14-1: **Developing a Theory of Evolution**

- ***Observing*** **that evolution occurs is simple: explaining** ***how*** **&** ***why*** **is more difficult**

- **The theory has been revised, but revisions *do not mean that evolutionary change itself is debatable or that evolutionary theory is merely a collection of vague hunches that are not supported by evidence.***

An Early Explanation for Evolutionary Change:

A. Prior to Darwin, ***Jean Baptist*** **de** ***Lamarck*** offered an explanation based on three assumptions:

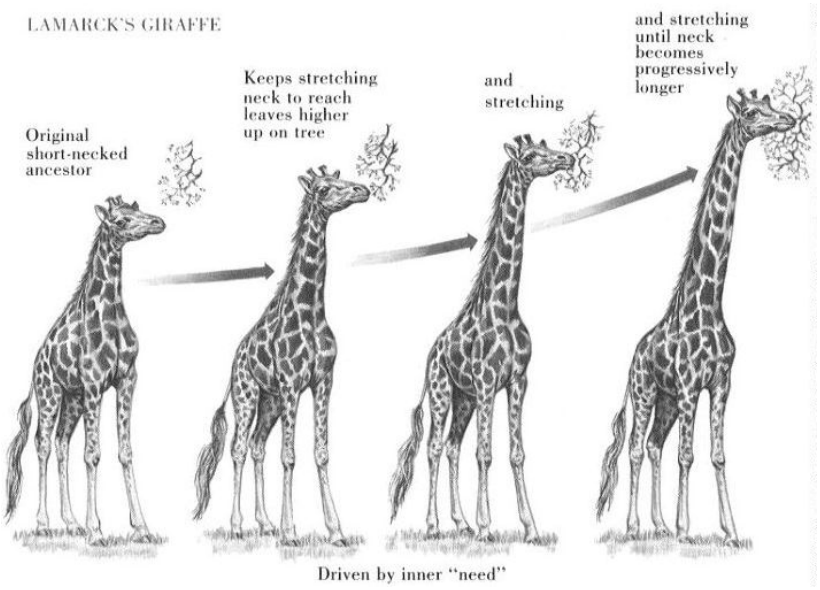
Ted-ed Misconceptions of evolution

(These assumptions are totally incorrect but were the first thoughts about evolution)

LaMarck's Assumptions

1. A Desire to Change

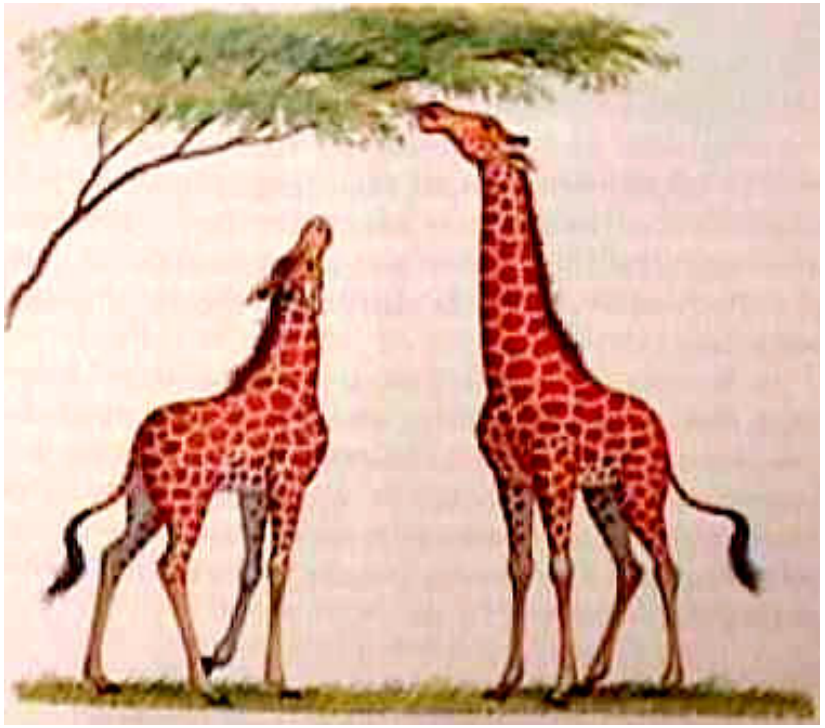
explanation: LaMarck *believed that organisms change because they have an inborn urge to better themselves and become more fit for their environment*



LaMarck's Assumptions

2. *Use and Disuse*

explanation: *believed that change occurred because organisms could alter their shape by using their bodies in new ways*

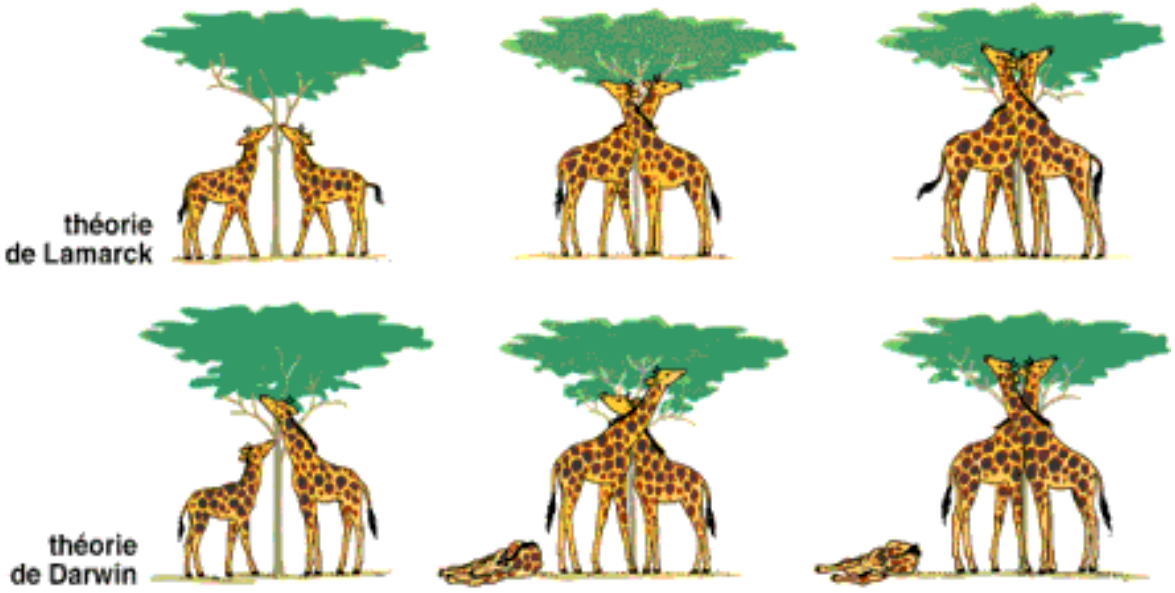


3. Passing on Acquired Traits

explanation: *believed that if an animal acquired a body structure during its lifetime, it could pass that change on to its offspring.*

While incorrect, Lamarck's contributions were significant because:

1. ***He was one of the first people to devise a theory of evolution and adaptation***
2. ***He also brought the concept of evolution to the attention of scientists***



Why Lamarck's mechanisms don't work:

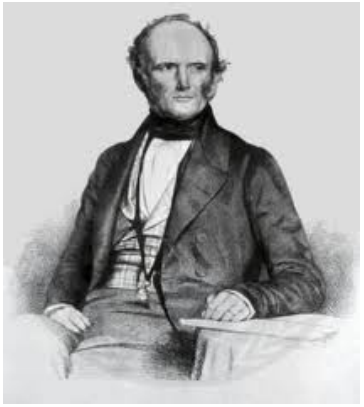
1. **Only *genes* and changes in *genes* are passed from parents to *offspring***

2. **There is no evidence that: *experience during its life can cause specific changes in an organism's genes***

3. **The 'weightlifter' example: *Years of proper exercise and diet, for example, can turn a weakling into a champion weight lifter. But that weight lifter's children cannot benefit genetically from the parent's pumping iron. If the children do not exercise and eat a proper diet, they will not develop large muscles, even if their parents were world champions!***

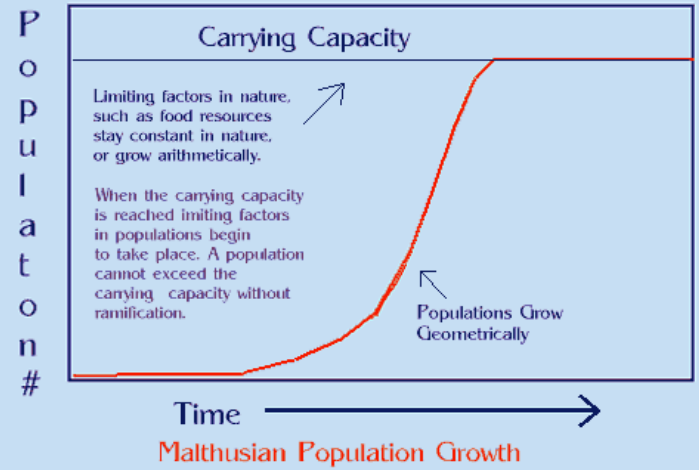
II. Ideas that Shaped Darwin's Theory of Evolution Ted-ed Age of the Earth

Person/Idea:	Significance to Darwin's Work:
Charles Lyell demonstrated that the Earth was very old and that it had changed over time	It was important that Earth was very old because it took long periods of time for millions of species to evolve from a common ancestor
In **artificial selection** the intervention of humans ensures that only individuals with the more desirable traits produce offspring	Variation either happened naturally or it did not. Nature must work in a process similar to artificial selection. This process would allow only those organisms best suited to their environment to survive and reproduce.



The Malthusian doctrine observed that human populations growth was prevented by famine, disease and war

The observation applied not only to humans but more to animals and plants because they produce even more offspring than we do.



14-2: Evolution by Natural Selection

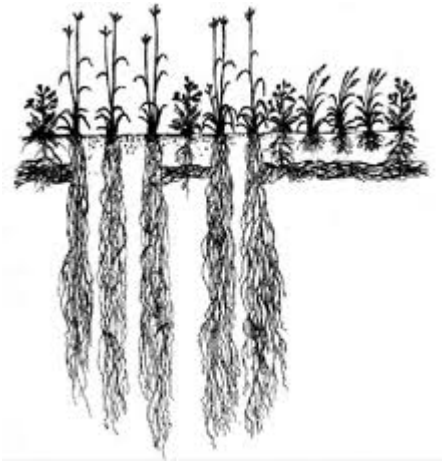
A.Darwin's line of reasoning:

1. Wild animals and plants show *variations* (just like domesticated ones)

2. Birthrates are *high*

3.Resources (called in text *life's necessities*) are scarce

4. These two facts above force organisms into a "*struggle for existence*"



5. Against the environment (example: *plant stems grow tall in search of sunlight; plant roots grow deep into the soil in search of water and nutrients.*)

6. Against each other (example: *Animals compete for food and space in which to build nests and raise young.*

B: Darwin's Principle:
Survival of the Fittest

Individuals whose characteristics are well-suited to their environment survive. Individuals whose characteristics are not well-suited to their environment either die or leave fewer offspring.

The Life of Alfred Russel Wallace HHMI

In what two ways is natural selection different from artificial?

1. **Occurs *over much longer periods of time***
2. **Occurs *without any goal or purpose***

Peppered Moths: Natural Selection In Action

Evolution in Action

In the beginning (of the 19th C.).....

1.Two colour variants of the moth: *light-coloured* (common) and *dark coloured* (rare)

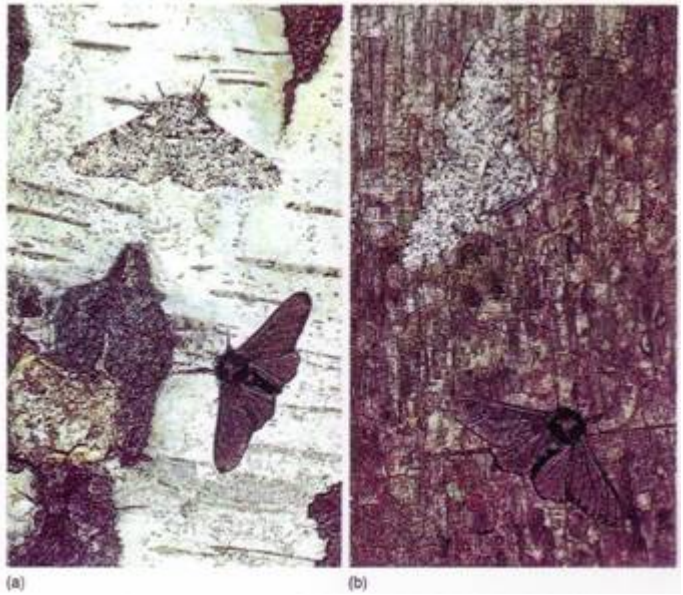
2. In daytime, moths hang out: ***resting***

on the bark of oak trees

3 Tree bark colour: ***light brown speckled with green***

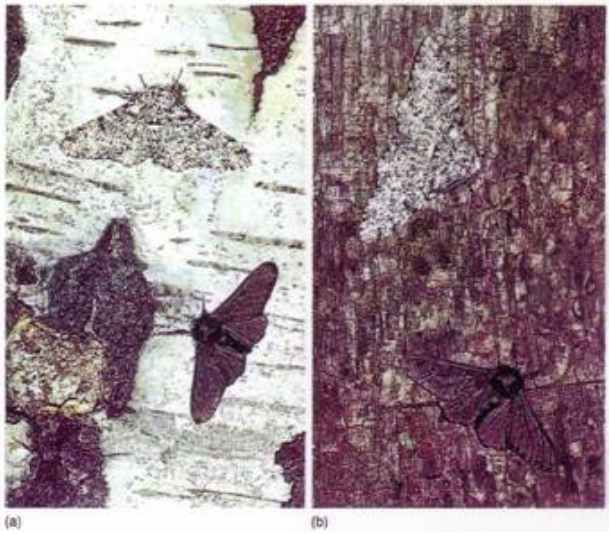
4. Then… the Industrial Revolution!

5. Pollution (from: ***<u>soot from burning coal</u>*****) affected trees** ***by staining the tree trunks dark brown.***



B.Biologists noticed that population of moths was changing *and that there were more moths with dark coloration.*

C. Evolutionary theory would hypothesize:



1. The major predator of the moth: *birds*

2. How birds locate prey: *eyes*

3. Moths that blend in w/ their surroundings are said to be *camouflaged*

4. As tree trunks darkened the colour variant they favoured changed *from the light coloured moths to the dark coloured moths*

5. Now, the dark moths were more *common* and more of them *survived* and got a chance to *reproduce*, passing on their *genes* for dark colour to their offspring

D. British ecologist *H.B.D. Kettlewell* tested this hypothesis by breeding, marking, and releasing equal numbers of each type of moth in two areas: *normally coloured* trees and *blackened soot* trees. After some time, he re-captured and counted his marked moths, and he found *that in unpolluted areas, more of the light-colored moths survived and in soot-blackened areas, more of the dark-colored moths survived.*

14-3 Genetics and Evolutionary Theory

Darwin's handicap: **He had no idea how the inheritable traits were passed from one generation to the next.**

Q. If Mendel was a contemporary of Darwin, why did Darwin not know of Mendel's findings?

Mendel's work remained unknown to most scientists until the early part of 20th century.

Genetic and evolutionary theory are inseparable. Today, we define *fitness, adaptation, species, and the process of evolutionary change in genetic terms.*

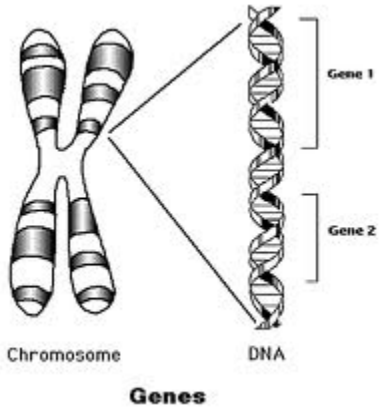
Genes: Units of Variation

Genes are:

- **Carriers of:** ***of inheritable characteristics***
- **Source of:** ***random variation upon which natural selection operates***
- ***Ted-ed Gene Mutations***

Other sources of variation:

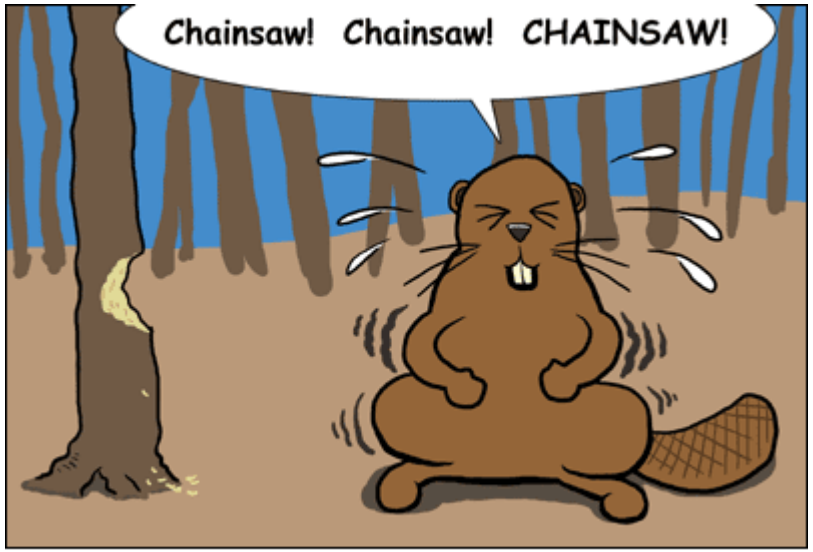
- ***Mutations***
- **Shuffling during *meiosis***



Variation doesn't occur b/c animals NEED or WANT to evolve (*Lamarck*'s theory):

Organisms can't cause DNA changes

Organisms can't prevent DNA changes



Adaptation doesn't involve trying.

Ted-Ed Evolution of Feathers

II. Raw Material for Natural Selection

Natural selection operates only on *the phenotypic variation among individuals*

Phenotype = *physical and behavioral characteristics*

Examples – traits that show phenotypic variation:

1. **Height**
2. **Colour of *skin/hair/eyes***
3. **Shape of *nose/curves of lips***
4. **Amount of *body hair***

In nature, organisms show *as many variations as humans*

1. **To the casual observer *one zebra looks***

much like any other zebra.

III. *Evolution as Genetic Change*

A. To describe evolution, biologists study *groups of organisms called populations.*

1. *Populations* (def'n): *is a collection of individuals of the same species in a given area whose members can breed with one another*

Ted-Ed Evolution in the Big City

B. Offspring share a group of genes, called *gene pool*

Gene pool contains: *a number of alleles for each inheritable trait*

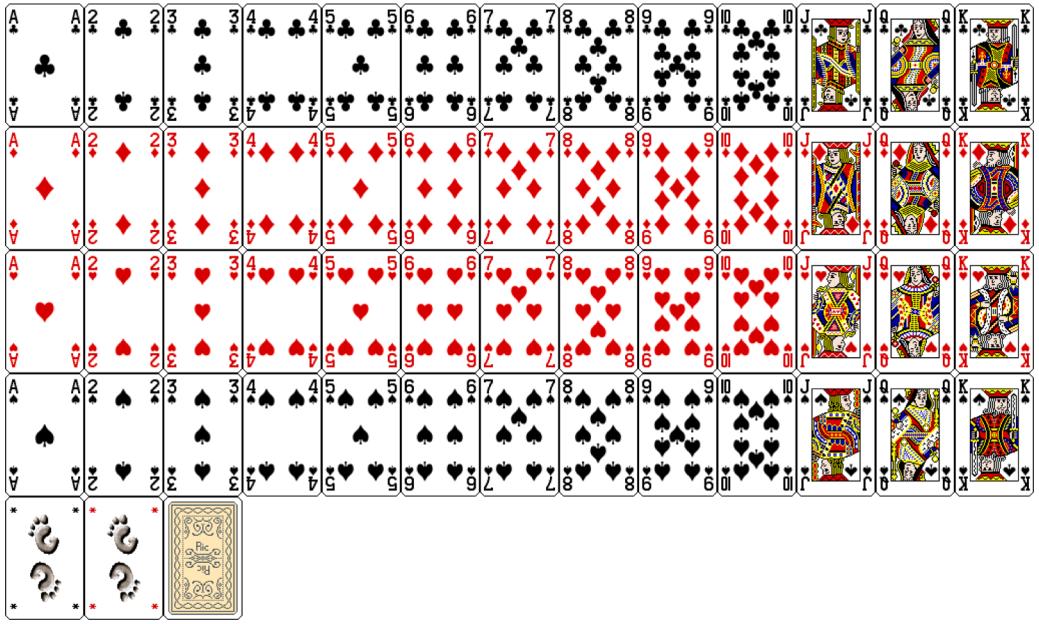
(eg bristle length)

Allele (def'n): *forms of a certain gene at a given point on a chromosome*

3. **Relative frequency (def'n):** ***the number of times an allele occurs in a gene pool compared with the number of times other alleles for the same gene occur***

a.Sexual reproduction alone doesn't *change the relative frequency of alleles in a population*

b. Shuffling alone doesn't change *the relative numbers of aces, kings, fours, or jokers in the deck*



C. Evolution (new def'n): ***is any change in the relative frequencies of alleles in the gene pool of a population***

1. Peppered moth example: ***The alleles for dark color increased when more dark-coloured moths appeared in the population.***

IV: Genes, Fitness and Adaptation

Adding "genes" to our definitions: ***segment of DNA that codes for a particular protein***

Fitness (new def'n): ***combination of physical traits and behaviors that help an organism survive and reproduce in its environment***

2. Adaptation (new def'n): ***process that enables organisms to become better suited to their environments***

Weightlifter example:

Muscles acquired as a result of exercise are not passed on to offspring. Thus they cannot be considered an evolutionary adaptation and cannot contribute to evolutionary fitness.

A gene that somehow allowed an individual to develop stronger muscles by doing less work or by eating less food, on the other hand, might be a useful adaptation under certain circumstances. This gene could be passed on to offspring.

V. A Genetic Definition for 'Species'

Past def'n: ***a group of organisms that looked alike***

1. **Used precise *physical descriptions***
2. **Differences seen *among individuals***
   were seen as imperfections or mistakes

This approach doesn't recognize *that variation in a population is the rule rather than the exception.*

New def'n of "species": *a group of similar-looking organisms that breed with one another and produce fertile offspring in the natural environment*

1. Implications of interbreeding:

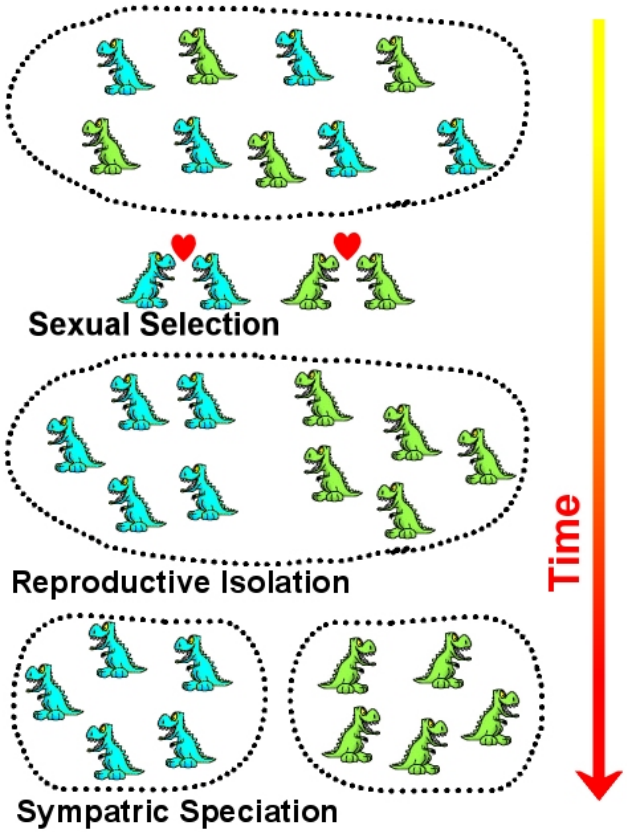
   a. Share *a common gene pool*

   b. Thus, a genetic change *that occurs in one individual can spread through the population as that individual and its offspring mate with other individuals*

   c. If this change increases fitness, *that gene will eventually be found in many individuals in the population*

14-4 The Development of New Species

Speciation (def'n): ***how new species evolve from old ones***



I. The Niche: How to Make a Living

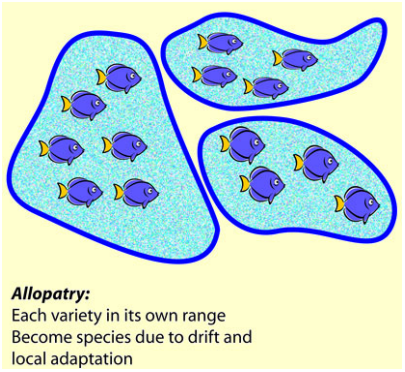
- **Niche (def'n):** ***the combination of an organisms' "profession" and the place in which it lives***
- **No two species *can occupy the same niche in the same location for a long period of time***

Q. Why would a species occupying an empty" niche be better able to survive that one that "shares" a niche with another species?

II. The Process of Speciation

A. New species usually form *only when populations are isolated, or separated.*

B. Reproductive isolation (def'n): *separation of populations so that they do not interbreed to produce fertile offspring*



Allopatry:
Each variety in its own range
Become species due to drift and
local adaptation

C. The agent for new species formation is: *reproductive isolation*

1. This may occur by:

a. Geographic barriers

- *rivers, mountains, roads*

b. Differences in ***courtship*** behaviours

In species with courtship rituals (breeding calls, mating dances, etc.), there is usually a complex, give-and-take "ritual" before actual mating takes place. This prevents "wasted effort" with a partner who will not produce fertile offspring with you!

c. Differences in *fertile* periods

- two species whose ranges overlap have different periods of sexual activity (or breeding season)

Rana aurora -
breeds January - March

Rana boylii - breeds late March - May

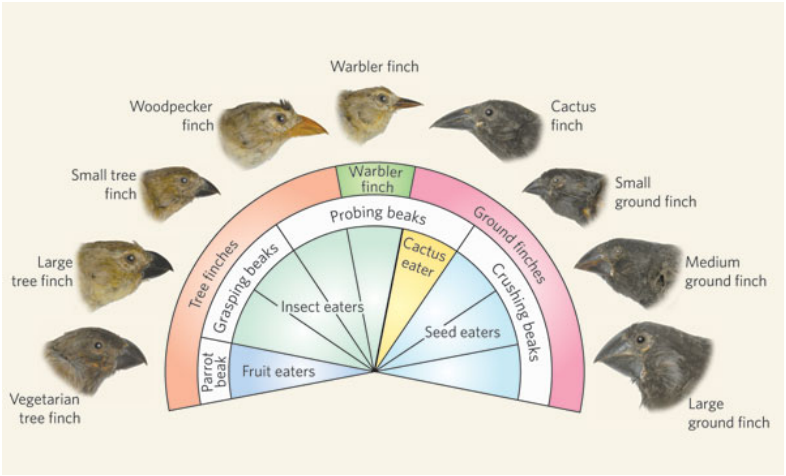
2. Once reproductive isolation in place:
***natural selection* increases differences between populations**

3. If genetic differences are sufficient, a
***new* species is formed**

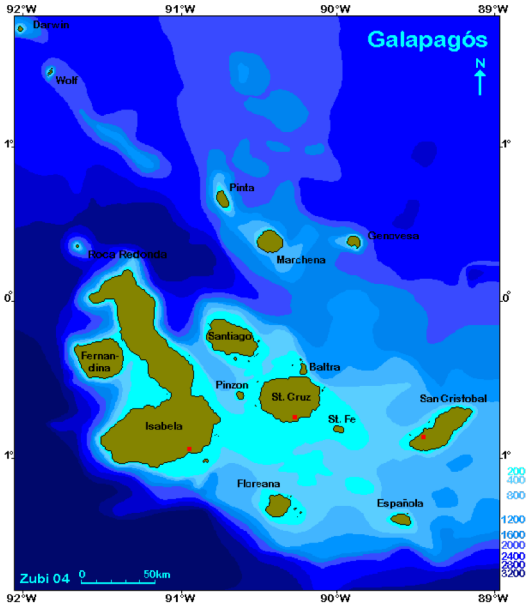
III. Darwin's Finches: An Example of Speciation

A **Darwin's finches:**

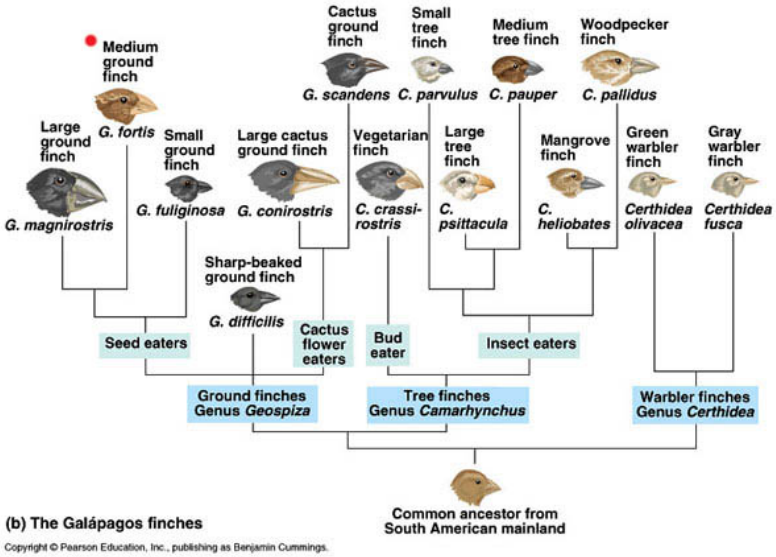
***1.<u>14</u>* different species**



2. Found on: *<u>Galapagos</u> <u>Islands</u>*



3. **All evolved from *a single ancestral species***



4. **Each exhibits unique:**
   a. ***Body structure***
   b. ***Behaviors***

5. **Each lives in a different *<u>niche</u>*, for e.g.:**

   a. **Adapted to feed differently:**

      i. **Some eat *small seeds***

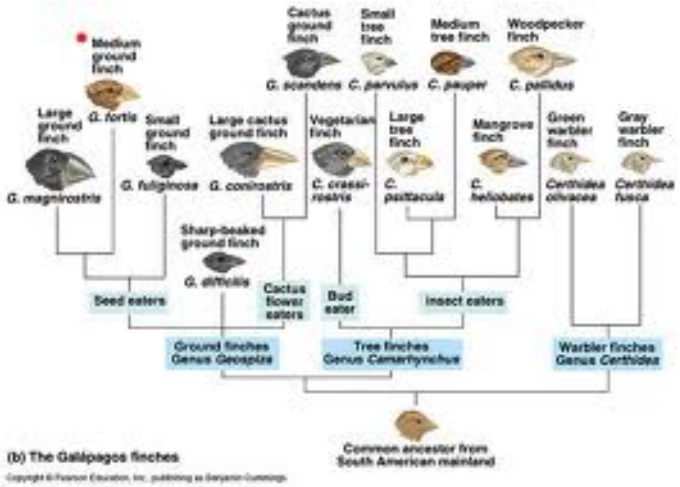
      ii. **Others *crack open much larger seeds***

      iii. ***seeds with thicker shells***

      iv. ***pick ticks***

      v. ***eat insects from inside dead wood***

      vi. ***drink the blood of large sea birds***



6. Process:

Step 1: Founding Fathers & Mothers:

Arrival on the Galapagos Islands of a few ancestral finches

Step 2: Separation of Populations:

Some finches move from island A to island B so they are isolated from each other

Step 3: Changes in the Gene Pool

Over time, the populations on each island became adapted to the needs of their environment

Step 4: Reproductive Isolation

The gene pools of the two bird groups do not mix because the two groups do not breed together → new species

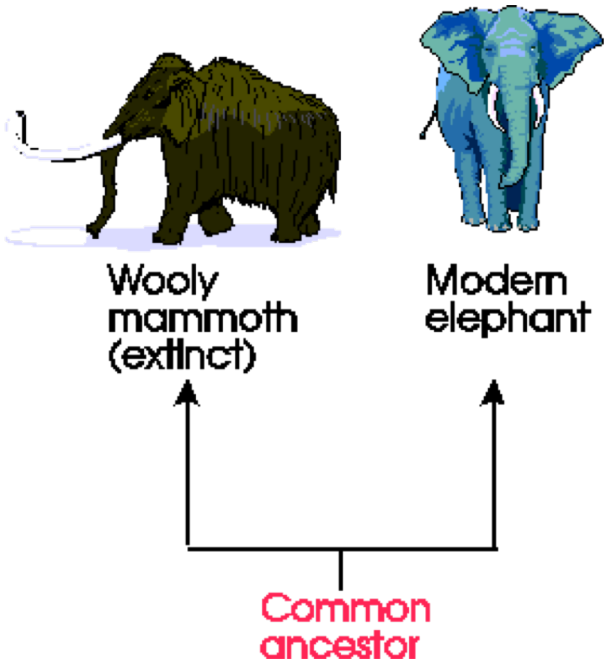
Step 5: Sharing the Same Island

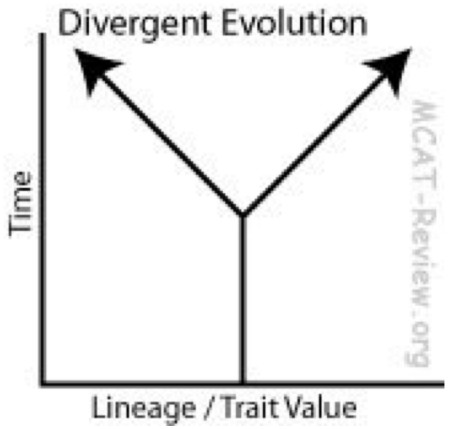
The two species occupy different niches so they can coexist together when sharing the same island

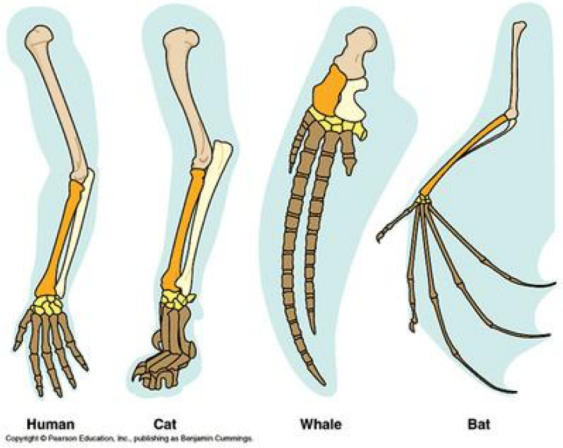
IV. Speciation and Adaptive Radiation

A. **Adaptive radiation = *divergent evolution***

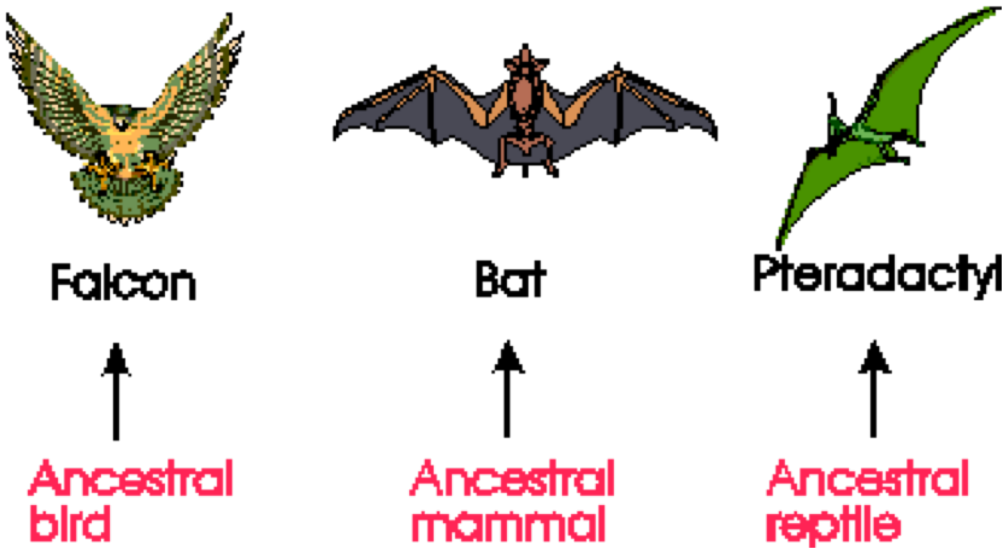
refers to one or a few species which diversify ("spread out") and generate multiple daughter species.





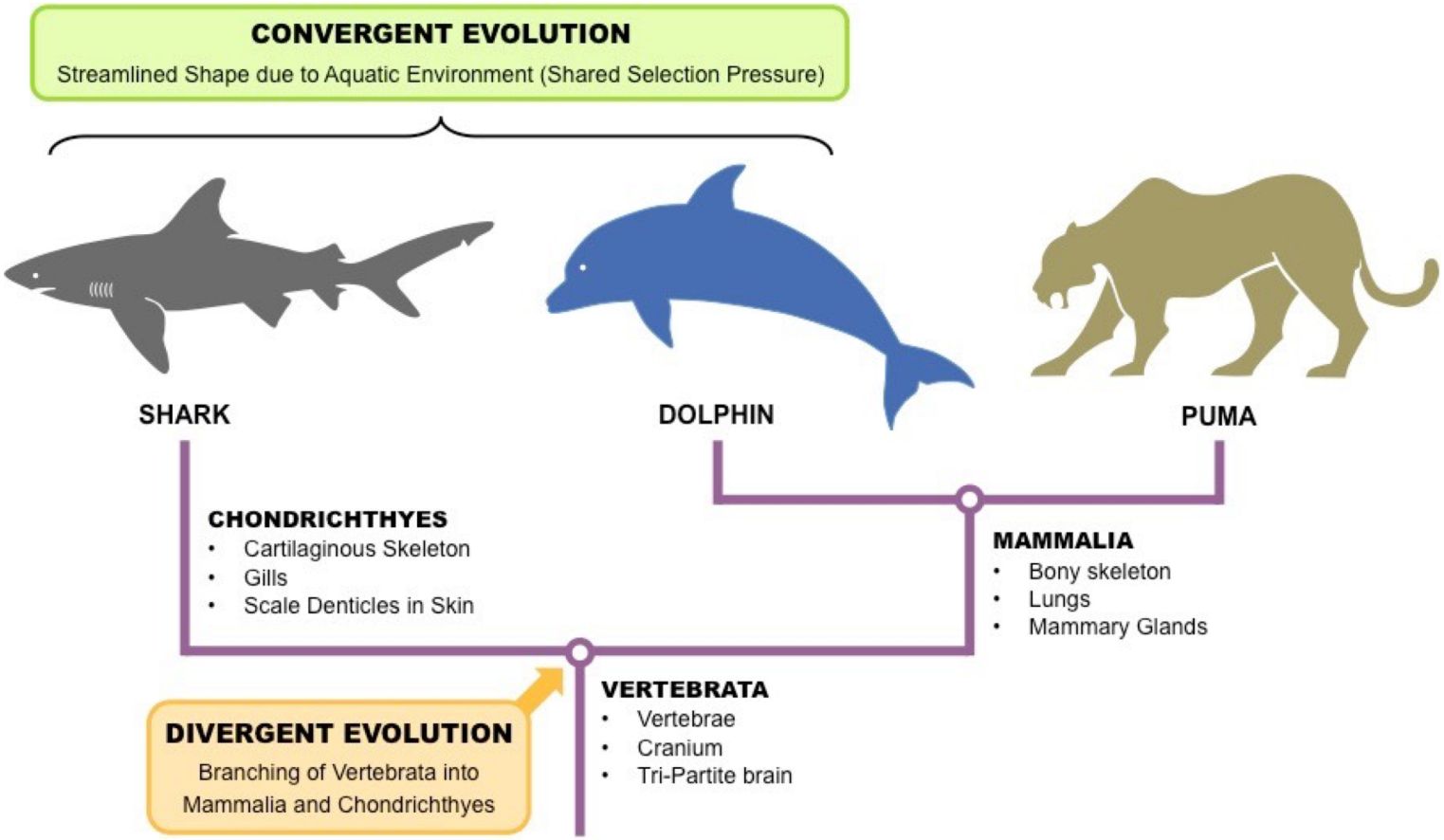


B. **The opposite of this is Convergent evolution (def' n):** ***Phenomenon in which adaptive radiations among different organisms produce species that are similar in appearance and behavior; opposite of divergent evolution***



C. Organisms exhibiting convergent evolution usually have analogous structures (def' n):

Structures that are similar in appearance and function but have different origins and usually different internal structures



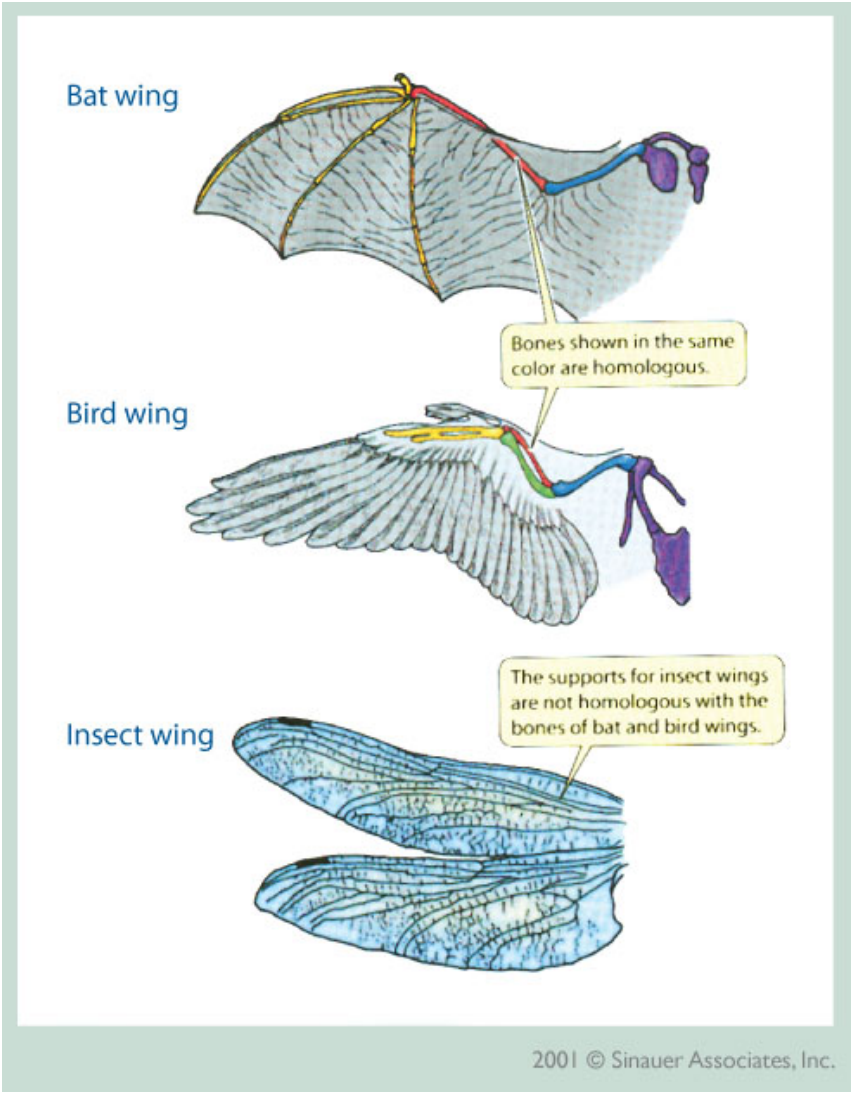
Example:

a. Wings of butterfly made of ***thin nonliving membrane with an intricate network of supports***

b. Wings of bird made of ***skin, muscles, and arm bones***

c. Wings of bat made of ***skin stretched between elongated finger bones***

d. In all cases, the function of these different structures: ***are the same***



14-5: Evolutionary Theory Evolves

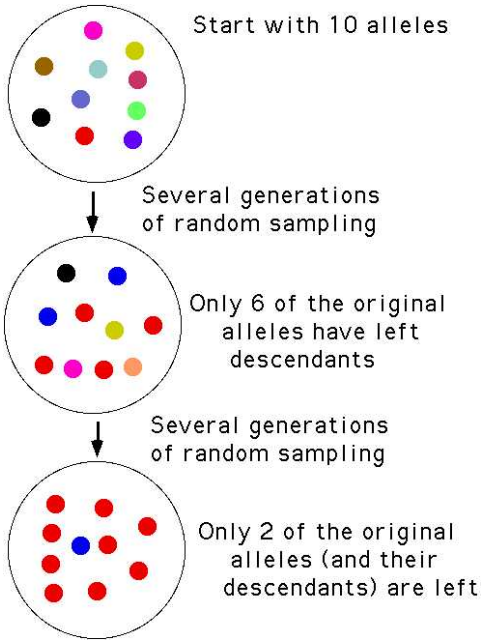
I. Genetic Drift Ted-Ed Five Fingers of Evolution

1. **Biologists now realize that *chance***

plays an even larger role in evolution

2. **Genetic drift (def'n): *random change in***

the frequency of a gene



3. How it works

a. **A new or rare allele becomes common, by CHANCE, after only a few variations**

b. **Occurs most efficiently in *small populations* because chance events are less likely to affect *all members* of a large population**

Rhinoceros example:

i. **Indian rhino: *one* horn;**
African rhino: *two* horns

ii. ***Natural selection* provided a distinct advantage to individuals with *horns*, but the two populations developed *different numbers* of horns because of *random genetic drift***

II. Unchanging Gene Pools

A. If a species is *well-adapted* to its environment and *it does not change over time*

B. No *new species* enter into competition with it, that species may remain unchanged for long periods of time

C. Such species are called

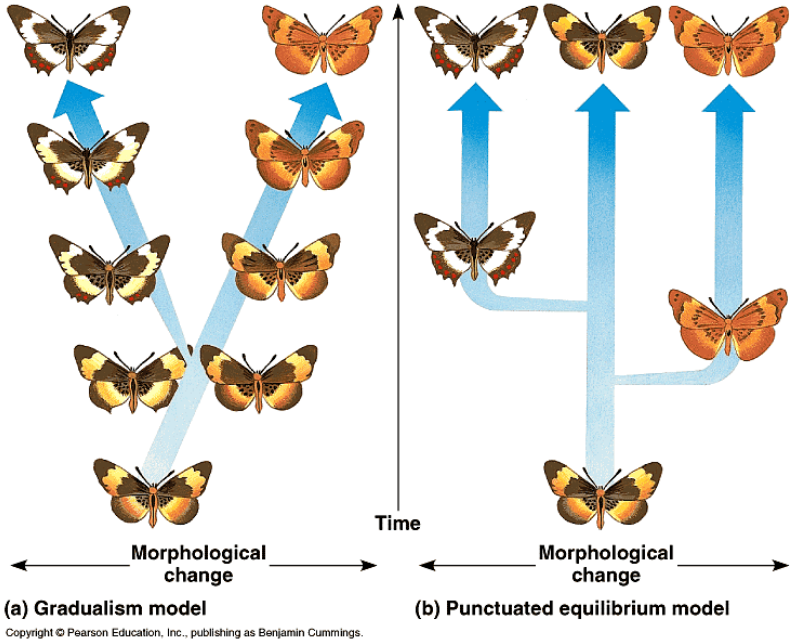
living fossils

III. Gradual and Rapid Evolutionary Change

1. Gradualism (def'n): ***theory that evolutionary change occurs slowly and gradually***

2. Species in equilibrium do not ***change*** very much between their appearance and their disappearance

3. Fossil record shows evidence of this equilibrium being upset: rapid changes over ***short periods*** of time



4. **Some scientists think these "rapid" changes are what create new species**

5. **How they could happen:**

    1. **In a small isolated population, genetic change can spread *more quickly* through fewer individuals**
    2. **Small population *migrates* to a new environment (empty niches!)**
    3. **Dramatic *changes* on the Earth, e.g. mass extinctions, caused by global *climate* change**
    4. **Mass extinctions = *empty* niches**

6. **Punctuated Equilibria (def'n): *pattern of long stable periods interrupted by brief periods of change***

Video: The 12 Days of Evolution (Smart Science)

Video: Why are we the only humans left? (Smart Science)