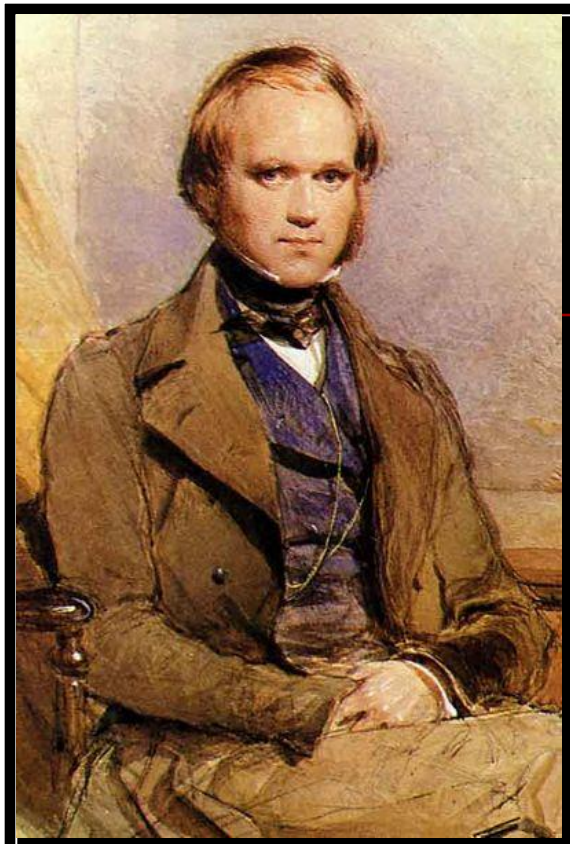
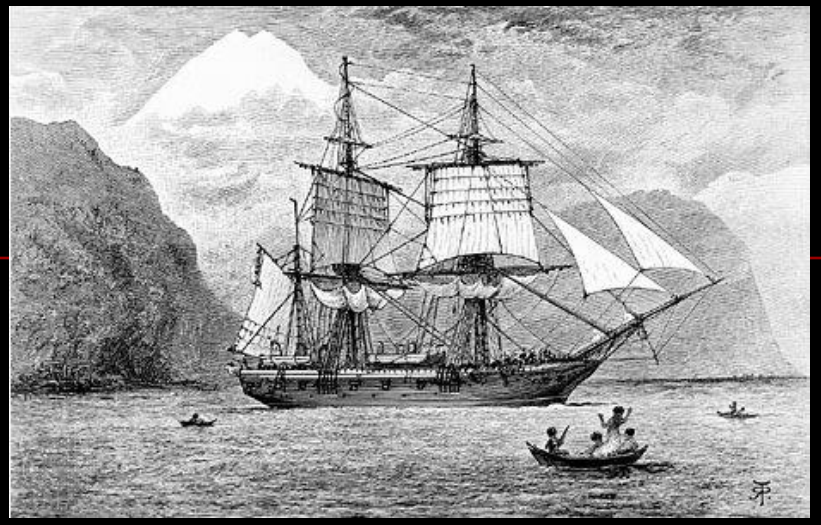
Evolution

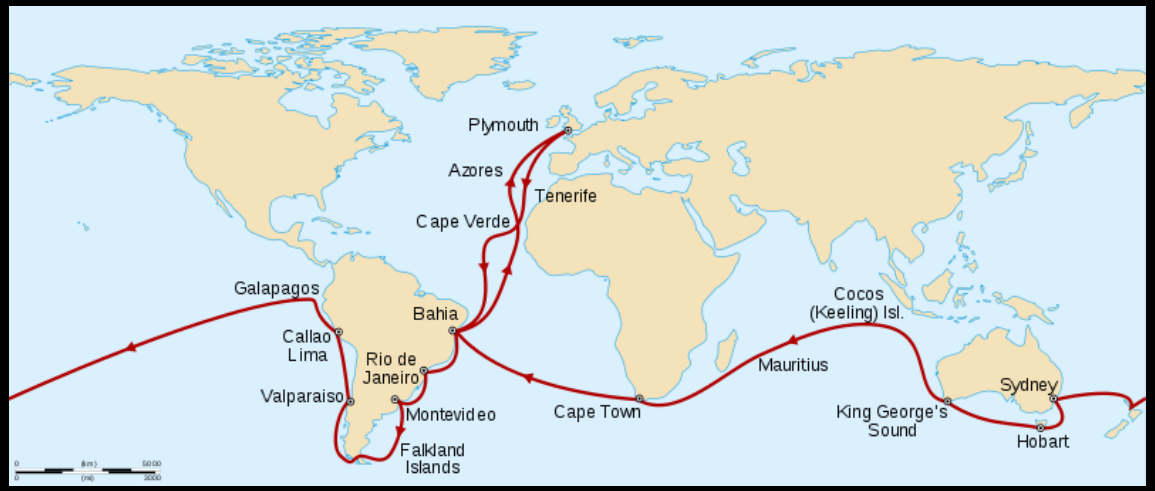
Darwin's Theory
Evolution of Populations
History of Life
Classification

Chapter 15-Charles Darwin's Theory of Evolution

- I. 15.1-Darwin's Observations
- A. Darwin sailed on the HMS Beagle in 1831 to make observations and collect specimens of plants and animals around the world; Eventually he did most of his studies in the Galapagos Islands, near Ecuador, in northern South America (on the equator)
- B. His observations about the variation among animals in a population led him to propose a hypothesis (a testable prediction) that eventually led to a theory, a well supported, testable explanation of phenomena (events) that occurred in the natural world






Plymouth
Azores
Tenerife
Cape Verde
Galapagos
Bahia
Callao
Lima
Rio de
Janeiro
Valparaiso
Montevideo
Falkland
Islands
Cape Town
Mauritius
Cocos
(Keeling) Isl.
Sydney
King George's
Sound
Hobart

Chapter 15-Charles Darwin's Theory of Evolution

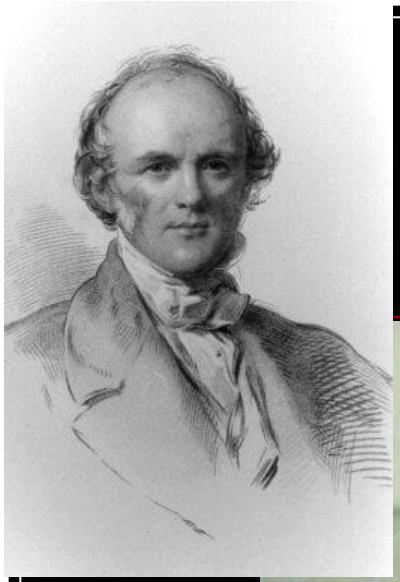
- I. 15.1-Darwin's Observations (continued)
- C. He observed
  - Plants and animals seemed well adapted to their environment
  - Plants and animals had many ways in which they survived and had offspring
  - In some places no animals lived, and wondered why!
  - Fossils that he found resembled organisms that were still alive

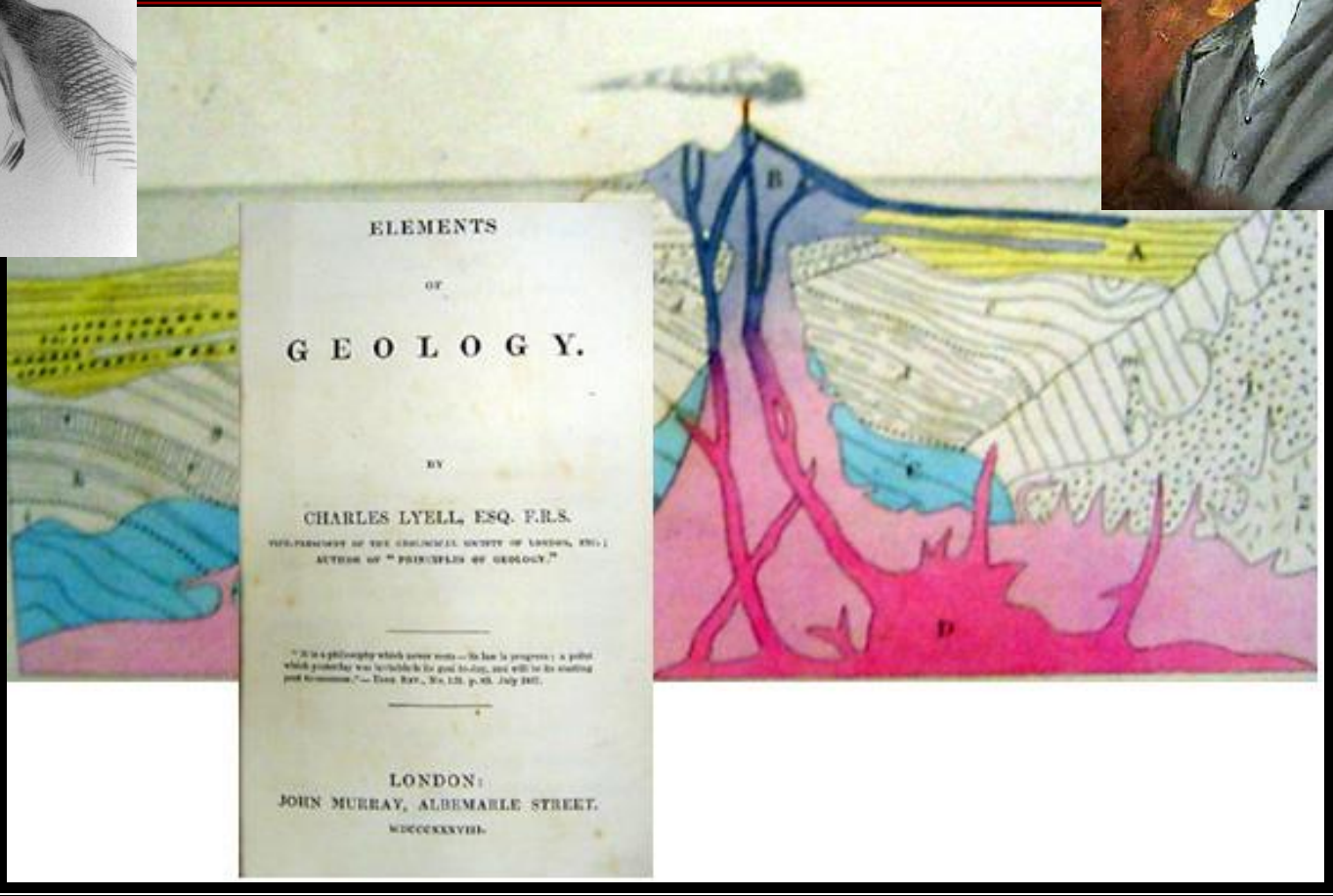
Chapter 15-Charles Darwin's Theory of Evolution

- II. 15.2-Ideas That Shaped Darwin's Thinking
- A. During his time, science was advancing and new ideas were being developed all the time. People still thought that most forms of life had been created only a couple thousand years before and had not changed since creation

Chapter 15-Charles Darwin's Theory of Evolution

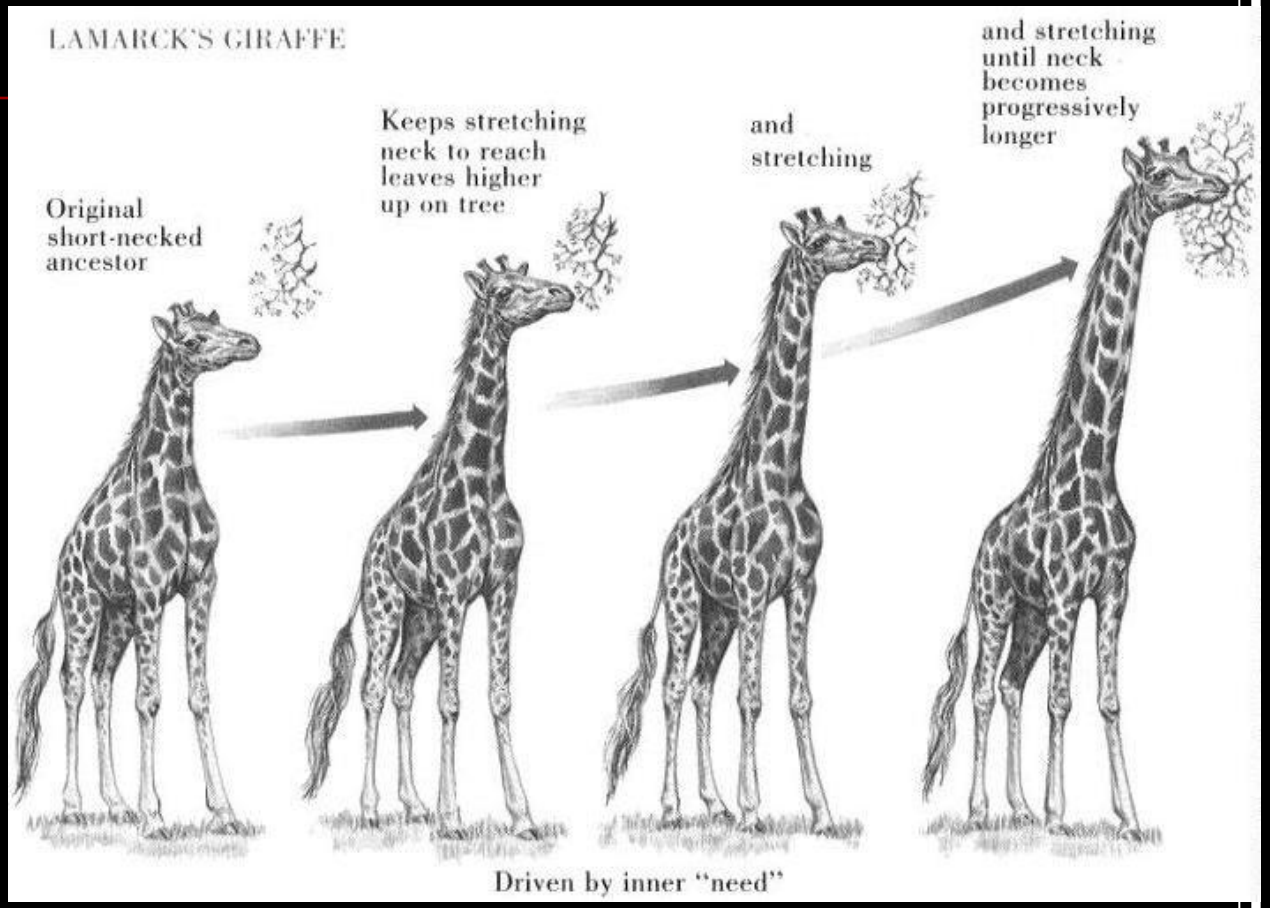
- II. 15.2-Ideas That Shaped Darwin's Thinking (continued)
- B. Lyell and Hutton
  - Geologists
  - Realized that the earth was many millions of years old, and had been slowly changing over time
- C. Darwin asked if the earth was so old and was changing over time, might life be changing as well?




ELEMENTS
OF
GEOLOGY.
BY
CHARLES LYELL, ESQ. F.R.S.
AUTHOR OF "PRINCIPLES OF GEOLOGY."
LONDON:
JOHN MURRAY, ALBEMARLE STREET.
MDCCCXXXVIII.

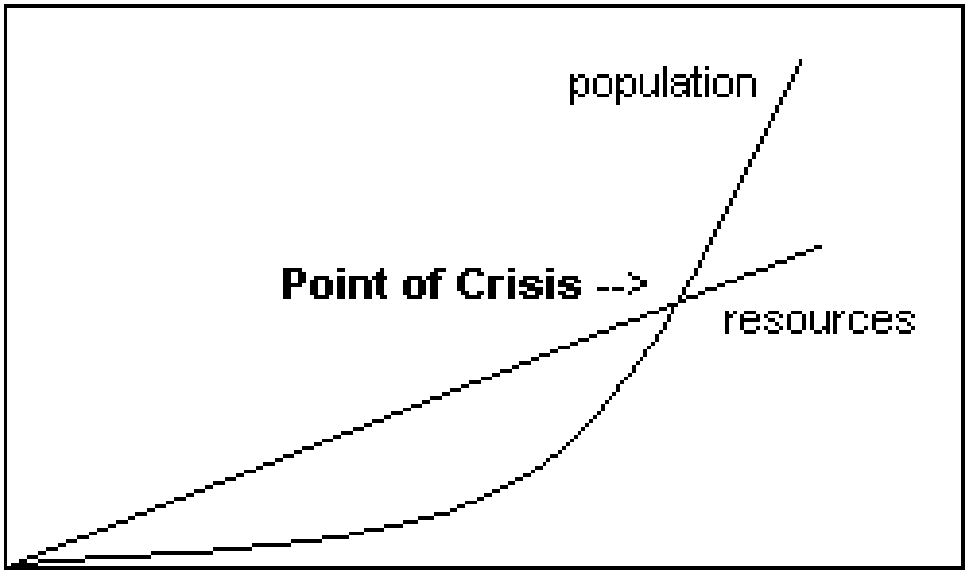
Chapter 15-Charles Darwin's Theory of Evolution

- II. 15.2-Ideas That Shaped Darwin's Thinking (continued)
- D. Jean-Baptiste Lamarck
  - Before Darwin,
  - His theory-by selective use of organs, organisms could acquire or lose traits *during their lifetime*. These *traits* could then be passed on to their offspring.
  - If this was true, you could grow your arms into wings by flapping them and trying to fly all the time! If this was true, you could pass on to your offspring the biceps that you worked on in the gym!


LAMARCK'S GIRAFFE
Original short-necked ancestor
Keeps stretching neck to reach leaves higher up on tree
and stretching
and stretching until neck becomes progressively longer
Driven by inner "need"

Chapter 15-Charles Darwin's Theory of Evolution

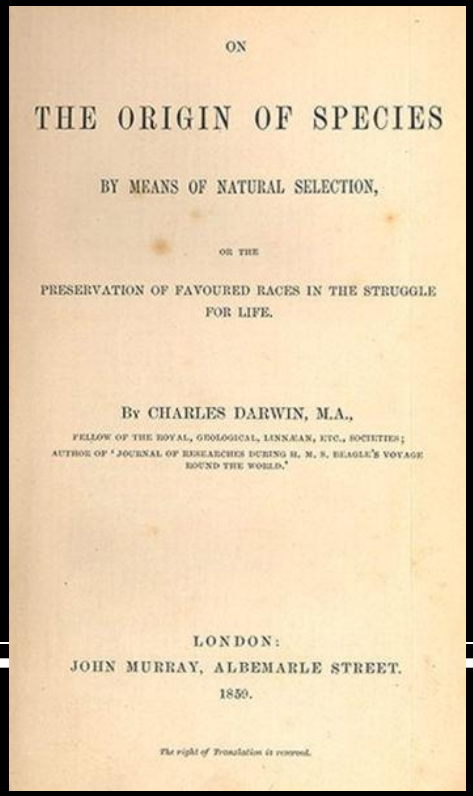
- II. 15.2-Ideas That Shaped Darwin's Thinking (continued)
- E. Thomas Malthus
  - Economist
  - Observed that people were being born faster than people were dying, which would eventually lead to a shortage of resources like food and space.
- F. Darwin reasoned that this might be happening with plant and animal populations
  - Competition among organisms would lead to survival of those best adapted to survive and reproduce in their environment



Malthus' Basic Theory

Chapter 15-Charles Darwin's Theory of Evolution

- III. 15.3- Darwin's Theory
- A. His published results of his research was called *On the Origin of Species*, published in 1858



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;

AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1859.

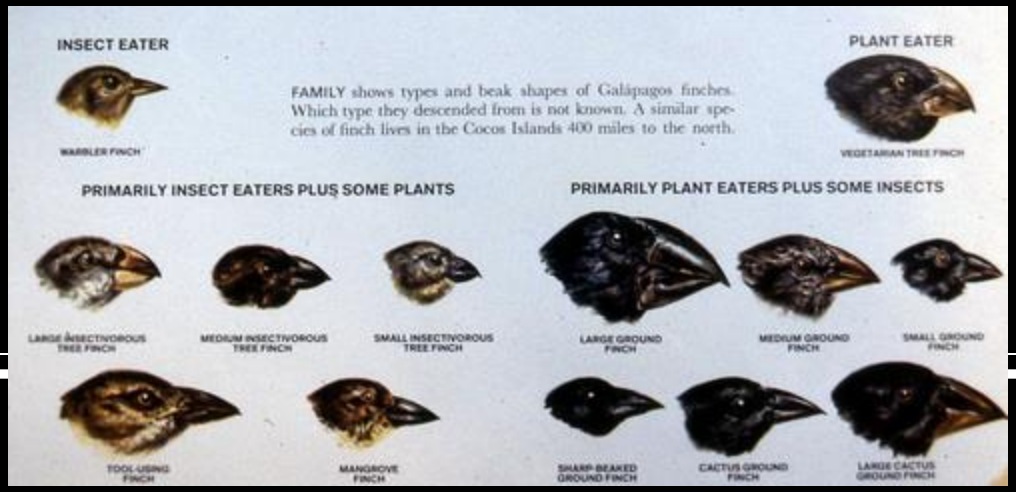
The right of Translation is reserved.

Chapter 15-Charles Darwin's Theory of Evolution

- III. 15.3- Darwin's Theory (continued)
- B. He argued
  - Differences between individual organisms in a population, or **variation**, exists.
  - Farmers used this natural variation to improve their crops and livestock. Called artificial selection
  - In natural selection, nature provides the variation, environmental factors select which variants will survive and reproduce
  - The struggle for existence leads to survival of the fittest

Chapter 15-Charles Darwin's Theory of Evolution

- III. 15.3- Darwin's Theory (continued)
- C. Over time, natural selection results in changes in the inherited characteristics of a population. This principle is called ***descent with modification***

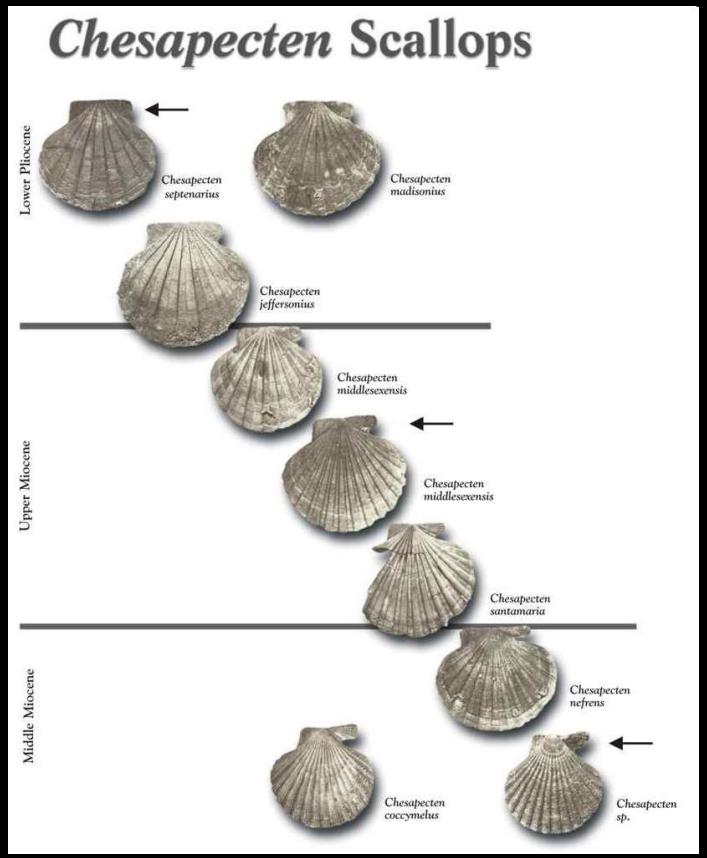


Chapter 15-Charles Darwin's Theory of Evolution

- III. 15.3- Darwin's Theory (continued)
- F. Evidence for evolution
  - Fossil record
  - Geographical distribution
  - Homologous structures
  - Similarities in early development

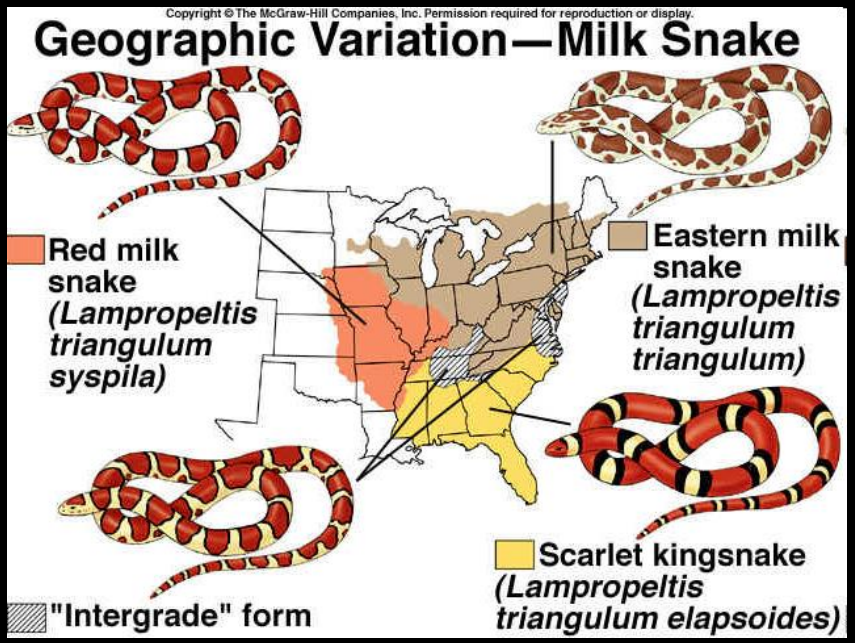
Evidence of Evolution- The fossil record

- 1. Fossil record- formed in rock and show variation over time



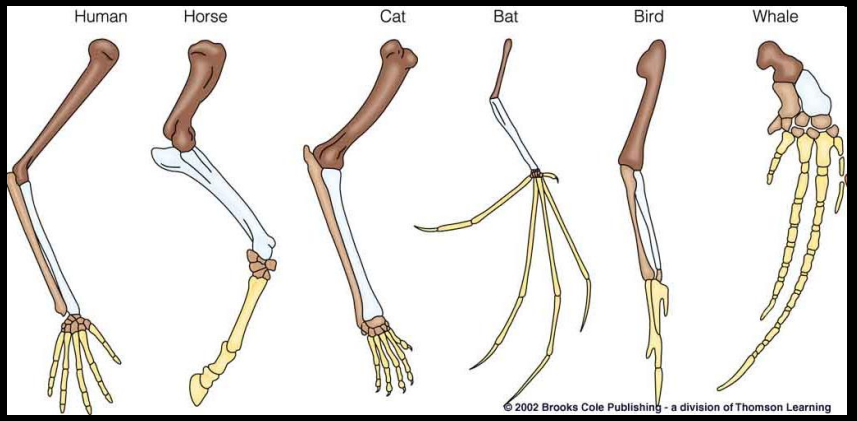
Evidence of Evolution- Geographical distribution

2. Geographical distribution of living organisms- Organisms that live in similar environments have similar features



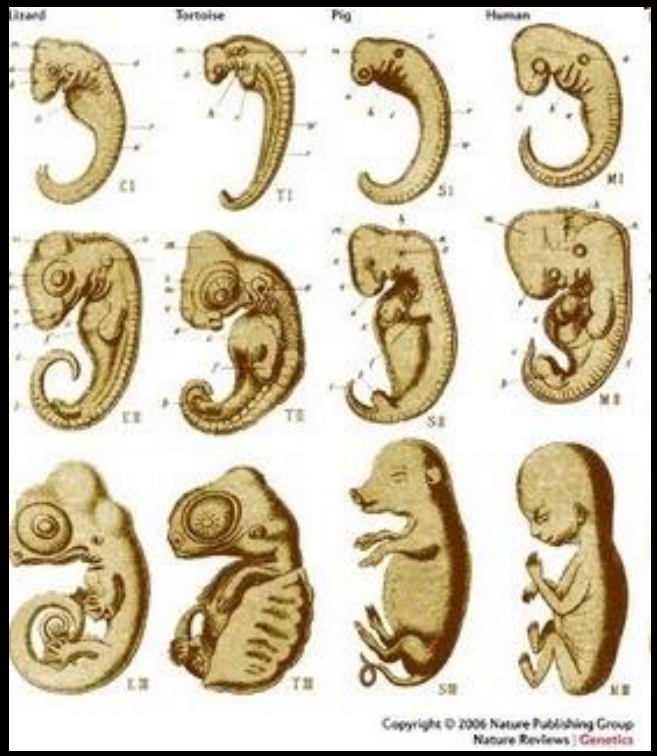
Evidence of Evolution- Homologous structures

3. Homologous structures of living organisms-Structures evolved to be slightly different and adaptive, but arise from the same embryonic tissue; Ex. Arms and wings



Evidence of Evolution- Similarities in early development

4. Similarities in early development- Ex. Between all vertebrates, from fish to mammals, the early stages of embryonic development are very similar

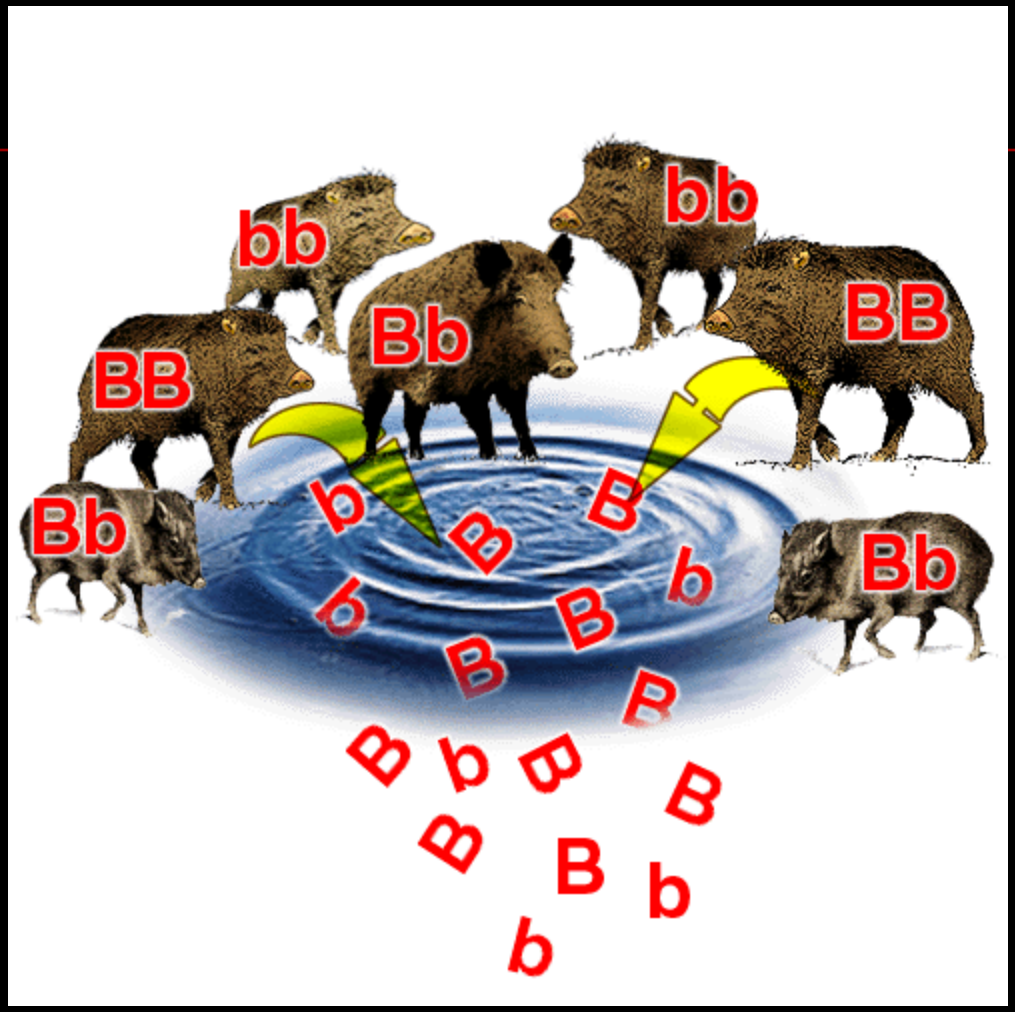


Chapter 16- Evolution of Populations

- I. 16-1 Genes and Variation
- A. Darwin did not know how heredity worked since DNA or genes had not been discovered
- B. Mendel Crossed pea plants in the 1860's but the importance of that work was not recognized until the 1900's
- C. Now genetics, molecular biology and evolution explain how evolution takes place

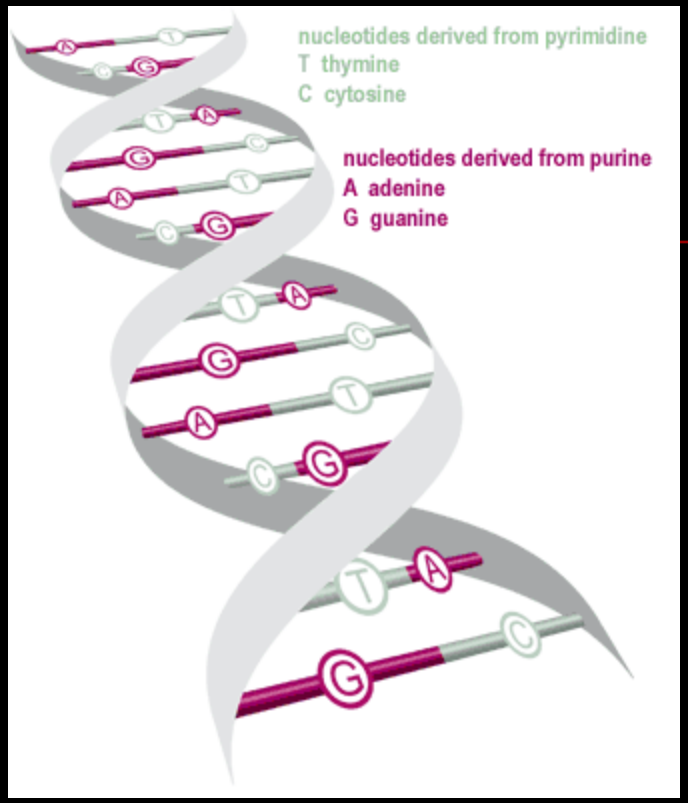
Chapter 16- Evolution of Populations

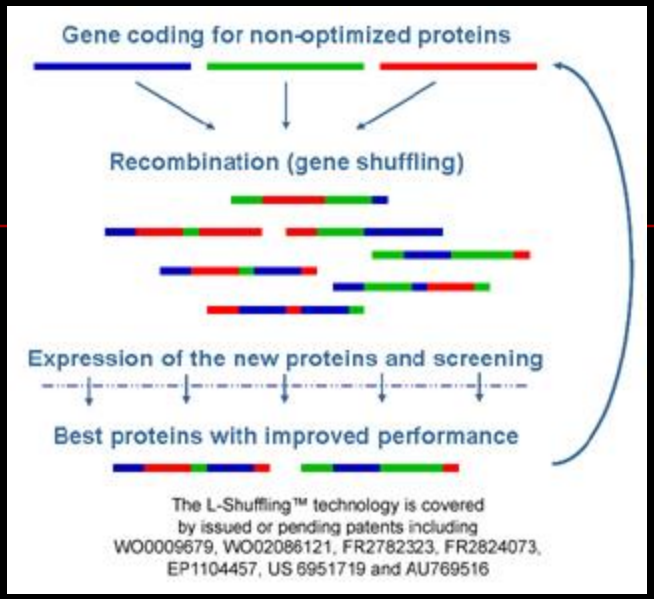
- I. 16-1 Genes and Variation (continued)
- D. Biologists study **gene pools**
  - The combined genetic information of all individuals in a population
  - Gene pools contain two or more alleles or forms of a certain gene for a certain trait-Ex fur color black or brown or white
  - The relative frequency of an allele is the number of times the allele occurs in a gene pool compared with the number of times other alleles occur Ex 60 % of alleles are black, 20% brown and 20% white

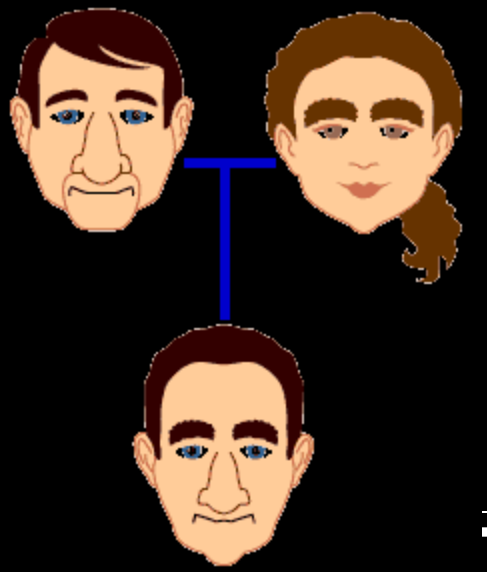

bb
bb
Bb
BB
BB
Bb
Bb
b
B
b
B
b
B
B
B
b
B
B
B
B
b
B
b

Chapter 16- Evolution of Populations

- I. 16-1 Genes and Variation (continued)
- G. Sources of genetic variation are mutation and genetic shuffling that results from sexual reproduction
  - Mutations, or a change in the DNA sequence occur when DNA replicates, or as a result of radiation or chemicals in the environment (mutagens)
  - Gene shuffling occurs when chromosomes separate during meiosis,
    - leads to crossing over and recombination
  - Like a deck of cards
    - shuffling leads to different hands but does not change the number of aces, kings, etc. in each deck, just mixes them up in different ways

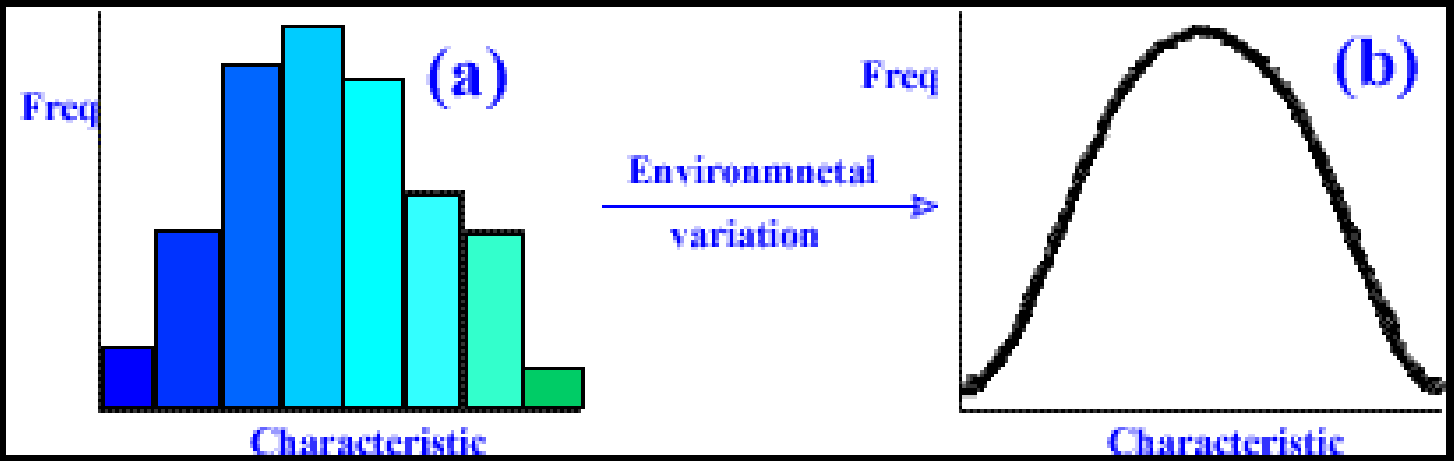

nucleotides derived from pyrimidine
T thymine
C cytosine
nucleotides derived from purine
A adenine
G guanine


Gene coding for non-optimized proteins
Recombination (gene shuffling)
Expression of the new proteins and screening
Best proteins with improved performance
The L-Shuffling™ technology is covered
by issued or pending patents including
WO0009679, WO02086121, FR2782323, FR2824073,
EP1104457, US 6951719 and AU769516



Chapter 16- Evolution of Populations

- I. 16-1 Genes and Variation (continued)
- J. The number of phenotypes produced for a trait depend on how many genes control that trait
  - Some controlled by one gene- **Single gene trait** -Ex. Hairline; single gene with 2 alleles
  - Most controlled by two or more genes- **Polygenic**- Ex. Height; many genes with 2 or more alleles
  - Phenotype frequencies in a population can be graphed, and form a bell shaped curve


Freq
(a)
Characteristic
Environmnetal
variation
Freq
(b)
Characteristic

Chapter 16- Evolution of Populations

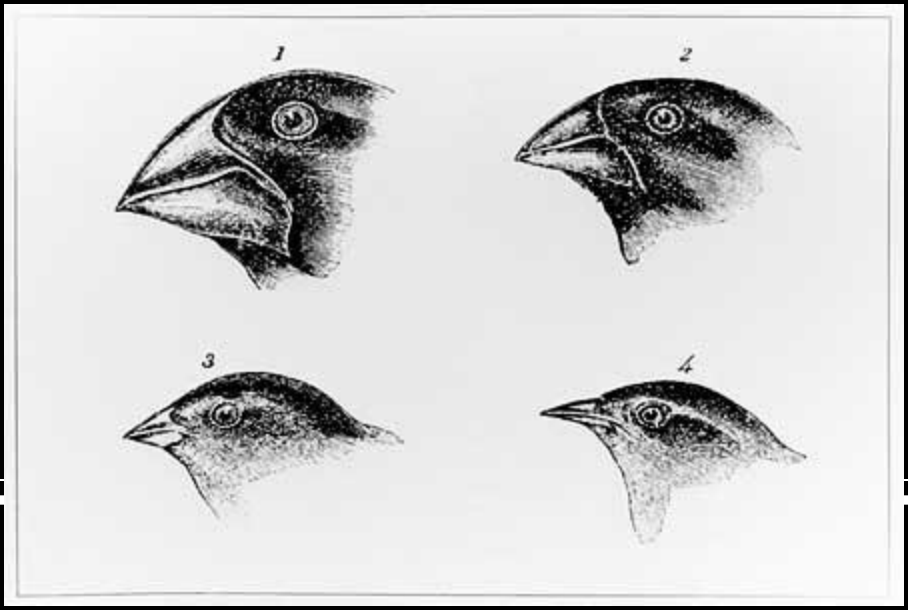
- II. 16-2 Evolution as Genetic Change
- A. Natural selection acts on phenotypes, not genotypes. Certain phenotypes survive and reproduce
- B. When an individual dies without reproducing, its genes are removed from the gene pool
- C. When an individual reproduces, the proportion of that individuals genes in the gene pool increases
- D. Genetically, evolution is any change in the frequency of genes in a population's gene pool. Therefore **evolution acts on populations, not on individuals**

Chapter 16- Evolution of Populations

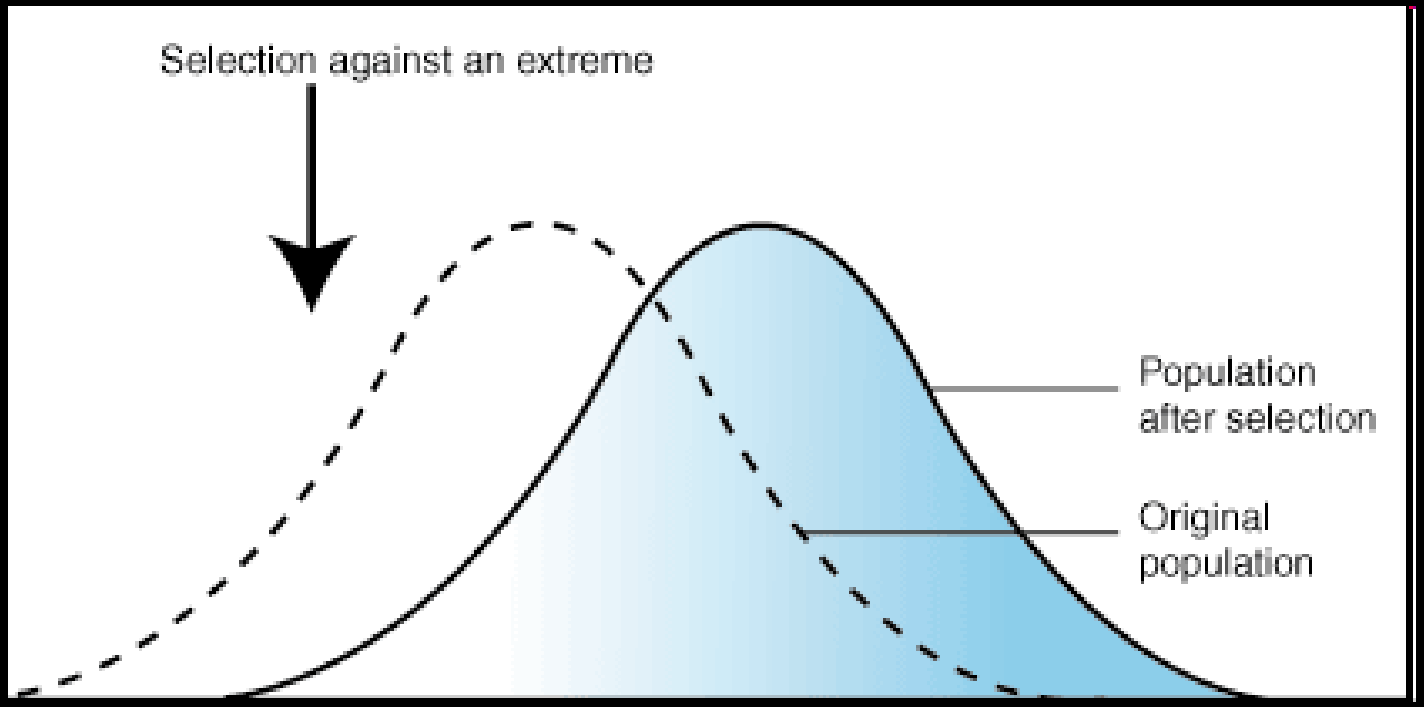
- II. 16-2 Evolution as Genetic Change (continued)
- E. Natural selection on single gene traits can lead to changes in the frequency of certain alleles, and therefore to evolution
- F. The effects of natural selection on polygenic traits are more complex. Natural selection can affect the distributions of phenotypes by **directional selection, stabilizing selection or disruptive selection**

Chapter 16- Evolution of Populations

- II. 16-2 Evolution as Genetic Change (continued)
- G. Directional selection-When individuals at one end of the curve have a higher fitness than the middle or the other end of the curve, directional selection toward the more fit trait occurs. Ex. Increase in beak size of Galapagos finches



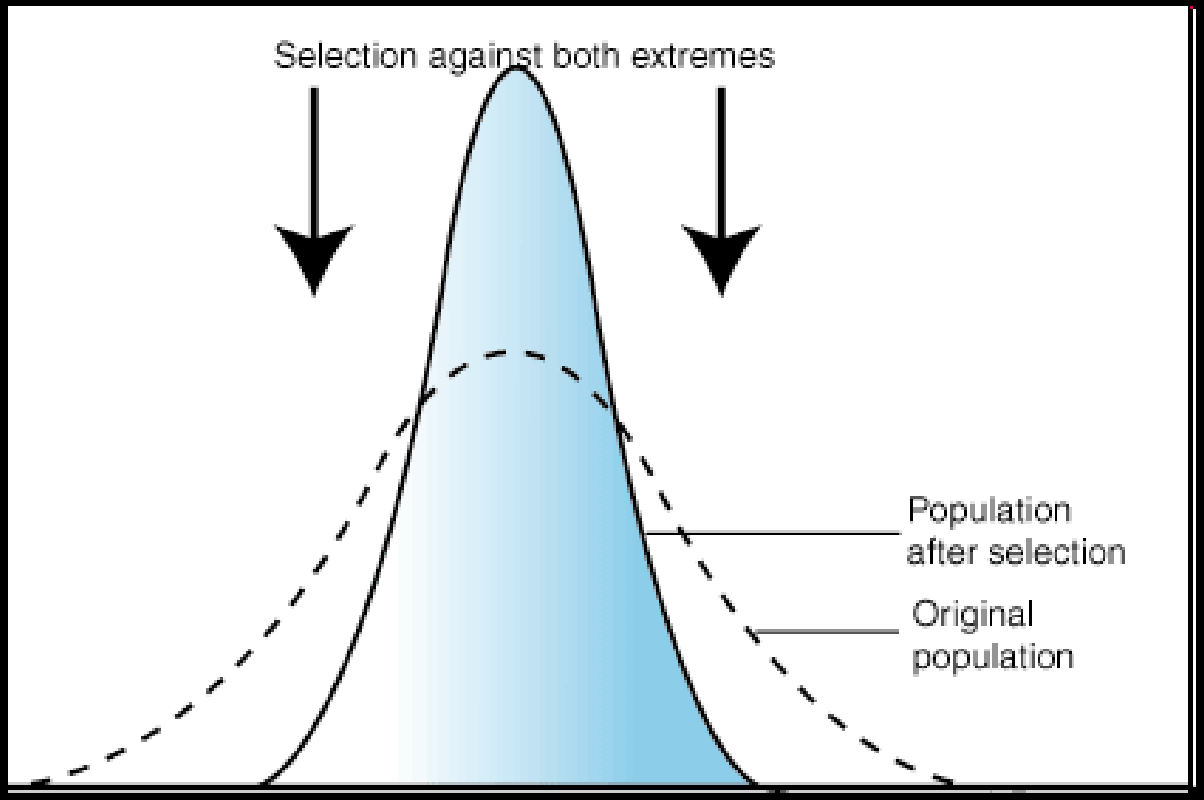
Directional selection



Chapter 16- Evolution of Populations

- II. 16-2 Evolution as Genetic Change (continued)
- H. Stabilizing selection-When individuals near the center of the bell curve have higher fitness that those at either end, stabilizing selection takes place. Ex. Birth weight of human babies

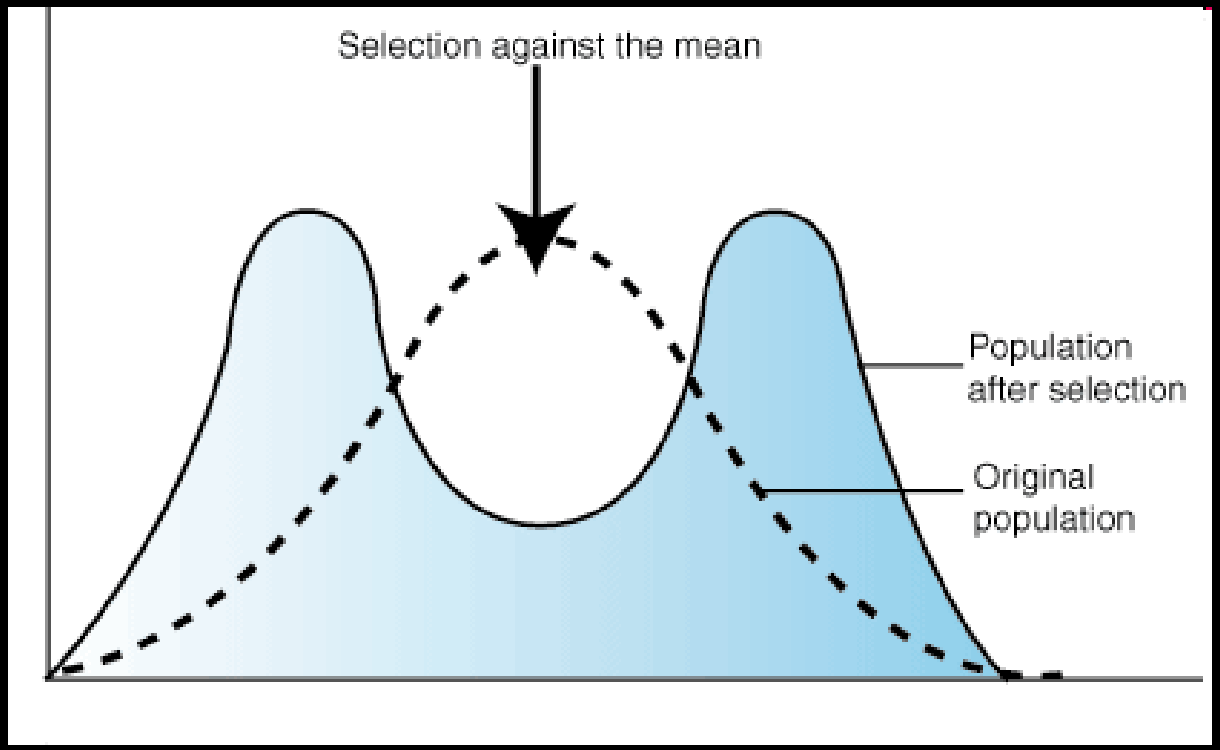
Stabilizing selection



Chapter 16- Evolution of Populations

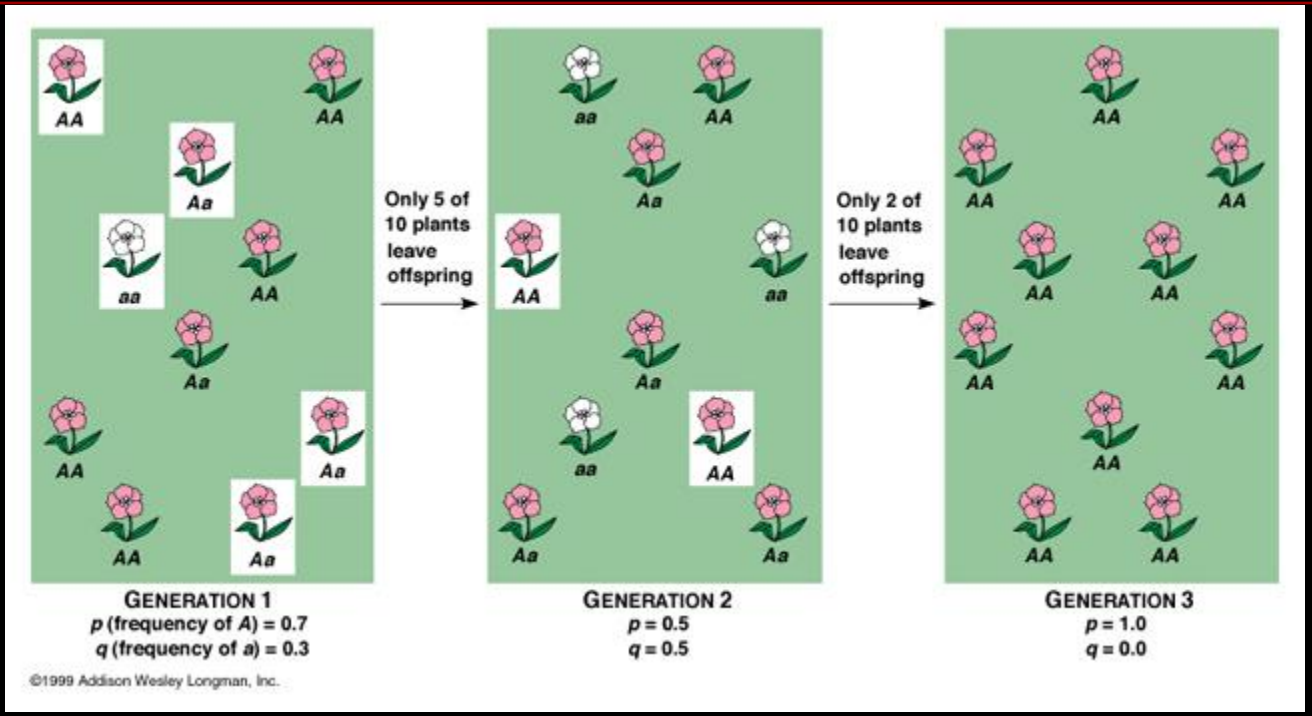
- II. 16-2 Evolution as Genetic Change (continued)
- I. Disruptive selection-When the individuals at both ends of the curve have a higher fitness than those in the middle, disruptive selection occurs. Ex. Bird beak size-if medium size seeds disappeared, large and small beak size would be most fit.

Disruptive selection



Chapter 16- Evolution of Populations

- II. 16-2 Evolution as Genetic Change (continued)
- J. Genetic Drift
  - Due to random changes in allele frequency
  - In small populations, individuals that carry a particular allele may leave more descendants than other individuals, just by chance
  - Over time, a series of chance occurrences can cause an allele to become common in a population
  - Can occur when a population colonizes a new habitat-causes the founder effect. Ex. Evolution of several hundred species of fruit flies found on the Hawaiian Islands; all descended from the same main island population


AA
AA
Aa
aa
AA
Aa
AA
Aa
AA
Aa
Only 5 of 10 plants leave offspring
aa
AA
Aa
AA
aa
Aa
aa
AA
Aa
Aa
Only 2 of 10 plants leave offspring
AA
AA
AA
AA
AA
AA
AA
AA
AA
GENERATION 1
p (frequency of A) = 0.7
q (frequency of a) = 0.3
GENERATION 2
p = 0.5
q = 0.5
GENERATION 3
p = 1.0
q = 0.0
©1999 Addison Wesley Longman, Inc.

Chapter 16- Evolution of Populations

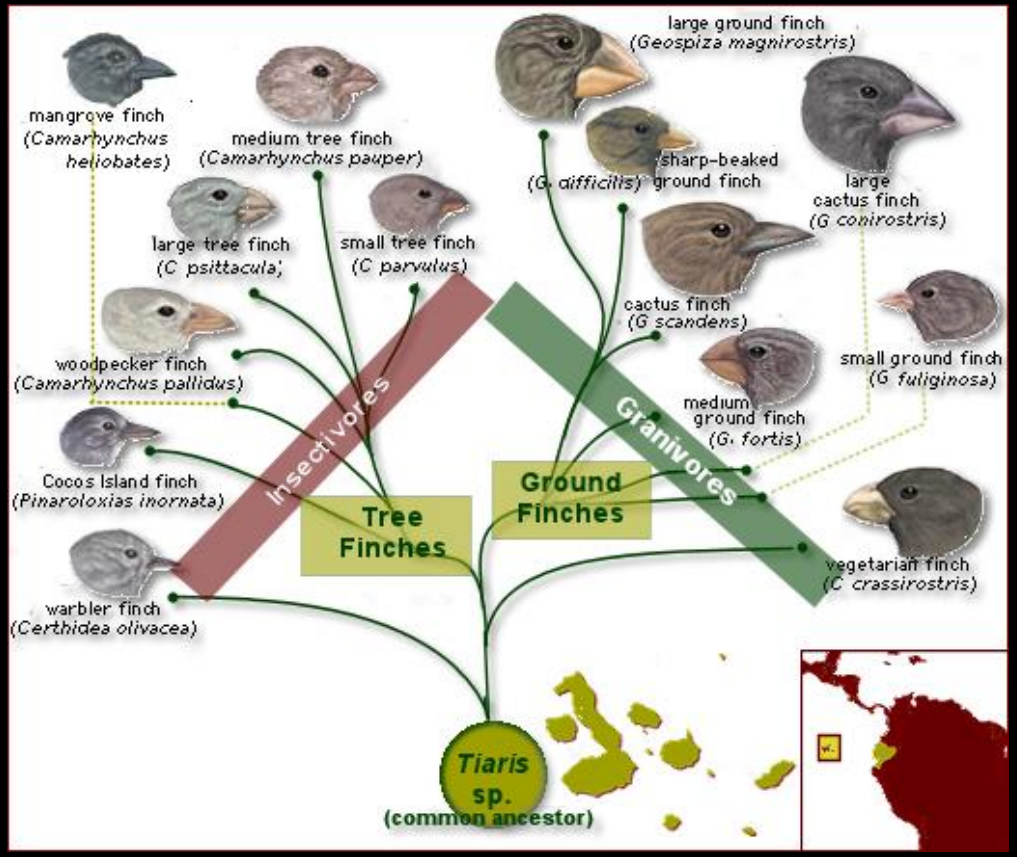
- II. 16-2 Evolution as Genetic Change (continued)
- K. The Hardy Weinberg principle explains why evolution might **not** occur
  - The allele frequencies in a population will remain constant unless one or more factors cause the frequencies to change
  - Requires five conditions to maintain genetic equilibrium from generation to generation:
  - Random mating, population must be very large, there can be no movement into or out of the population, no mutations and no natural selection
  - If any of these conditions are not met, evolution will occur

Chapter 16- Evolution of Populations

- III. 16-3 The Process of Speciation
- A. Definition-formation of a new species
- B. As new species evolve they become *reproductively isolated* from each other-the new and changed populations can't mate. This is due to:
  - Behavioral isolation-different courtship rules for example
  - Geographic isolation-river or mountain range separates the two populations
  - Temporal isolation-when the populations reproduce at different times

Chapter 16- Evolution of Populations

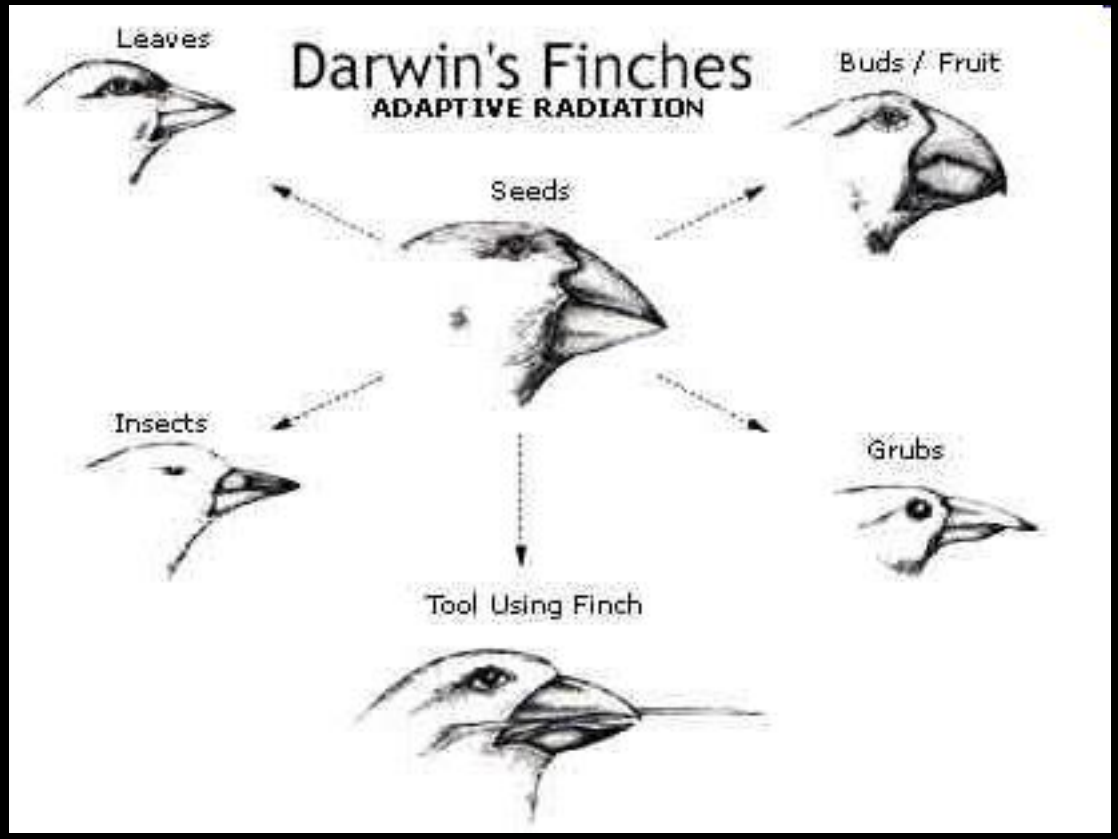
- III. 16-3 The Process of Speciation
- C. Examples In nature of natural selection
- Beak size and shape of Galapagos finches-Variation existed, the selective pressure was the availability of food types. Beaks evolved to best get the available food in different regions of the Galapagos Islands


large ground finch
(Geospiza magnirostris)
mangrove finch
(Camarhynchus heliobates)
medium tree finch
(Camarhynchus pauper)
sharp-beaked
ground finch
(G. difficilis)
large
cactus finch
(G conirostris)
large tree finch
(C psittacula)
small tree finch
(C parvulus)
cactus finch
(G scandens)
small ground finch
(G fuliginosa)
woodpecker finch
(Camarhynchus pallidus)
medium
ground finch
(G. fortis)
Insectivores
Granivores
Cocos Island finch
(Pinaroloxias inornata)
Tree
Finches
Ground
Finches
vegetarian finch
(C crassirostris)
warbler finch
(Certhidea olivacea)
Tiaris
sp.
(common ancestor)

Chapter 16- Evolution of Populations

- III. 16-3 The Process of Speciation
- Speciation occurred by
  - the founding of a new population
  - geographic isolation
  - changes in the new population's gene pool
  - reproductive isolation
  - ecological competition

Examples In nature of natural selection



Chapter 17-The History of Life

- The Fossil Record
- Earth's Early History
- Evolution of Multicellular Life
- Patterns of Evolution

Chapter 17-The History of Life

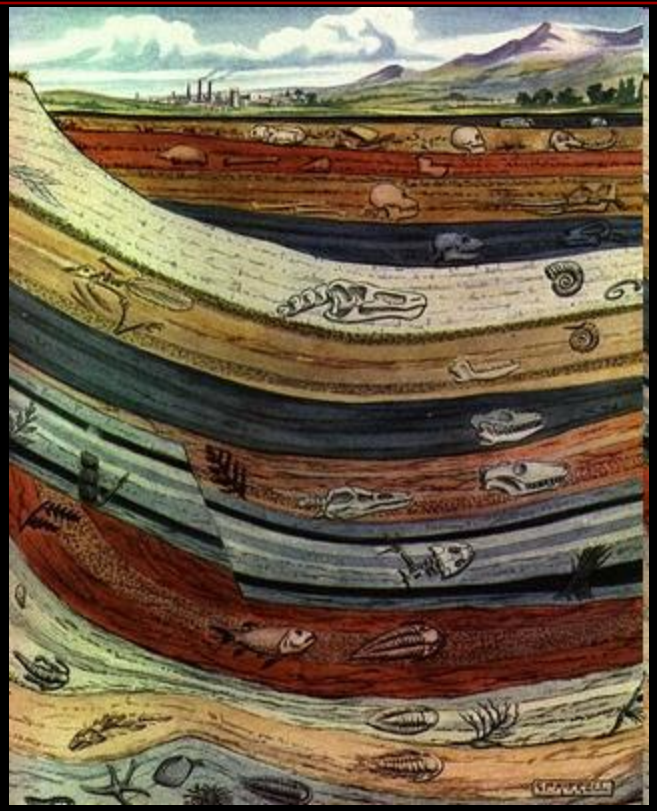
- I. 17-1 The Fossil Record
- A. Shows how different groups of organisms have changed over time
- B. Certain fossils are found only in rocks from a certain age
- C. More than 99% of all the species that have ever lived are extinct

Chapter 17-The History of Life

- I. 17-1 The Fossil Record
- D. Most organisms die without leaving a fossil behind.
  - Most fossils form in sedimentary rock (sand, clay in river or lake beds) and are exposed and weathered by wind and heat
  - Many do not survive or are fragmented and not intact

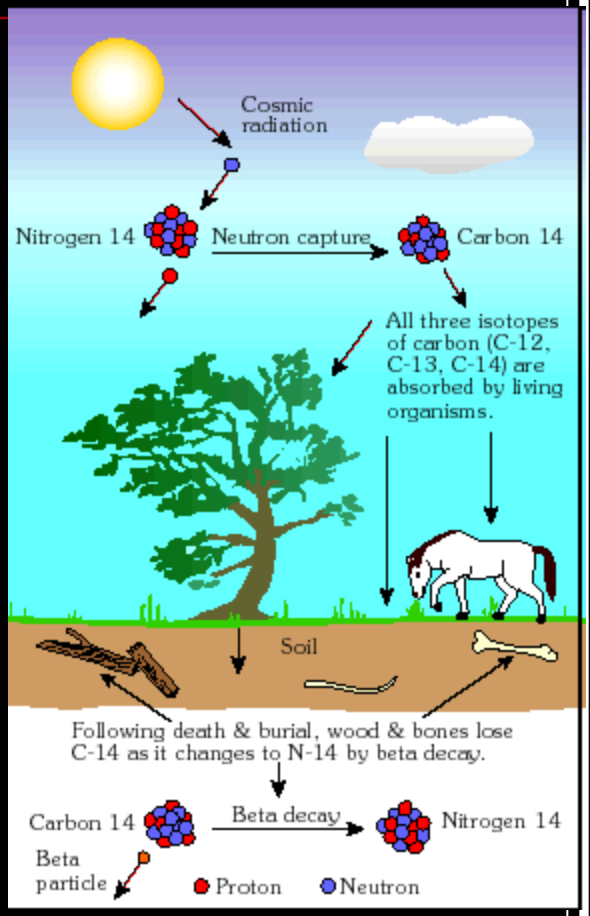
Chapter 17-The History of Life

- I. 17-1 The Fossil Record
- E. Forces in the earth lift up and expose the rock layers containing the fossil
- F. Relative dating-the age of the fossil is determined by comparing in placement with that of other fossils in other layers
  - Index fossils (reference fossils) may be used



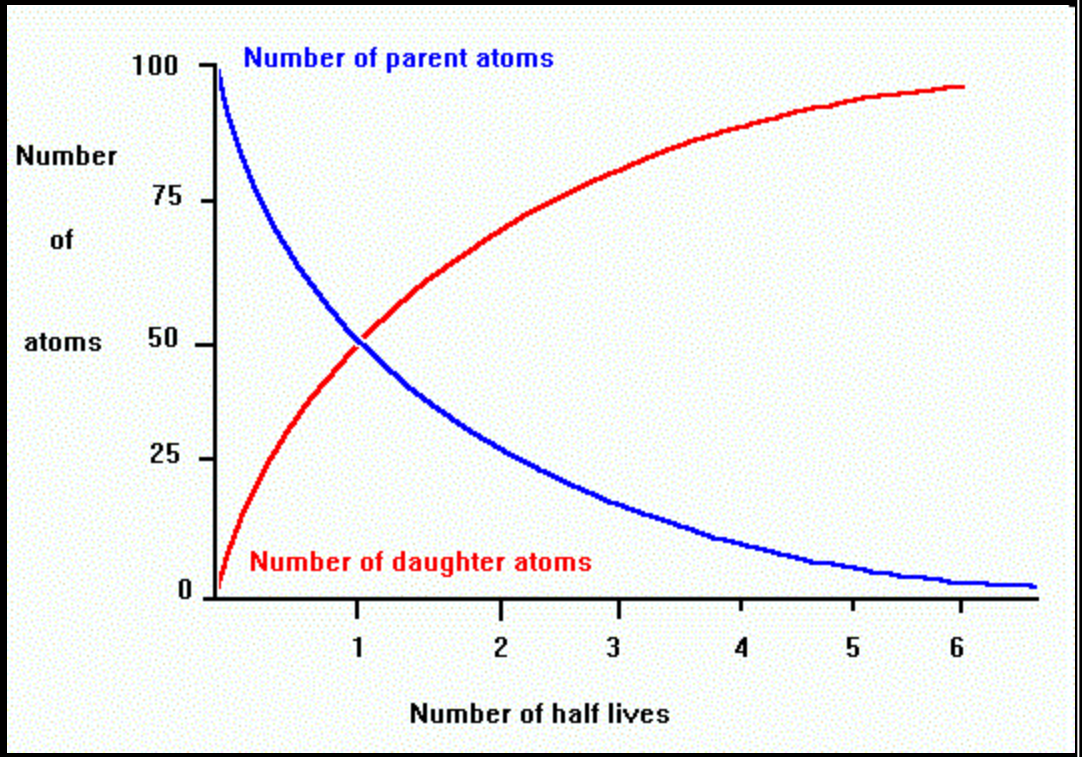
Chapter 17-The History of Life

- I. 17-1 The Fossil Record
- G. Radioactive dating
  - uses the half-life of a radioactive form of an element to determine the age of the fossil
  - In nature there are several forms of carbon-isotopes
  - Matter is a mixture of these isotopes.
  - C-14 is radioactive, and decays into C-12.



Radiometric Dating: C-14 dating

- The time it takes for half of the starting material's C-14 to decay is called the half life.
- The other form of carbon, C-12, does not decay.
- By comparing the amount of C-14 to the amount of C-12, scientists can calculate the age of the fossil



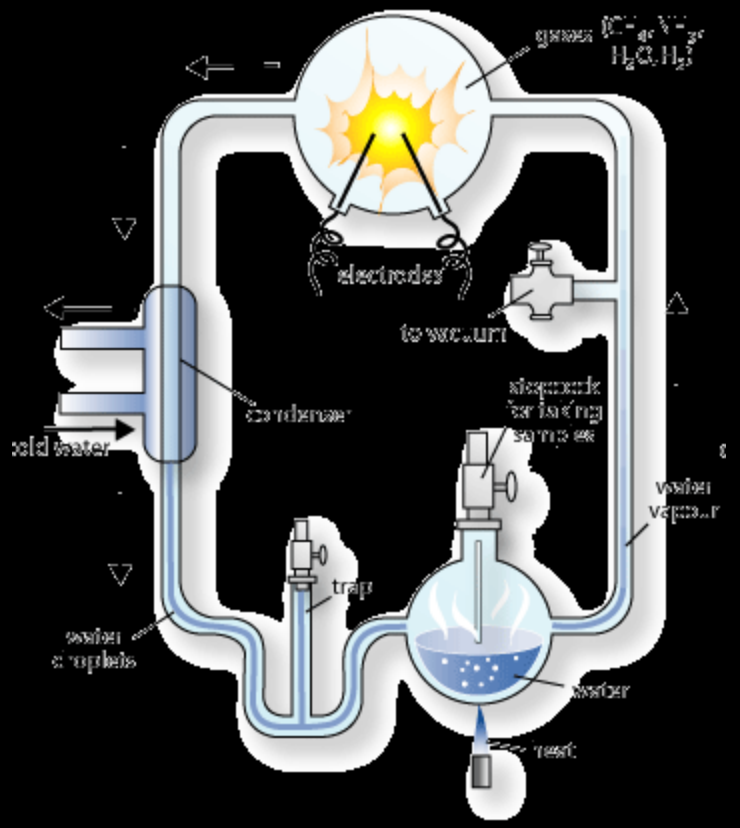
Chapter 17-The History of Life

- I. 17-1 The Fossil Record
- H. Geologic time scale-divisions represent evolutionary time-Eras
  - Precambrian (650-544 mya, 90% of the earth's history)
  - Paleozoic (544-245 mya), Mesozoic (245-65 mya) and Centozoic (6.5mya-present)

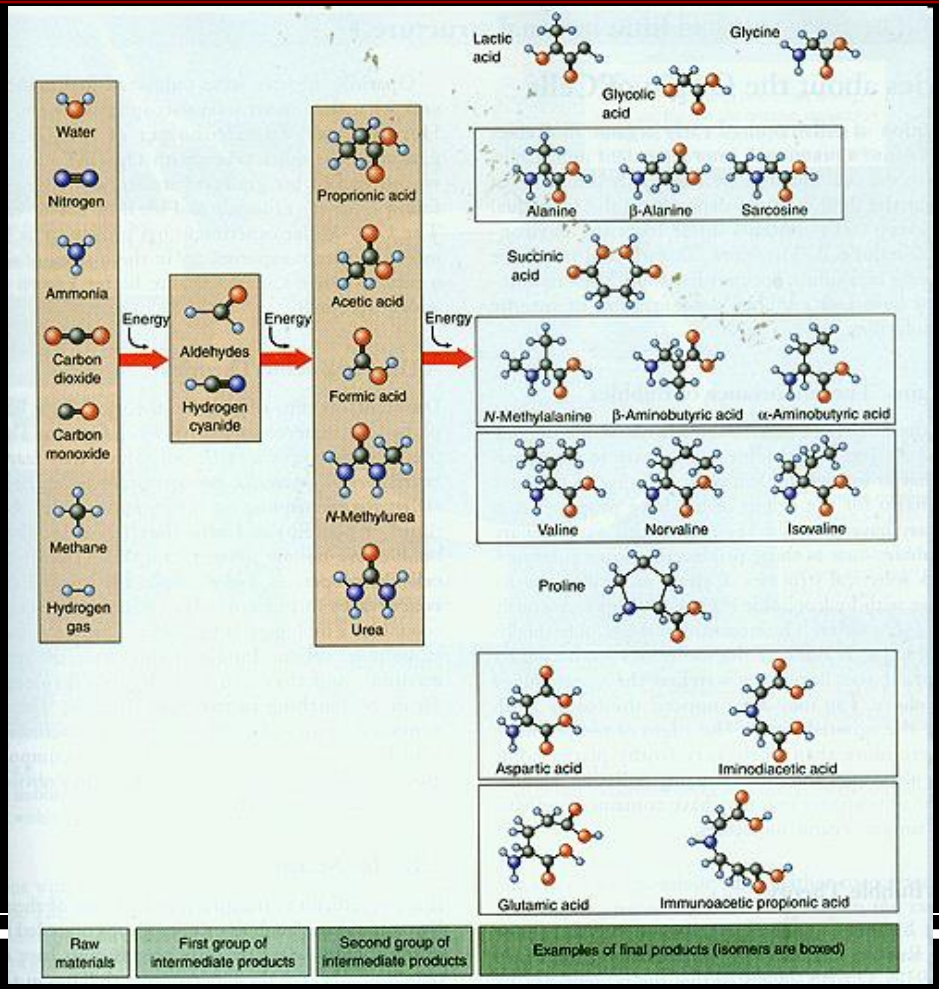
  Eras are divided into periods (Ex. Mesozoic is divided into Triassic, Jurrasic and Cretaceous)

Chapter 17-The History of Life

- II. 17-2 Earth's Early History
- A. Earth's early atmosphere probably contained hydrogen cyanide, carbon dioxide, carbon monoxide, nitrogen, hydrogen sulfide and water
- B. Since the 1950's, scientists have showed that when the molecules present on earth at that time are placed in a sealed container and electrical current is passed through, amino acids and molecules used to make RNA and proteinoids form



Formation of the first organic (carbon/hydrogen-based) molecules



Chapter 17-The History of Life

- II. 17-2 Earth's Early History
- C. RNA probably evolved first, then DNA
  - RNA can act as an enzyme and replicate itself
  - DNA is more stable than RNA
- D. Single celled prokaryotic organisms formed from microspheres of proteinoids and RNA and started producing oxygen
- E. Eventually the atmosphere contained enough oxygen that some species died off, and others developed more efficient ways of using oxygen for respiration to produce energy

RNA World

Primordial Soup with amino acids

↓

???

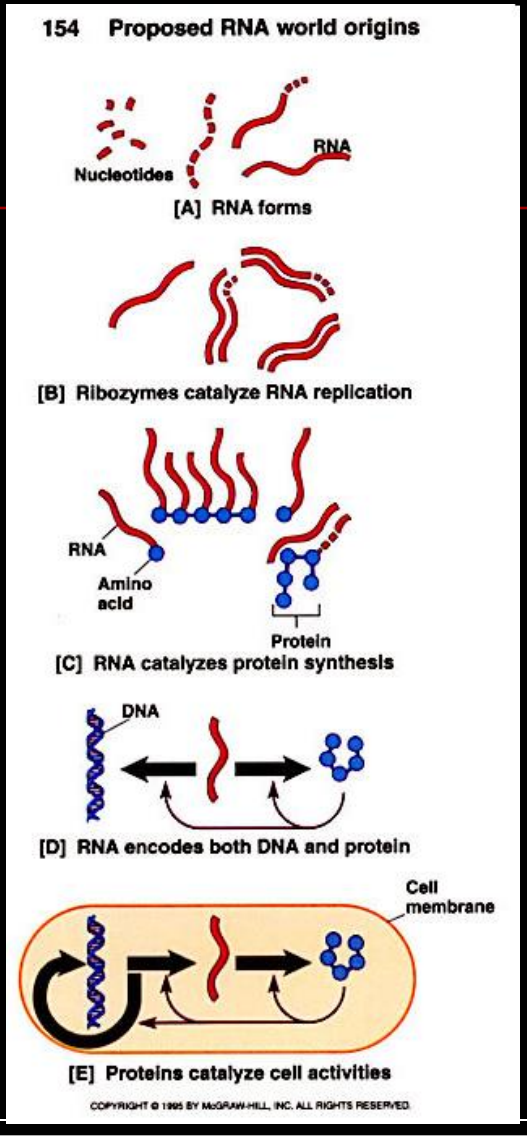
↓

RNA World

↓

DNA World

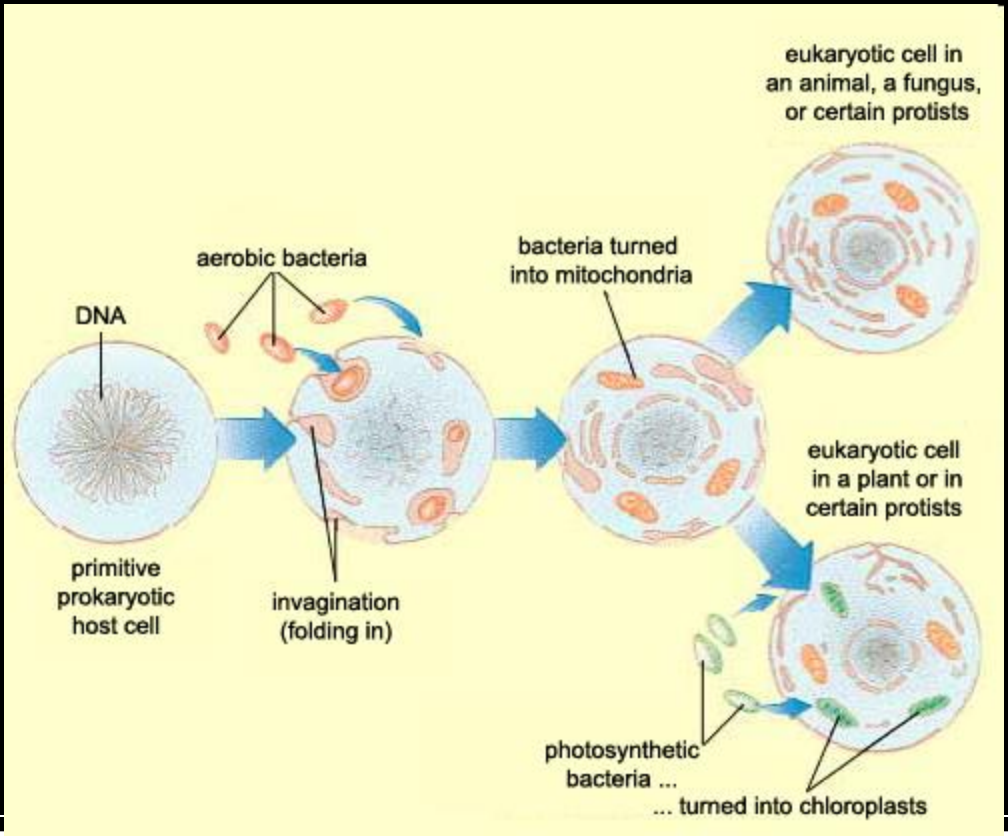
(Life as we know it)



Chapter 17-The History of Life

- II. 17-2 Earth's Early History
- F. Small prokaryotes started living inside larger ones and this led to the evolution of eukaryotic cells
  - Called **endosymbiotic theory**
  - eukaryotic cells arose from living communities formed by prokaryotic organisms

Endosymbiotic Theory

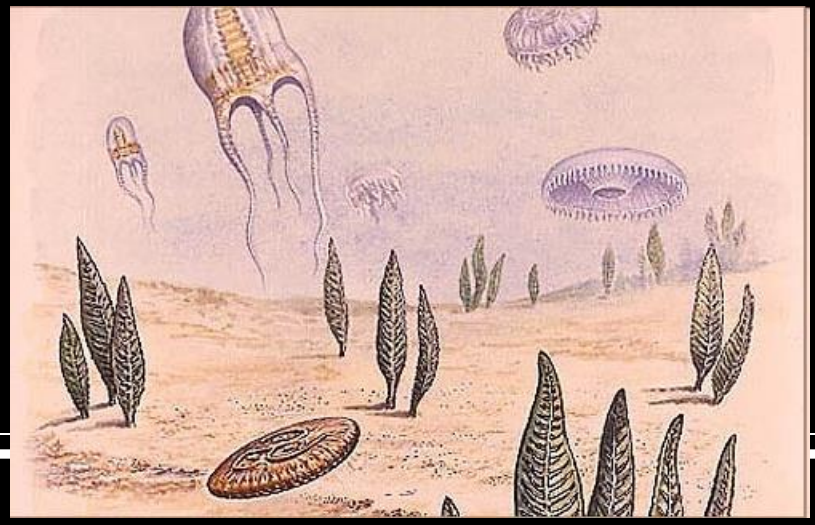


Chapter 17-The History of Life

- II. 17-2 Earth's Early History
- G. Most prokaryotes reproduce asexually by division
- H. Next, cells began to reproduce sexually
  - sped up the process of evolution
  - Led to more genetic variation in the populations of organisms
- I. A ***few hundred million years later***, multicellular life evolved

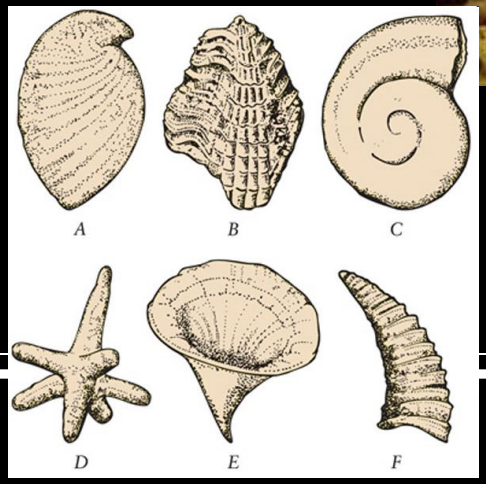
Chapter 17-The History of Life

- III. 17-3 Evolution of Multicellular Life
- A. As the Precambrian era ended and the Paleozoic era, Cambrian period started, multicellular life began to evolve



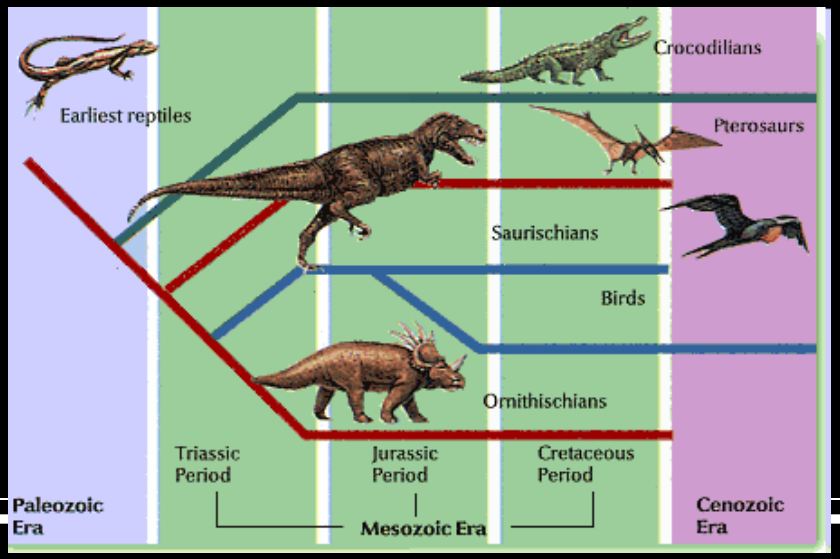
Cambrian-Paleozoic Era

- B. Life diversified during this period, organisms got hard shells and outer skeleton and most animal phyla evolved-Cambrian explosion



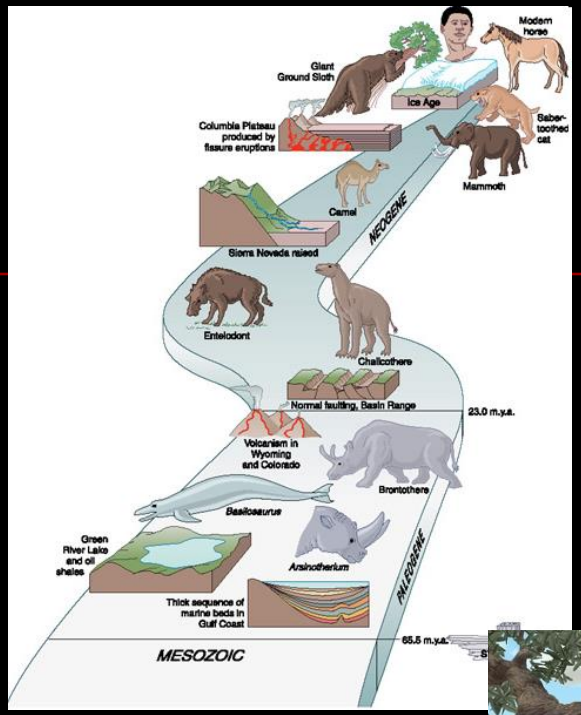
Chapter 17-The History of Life

- III. 17-3 Evolution of Multicellular Life
- C. By the end of the Paleozoic era, invertebrates and vertebrates evolved
- D. Mesozoic era was dominated by dinosaurs and flowering plants. Dinosaurs died off at the end of the Mesozoic era



Cenozoic Era

- E. During the Cenozoic era, mammals dominated



Chapter 17-The History of Life

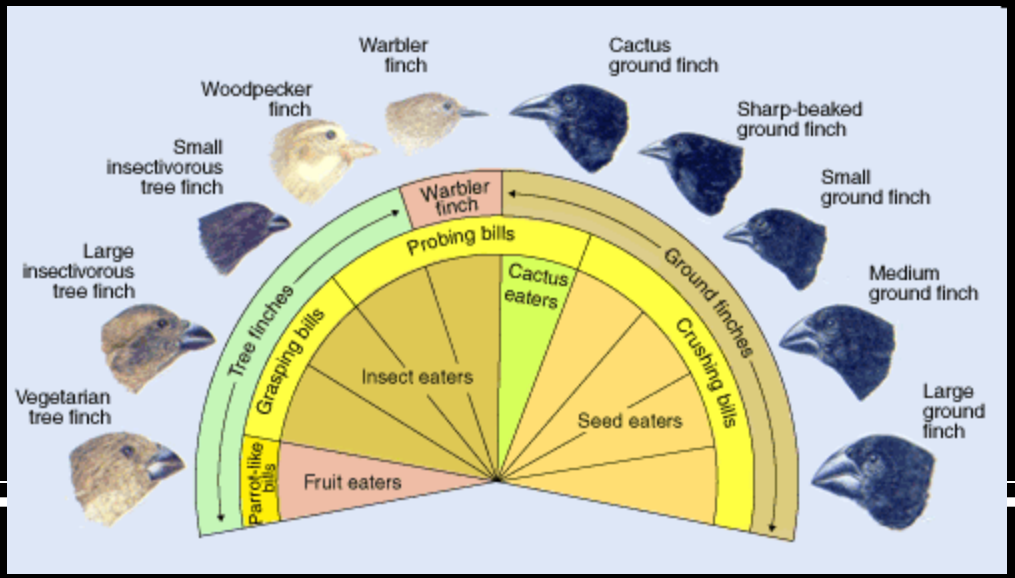
- IV. 17-4 Patterns of evolution
- A. Macroevolution-Large-scale evolutionary changes that take place over a long period of time
- B. Six patterns-mass extinctions, adaptive radiation, convergent evolution, coevolution, punctuated equilibrium and changes in developmental genes

Chapter 17-The History of Life

- IV. 17-4 Patterns of evolution
- C. Mass extinctions-huge numbers of species disappear at one time Ex. Dinosaurs

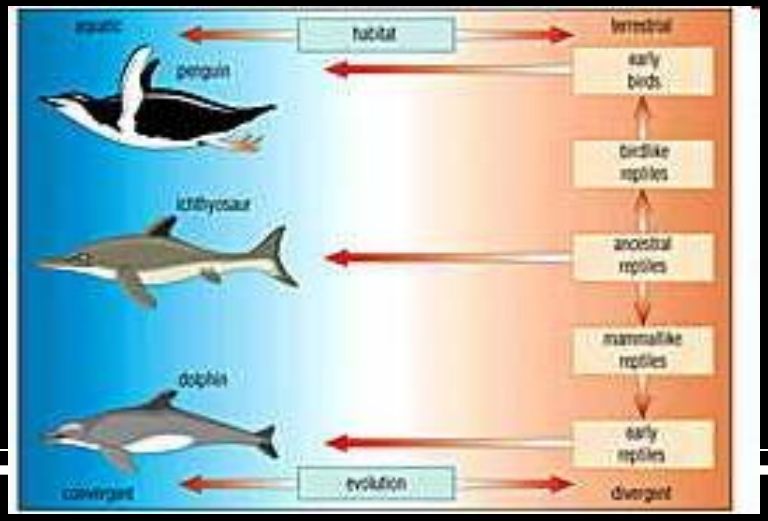
Adaptive Radiation

- D. Adaptive radiation-A single species evolves into several different forms that live in different ways. Ex. Dinosaurs-why they "ruled the earth"



Chapter 17-The History of Life

- IV. 17-4 Patterns of evolution
- E. Convergent Evolution-The process by which unrelated organisms come to look like one another. Ex. Swimming animals-sharks, fish, marine mammals like whales and seals

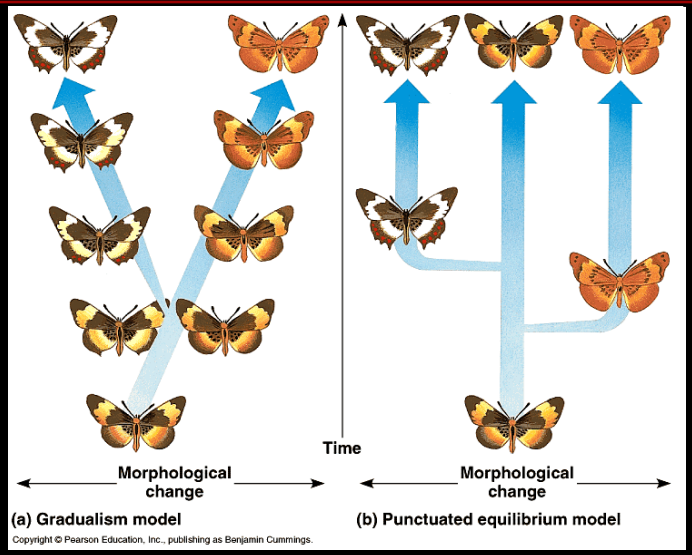


Convergent and Coevolution

- F. Coevolution-organisms that are closely connected to one another by ecological interactions evolve together in response to changes in each other's environments. Ex. Flowers and insects that pollinate them

Chapter 17-The History of Life

- IV. 17-4 Patterns of evolution
- G. Punctuated Equilibrium
  - Evolution does not occur at the same rate all the time
  - Long stable periods where no changes occur, interrupted by brief periods of rapid change, in response to changes in the environment



Chapter 17-The History of Life

H. Developmental Genes and Body Plans

- Master control genes ***(Hox*** genes) establish body plans in **all organisms, from insects to humans**.
- Changes in *hox* genes lead to different body plans.
- Small changes in the timing of expression of hox genes can lead to changes in body plans

Hox Genes in Flies, Mice and Chickens and Snakes