EVOLUTION UNIT

Evolution

- the process of change that produces new species from preexisting species over time.

Adaptation

- an inherited trait that promotes survival and reproduction for a species.; the process of becoming better suited to the environment.

Variation -

- the existence of various alleles and phenotypes in a population for traits. (e.g. There is great variation in human height, eye color, etc.)

Who Came First with the animals? (see p. 660)

Time Line:

prokaryotic cells - eukaryotic cells - worms - clams - fish - amphibians - reptiles - dinosaurs - mammals - birds - placental mammals - humans

Explain the process of natural selection and artificial selection. (pp. 664-667)

artificial selection - human selection of particular traits when breeding plants or animals.

- the selective breeding of organisms by man to produce desired traits in the offspring. (Eg. Dog breeds, race horses, cattle breeds, roses, etc.)
- also relates to genetic engineering e.g. placing recombinant DNA in organisms , transgenic organisms

natural selection - process whereby the the characteristics of a population change because individuals with certain inheritable traits survive specific local environmental conditions ***(***the process by which the environment allows only the better adapted organisms to survive and to reproduce***)***

The Case of the Peppered Moth (also called Industrial Melanism) - p. 644 read

- modern day example of evolution (natural selection) that has occurred over a short period
- occurred in England during the industrial revolution
- before pollution most moths were light with a few dark mutants. After pollution stained tree trunks the dark moths were naturally selected to survive. Population became mostly dark moths.

The Advancement of the Theory of Evolution

Many scientists have played important roles in the development of evolutionary knowledge. Some have directly theorized about the evolutionary process while others have affected the thinking of those doing the theorizing.

Georges Cuvier

- developed the science of paleontology.
- proposed the theory of **catastrophism**. - he said that catastrophes (natural disasters like floods , volcanoes, etc.) had periodically destroyed species in one area while not affecting species in a nearby area, which would then repopulate the affected regions.

Charles Lyell

Prposed the theory of uniformitism. that states that the earth was very old, that it had been slowly changing, and was still changing. And that geological processes operated at the same rates in the past as they do today. No irregular, unpredictable, catastrophic events shaped earths history. His ideas also lead Darwin to think that perhaps living things also changed slowly over long periods of time.

Jean Baptiste Lamarck - produced two laws to account for changes in organisms: (both are false now)

A. **The Law of Use or Disuse**

This law states that if an organism uses a particular organ it remains active and strong but if it is not used then it becomes weak and eventually disappears. For example, The necks of giraffes were originally short because they feed upon grasses and shrubs close to the ground. As the food supply near the ground decreased, giraffes had to stretch their necks to reach food in trees.

B. The Law of Inheritance of Acquired Characteristics

- states that the characteristics of an organism developed through use and could be passed on to the offspring of the next generation.

eg. since giraffes stretched their necks during their lifetime then this trait was passed onto their offspring.

Lamarck's Theory was rejected for the following reasons:

(I) He thought that an organism could change its structure because it felt a need to do so. This is false.
(ii) He thought **Acquired characteristics** can be inherited. this was false: Only genetic traits can be inherited
(iii) All experiments conducted to support the theory failed.

Thomas Malthus - wrote a famous essay on the Principle of Population. He stated that the ever increasing human population was exceeding the food supply needed to feed it. To keep a balance between the need for food and the supply of food, millions of individuals had to die by disease, starvation or war.

Charles Darwin -stated the theory of Evolution and Natural Selection. His theory was the result of information from a number of different sources (Cuvier, Lyell, Malthus, LaMarck) and his own research and observations , especially of the Finches on the Galapagos Islands.

This idea helped Darwin to formulate the concept of natural selection. Darwin realized that all organisms overpopulate and therefore all individuals can not survive. Those that do not survive have more favorable variations. Nature selects the survivors. The result of natural selection would be evolution since these favorable variations would be passed on to their offspring.

Darwin traveled on the HMS Beagle from 1831 -1836. He made personal observations of animal species, in particular finches, on the Galapagos Islands. **Darwin observed 13 species of finch** that were similar to each other in many ways and similar to the species of finch found on the mainland. The notable difference lay in the **shape of their beaks**. It appeared to Darwin that the **different beak shapes were adaptations** for eating the certain **types of food** characteristic of the various geographic locations. For example, some beaks were adapted to be large and crushing bills to eat seeds, some were parrot-like to eat fruit and some were chisel-like to probe for insects in the bark of trees.

Close to the same time Darwin was working on his theory British naturalist **Alfred Wallace** was working on a similar theory. His observations had led him to many of the same conclusions as Darwin and it is because of this that Darwin stopped delaying the publication of his ideas and published his observations in 1859 under the title **On the Origin of the Species** by Means of Natural Selection.

Since living space and food are limited. Offspring in each generation must compete against themselves and with other species for the necessities of life. Only a small fraction can possibly survive long enough to reproduce.

Those individuals in a species with characteristics that give them an advantage are better able to compete, survive and reproduce. Those with the poorer characteristics die without leaving offspring. Since nature selects the organisms that survive, the process is called natural selection. Over many generations, favorable characteristics gradually accumulate in the species and unfavorable ones disappear. Eventually, the accumulated changes become so great that the net result is a new species.

Comparison between Lamarck's and Darwin's Theories

Major Similarity:

Both believed that evolution was related to a change in the environment.

Major Differences

(I) **Numbers**

Lamarck believed that individuals evolved while Darwin believed that evolution occurred within a population. Darwin said that evolution occurred when an entire population changed.

(ii) **Timing**

Lamarck believed that variations occurred after the environment changed. Darwin believed that variations were always present and when the environment changed those organisms with the most suitable variations for the new environment survived while those with the less suitable variations died off.

Q: **How would Darwin explain Lamarck's giraffe example?**

A: Darwin would say that there were always longer and shorter necked giraffes, the result of separate alleles for a trait. In times when food was scarce, the longer necked giraffes survived better and were naturally selected. In each generation, there were more long necks and fewer short necked giraffes until a drastic food shortage wiped out the short necks.

Q: **Why was Darwin unable to explain the mechanism of inheritance of traits in his theory?**

A: Darwin was unable to account or explain the mechanism of inheritance of traits in his theory because we had no knowledge of genetics at that time. He has no knowledge of Mendel's experiments on pea plants and his laws of inheritance, segregation or independent assortment.

Q: **How does knowledge of Mendelian Genetics and mutations support Darwin's theory?**

A: Darwin's natural selection mechanism is based on the assumption that in any population of organisms there is variation of traits. Those with the best traits suited to the environment get naturally selected to survive.. Those not suited, die off. Mendelian genetics explains why variations exist in a population of organisms; it is due to his three principles of dominance, segregation and independent assortment.

The Modern Theory of Evolution

The modern theory of evolution supports natural selection. Scientists do not refute that evolution does occur, just about how it occurs. Modern evolutionary theory is strongly supported by evidences such as DNA comparison, comparative embryology, comparative biochemistry, etc.

Today we know that the evolutionary relationships between organisms is reflected in their DNA. Similarities between gene sequences indicates how closely organisms are related (e.g DNA told us that dogs are closely related to bears!) We can study the evolutionary history of a gene by using DNA sequencing (e.g. the protein hemoglobin has been well studied - see p. 667, fig. 19.18)

<u>Types of Current Evidence that Supports the Modern Theory of Evolution</u>

1. **The Fossil Record (read p. 659**.)

Fossil record - the history of life as determined by the relative age of fossils.

fossil - any trace or remains of an organism that has been preserved by a natural process.

sedimentary rock - rock formed by laying down horizontal layers of sediment. This is done by water erosion and deposit. Over time, as the sediment grows thicker, the pressure and weight harden the lower layers into sedimentary rock.

Fossils are generally found in sedimentary rock Because of the way sedimentary rock is formed, it can tell us a lot about the evolution of species (what came first) and help us "date " fossils. Sedimentary rock is laid down in horizontal layers called beds, one on top of the other over millions of years. As a result, the deeper layers are the oldest and the upper layers are the youngest. This principle is called **"superposition"**.

Layer D (youngest rock and most advanced fossils)
Layer C
Layer B
Layer A (oldest rock and least complex fossils)

2. Biogeography (p 663)

- is the study of the geographical distribution of species.
- biogeography shows that geographic isolation of the same species in different areas can lead to the formation of new species. The physical separation of similar organisms by geographical barriers such as oceans, mountains, etc. can cause the formation of new species. Populations become cut off from each other and can no longer inter-breed. Random mutations or natural selection will occur differently in these populations over time.

3. Comparative anatomy (read p. 664 - 665)

looks at presence of homologous structures and vestigial organs/structures in organisms to show if organisms are closely related (share a common ancestor), distantly related or not related at all.

Homologous structure - a structure having a common ancestry but with different uses in various species.

Eg. The wings of bird, bats, the flipper of a whale and a human arm all have the same number of bones in the same type of arrangement. Although they each have different functions, their common bone plan indicates that these animals evolved from a common ancestor**. (See fig. 19.15)**

Vestigial organ - small incomplete organs or structures that have no apparent function .
Eg. A python (big snake) has vestigial leg bones buried in its muscle tissue towards its rear end that have no function.
The appendix in humans was an extension on the intestine that we don't have anymore.
Our tail - bone (the coccyx) was once an attachment point for a tail.

Vestigial organs- are considered to be the "remains" of organs we once had and have lost through evolution. They help show who we may be related to - what ancestors we have in common.

4. Comparative embryology (p. 665)

This is the study of the earliest stages of embryo development. Organisms that share a common ancestor (organisms that are more closely related) go through similar stages of development and therefore have embryos that look very much alike. **(See fig. 19.17)** The embryos of birds and reptiles look very similar, showing they share common ancestry.

5. Heredity (p. 666)

The laws of heredity and genetics are clearly understood today. The variations that occur in organisms can be explained.

6. Molecular Biology (p. 666)

DNA sequencing allows us to compare DNA sequences (genes) in organisms.
Organisms which have evolved from common ancestors show more similarities in DNA
Organisms which have identical or very similar sequences in the amino acids making up their proteins are closely related and share common ancestors. Eg. Humans are closely related to chimpanzees because many of our proteins are the same. E.g. human Cytochrome C, an important protein in our metabolism, is identical to that in a chimpanzee. This tells us that chimps and humans are closely related in the evolutionary tree.

See the evolution of cytochrome C, p. 666, fig. 19.18.

DO: "Comparing Primate Hemoglobin" Activity:
DO: Worksheet on Comparitive anatomy and Embryology

<u>**Getting the Age of a Fossil: Absolute dating verses Relative Dating of Fossils**</u>

The statement "I am older than you, you are older than your sister" etc. is similar to **relative dating.** It doesn't give an exact age but age in relation to something else. We tell the age of many fossils from the rock layer it is found in.

relative dating. - Using the rock layer a fossil lies in to determine the age of the fossil.

Absolute dating - would be like "you can tell the age of a tree by counting the rings in the stem". **It is an exact way to measure the age in years.**

Any method which gives the actual age of a fossil is called absolute dating. The most accurate and reliable method for dating fossils is radioactive dating.

Radioactive dating - a dating method based on the rate of disintegration of radioactive isotopes.
Formula:

All fossils contain **radioactive isotopes**. Living organisms accumulate certain radioactive isotopes when they are living. Once these organisms die, the radioactive isotopes start to breakdown. Radioactive dating is based on the fact that certain elements have unstable isotopes. These isotopes break down at a known rate, called the "**half - life**".

Half life - is the amount of time it requires to breakdown half of the originally accumulated radioactive compound and have it replaced by one half decay product.

By analyzing how much of a radioactive isotope is left in a fossil or in the rock in which it was found, we can determine the approximate age of a fossil.

Eg. Carbon -14 dating:

The half - life of carbon 14 is 5730 years. If a fossil was formed 5730 years ago, it would have only ½ of its original carbon 14 left. The other ½ would have changed into nitrogen 14. By comparing the ratio of carbon 14 and nitrogen 14 in the fossil, scientists can determine the age of the fossil. This method requires that fossils contain organic matter and does not work for any fossils over 50,000 years old. So other radioactive isotopes are used to date older fossils.

$$N_f = N_0\left(\frac{1}{2}\right)^{\frac{t}{h}}$$

Where N_f = final amount, N_0 = initial amount

t = time (years) h = halflife

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DO: **thinking lab p. 662** (can do this without formula)

Other Radioactive dating problems to solve:

(A) A fossil contains 1/16 of the original carbon-14. How old is the fossil if the half-life of carbon-14 is 5730 years?

(B) A rock that is known to be 3.5 billion years old contains 1/32 of the original amount of uranium-235. What is the half-life of uranium-235?

(C) What fraction of carbon-14 remains in a fossil that is approximately 17 190 years old? The half-life of carbon-14 is 5730 years.

OBJ: ***Define population genetics, gene pool, allele frequency. (glossary or p. 646, 677- 679, 681***)

population genetics - The branch of science that deals with the statistical analysis of the inheritance and prevalence of genes in populations.

Allele frequency - how often an allele occurs in the organisms of a population.

e.g. The frequency of occurrence of the white allele in peppered moths is 10% of the population. This means that 10% of the moths in a population carry the recessive white color gene. Some a heterozygous, some are homozygous.

The Hardy Weinberg Principle

Gene pool - all of the genes for all of the traits in a given population.

Genetic equilibrium - the condition in which the gene frequencies of a population are stable and do not change.

This is a mathematical principle which helps prove that sexual reproduction and the variety it causes in offspring is not enough alone to cause evolution to occur. It mathematically proves that with just sexual reproduction and no natural selection events taking place, the gene pools of populations would stay in genetic equilibrium. Evolution occurs when the frequency of alleles in the gene pool change due to other factors such as mutations, migration, etc.

Genetic equilibrium - the condition in which allele frequencies do not change from one generation to the next.

The Hardy -Weinberg Principle shows that in a make believe, model population, the Genetic equilibrium will not change unless there are mutations occurring or other outside forces. The model population the principle uses is based on 5 controlled things which normally cause natural selection to occur:

1. A large population - population must be large to minimize sampling errors
2. No immigration or emigration in the population - exchange of genes between members of other populations will not occur.
3. No mutations in the population - the alleles in a population will not change
4. Random mating in the population - there is no mating preferences
5. No natural selection - natural selection must not favor any traits over other traits.

Obviously, no population works entirely this way. But, if these factors could be kept constant, as in the Hardy - Weinberg model, there would be no chance for changes in gene frequencies; - no chance for speciation and evolution. The fact that we do see changes in allele frequencies in real populations proves that evolution does occur. The failure of the Hardy - Weinberg Principle to hold true in real populations shows us that evolution does occur.

The Hardy - Weinberg model formula is:

$\mathbf{p^2 + 2pq + q^2 = 1.0}$ where p = freq. Of the dominant allele
where q = freq. Of the recessive allele

p^2 - gives us the frequency of the homozygous dominant genotypes in the population eg. GG

2pq - gives us the frequency of the heterozygous genotypes in the population eg. Gg

q^2 - gives us the frequency of the homozygous recessive genotypes in the population eg. gg

Also:

$p + q = 1.0$ where p = freq. of occurrence of the dominant allele
q = freq. of occurrence of the recessive allele

To show that natural selection is occurring, biologists determine the allele frequencies in a population. E.g. How often the T allele occurs in a pea plant population as compared to the t allele. They then use the Hardy - Weinberg principle to calculate and compare the frequencies of the genotypes in the population.

E.G. Imagine 30 pea plants. In all , they have 60 alleles present for height (each plant has 2 alleles). A survey tells you that the frequency of occurrence of the T allele is 0.6 (60%) and the frequency of the t allele is 0.4 (40%). You can now use the Hardy - Weinberg principle formula to calculate the genotype frequencies of the population.

Given : $p = 0.6$
$q = 0.4$

$$p^2 + 2pq + q^2 = 1$$
$$(0.6)^2 + 2(0.6)(0.4) + (0.4)^2 = 1$$
$$0.36 + 0.48 + 0.16 = 1$$

The genotypic frequencies in the population are: TT = 36%
Tt = 48%
tt = 16%

IMPORTANT: **The Hardy -Weinberg principle states that if there is no evolution or natural selection going on in this population , then there will be no change in theses genotype frequencies over time.**

Lets assume that for the next few years, some pollen from another nearby garden of pea plants fertilizes some of the pea plants in your garden (in - migration and random mating). Years later, you again survey your plants for height **and find that the allele frequency of the T allele is now 73% (0.73) . This would be proof that natural selection is occurring! Lets calculate the new genotype frequencies:**

First, find q:

Given: $p = 0.73$
$q = ?$

$$p + q = 1.0$$
$$0.73 + q = 1.0$$
$$q = 1.0 - 0.73$$
$$q = 0.27$$

Given : $p = 0.73$
$q = 0.27$

$$p^2 + 2pq + q^2 = 1$$
$$(0.73)^2 + 2(0.73)(0.27) + (0.27)^2 = 1$$
$$0.5329 + 0.3942 + 0.0729 = 1$$

New genotype frequencies:
The new genotypic frequencies in the population are: TT = 53.29 %
Tt = 39.42 %
tt = 7.29 %

Compare these to the old frequencies:

Old Genotype frequencies
TT = 36%
Tt = 48%
tt = 16%

The genotypic frequencies have changed!!!

IMPORTANT: **According the Hardy - Weinberg principle, this means that natural selection events are occurring because gene frequencies will stay in genetic equilibrium unless one of the 5 natural selection factors are acting upon them.**

<u>Other Hardy Weinberg problems to solve:</u>

Examples:

(A) If 16% of a Hardy-Weinberg population expresses a particular recessive trait, calculate the percentage of the population that would have the heterozygous genotype of this trait.
(B) For a population in Hardy-Weinberg equilibrium, the frequency of the recessive allele is 0.3. What percentage of the population is heterozygous?
(C) The frequency of a dominant allele for a certain trait in a Hardy- Weinberg population is 0.9. What percentage of individuals would be expected to express the dominant trait?
(D) If 16% of a Hardy-Weinberg population expresses a recessive trait, what percentage of the population is homozygous for the dominant trait?

OBJ: ***Complete "Population Genetics and the Hardy-Weinberg Principle" , CORE LAB #8, pp. 684-685.***

<u>Evolutionary Mechanisms and their Effects on Biodiversity</u> (pp. 689 - 695)

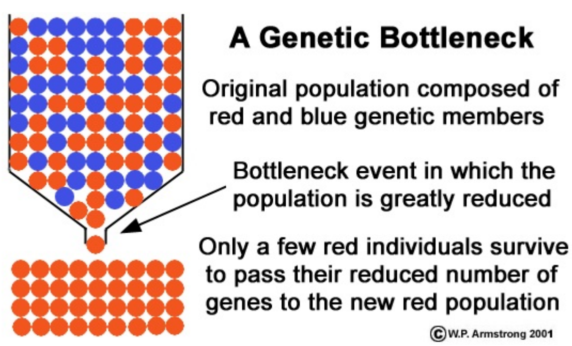
-each of these mechanisms has the potential to disrupt Hardy-Weinberg equilibrium

There are 6 mechanisms:

1) **mutations** (p. 688)
- provide new alleles in a population and may provide more variation for evolution to occur. It must provide a natural selective advantage (e.g. the ability of the California ground squirrel to break down rattlesnake venom if bitten).
- can happen more quickly in quickly reproducing organisms such as bacteria

2) **genetic drift** - (p. 689) the change of frequencies of particular alleles in a **small population**; **<u>caused by chance alone</u>**. The smaller the population, the less likely it is that the parent gene pool will be reflected in the next generation. Two causes of genetic drift are:

(A) **bottle neck effect** - (p. 690) certain alleles become "over represented" and other alleles become under represented or absent in a population due to chance.
- cause: occurs when a population is greatly reduced by events such as natural disaster or over hunting



Example: Northern elephant seals were overhunted to only about 20 remaining. They were protected so that the gene pool in these seals comes form the 20 that were left to breed. Many traits were lost with the deaths of the others. DNA studies show little genetic variety - very different from other elephant seal populations

Example : Cheetahs - have died off to low numbers due to disease and over hunting. Not much genetic diversity remains. Now there is an overabundance of genetic disorders. The population is not “genetically healthy” and it is a cause of great conservation concerns in saving them (too much “inbreeding” - the gene pool is too small)

(B) **founder effect** - (p. 691) cause of genetic drift due to a small group of individuals colonizing a new area; the small group will not contain all the genes present in the parent population.

Example: This has occurred in Newfoundland. Most of our population came from certain areas in England and Ireland, in many cases those related to each other. We have had little immigration or out-migration over the years so we do not have a good representation of the entire gene pool in our population.

Example: Hawaiin honeycreepers - see p. 691- individuals became isolated on different islands and evolved into different species.

3) **gene flow** - (p. 692) the movement of new genes into a gene pool (result of genes being transferred from one population to another). This movement can reduce differences between populations that were caused by isolation and genetic drift.

Example: For instance, if all red haired people were to leave Ireland, the next generation there would likely have very few people with this trait.

Example: For example, during the Vietnam War, U.S. soldiers had children in Southeast Asia with Vietnamese women during the war there in the 1960's and early 1970's. Although most of them returned home, they altered the gene pool frequencies of the Vietnamese population.

4) **non - random mating** - (p. 692) any situation in which individuals do not choose mates on a random basis, such as mating based on proximity (closeness), relatedness or phenotype (looks).

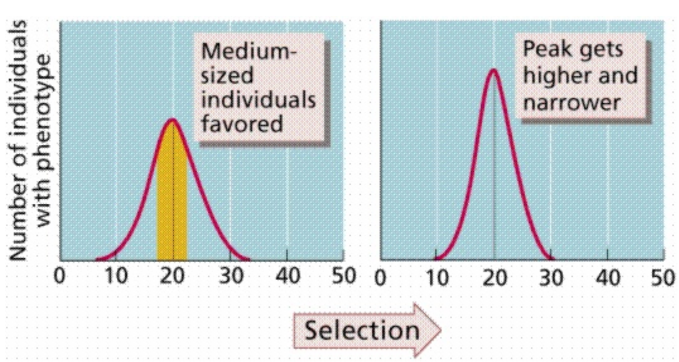
Example: Inbreeding is a form of nonrandom mating Fewer available partners leads to less randomness in the selection of a mate. It was formerly common in humans, before we got better transportation. High levels of inbreeding lead to the loss of the heterozygous genotype of a trait.

Example: the Florida Panther has experienced inbreeding and its population is considered to be in an unhealthy state due to nonrandom breeding, having a high occurrence of harmful genes being passed on.

5) **natural selection** - (p. 693 - 694). There are 3 types of natural selection:

(A) **stabilizing selection** - (p. 693)

- favours an intermediate phenotype and acts against extreme variants.
- e.g. mid-sized new babies are naturally selected over extremely large or extremely small ones to survive.



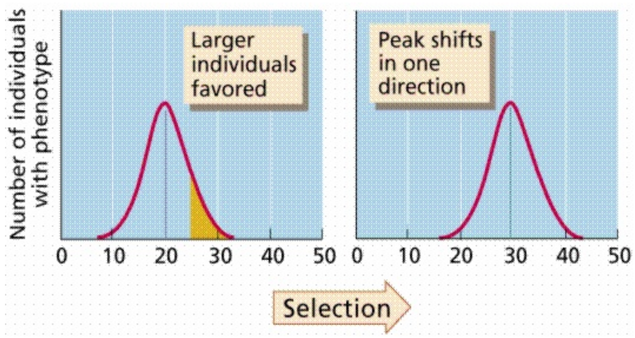
-
also study the distribution graphs on p. 693)

(B) **directional selection** (p. 693)

- A process of natural selection that tends to favor phenotypes at one extreme of the phenotypic range.
- **is common during times (a) environmental change or (b) when an organism enters a new environment that has different conditions than the old one.**

Example: **the Galapagos finches originated from one mainland species when they entered new environments on the Islands and speciated as a result.**

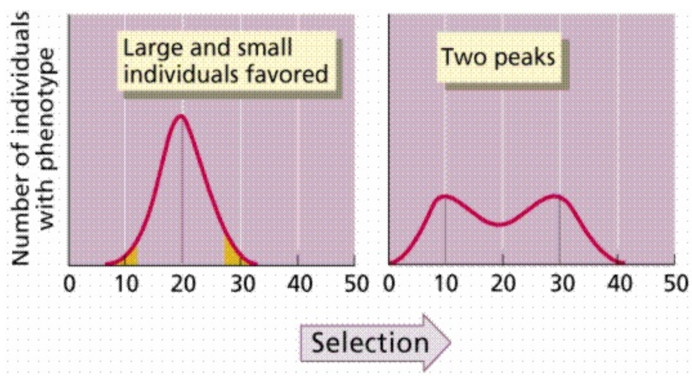
Example: **ancient horses were adapted to a forested land but have adapted to grasslands as the environment changed over time.**



Important: **also study distribution graphs on p. 692**

(C) **disruptional selection** (p. 694)

- A process of natural selection that favors individuals at both extremes of a phenotypic range and the intermediate (middle- range) phenotypes die off (fail).



- **also study the distribution chart on p. 695**

Example: **in male Koho salmon, the smaller ones and the larger ones are favoured over the mid - sized ones.**

6) **Sexual selection** - (pp. 695 - 696).

This is the selection of mates based upon physical (e.g. Coloration) or behavioral (e.g. mating dances or rituals) characteristics. If certain characteristics give an animal an advantage in being chosen for a mate, then there is a better chance of his/her alleles being passed on and kept in a population.

Example: Elephant seals. In October, a single male, which can be three times larger than the female, will claim a harem of as many as a hundred females, and will fight any other male that approaches his territory. Only fully mature males have the size and strength to keep such a harem. Also, when a male approaches a female, the female cries and starts a fight among males so she will be fertilized by the strongest of them. This is an example of sexual selection enticed by the females.

Example: In birds, a form of sexual selection occurs when males compete for territories. The most dominant males out compete other males and manage to acquire the best territories. These males are known to get more chances to mate with females. .

Speciation.

Species - a group of closely related organisms capable of interbreeding and producing fertile offspring

Speciation - the formation of a new species.

Transformation and Divergence (see p. 708) : ***- two general pathways that lead to speciation***

transformation - the transformation of an existing species into a new species. It is caused by accumulated changes over a long period of time.

Divergence - one or more species arise from a parent species while the parent species continues to exist.

Important: Study FIGURE 21.8, p. 708.

The Conditions Which Cause Speciation: (See pp. 708 - 709)

In order for speciation to occur, they must remain reproductively isolated (unable to breed) . Two major conditions which would cause this are:

1. **Geographical barriers** - physical barriers such as mountains, valleys and water bodies that separate populations.
2. **Biological barriers -** any factor that prevents species from breeding together even though they live in the same area.

geographic isolation - when a physical barrier such as a canyon, or large water body separates a breeding population into 2 or more separate populations.

Since no two environments are identical, natural selection operates differently in each location. The gene pools of the separated populations begin changing in different ways.

Example: 2 squirrel populations, one on each side of the Grand Canyon are different species that came from one ancestral species which was separated into 2 populations by the Grand Canyon. Over time., differences in their environments and natural selection events lead to them evolving into 2 separate species though DNA shows they are very closely related.

Types of Biological Barriers Which Contribute to Speciation (see pp. 709- 711)

1. **pre-zygotic barriers** - impede mating between different species or prevent the fertilization of the ova. 5 types of this are:

(A) **behavioral isolation** - animals must have the correct courtship rituals to attract a mate (e.g. 2 similar birds will not mate if they do not sing the correct "song" or go through the proper "rituals the correct chemical pheromones must be secreted by many insects and animals for mating to occur, etc)

(B) **habitat isolation** - 2 species in the same general area may live in different habitats so seldom if ever come into contact with each other. (Eg. One snake species prefers meadows while the other lives near water)

(C) **temporal isolation** - similar species may live in the same habitat but mate at different times of the day, month, year.

(D) **mechanical isolation** - species live in same habitat but are anatomically not capable of breeding. E.g. Genitals of some insects operate in a lock and key fashion.

(E) **gametic isolation** - the gametes are unable to complete fertilization. The sperm cannot penetrate the egg or sperm may not be able to survive inside female reproductive tract.

2. **Post - zygotic barriers** - prevent hybrids from developing into normal, fertile individuals. There are 3 types of this:

hybrid - organism produced when two different species mate.

(A) **hybrid inviability** - incompatible genetics stops the growth/development of the embryo before birth. (Miscarriage happens) This happens when you breed sheep with goats.

(B) **hybrid sterility** - offspring is sterile so offspring cannot have children. E.g. A horse and a donkey can mate to produce a mule but mules are sterile. You cannot mate two mules to get more mules.

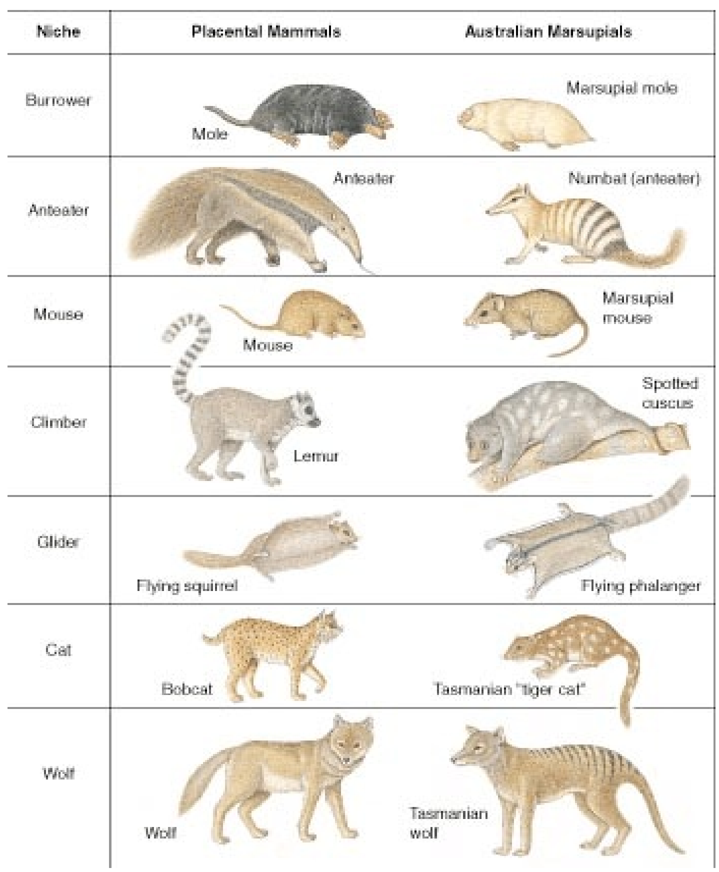
(C) **hybrid breakdown** - 1st generation of hybrids are fertile and can have offspring but their offspring are infertile or "weak" (die young).

<u>Aadaptive radiation as a mechanism for speciation. (pp. 720-721)</u>

Adaptive Radiation - the diversification of a common ancestral species into a variety of species, all of which are adapted differently to the environment.

This happens when a species finds its way into a new environment which is favorable to it. The environment must have lots of food, few competitors and few predators. With less competition, many traits which were not valuable may suddenly become favorable. New niches are open in the environment to be filled. This can cause one species to evolve into many new species.

An example of adaptive radiation are the many species of Finch birds on the Galapagos Islands.(Darwin's Finches) They came form the same original ancestor but there are over 13 different species. They have evolved different beak sizes, beak shapes, body sizes, etc. depending on the environment they live in and the food they eat.



<u>Convergent and Divergent Evolution (p. 721)</u>

convergent evolution - evolutionary process in which similar traits show up in two or more unrelated species because each species has independantly adapted to similar environmental conditions, not because they share a common ancestor. They usually occupy a similar niche so similar traits get naturally selected. (see chart)

Eg. Birds and bats both have wings. They share similar environmental conditions which lead to these adaptations but the wing structures are quite different.

Eg. Marsupials in Australia have converged on similar lines to placental mammals elsewhere:

Divergent evolution - a pattern of evolution in which species that were once similar to an ancestral species become increasingly different over time (they diverge). Divergent evolution has also been defined as the method of evolution accounting for the presence of homologous structures.

Divergence is said to occur when there are very different (diverse) features—in plants or animals which ought to be "closely related."

example: the divergence of the man and chimpanzee lines.

Example The hemoglobin amino acid sequence differ in different organisms, which means that some divergent evolution has taken place from a common ancestor.

The process of coevolution. (pp. 722-723)

coevolution - evolutionary process in which two species of organisms that are dependant on each other (tightly linked) evolve together (e.g., predator and prey), each population responding to changes in the other population.

E.g. Many insects have extraordinarily long tongues to reach the nectar inside of long, tube-like flowers.

E.g. Monarch butterfly and milkweed plant. Milkweed have a toxin in leaves which prevents many animals from feeding on it but the Monarch's larvae are immune to it. The toxin builds up in the larvae and is passed on to the adult Monarch butterfly, making it toxic to would - be predators. Many birds avoid eating the monarch.

Gradualism and Punctuated equilibrium (pp. 723-725)

Currently 2 theories that discuss how fast evolution has occurred:

1. Theory (model) of Gradualism
2. Theory (model) of Punctuated Equilibrium (Gould and Eldridge)

Gradualism Model: (Darwin thought this)

- evolution occurs at a slow, steady pace before and after divergence.
- Big changes occur as the result of many small changes

Fossil evidence for this model is scarce. Most often the fossil record shows sudden appearance and then sudden disappearance of a species.

Punctuated Equilibrium Model: (proposed by two scientists Eldridge and Gould)

- environments show evidence of remaining stable fro long periods of time. Natural selection stabilizes and this causes populations to remain unchanged for long periods of time. The theory says that the earth remains in long periods of equilibrium punctuated (interrupted) by shorter periods of divergence, most likely caused by severe changes in the environment.

- fossil evidence shows more fossils from the periods of equilibrium than from the punctuated divergences (shorter periods up to 50,000 years)

Important: **Study Fig. 20.21, p. 724**

The Origin of Life (From STSE)

1) **Panspermia Theory**

This theory suggests that life came from some other source outside of the earth and then migrated to earth either through intelligent beings or by chance.

2) **Intelligent Design**

This is the concept that all biological origins on earth have followed a pattern which set out as a product of some intelligent cause or agent. It maintains that life and its mechanisms are too complex to have evolved by chance. (Aliens!!!???)

3) **Gaia Hypothesis**

This comes from the Greek word, meaning "mother earth". It was developed by James Lovelock. It suggests that the earth, including all of its abiotic and biotic components may constitute a huge, living, self-regulating system. It states that the biota (the sum of all organisms) controls various properties of the atmosphere, ocean and lands.

4) **Lynn Margulis Hypothesis or Symbiogenesis**

This was developed as a result of observations of organelles, such as chloroplasts and mitochondria, and it revealed that they were similar to prokaryotic cells. It is the belief that through symbiotic relationships, these organelles become incorporated into eukaryotic cells through partnerships that formed between cells. Through the relationship these organelles became functional structures within the partner cells in return for nutrition, protection and so on.

5) **Haldane- Oparin Hypothesis or Heterotrophic Hypothesis** (1920-30)

This **is the most widely accepted theory** and suggests that the first organic compounds were formed by natural chemical processes on the primitive earth and that the first life-like structures were heterotrophs. The major concepts that make up this hypothesis are:

- Primitive atmosphere was very hot and consisted of **hydrogen (H_2), water vapor (H_2O), ammonia (NH_3) and methane (CH_4).**
- Oceans when first formed were not much below the boiling point of water. They have been described as "hot, thin soup" in which chemical reactions occurred rapidly.
- Energy in various forms such as **UV light, lightening and volcanic heat** was available to bring about the synthesis of organic compounds from the inorganic compounds listed above.

- They developed biochemical systems to process organic nutrients from their environment ; they became heterotrophs

- they **released carbon dioxide into the oceans and atmosphere (100's of millions of years)**
- Eventually organisms developed that could use light energy and formed the first **photosynthetic organisms**. This **added oxygen** to the oceans and the atmosphere.

- The **presence of oxygen** allowed for the development of organisms which use oxygen in cellular respiration (more efficient)

6) **Miller and Urey** (1953).

Miller and Urey produced an experiment to try and prove the origin of life. They took the materials present on the earth at that time: **methane, ammonia, water and hydrogen** and placed them in a flask. They exposed the flask to sparks to represent the sunlight and lightening on the earth at that time. They discovered that from such an experiment it was possible to create organic compounds (amino acids) that could have been the beginning of life on earth.

AND ,,,,,,,that's the

END of the COURSE!!! (CAN YOU BELIEVE IT???!!!!)