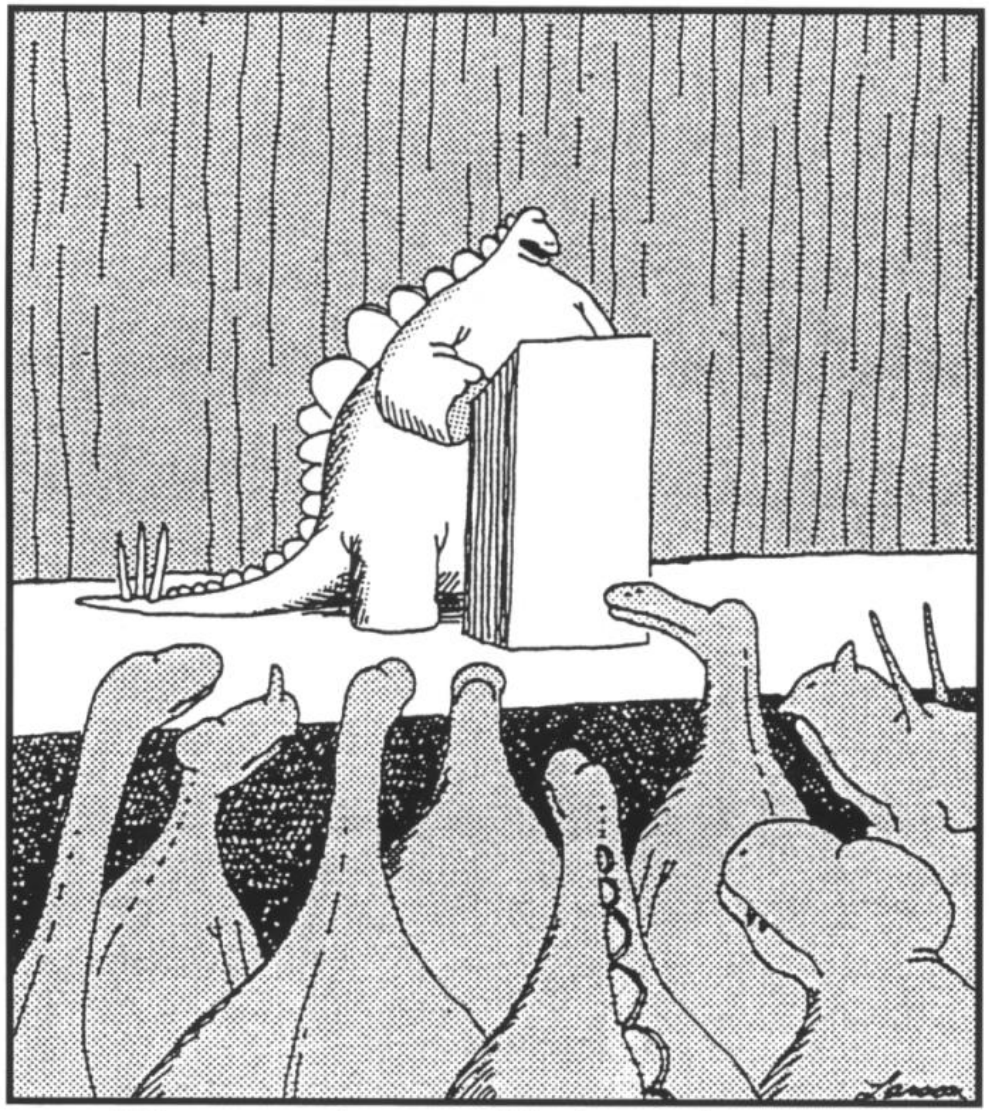
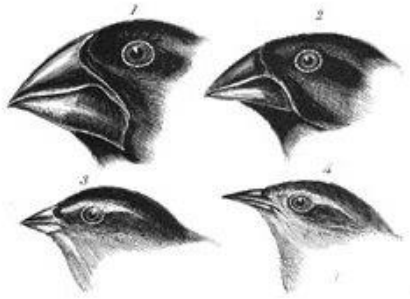


"The picture's pretty bleak, gentlemen. . . .
The world's climates are changing, the mammals
are taking over, and we all have a brain
about the size of a walnut."

Evolution

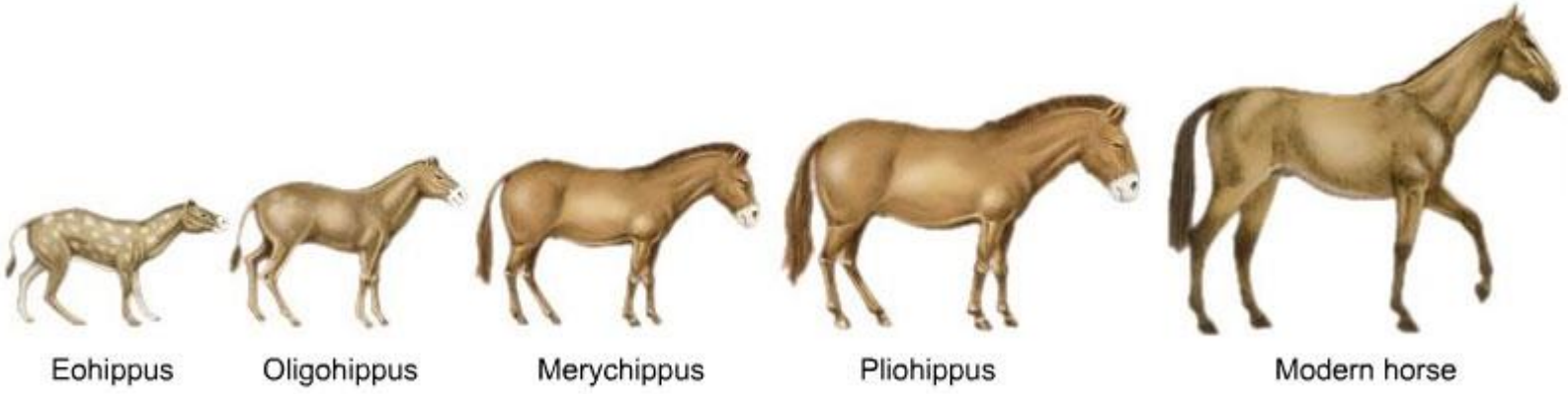


Theory:

A well-substantiated **explanation of some aspect of the natural world**, based on a body of facts that have been repeatedly confirmed through **observation and experimentation**.

Evolution:

Decent with modification; transformation of a species through time, including both changes that occur within species, as well as the origin of new species.



EVOLUTION

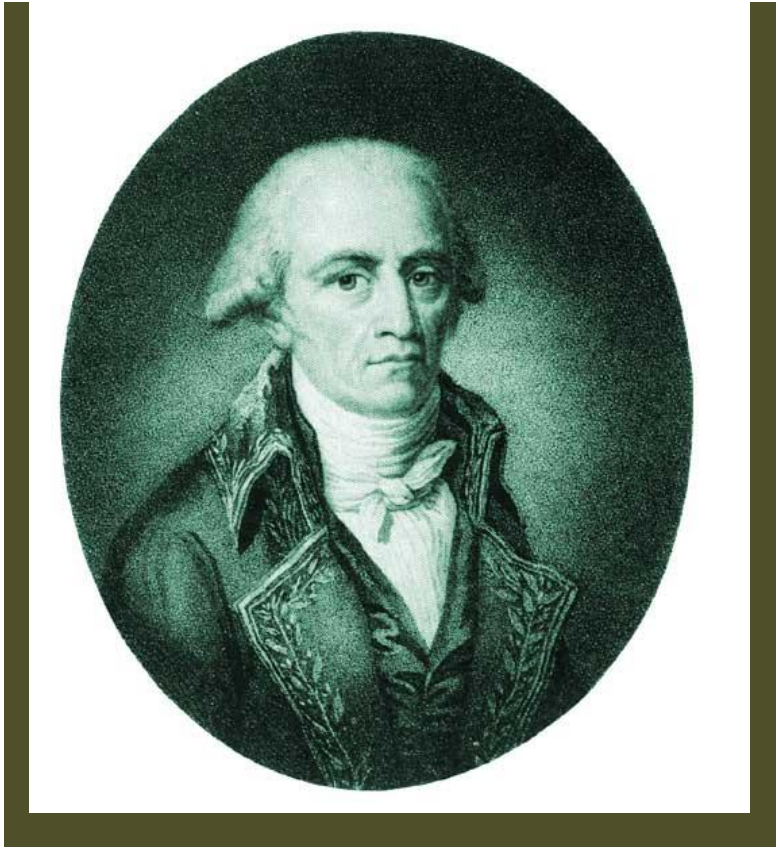
HUTTON & LYELL

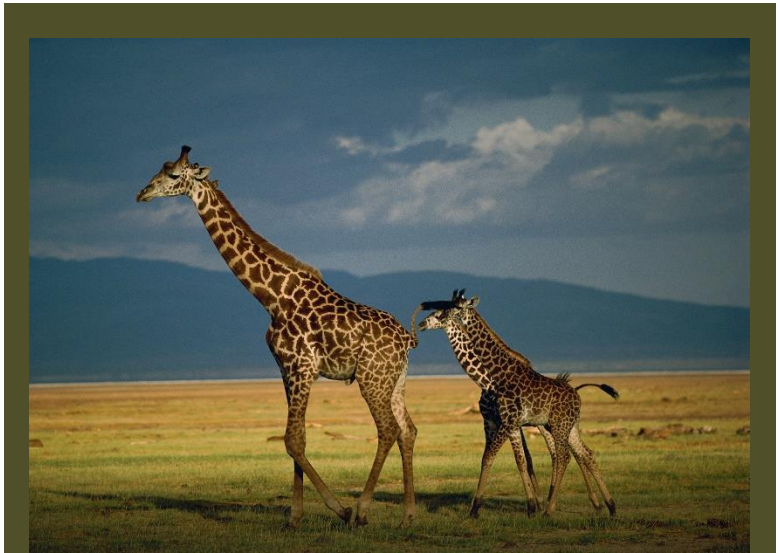
Hutton – *Geological forces take a long time and therefore Earth must be more than a few thousand years old.*

Lyell – *The forces that shaped the Earth took much longer than a few thousand years and these same forces are in action presently.*

1795 – *Lyell Provided conclusive evidence to support the theory of gradualism first proposed by James Hutton.*

Gradualism – profound geologic change can happen over long periods of time and these same forces are still active today.



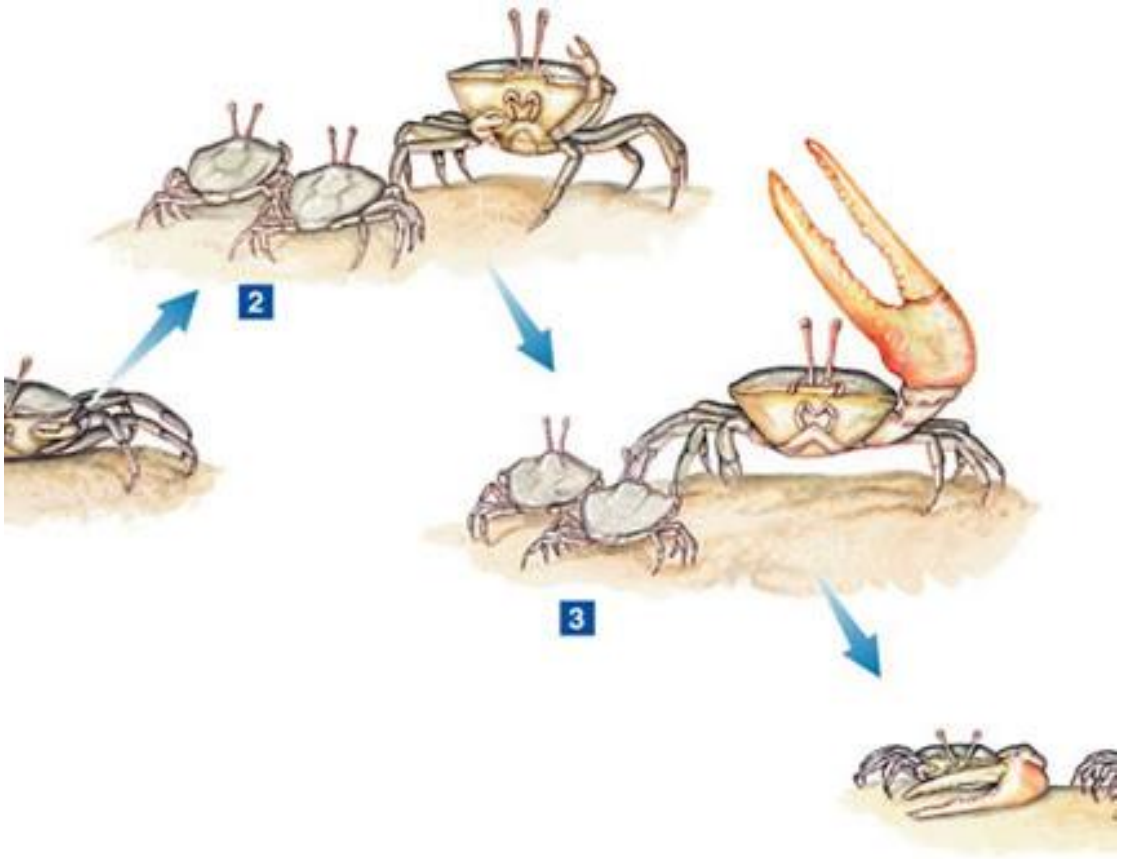


Early ideas about Evolution

Jean Baptiste Lamarck

One of the first to recognize that living things have changed over time.

Individual organisms can cause physical changes in a lifetime that are then passed on to their offspring.



Early Ideas About Evolution

Lamarck's Theory of Evolution:

1. All organisms continually change

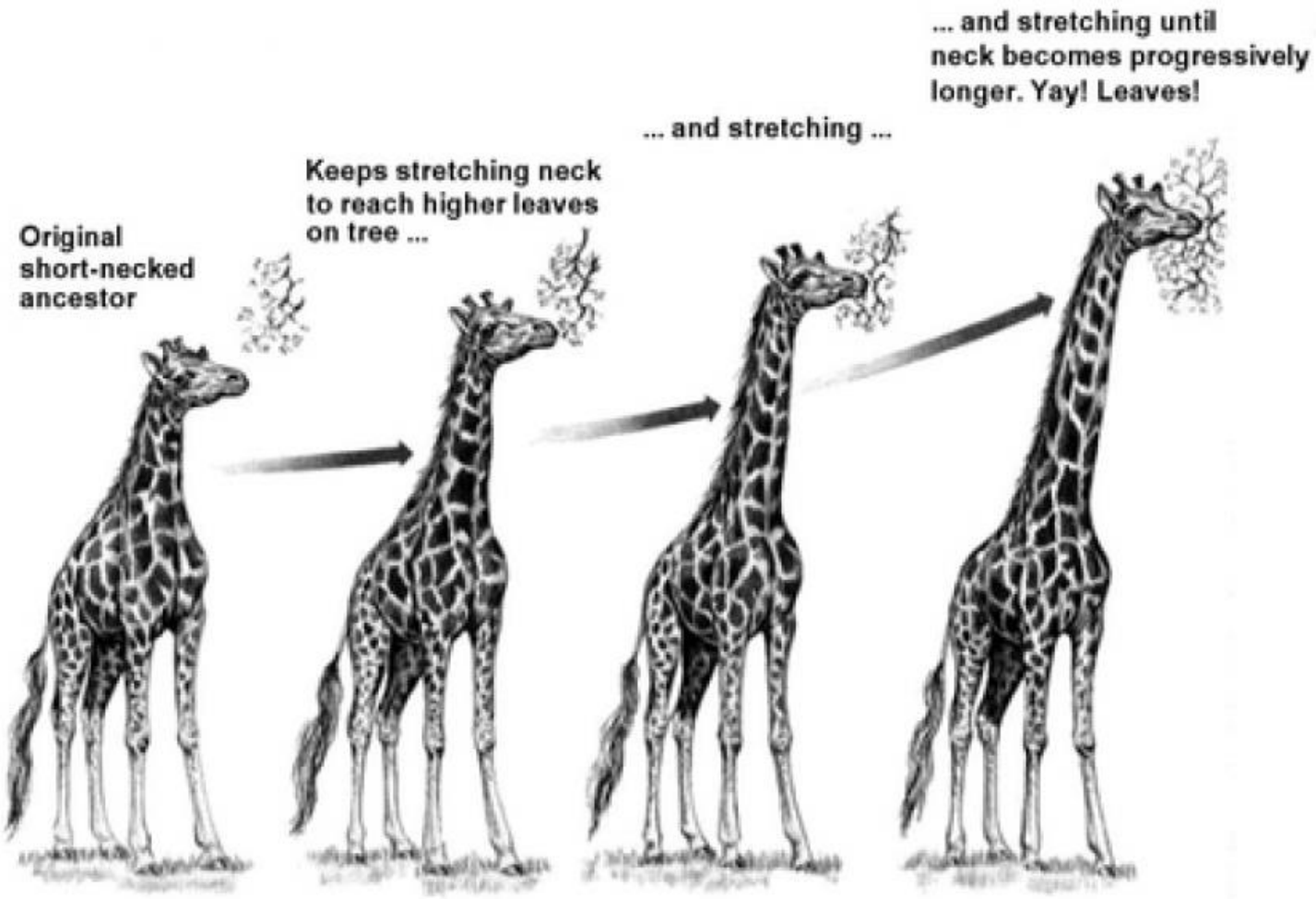
   in order to reach "**perfection**".

2. Organisms can alter their bodies

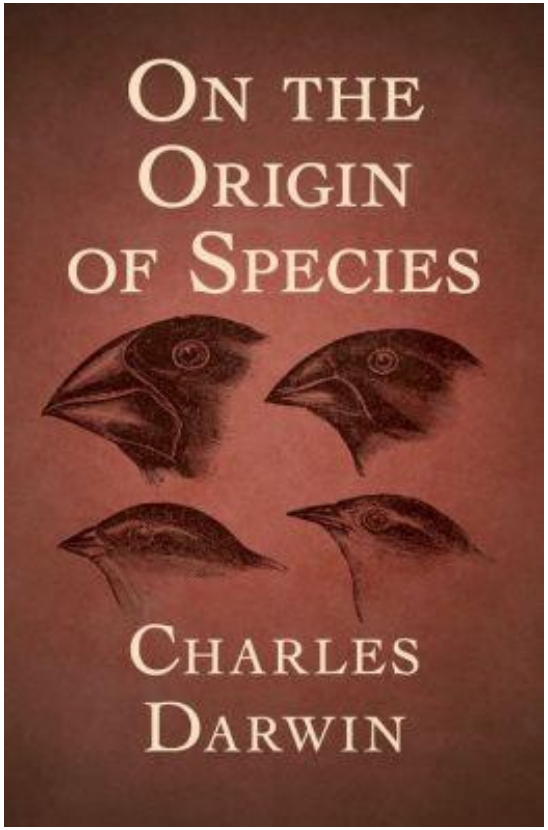
   by **use and disuse**

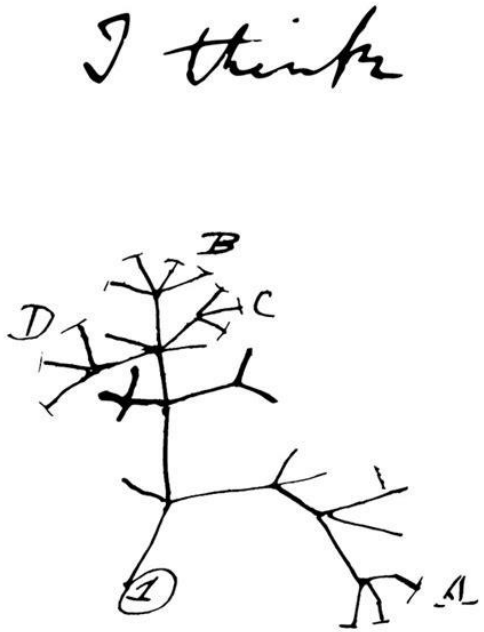
3. He claimed that these **acquired**

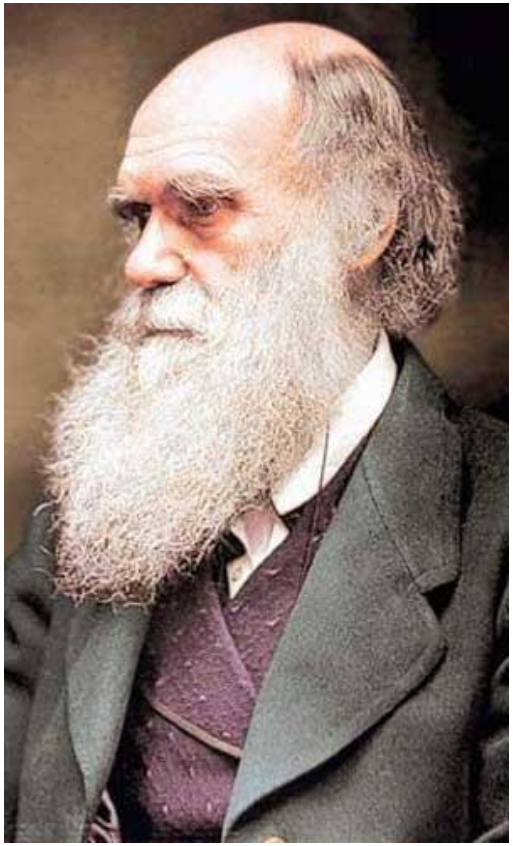
   characteristics can be inherited



Lamarck's Giraffe







Charles Darwin
1809 - 1882

Darwin's Inferences

Three inferences based on five observations:

Observation 1

Populations have the potential to increase exponentially.

But…

Observation 2

Populations generally remain stable once they reach a certain size.

And…

Observation 3

Natural resources are limited

Inference #1

Not all offspring survive and reproduce because of a struggle for resources.

Darwin's Inferences

Three inferences based on five observations:

Observation 4

Individuals in a population are not identical, they vary in many characteristics.

And…

Observation 5

Many characteristics are heritable.

Inference #2

Some individuals are more likely to survive and reproduce because of their heritable traits.

Darwin's Inferences

Three inferences based on five observations:

Inference #1

Not all offspring survive and reproduce because of a struggle for resources.

And…

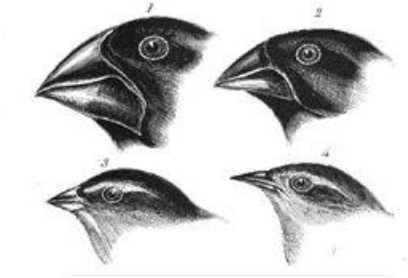
Inference #2

Some individuals are more likely to survive and reproduce because of their heritable traits.

Inference #3

Difference in survival is non-random, with some traits being passed on at a higher rate will appear more frequently in the next generation.

Principles of Evolution



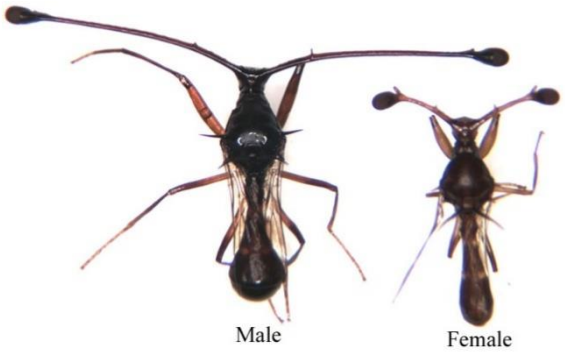
<u>Adaptation</u>:

A change or the process of change by which an organism or species becomes better suited to its environment.

Inherited

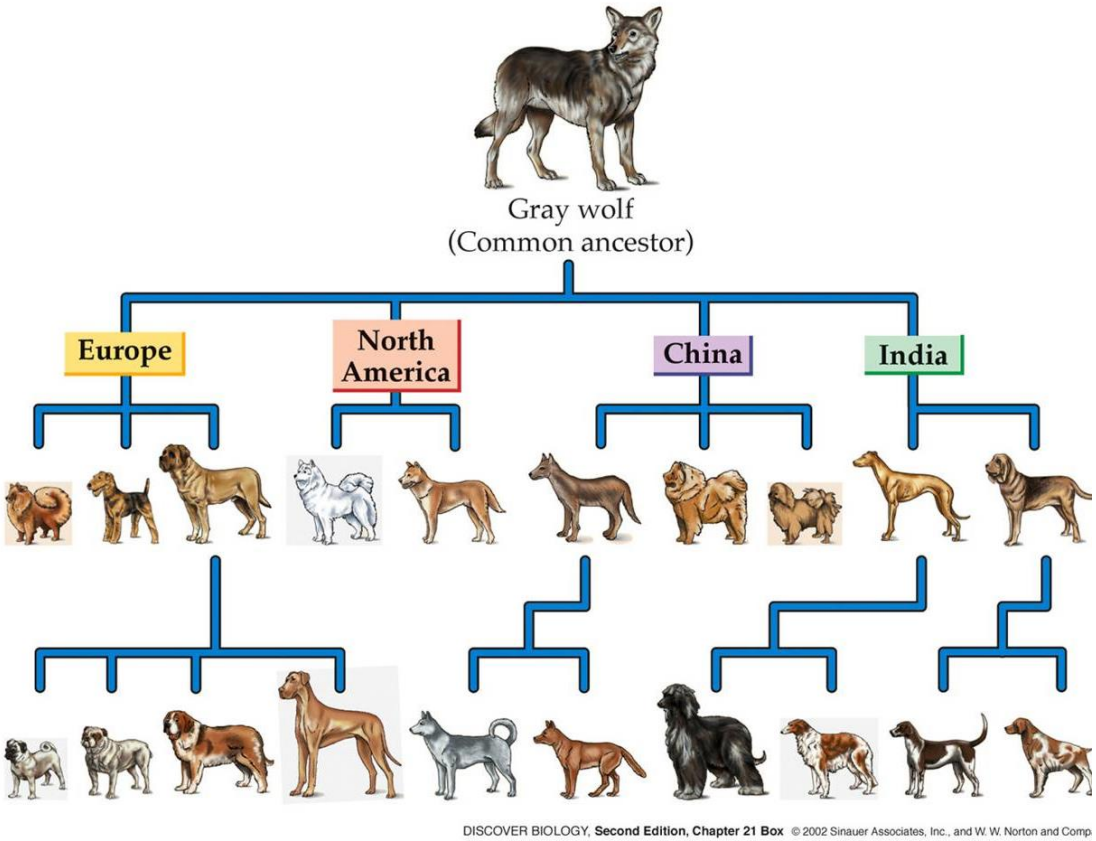
Behavioral

Teleopsis breviscopium



<u>Fitness</u>:

the genetic contribution of an individual to the next generation's gene pool.



Principles of Evolution cont.

Artificial Selection:

accelerated change in species when organisms were bred for specific characteristics.

Principles of Evolution cont.

Natural Selection: The process in which individuals with a particular trait tend to leave more offspring in the next generation than do individuals with a different trait.

Two Basic Ideas:

1. Organisms usually produce **more than enough offspring**.

2. All individuals formed from sexual reproduction will be genetically different. (**Genetic variation**)

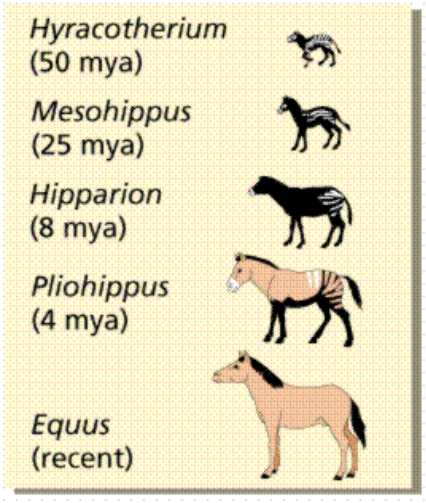
Natural Selection

For natural selection to occur there must be…

1. **A struggle for existence.** Individuals and species compete for limited resources available in their environments and only some are successful.

2. **Survival of the fittest:** only those species best adapted for their environment survive and pass on genetic traits

3. **Descent with modification:** all living species have descended (with changes) from other species



Natural Selection ➡ Evolution

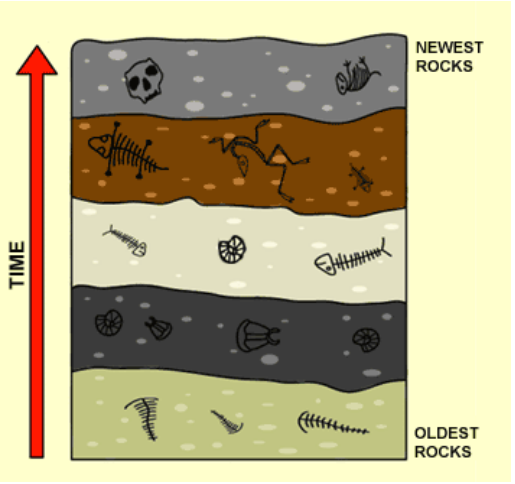
How can natural selection lead to evolution?

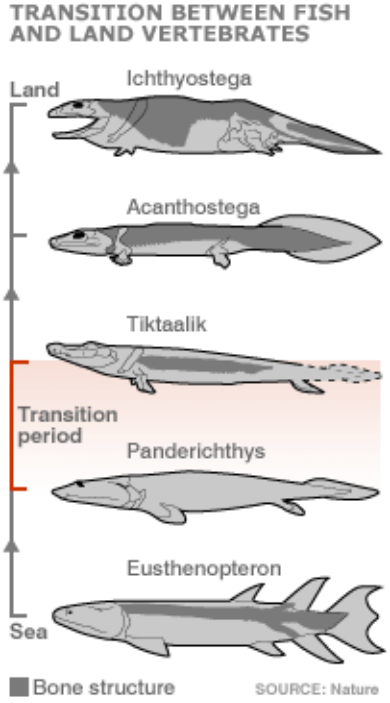
1. Genetic mutations can increase variations that may become successful
2. Environments change so genes in populations shift with the need to adapt to different conditions

Evidence of Evolution

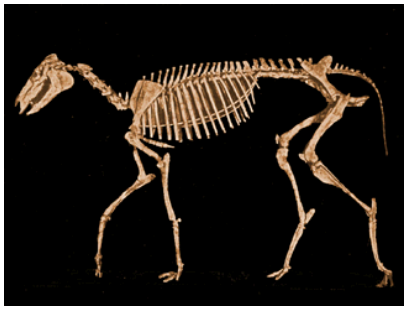
Fossil Records

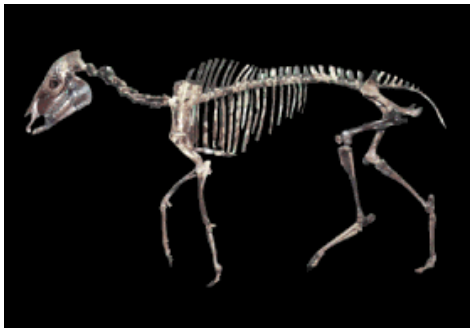
- By comparing fossils from different rock layers, scientists can see how life has changed over time.
- Hundreds of transitional fossils have been found which show in between stages of evolution. This is an "incomplete record" with many gaps

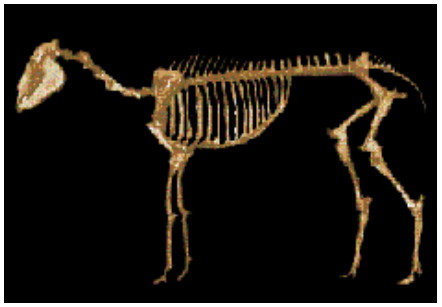


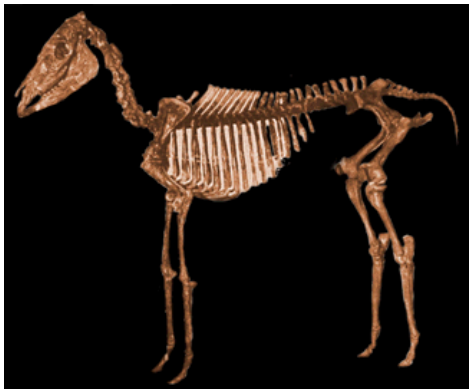


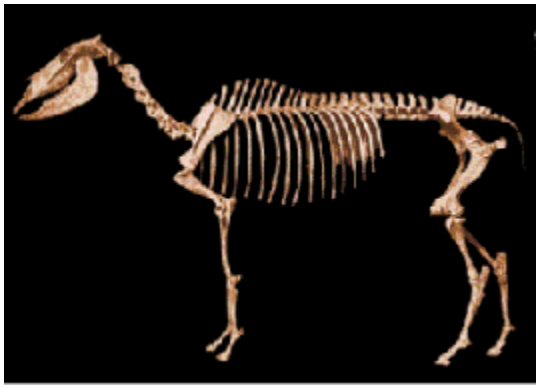
Evolution of the Horse

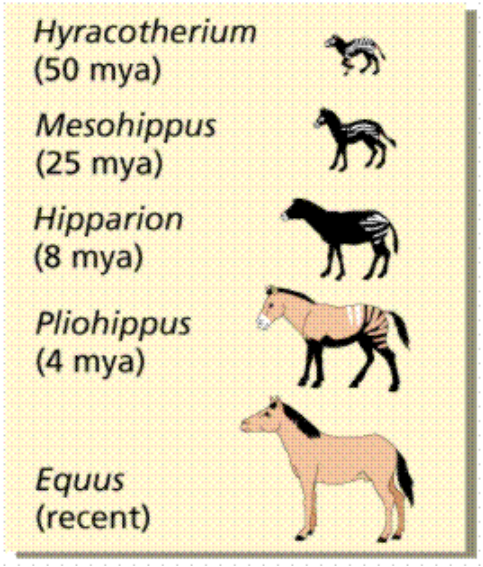












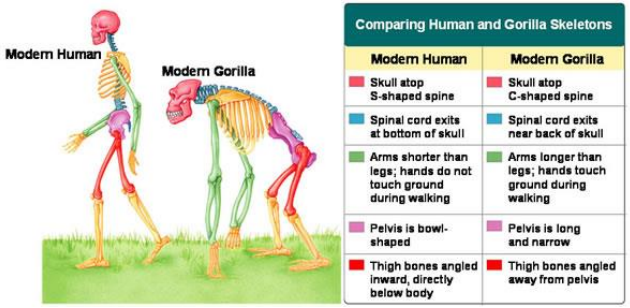
Evidence of Evolution

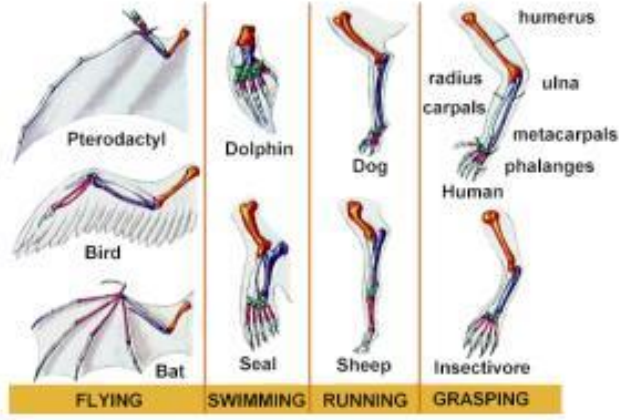
Anatomical Adaptations

- *Homologous structures:* structures that are the same between different organism even though the functions may differ based on adaptations to the environment

- Supports the idea

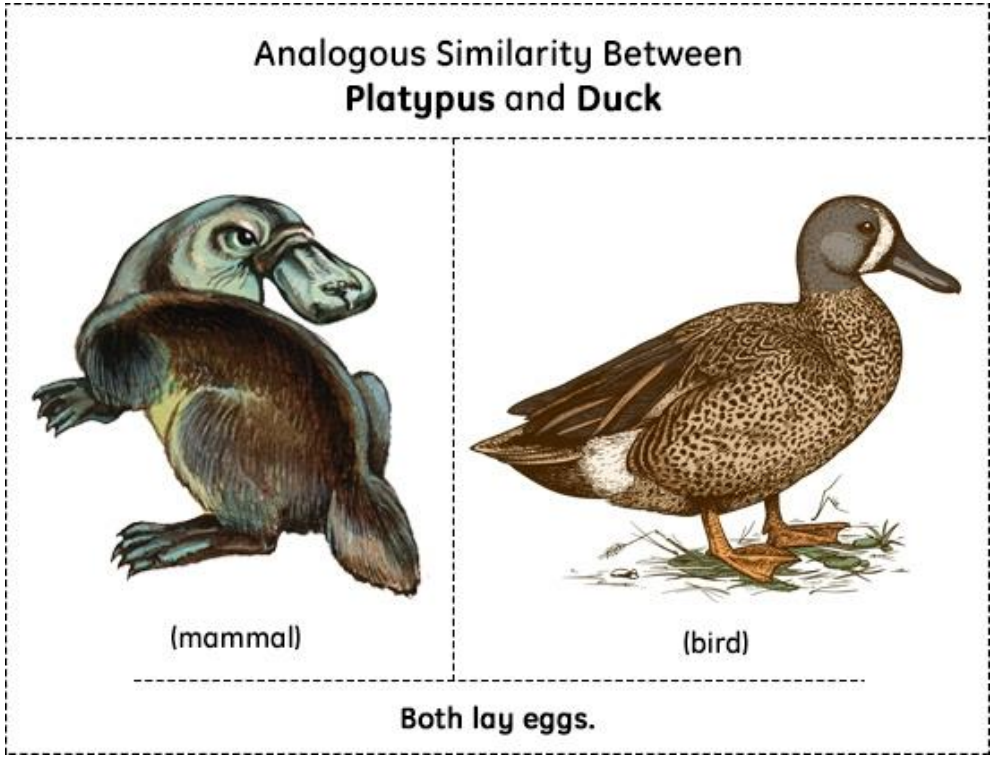
  of a **common ancestor**





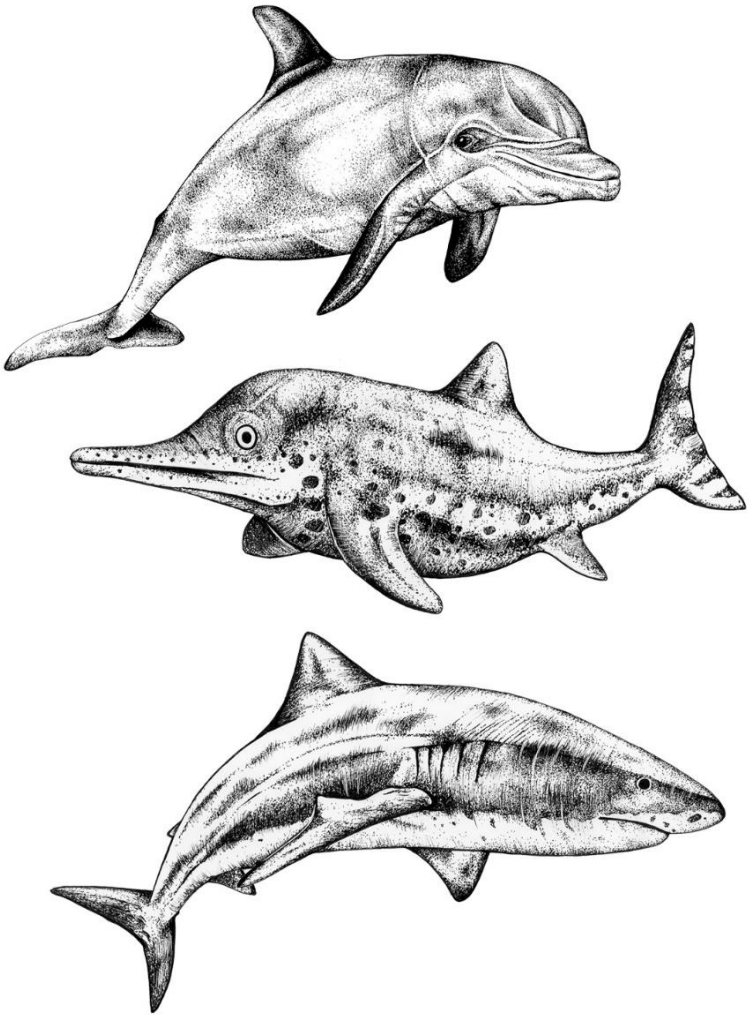
EVIDENCE OF EVOLUTION

Analogous structures: structures that are formed differently for different organism even though the function may be the same



Evidence of Evolution

Convergent Evolution: the process by which unrelated species evolve similar physical characteristics because they have similar lifestyles.

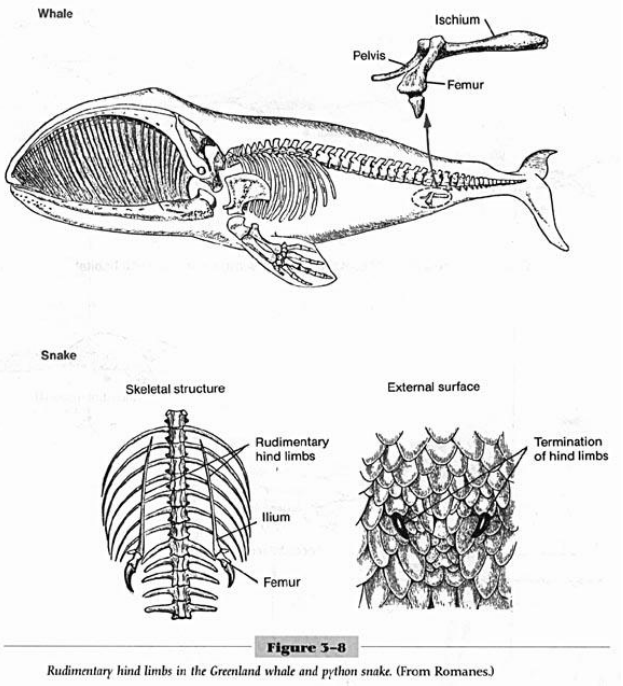


Evidence of Evolution

Vestigial Structures

Anatomical structures that appear to have no present day use but may have been used in ancestral species

Human “tailbone”



Pelvic bones in whales and snakes

VESTIGIAL STRUCTURES IN HUMANS

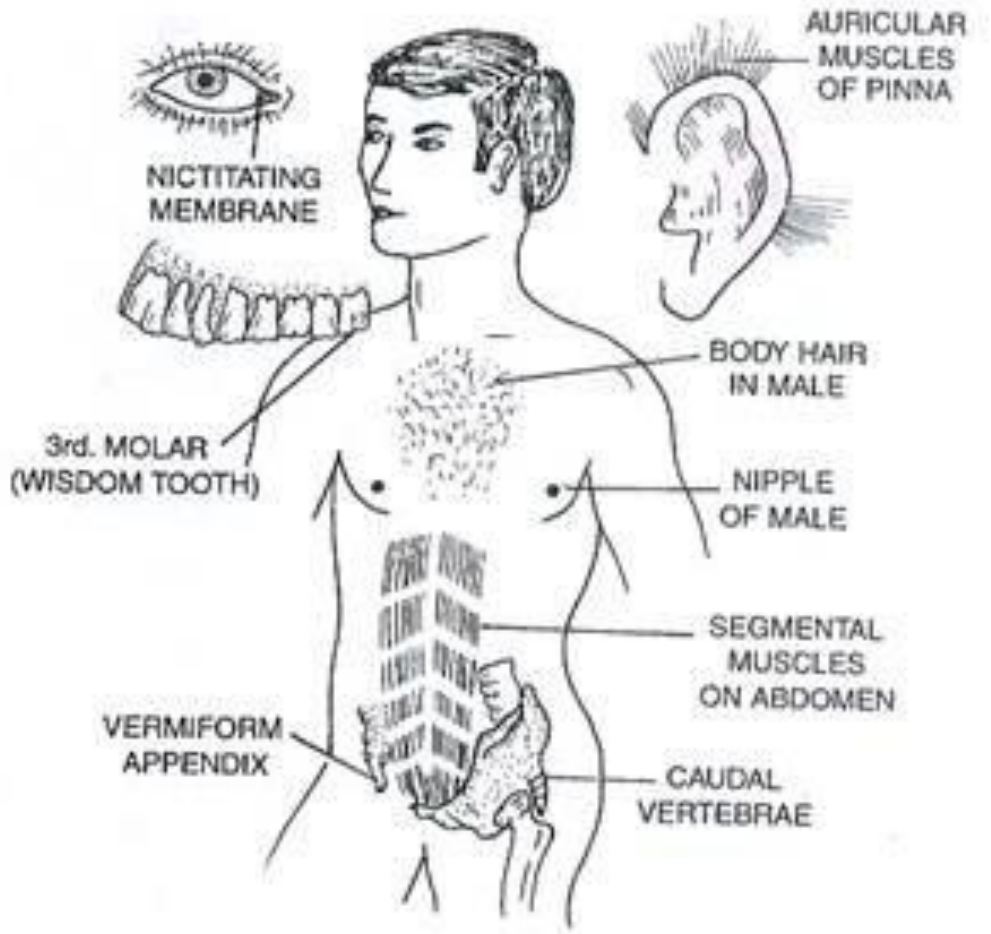
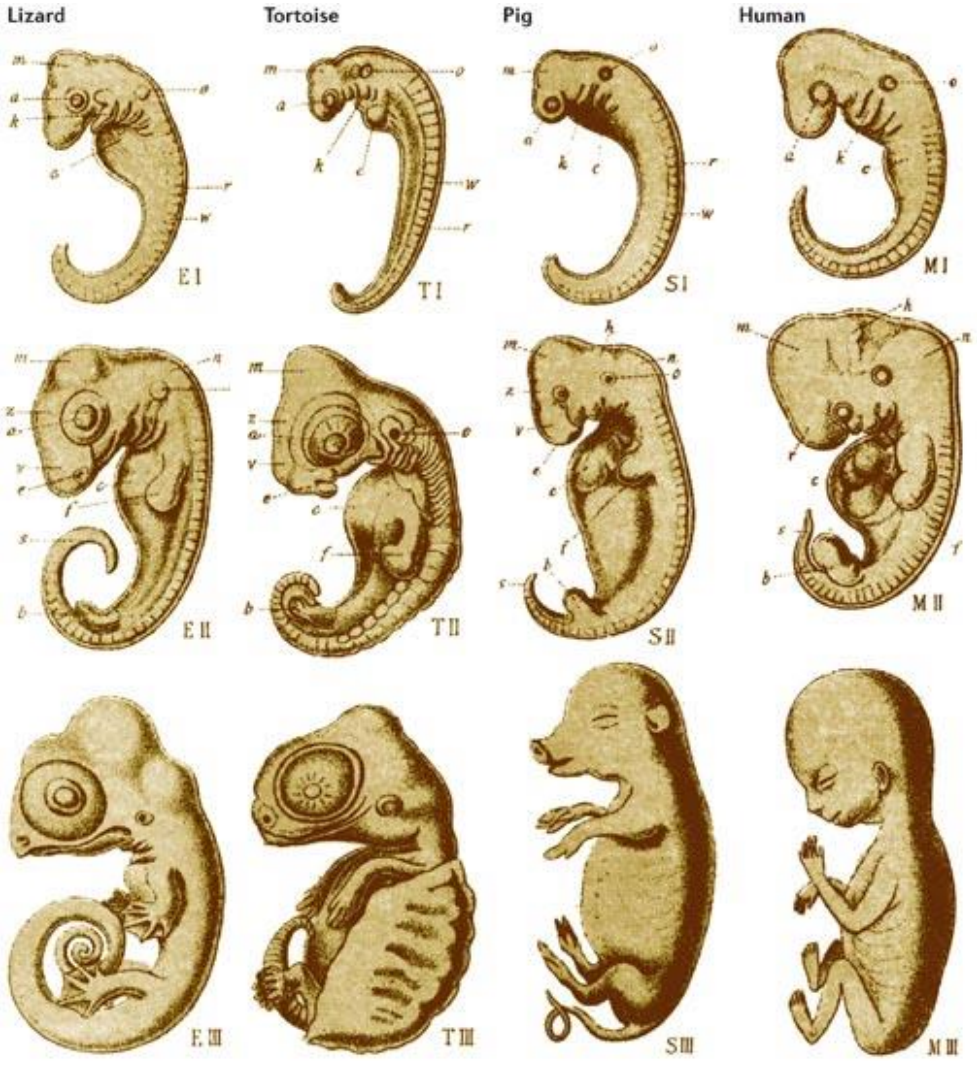


Fig. 7.26. Some vestigial organs in human body.

Evidence of Evolution

Embryology

The study of similarities in organisms during embryonic stages of development



Evidence of Evolution

Biochemistry

- The same DNA bases are used in all life forms
- DNA sequences differ based on evolutionary relationships

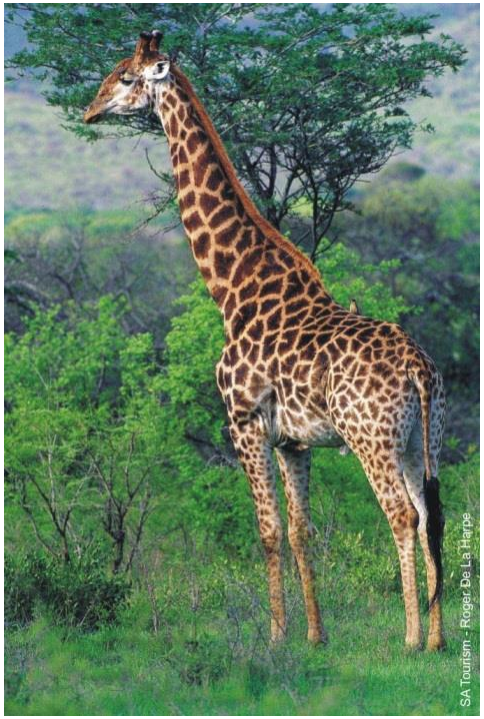
Examples: Human DNA is 98% similar chimpanzees

Human DNA is 30% similar to a banana!

Evidence of Evolution

Structural Adaptations

Examples: long necks in giraffes,
webbed feet in a duck



Evidence of Evolution

octopus

Predator-Prey Relationships

Examples: camouflage, mimicry

The Mimic Octopus (All **Three** Pictures!!)

Mimics: flatfish, sea snakes, jawfish, mantis shrimp, lionfish and others!

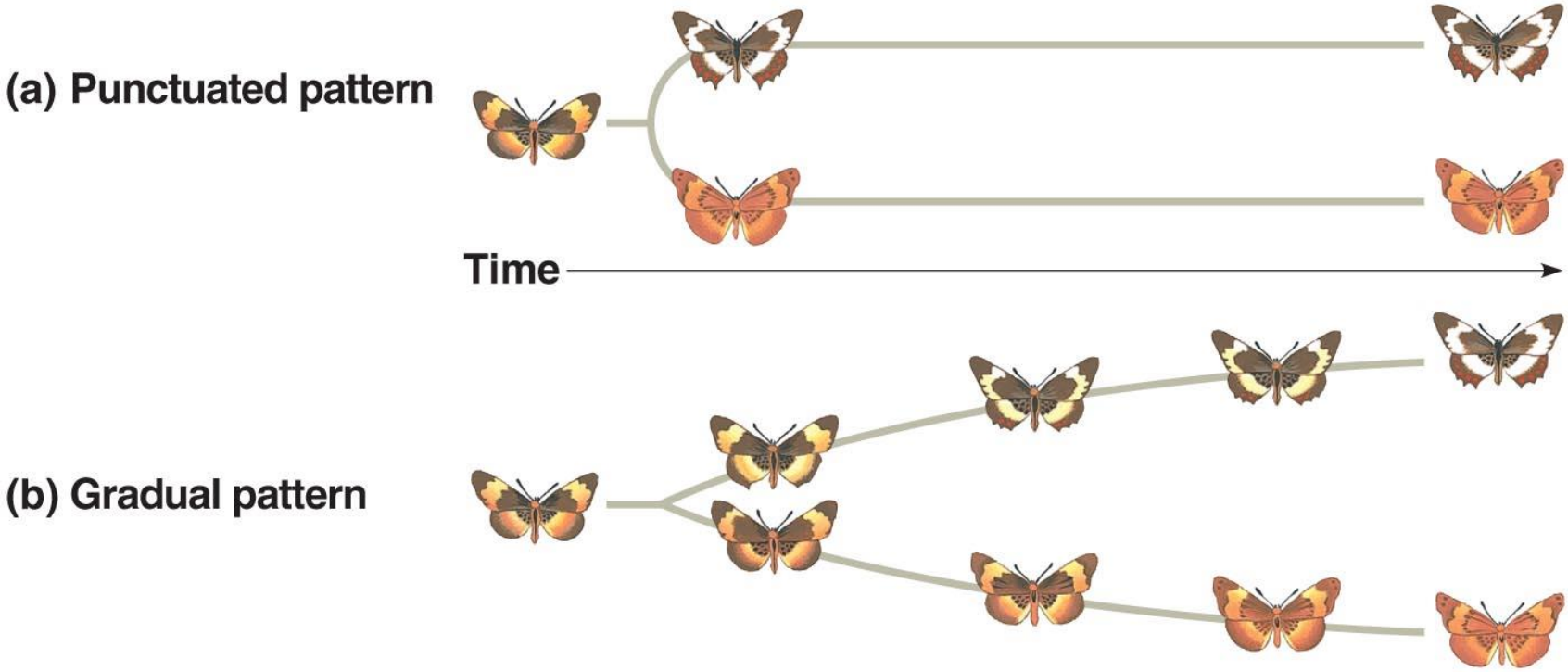
Modern Synthesis of Evolution

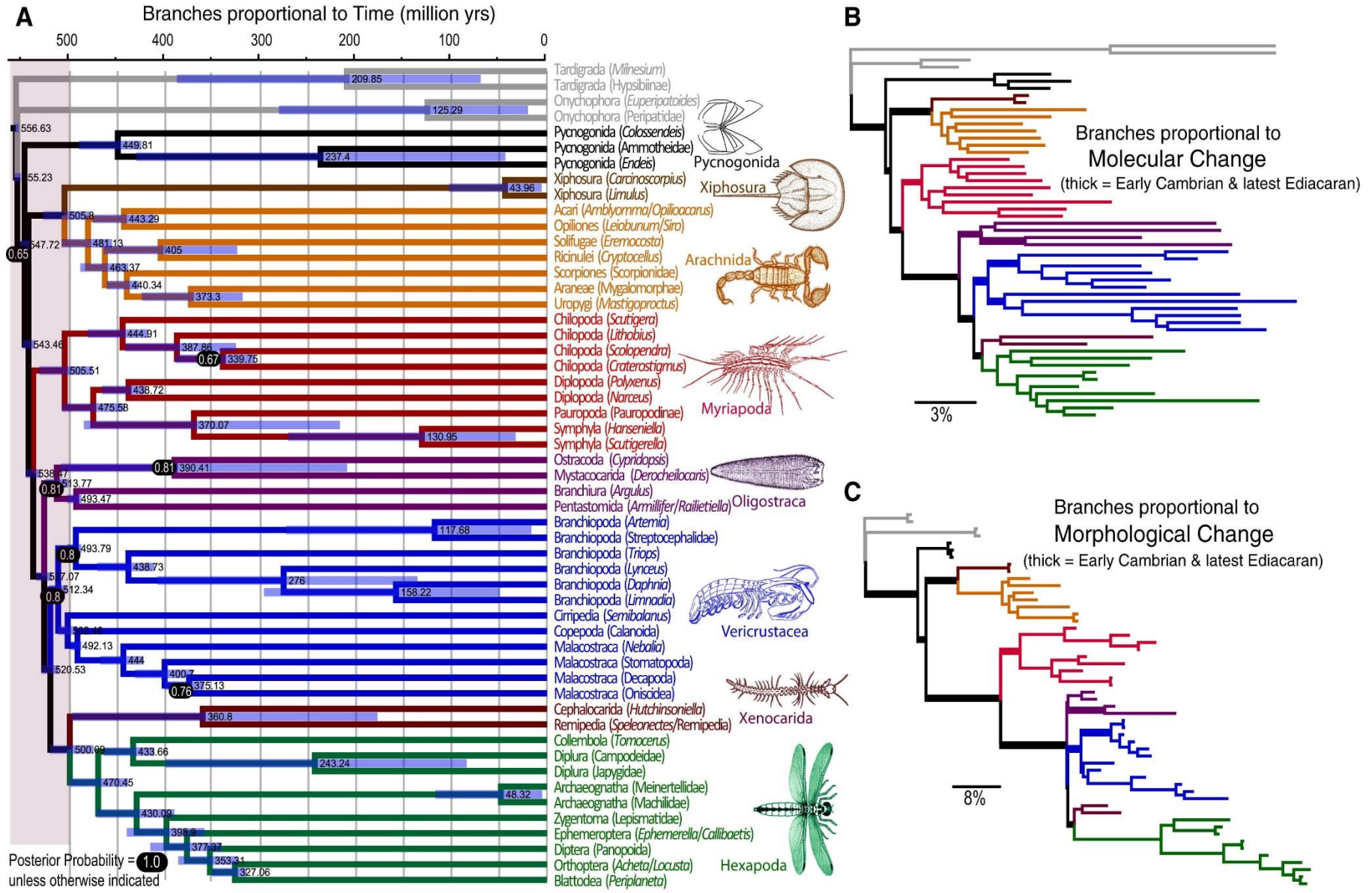
The **modern synthesis of evolution** states that:

1. Populations as the unit of evolution.

2. Natural selection as the most important mechanism of evolution.

3. Gradualism explains how large changes can evolve as an accumulation of small changes occurring over long periods of time.




A
Branches proportional to Time (million yrs)
500
400
300
200
100
0
Tardigrada (Milnesium)
Tardigrada (Hypsibiinae)
Onychophora (Euperipatoides)
Onychophora (Peripatidae)
Pycnogonida (Colossendeis)
Pycnogonida (Ammotheidae)
Pycnogonida (Endeis)
Xiphosura (Carcinoscorpius)
Xiphosura (Limulus)
Acari (Amblyomma/Opilioacarus)
Opiliones (Leiobunum/Siro)
Solifugae (Eremocosta)
Ricinulei (Cryptocellus)
Scorpiones (Scorpionidae)
Araneae (Mygalomorphae)
Uropygi (Mastigoproctus)
Chilopoda (Scutigera)
Chilopoda (Lithobius)
Chilopoda (Scolopendra)
Chilopoda (Craterostigmus)
Diplopoda (Polyxenus)
Diplopoda (Narceus)
Pauropoda (Pauropodinae)
Symphyla (Hanseniella)
Symphyla (Scutigerella)
Ostracoda (Cypridopsis)
Mystacocarida (Derocheilocaris)
Branchiura (Argulus)
Pentastomida (Armillifer/Railietiella)
Branchiopoda (Artemia)
Branchiopoda (Streptocephalidae)
Branchiopoda (Triops)
Branchiopoda (Lynceus)
Branchiopoda (Daphnia)
Branchiopoda (Limnadia)
Cirripedia (Semibalanus)
Copepoda (Calanoida)
Malacostraca (Nebalia)
Malacostraca (Stomatopoda)
Malacostraca (Decapoda)
Malacostraca (Oniscidea)
Cephalocarida (Hutchinsoniella)
Remipedia (Speleonectes/Remipedia)
Collembola (Tomocerus)
Diplura (Campodeidae)
Diplura (Japygidae)
Archaeognatha (Meinertellidae)
Archaeognatha (Machilidae)
Zygentoma (Lepismatidae)
Ephemeroptera (Ephemerella/Callibaetis)
Diptera (Panopoida)
Orthoptera (Acheta/Locusta)
Blattodea (Periplaneta)
Pycnogonida
Xiphosura
Arachnida
Myriapoda
Oligostraca
Vericrustacea
Xenocarida
Hexapoda
209.85
125.29
556.63
449.81
237.4
55.23
43.96
505.8
443.29
547.72
481.13
405
0.65
463.37
440.34
373.3
444.91
543.46
387.86
0.67
339.75
505.51
438.72
475.58
370.07
130.95
0.81
390.41
538.47
513.77
0.81
493.47
117.68
493.79
0.8
438.73
517.07
276
512.34
158.22
0.8
492.13
444
520.53
400.7
375.13
0.76
360.8
500.89
433.66
243.24
470.45
48.32
430.09
398.9
377.37
353.31
327.06
Posterior Probability = 1.0
unless otherwise indicated
B
Branches proportional to
Molecular Change
(thick = Early Cambrian & latest Ediacaran)
3%
C
Branches proportional to
Morphological Change
(thick = Early Cambrian & latest Ediacaran)
8%

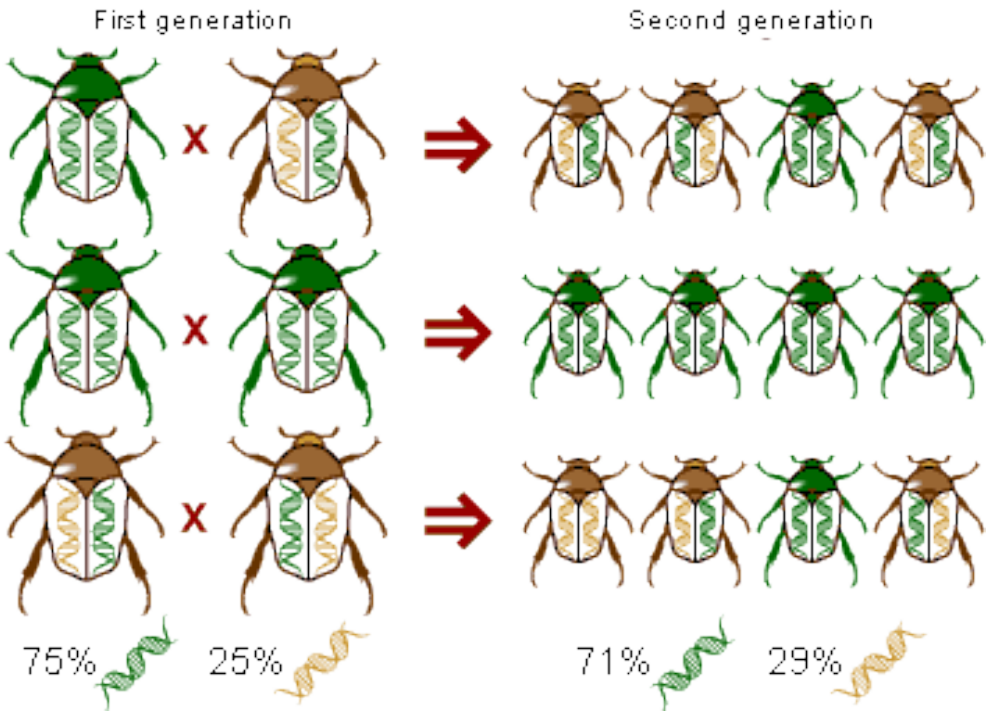
Chapter 17
EVOLUTION OF POPULATIONS

Read 17.1-17.3

Evolution of Populations

Natural Selection occurs at the population level.

A population of a species may change due to environmental factors that shift the natural selection toward or away from a specific trait



Evolution of Populations

Variation:

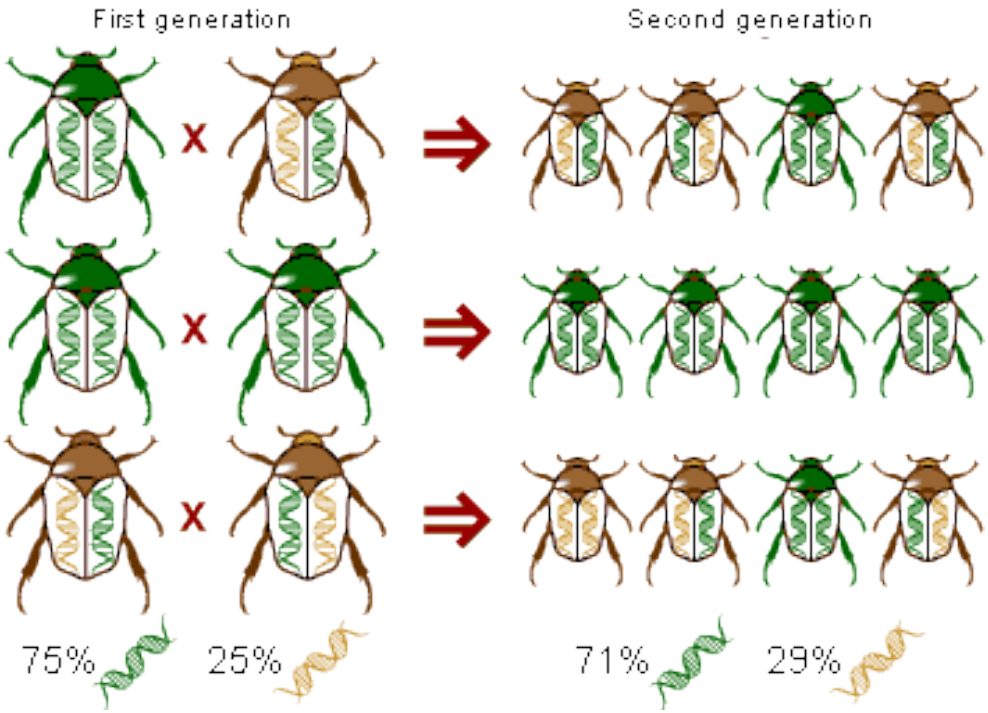
inheritable differences in DNA within a population

Gene Pool:

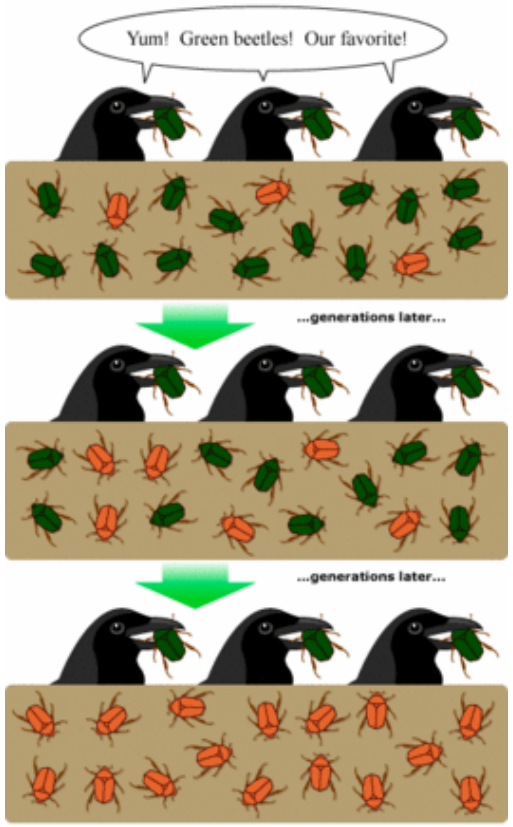
genes for a trait that are present in a population (*represented by alleles*)

Microevolution:

change in the frequencies of alleles in a population over time



Evolution of Populations cont.



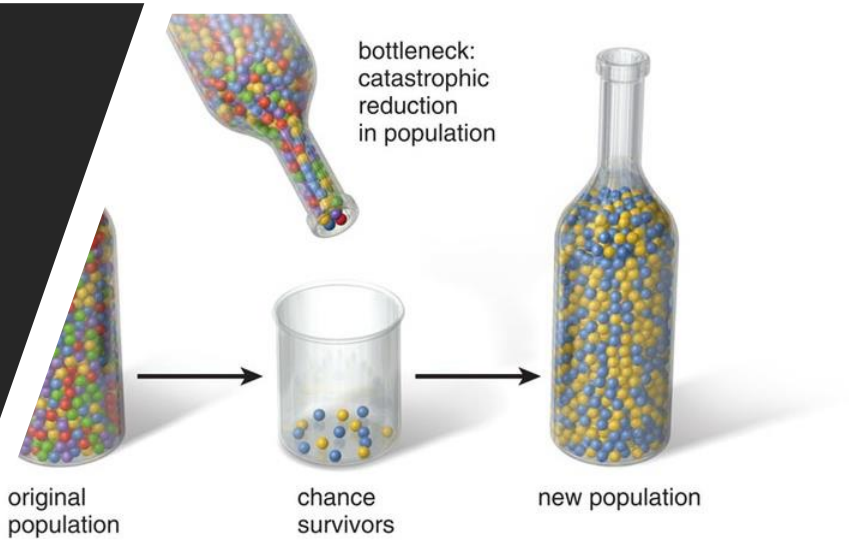
- Variation means that organisms within a population have traits that set them apart
- Within the gene pool alleles for each variation are present but some may be more successful than others
- Through microevolution, eventually the alleles in the population favor the trait that is more successful

Sources of Genetic Variation in a Population

1. ***Genetic Mutations:***
   change in DNA

2. ***Genetic Drift***:
   random changes due to small population size

3. ***Migration / Gene Flow***:
   individuals move into and out of a population such that new genes can be introduced



Sources of Genetic Variation cont.

4. ***Non-random mating***:
individuals choose their mates based on specific traits

(*Sexual Selection*)

5. ***Natural Selection***:

Environmental changes can result in a change in abundance of members in a population with a favorable trait.

The opposite of evolution is **genetic equilibrium**.

(Life is static, and nothing changes)

***Genetic equilibrium*:** allele frequency stays the same

5 Conditions **Required** to maintain equilibrium

1. Random Mating
2. Large Population
3. No movement in or out of population
4. No mutations
5. No Natural Selection

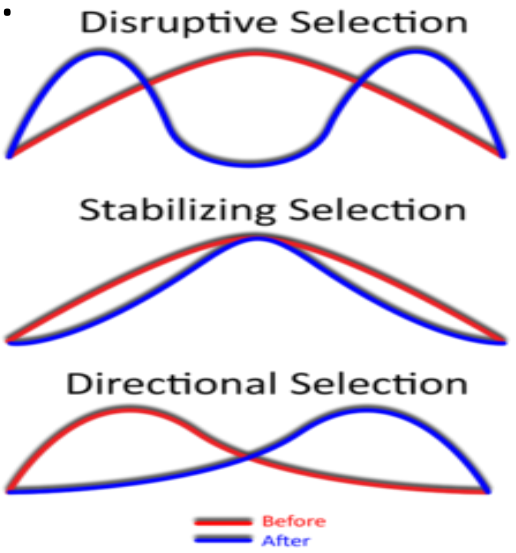
Can you think of a population that would not evolve?

Changes in Populations

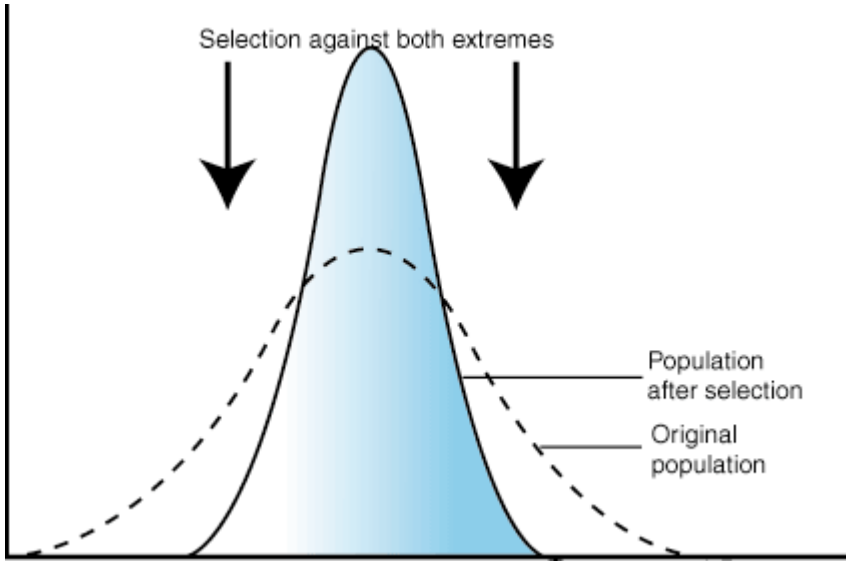
Polygenic trait: a trait controlled by two or more genes.

A single polygenic trait often has many possible genotypes and even more different phenotypes.

Changes in traits within a population can cause a genetic drift towards a specific appearance or adaptation



Patterns of Natural Selection

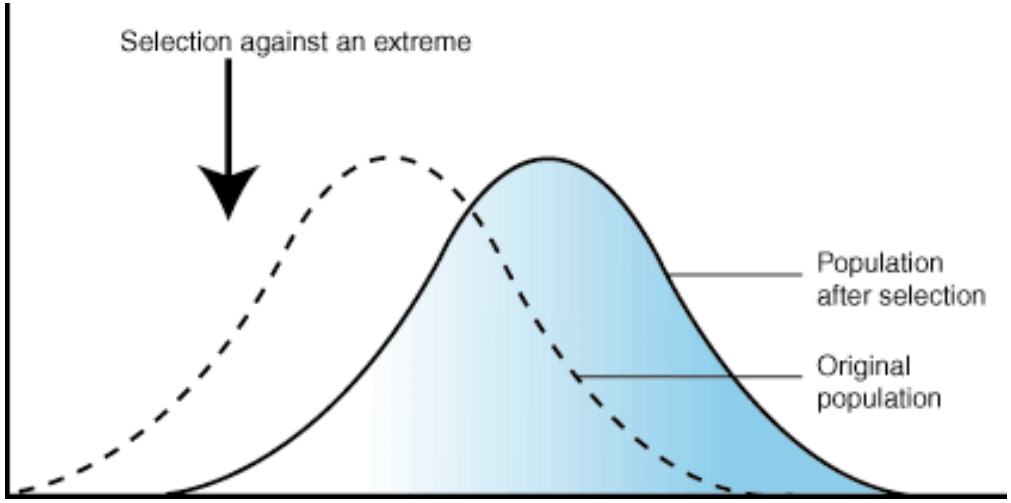


Dotted- before natural selection
Solid- after natural selection

Stabilizing Selection

the average individual is favored (more likely to survive)

Patterns of Natural Selection

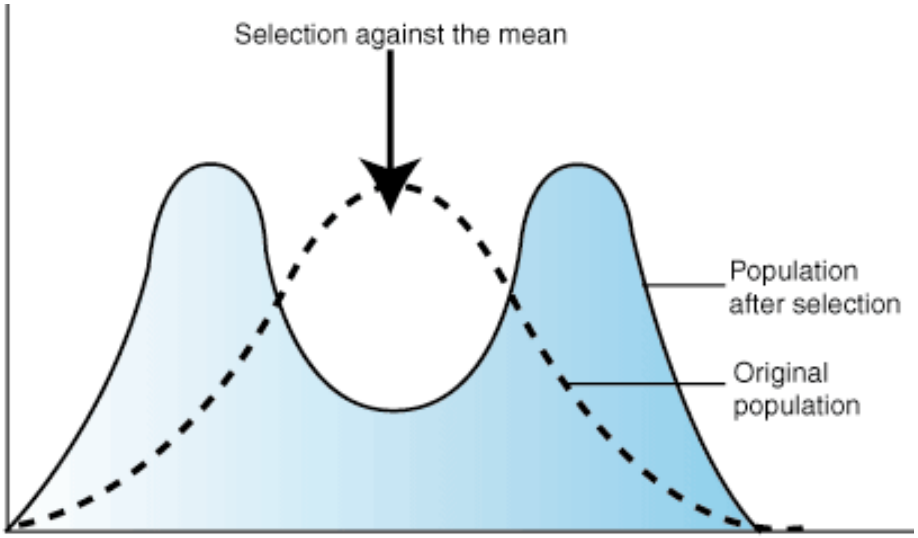


Dotted- before natural selection
Solid- after natural selection

Directional Selection

one of the extreme forms is favored (more likely to survive)

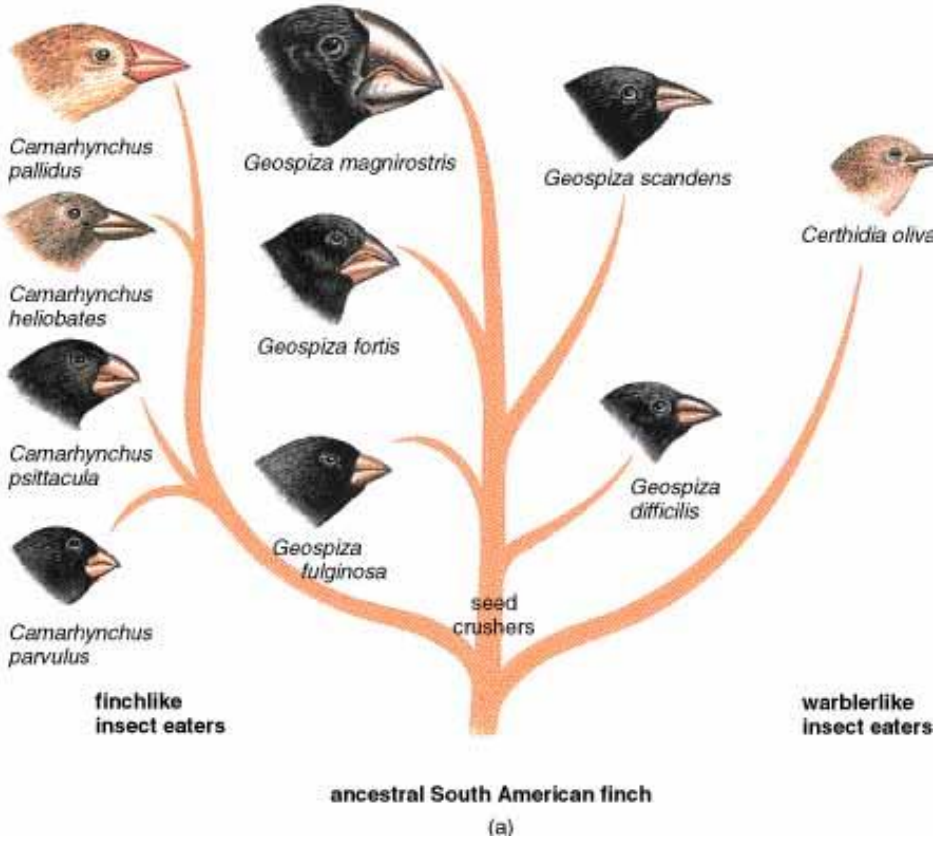
Patterns of Natural Selection



Dotted- before natural selection
Solid- after natural selection

Disruptive Selection

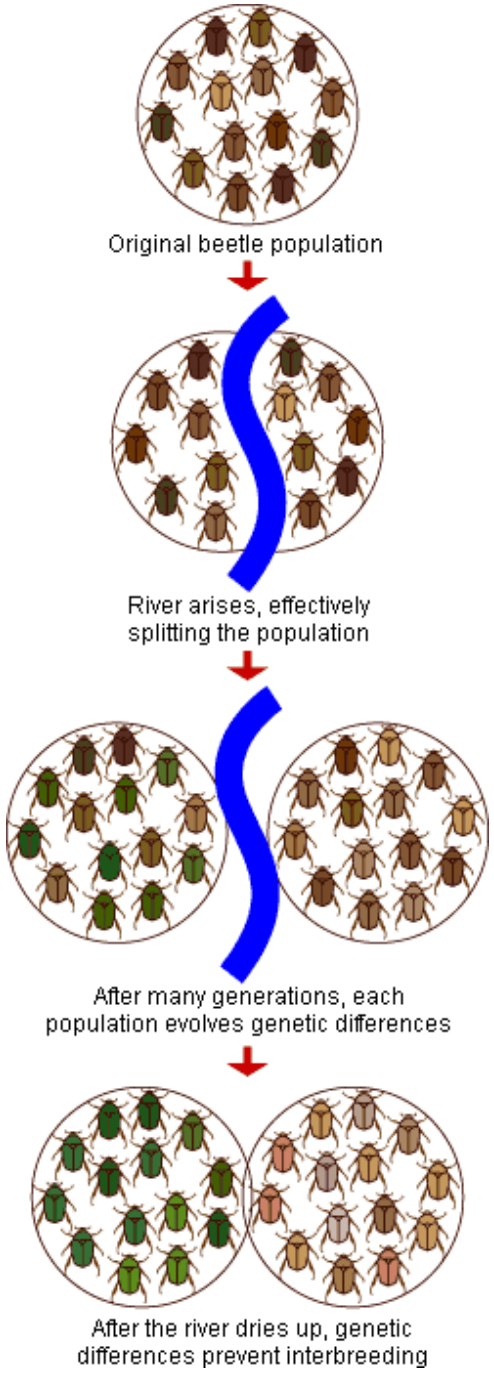
both the extreme forms are favored (more likely to survive)



A **genetic drift** toward a specific trait or **isolation** of a part of a species can lead to the development of a new species

Speciation: changes leading to formation of a new species

Changes in Populations



Patterns of Natural Selection

- The development of a species, when a portion of the population becomes isolated from the rest of the population due to geographic separation is an example of….

Geographical Isolation

Rana aurora

Breeds from January- March

Rana boylii

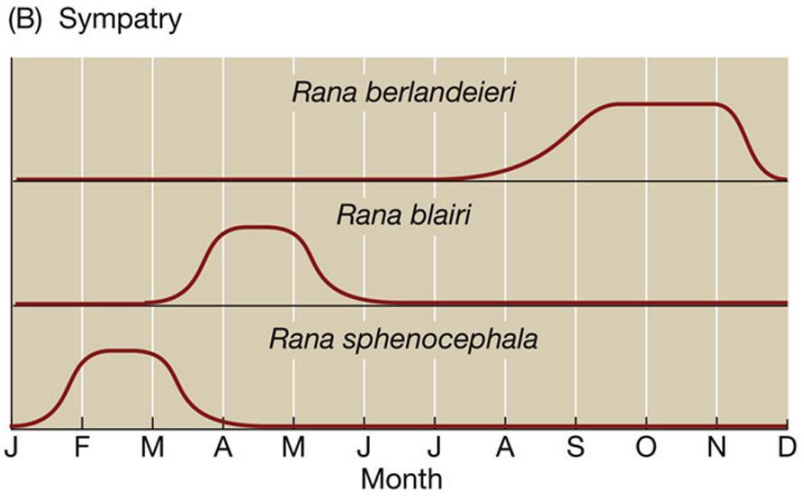
Breeds from March - May

These two frogs are unable to mate and as a result are two different species due to …

Reproductive Isolation

Changes in Populations

- Isolating mechanisms that can lead to speciation:
  - Reproductive Isolation
  - Behavioral Isolation
  - Geographic Isolation
  - Temporal (time) Isolation



LIFE 9e, Figure 23.9 (Part 2)

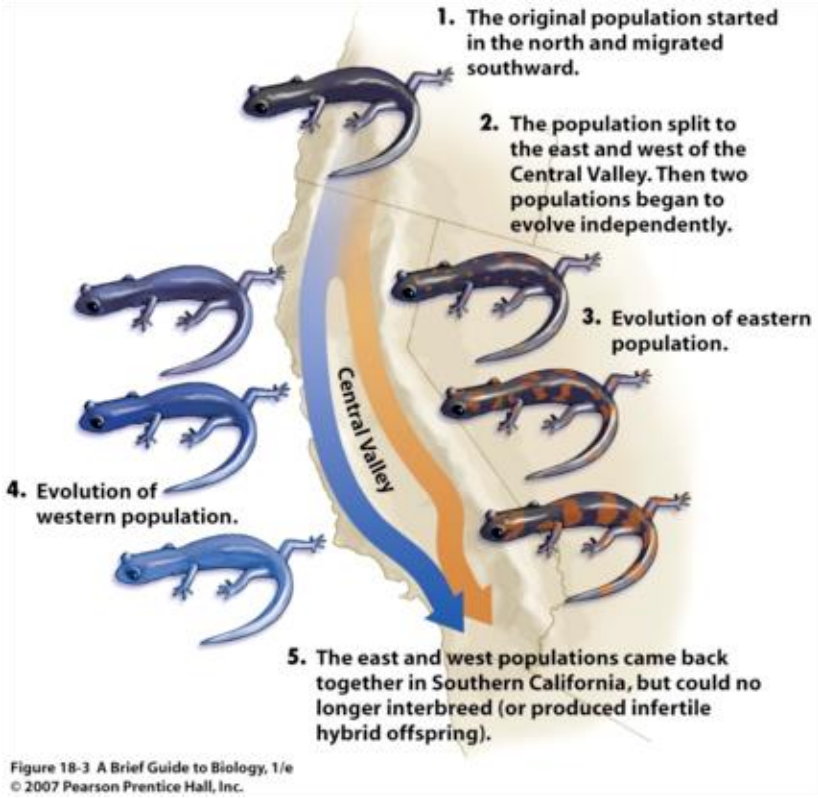
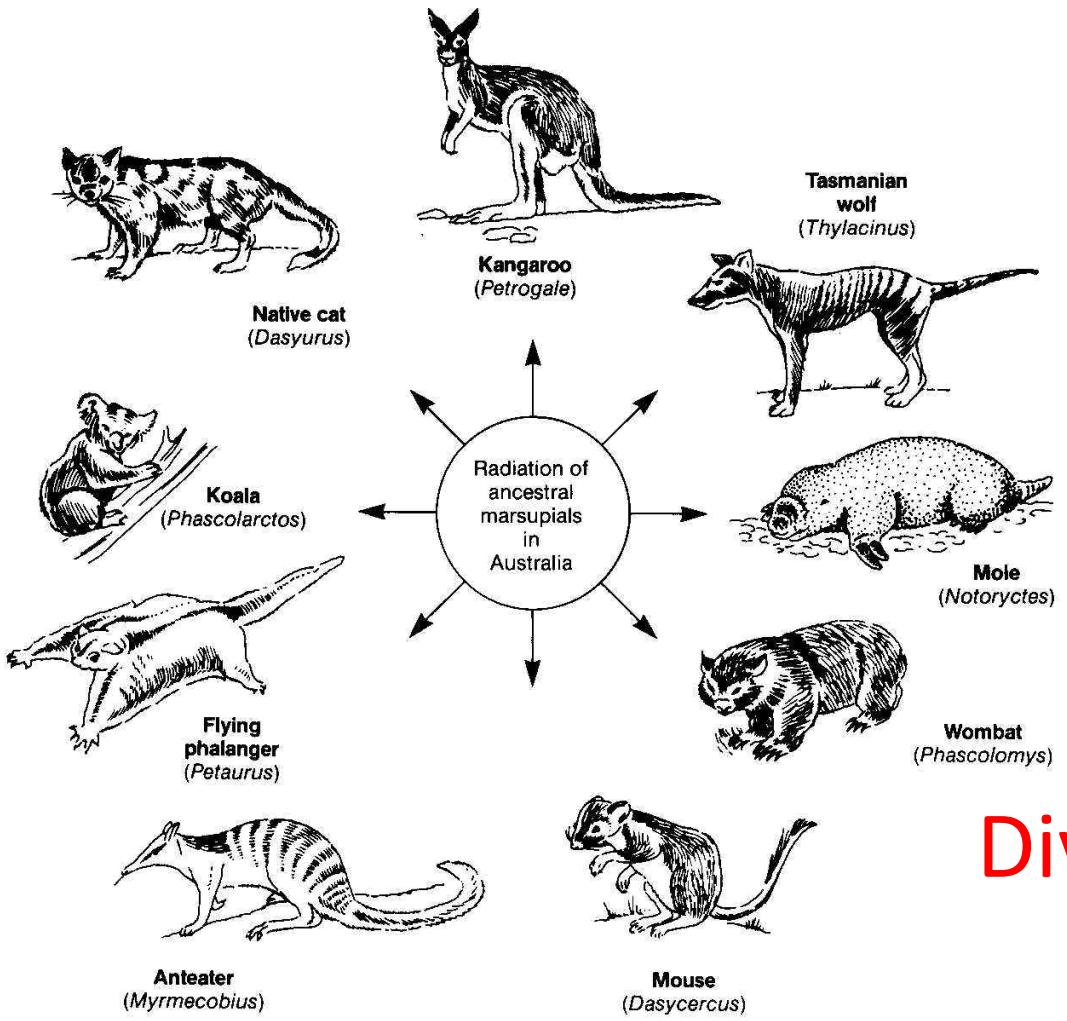


Figure 18-3 A Brief Guide to Biology, 1/e

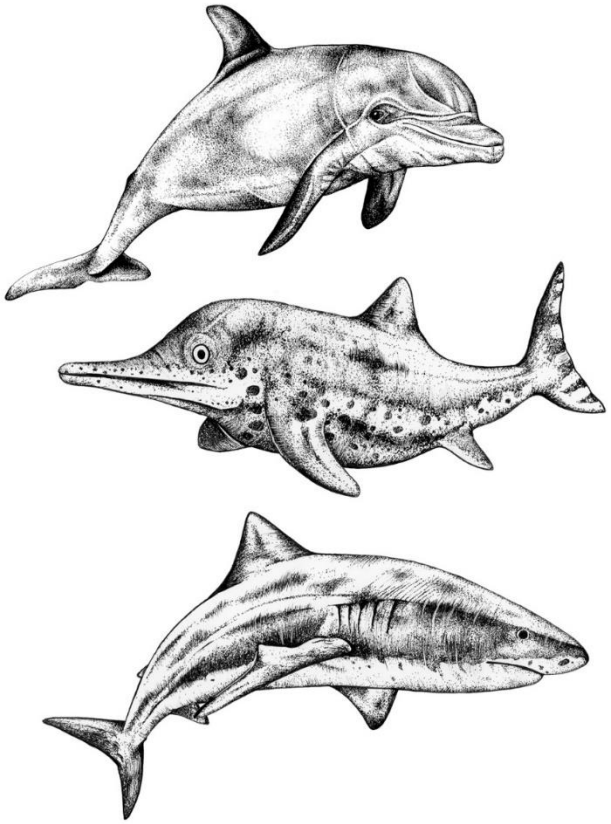
Patterns of Evolution



The pattern where many different species are linked to one common ancestor …

Divergent Evolution

Patterns of Evolution



Do these organisms share traits in common?

Where are all of these organisms found?

Why do these organisms share similar traits?

This is called… Convergent Evolution