

EVOLUTION**Key Concepts**

- 24.1 The Evolution of the Concept of Evolution
- 24.2 Evidences of Evolution
- 24.3 Evolution from Prokaryotes to Eukaryotes
- 24.4 Lamarckism
- 24.5 Darwinism
- 24.6 Neo-Darwinism

EXERCISE**SECTION I: Multiple Choice Questions**

Select the correct answer from the following choices.

1. Using the Hardy-Weinberg Principle, which expression represents the frequency of the homozygous recessive genotype?
 - (a) P^2
 - (b) $2Pq$
 - (c) q^2
 - (d) $d \cdot q$
2. The process of ----- and ----- generate variation, and ----- produces adaptation to the environment.
 - (a) sexual recombination ----natural selection----mutation
 - (b) genetic drift ----- mutation ----- sexual recombination.
 - (c) mutation ----- sexual recombination --- natural selection
 - (d) mutation----- natural selection ---- genetic drift.
3. Natural selection is sometimes describe as survival of the fittest. Which of the following most accurately measures an organisms fitness?
 - (a) its mutation rate.
 - (b) how many fertile offspring it produces.
 - (c) its ability to withstand environmental extremes.

4. Which of the following is a true statement about Charles Darwin?
- he was the first to discover that living things can change, or evolve.
 - he based his theory on the inheritance of acquired characteristics.
 - he worked out the principle of population genetics.
 - he proposed natural selection as the mechanism of evolution.
5. In science the term theory generally applies to an idea that:
- is a speculation lacking supportive experiments.
 - attempts to explain many related phenomena.
 - is synonymous with what biologist means by hypothesis.
 - is considered a law of nature.
6. The smallest biological unit that can evolve over time is:
- a specie
 - an individual organism
 - an ecosystem
 - a population
7. Which of the following ideas is common to both Darwin's and Lamarck's theories of Evolution?
- adaptation results from different reproductive success.
 - evolution drives organisms to greater and greater complexity.
 - evolutionary adaptation results from interactions between organisms and their environment.
 - the fossil record supports the view that species are fixed.
8. Which of the following pairs of structures is least likely to represent homology?
- the wings of a bat and the forelimbs of a human
 - the haemoglobin of a baboon and that of a gorilla
 - the brain of a cat and that of a dog
 - the wings of a bird and those of an insect
9. All organisms share the same genetic code. This commonality is evidence that:
- evolution is occurring now.
 - convergent evolution has occurred.
 - all organisms are descended from a common ancestor.
 - evolution occurs gradually from.
10. Which of the following is an example of vestigial structure in humans?
- human tailbone
 - nipple on male mammals
 - sixth finger found in some humans
 - human knee cap

Answers

1	(c)	2	(c)	3	(b)	4	(d)	5	(b)
6	(d)	7	(c)	8	(d)	9	(c)	10	(a)

SECTION II: Short Questions**Give short answers of the following questions.****Q1. How biogeography does provide evidence for evolution?****Answer**

Darwin saw the geographic distribution of species (biogeography) as strong support for common descent. He realized that there was a closer match between a species and:

- 1) A geographically nearby species, even when the environments for the two differed a good deal, than there was between that species and
- 2) Other species living in essentially the same type of environment, but that are geographically distant. Darwin observed Galapagos finches. The birds are similar to South American finches, but have adapted to resemble a variety of European birds (not from the finch group) based on their environments. No placental ground mammals are native to Australia or New Zealand, but thrived when introduced. This shows the process of radiation and adaptation.

Q2. Justify Lamarck as an early proponent of evolution.**Answer**

Lamarck was an early proponent of the idea that Evolution occurred and proceeded in accordance with the natural laws. Lamarck is regarded as a premier authority on invertebrate zoology. He is remembered, at least as a taxonomist of considerable stature. In 1809, he published a book *Philosophie Zoologique* (Zoological Philosophy).

Q3. State the drawbacks of Lamarckism.**Answer**

The anatomical, biochemical and behavioral characteristics that individual organism displays as it develops through life is known as its phenotype. However, the phenotype that an individual actually develops is somewhat conditional and is based on two key factors:

- 1) The fixed genetic potential of the organism (or its genotype); this refers to specific qualities of its genetic material, or DNA.
- 2) The environmental conditions which an organism experiences as it grows.

The first point of Lamarckism i.e. use and disuse of organs may be acceptable but the characteristics which are acquired through this process during the life time have no genetic bases and therefore cannot be inherited to the next generation. Actually the sciences of that time were unaware of the mechanism of inheritance which were proposed by Mendel 1865.

Q4. What are the contributions of the following scientists? Lamarck, Darwin, Alfred Wallace, Charles Lyell, James Hutton, and Thomas Malthus.**Answer****Contribution of Lamarck**

He was a French naturalist, soldier and biologist. Lamarck was an early proponent of the idea that Evolution occurred and proceeded in accordance with the natural laws. Lamarck is regarded as a premier authority on invertebrate zoology. He is remembered, at least as a taxonomist of considerable stature. In 1809, he published a book *Philosophie Zoologique* (Zoological Philosophy). •

Contribution of Darwin

Charles Darwin was born in England in a wealthy family. Alfred Russell Wallace was the man who motivated Darwin to publish his book *The Origin of Species by Means of Natural Selection*. It appeared in November of 1859. Only a passing reference to man's place in Evolution was mentioned in *The origin of Species*. Twelve years later, Darwin *Decent of Man* was published. This was about the Evolution of man. Darwin was much more willing to explore the implication of natural selection, particularly in relation to humans, than Wallace was.

Contribution of Thomas R. Malthus

Darwin returned to the England in 1836. Soon afterward, he read a work written by the English political economist Thomas R. Malthus (1766-1834), *An Essay on the principle of population*. Malthus noted that human populations have the capacity to increase exponentially ($1 \Rightarrow 2 \Rightarrow 4 \Rightarrow 8 \Rightarrow 16$) and food supply has the capacity to increase arithmetically ($1 \Rightarrow 2 \Rightarrow 3 \Rightarrow 4 \Rightarrow 5$). Such a relation could result only in a struggle for food and hence of existence itself.

Contribution of Alfred Russell Wallace

In 1858 Darwin received a letter from a fellow naturalist, Alfred R. Wallace (1823-1913), who was travelling at that time in Malays. Wallace enclosed an essay that he had written, and he asked Darwin to read it and then forward it to Lyell. In the essay Darwin found, almost in his own terms, the theory of the origin of species by means of natural selection. Darwin almost yielded to Wallace the honor of being the first man to announce the theory. However, his friends (Charles Lyell and Joseph Dalton Hooker) arranged to present the two papers under joint authorship using a single title, *On the Tendency of Species to Form Varieties; and on the Perpetuation of Selection*. The papers were presented to the Linnaean Society in London on July 1, 1858.

Contribution of Charles Lyell and James Hutton.

In the earlier 1830s, Charles Lyell published a book *Principle of geology*. Darwin took this book on the voyage. This book presented arguments to support a theory of geological change proposed by James Hutton called theory of uniformitarianism. Lyell pointed out the mountains, valleys, deserts; river, lakes and coastlines could have come through the action of existing forces and natural conditions. A river slowly carves a valley. Mountains are worn down to hills and finally plains. The slow pace of these geological processes, which still occurs today, indicated the Earth had to be much older than generally believed a possibility that fired Darwin imagination. If the Earth of today is so old and so changed, what was it like thousands of year's ago?

Q5. Describe the role of Alfred Wallace in motivating Darwin to publish

Answer

- Alfred Russell Wallace was the man who motivated Darwin to publish his book *The Origin of Species by Means of Natural Selection*. It appeared in November of 1859. Only a passing reference to man's place in Evolution was mentioned in *The origin of Species*. Twelve years later, Darwin's *Descent of Man* was published. This was about the Evolution of man. Darwin was much more willing to explore the implication of natural selection, particularly in relation to humans, than Wallace was. In addition, Wallace was a champion of rather social causes and later openly embraced spiritualism- all elements that resulted in the down – play of his role in the discovery of natural selection.

Q6.Why the theory of natural selection is attributed to Darwin?**Answer**

Alfred Russell Wallace was the man who motivated Darwin to publish his book *The Origin of Species by Means of Natural Selection*. It appeared in November of 1859. Only a passing reference to man's place in Evolution was mentioned in *The origin of Species*. Twelve years later, Darwin's *Descent of Man* was published. This was about the Evolution of man. Darwin was much more willing to explore the implication of natural selection, particularly in relation to humans, than Wallace was.

Q7. Define: Neo-Darwinism, Hardy-Weinberg principle, genetic drift, bottleneck effect, founder effect, speciation, allopathic speciation, preparation speciation and sympatric speciation; half-life period.**Answer****Neo-Darwinism**

When Lamarck and Darwin put forward their ideas, practically nothing was known about heredity. The emergence of population genetics has provided a clear understanding of inheritance and variation among the individuals of a population and firm support for Darwinian Theory. This reappraisal of the theory of natural selection in terms of modern population genetics is sometimes called Neo-Darwinism.

Hardy-Weinberg principle

They pointed out that the frequencies of various genotypes in a population can be described mathematically which is now known as Hardy-Weinberg principle. According to the hardy-Weinberg principle, both the ratios of genotypes and the frequency of alleles remain constant from one generation to the next in a sexually reproducing population, provided other conditions are stable.

Genetic Drift

Variation in the relative frequency of different genotypes in a small population, owing to the chance disappearance of particular genes as individuals die or do not reproduce.

Bottleneck Effect

The reduction of population size with some specific allele and genotype due to natural disaster is called bottleneck effect. For example, events such as earthquakes, floods, or

but have different proportions and ratios of allele and genotype frequencies.

Founder Effect

The founder effect is a particular example of the influence of random sampling. It was defined by Ernst Mayr as: "The establishment of a new population by a few original founders (in an extreme case by as single fertilized female) which carry only a small fraction of the total genetic variation of the parental population."

Speciation

The evolutionary process by which new biological species arise is called speciation. Each idea is based on the degree to which populations undergoing this process is geographically isolated from one another.

Sympatric Speciation

It occurs when populations of a species that share the same habitat become reproductively isolated from each other. It most commonly occurs through polyploidy. Sympatric speciation is rare. It occurs more often among plants than animals, because a tetraploid plant can fertilize itself and create offspring.

Allopatric Speciation

It is the most common form of speciation. It occurs when populations of a species become geographically isolated. When populations become separated, gene flow between them ceases. Over time, the populations may become genetically different in response to the natural selection imposed by their different environments. If the populations are relatively small, may experience a founder effect: the populations may have contained different allelic frequencies when they were separated.

Parapatric Speciation

Parapatric speciation is extremely rare. It occurs when populations are separated not by a geographical barrier, such as a body of water, but an extreme change in habitat. While populations in these areas may interbreed, they often develop distinct characteristics and lifestyles. Reproductive isolation in these cases is not geographic but rather temporal or behavioral. For example, plants that live on boundaries between very distinct climates may flower at different times in response to their different environments, making them unable to interbreed.

Q8. Name any five vestigial structures found in man.

Answer

Human vestigial organs are those organs that have lost all or most of their original functions through Evolution. There are about 90 such structures present in our body.

- 1) **Vermiform appendix** is a vestige of the cecum.
- 2) **Coccyx** or **tailbone** is the remnant of a lost tail.
- 3) The **wisdom teeth** are vestigial third molars that human ancestors used to help in grinding down plant tissue.
- 4) Humans have **ear muscles** that are minimally developed and non-functional, but some people are able to move their ears in various directions.

Q9. What is the contribution of radiometric dating to the paleontological analysis?

Answer

Geologists and paleontologists, use techniques to determine the actual ages of rocks and the fossils they contain. The most common method is called radiometric dating or often called radioactive dating, is based on the fact that living organisms contain certain radioactive isotopes in certain ratio. For instance, living organisms have the same constant ratio ^{14}C , a radioactive isotope to ^{12}C , a stable isotope, as does Earth's atmosphere. However, when an organism dies, its ratio of ^{14}C to ^{12}C starts to drop, because ^{14}C decays to other chemical elements, and the organisms no longer obtains any ^{14}C from the atmosphere. Each radioactive isotope has a fixed rate of decay known as half-life. The half - life is the amount of time it takes for one half of the initial amount of the parent radioactive isotope, to decay to the daughter isotope. For example, ^{14}C has a half-life of 5600 years, meaning that half of the ^{14}C in a specimen decays in about 5600 years, half remaining ^{14}C decays in the next 5600 years and so on, until all the ^{14}C is gone. Knowing both the half-life of a radioactive isotope and the ratio of radioactive to stable isotope in a fossil enables us to tell how old the fossil is. For instance, if a fossil has a ^{14}C to ^{12}C ratio half that of atmosphere, it is about 5600 years old; a fossil with one-fourth the atmospheres ratio is about 11,200 years old.

Q10. Hypothesize whether Lamarck was criticized in his day for advocating the ideas of evolution or for the mechanism he proposed.

Answer

In 1802, society in general was un-accepting the ideas of evolutionary change, and evidence for evolution had not been developed thoroughly enough to convince most scientists. Thus, Lamarck was criticized in his day more for advocating ideas of evolutionary change than for the mechanism he proposed for that change.

SECTION III: Extensive Questions

Q1. Describe creationism, the theory of evolution as two contradictory ideas.

Answer

The Evolution of the Concept of Evolution

The two major and contradictory ideas accounting for the origin of life on Earth are:

- a) special creation,
- b) theory of Evolution.

Theory of Special Creation Versus Evolution

Concept of Special creation

The supporters of special creation are called creationists. They have believed that, during a limited period, God created the universe and man as supernatural event at a particular time in the past. This theory explains that every species was individually created by God in the form in which it exists today and is not capable of undergoing ~~any change~~. It was the generally accepted explanation of the origin of life until the

of 24 hours duration. They reject any other possible views and rely absolutely on inspiration, meditation and divine revelation.

Concept of Evolution

The supporters of Evolution are called evolutionists. They have believed that the universe and man did not always exist in their present form; neither are they the product of a sudden creative act, but rather the result of innumerable changes from the lower to the higher, each step is advance begin an evolution from a pre-existing condition. Modern biologists believe that the Earth is over four billion years old. Then about 3.5 billion ago, life began. According to Evolution of life on earth had emerged as a unicellular prokaryote then with the passage of time variation have been accumulated, and new species came into existence. The current biodiversity including man is the descendent of the earliest unicellular prokaryote that might had originated spontaneously.

Faith accepts things for which there is no evidence in scientific sense. This means that logically there can be no intellectual conflict between scientific and theological accounts of creation, since they are mutually exclusion realm of thought. Scientific truth to the scientists is tentative, but theological truth to the believer is absolute. Since then process of special creation occurred only once and therefore cannot be observed. Science concerns itself only with observation phenomena and such will never be able to prove or disprove special creation.

Q2. Relate Quranic injections to the process of evolution of man.

Answer

Allah Almighty started the creation of life on Earth, and then left it to evolve as a result of learning from the adaption to various environments, with intervention from Him to make His creation better. As far as origin of man is concerned, Allah Says in Quran:

يَتَّيْهَا النَّاسُ أَتَقُوا رَبَّكُمْ الَّذِي خَلَقَكُمْ مِنْ نَفْسٍ
وَاحِدَةٍ وَخَلَقَ مِنْهَا زَوْجَهَا وَبَثَّ مِنْهُمَا رِجَالًا كَثِيرًا وَنِسَاءً

(Sura Nisa: Verse 1)

O mankind! Be careful of your duty to your Lord Who created you from a single soul and from it created its mate and from them has spread a multitude of men and women.

This verse tells us that beginning of life was a single soul, and then its mate came out of it. Biological science tells us that the earliest form of life was represented by single cell organisms found in water, and then these multiplied by splitting themselves. With the course of time, reproduction started to be by mating pairs, instead of the archaic forms of splitting or dividing.

الَّذِي أَحْسَنَ كُلَّ شَيْءٍ خَلَقَهُ، وَبَدَأَ خَلْقَ الْإِنْسَانِ مِنْ طِينٍ

(Sura Sajda, Verse 7)

In this verse, we are told that Allah (Praise to Him) creation the creation of human beings out of clay, but that was the beginning , then He improved His creation making it better.

The most relevant word in this verse is “began” (bada-a), which tells us clearly that creation happened in a process that had a beginning, not just at once.

وَقَدْ خَلَقَكُمْ أَطْوَارًا ﴿١٤﴾

(Sura Noor, Verse 14)

He has created you in diverse (and successive) stages.

This verse may be interpreted to refer to the successive stages of the development of a foetus in its mother’s womb. However, it can also be interpreted to refer to the successive stages of the human evolution.

وَإِذْ قَالَ رَبُّكَ لِلْمَلَائِكَةِ إِنِّي خَلِيقٌ بَشَرًا مِّن صَلْصَلٍ مِّن حَمَإٍ
مَّسْنُونٍ ﴿٢٨﴾

(Sure Al-Hajar Verse 28)

We created the human being from stinking, smooth, (and wet) clay.

This verse gives a very specific description of the environment where life started. It refers to swamps where still water is combined with the earth soil, which creates stinking but smooth clay easy to take different forms.

This is exactly what biologists have come up with to explain the beginning of life on Earth.

الَّذِي خَلَقَكَ فَسَوَّاكَ فَعَدَلَكَ ﴿٧﴾

(Sura Infitar, Verse 7)

It is He Who created you, fashioned you perfectly, and made you with the right proportions (straightened you up, to walk in an upright position).

This verse may refer to three main stages of the creation of human beings. The first was creation of a living cell (The Arabic verb khlaqa, created). The second was the change from unicellular prokaryote organism to the multi-cellular eukaryote animal organism (The Arabic verb sawwa, fashioned you perfectly). The third was the human departure from the animal stage (The Arabic verb ‘adala, made you walk in an upright way).

Q3. Explain how biogeography provides an evidence for evolution.

Answer

Evidence of Evolution

in nature that teaches them more about Evolution. Some types of evidence, such as fossils and similarities between related living organisms, were used by Darwin to develop his theory of natural selection and are still used today. Others, such as DNA testing, were not available in Darwin's time, but are used by scientists today to learn more about Evolution. In this section, you will learn about evidences from biogeography, paleontology, comparative anatomy and molecular biology.

The study of geographical distribution of plants and animals on Earth is called biogeography. Biogeography gives evidence of prehistoric climates, habitats and animal distribution pattern. Biogeography studies show that life-forms in different parts of the world have distinctive evolutionary history.

Specific Pattern of Distribution

Darwin noticed that South America lacked rabbits; even though the environment was quite suitable to them. He concluded that there are no rabbits in South America because rabbits originated somewhere else and they had no means to reach South America.

Armadillo is found only in America. The evolutionary view of biogeography predicts that contemporary Armadillo are modified descendants of earlier species that were present in these continents and the same has been confirmed by fossil records.

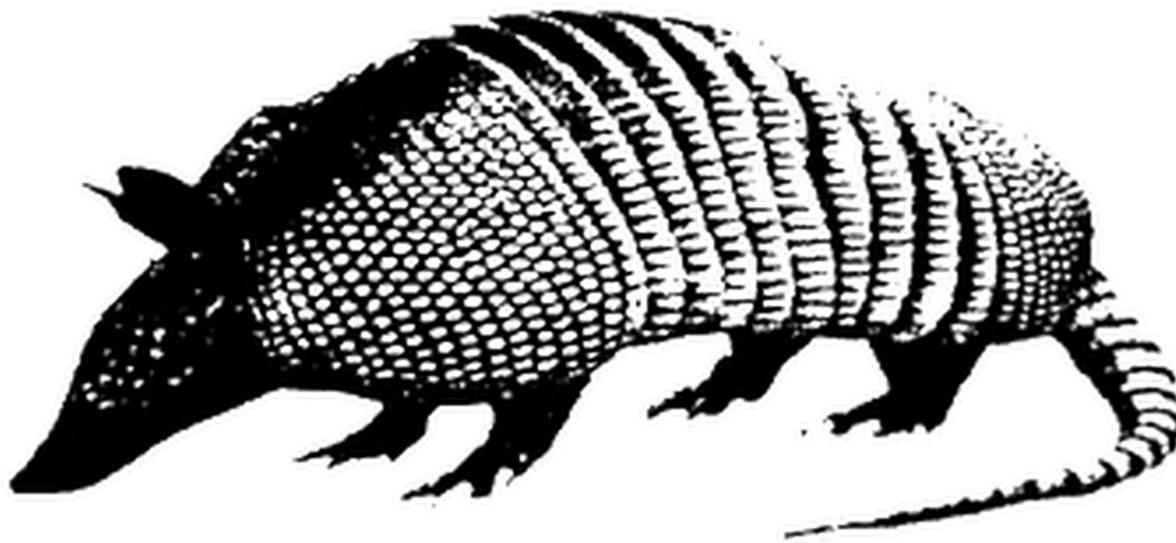


Figure: Armadillo

Factors Inhibiting Distribution of Organisms

Bio-geographical studies show that species have restricted distribution from the center of origin due to some kind of barrier like physical such as an ocean, desert or mountain, environmental such as an unfavorable climate; or ecological such as the presence of organisms that compete with it for food as shelter.

Q4. Describe the evidence of evolution that comes from paleontology, comparative anatomy and molecular biology.

Answer

Evidence from Paleontology

Paleontology is the science of discovery, identification and interpretation of fossils. The succession of fossil forms is strong evidence in favor of evolution. It provides a

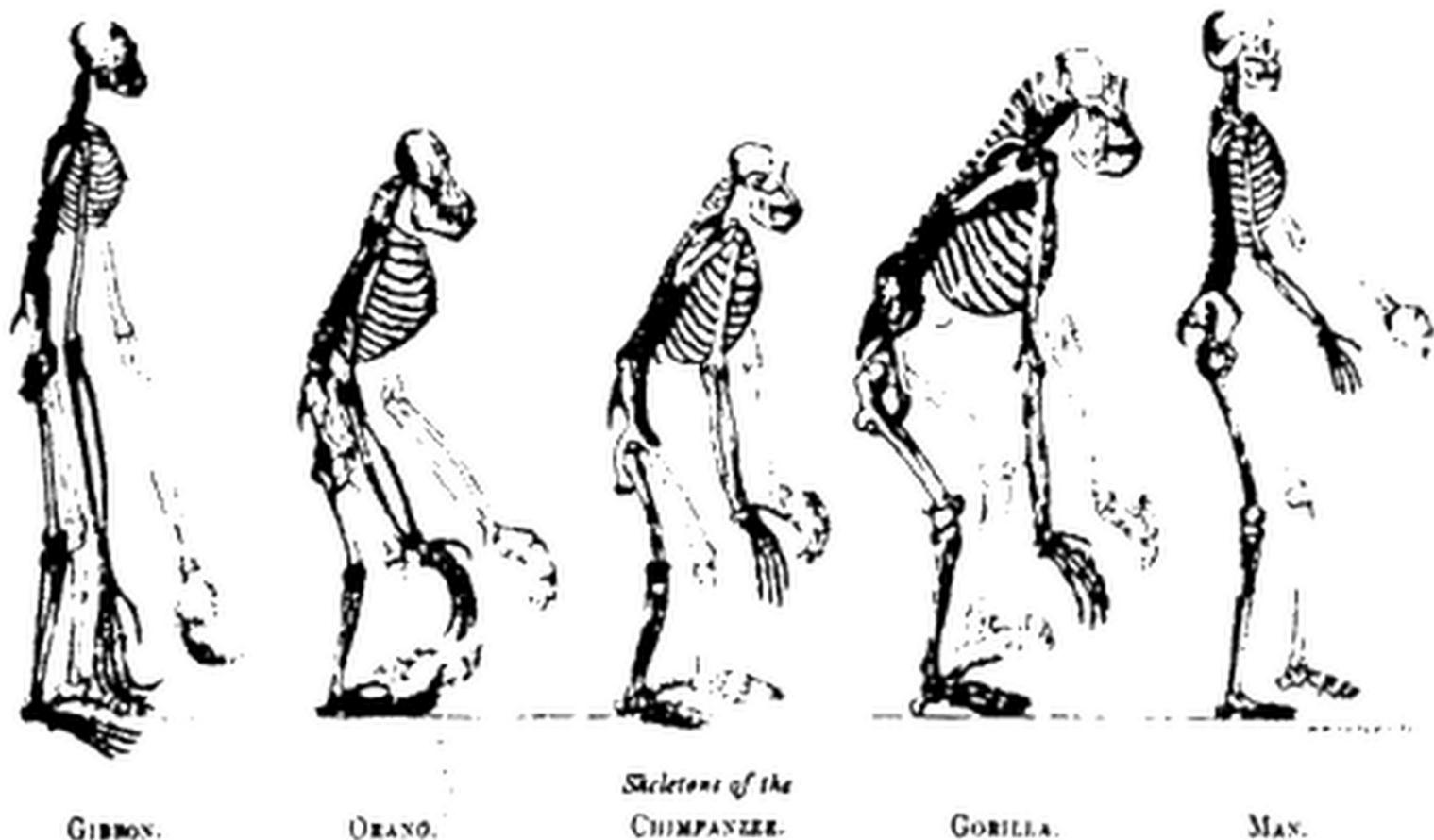
Oldest Known Fossils

For instance evidence from other modern biological sciences places prokaryotes as the ancestors of all life and predicts that prokaryote should precede all eukaryotic life. In the fossil record, indeed, the oldest known fossils are prokaryotes.

Chronological Sequence of Vertebrate Fossil

Another example is the chronology sequence of the different classes of vertebrates in the fossil record. Fossil fishes the earliest vertebrates, with amphibians next, followed by reptiles then mammals and birds. This sequence is consistent with the complexity of their organ system.

Sometimes, the fossil record allows us to trace the history of particular organism, such as modern day horse *Equus*. The earliest had four toes. Over the time the number of toes reduced to three, in the modern horses to one, a large central toe that ends in a hoof. The evidences of fossil record support the common decent hypothesis.



Evidence from Comparative Anatomy:

Comparative study of the anatomy of groups of animals or plants reveals that certain parts of the organisms have similarities in structures while others have similarities in functions.

Homologous Organs Represent Divergent Evolution

Body parts that are similar in structure but different in function because they were inherited from a common ancestor are called homologous structures and their similarity is called as homology. This pattern of evolution in which different species have been evolved from common ancestors at different habitats is known as divergent evolution.

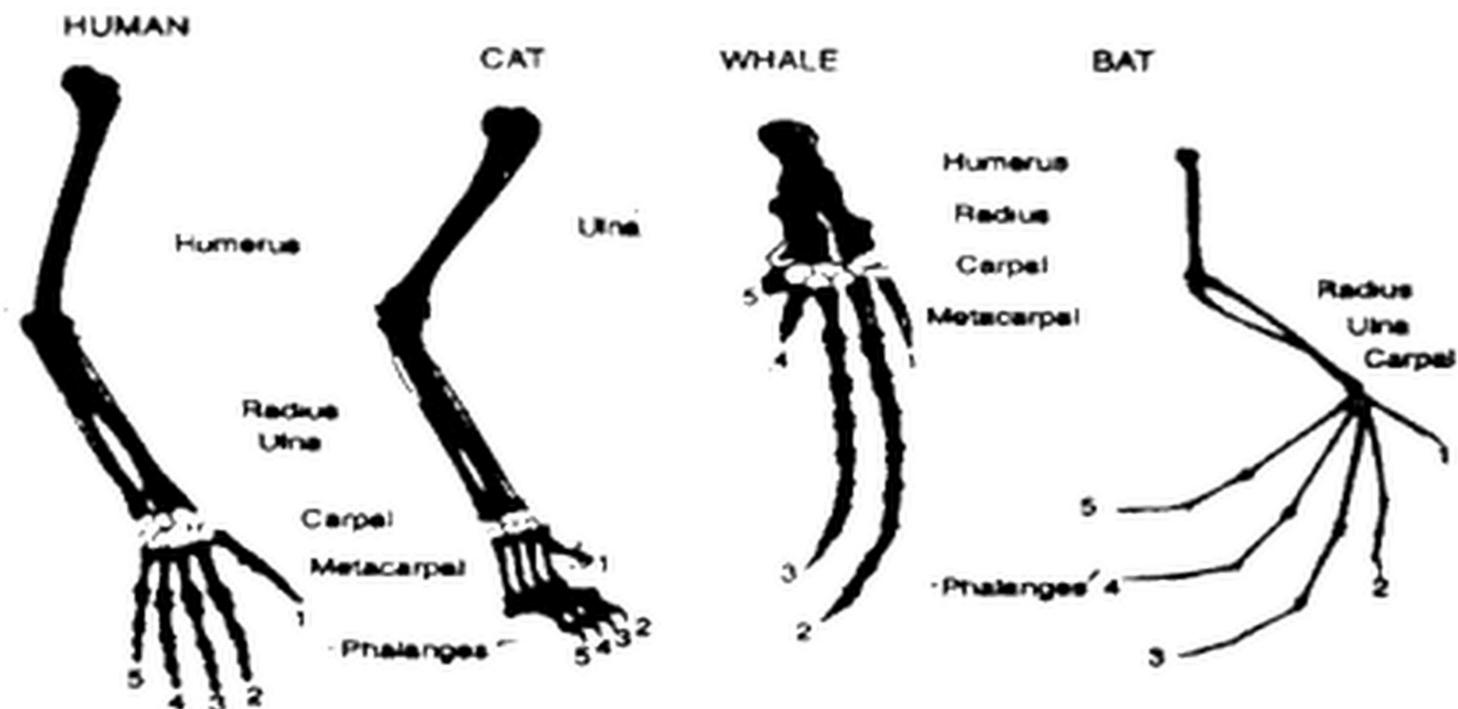


Figure: Homologous Structure

For example, the basic structure of all the flowers is same. Similarly the limb-bone pattern of all tetrapods from amphibian to mammals has the same structural plan. It is called pentadactyl limb. Vertebrate forelimbs are used for flights (birds and bats), orientation during swimming (whales and dolphins), running (horses), climbing (arboreal lizard), or swinging from tree branches, yet all vertebrate forelimbs contain the same sets of bones organized in similar ways, despite their dissimilar functions.

Analogous Organs Represent Convergent Evolution

On the other hand the organs which are similar in function but different in structure are called analogous organs, e.g; wings of the bird and butterfly. Analogous structure are of evolutionary interest because they demonstrate that population with separate ancestors may adapt in similar ways to similar environmental demands. This pattern of evolution in which different species have been evolved from different ancestors at a common habitat is known as convergent Evolution.

Vestigial Organs

Human vestigial organs are those organs that have lost all or most of their original functions through Evolution. There are about 90 such structures present in our body.

Vermiform

(1) **Vermiform appendix** is a vestige of the cecum. (2) **Coccyx** or **tailbone** is the remnant of a lost tail. (3) The **wisdom teeth** are vestigial third molars that human ancestors used to help in grinding down plant tissue. (4) Humans have ear muscles that are minimally developed and non-functional, but some people are able move their ears in various directions.

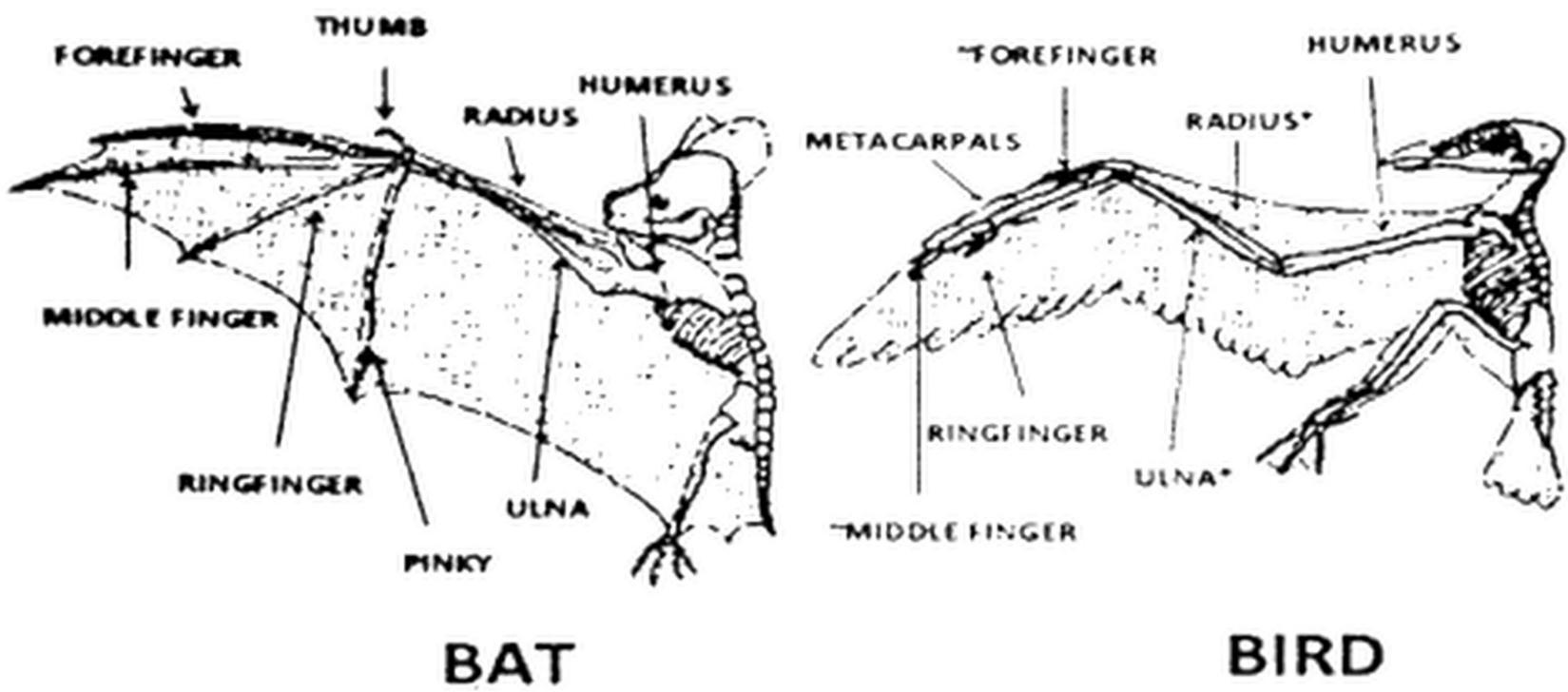


Figure: Showing comparative anatomy of Analogous organ

Evidence from Molecular Biology

Almost all living organisms use the same basic biochemical molecules, including DNA, ATP and identical enzymes. Further, organisms utilize the same DNA triplet code and the same twenty amino acids in their proteins. Organisms even share the same type of interons. Cytochrome c is a molecule that is used in the electron transport system in all the organisms. There is obviously no functional reason why these elements need to be similar, but their similarity can be explained by decent from a common ancestor.

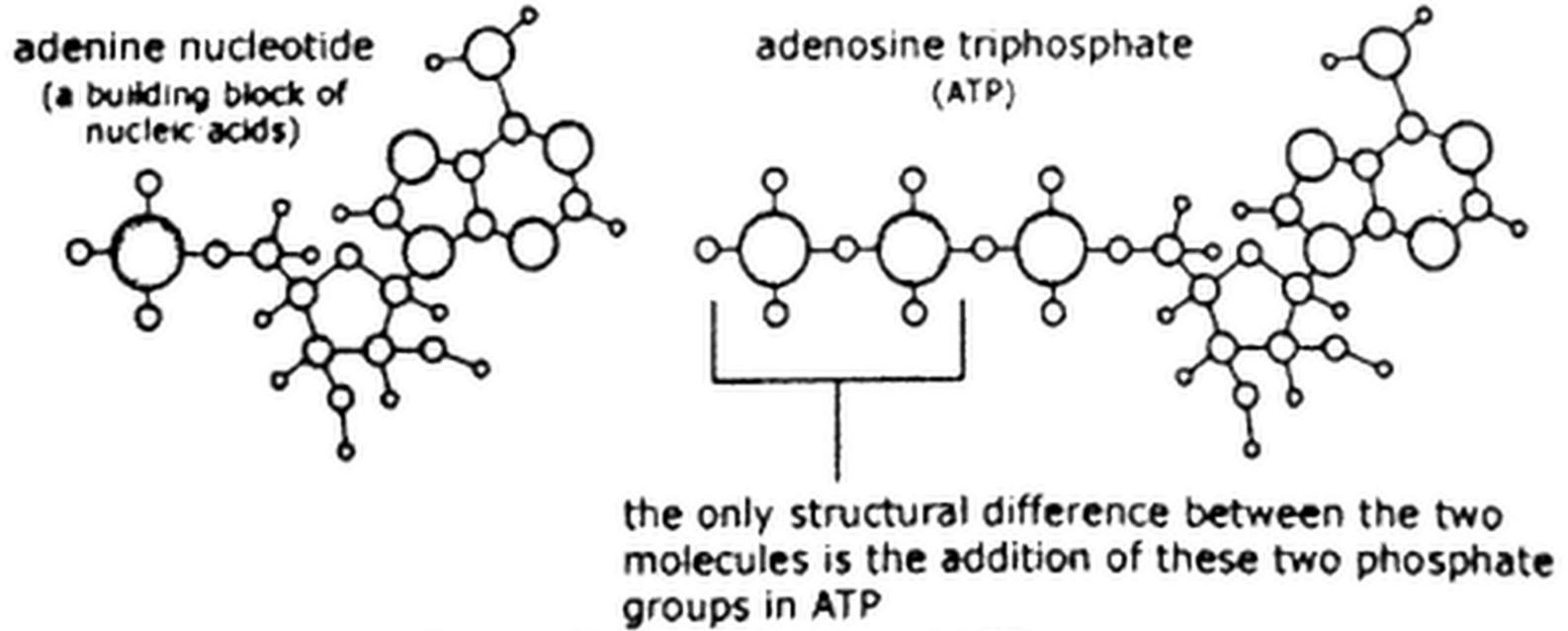


Figure: Showing structure of ATP

Q5. Describe the theories that have been put forwarded about the mechanism of evolution of eukaryotes from prokaryotes.

Answer

Theories about Evolution of Eukaryotes

As per fossil record the eukaryotes appeared 1.9 to 2.1 billion years ago. They arose from prokaryotes. There are two theories that have been put forward about the

b) Endosymbiosis Theory.

Membrane Invagination Theory

A number of alternative hypotheses for the origin of eukaryotic cells have been suggested. One of these proposes that the prokaryotic cell membrane folded inward and invaginated to enclose copies of genetic material, thereby forming several double membraned entities within a single cell. These entities could then have evolved into the eukaryotic nucleus, mitochondrion and chloroplast.

Regardless of the exact mechanism involved, the emergence of the eukaryotic cell led to dramatic increases in complexity and diversity of living organisms on Earth. At first, organisms were capable of existing only as independent single cells. Later, however, some evolved into multicellular organisms in which various cells became specialized for many different functions. These multicellular forms became adapted to life in a great variety of environment.

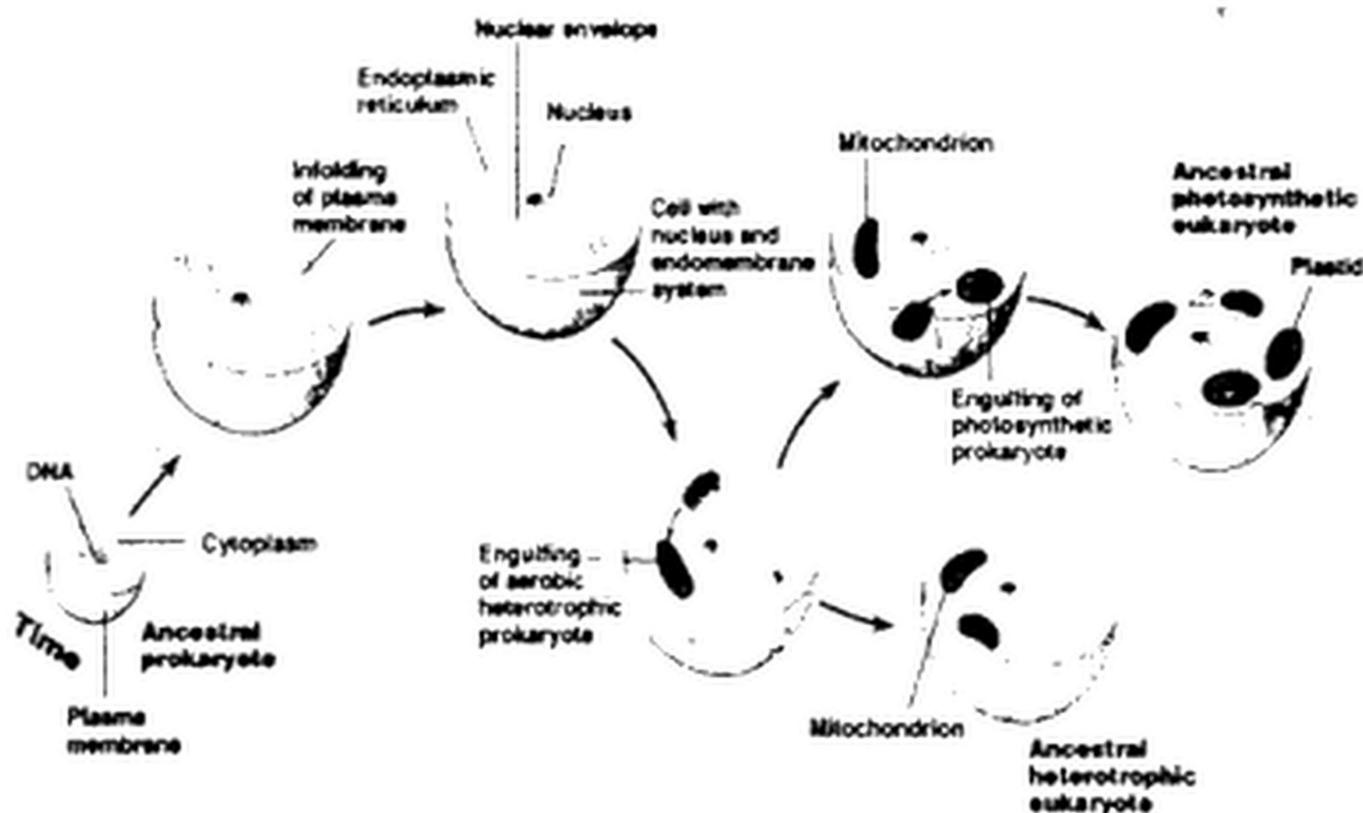


Figure: Evolution of Eukaryotes cell from Prokaryotes cell

Endosymbiosis Theory

The endosymbiosis theory (*symbiosis* means living together and *endo* means within) was proposed by Lynn Margulis. The first step in the evolution of a eukaryotic cell is thought to have occurred when a large anaerobic amoeboid prokaryote ingested a small aerobic bacterium and stabilized its prey as an endosymbiont rather than digesting it. This aerobic bacterium developed into a mitochondrion, the site of aerobic respiration in eukaryotic cells. Possession of such mitochondrion-like endosymbionts conferred the advantages of aerobic respiration on its host. Flagella may have derived through the ingestion of prokaryotes similar to spirochetes.

Chloroplasts are thought to be derived from symbiotic photosynthetic bacteria. In addition, both mitochondria and chloroplasts are similar in size to bacteria, have their own DNA, have ribosomes similar to those of bacteria, and produce a limited portion

the endosymbionts must have transferred, over time, some of their genes to the host nucleus and thus relinquished for their independence for the sake of symbiotic relationship.

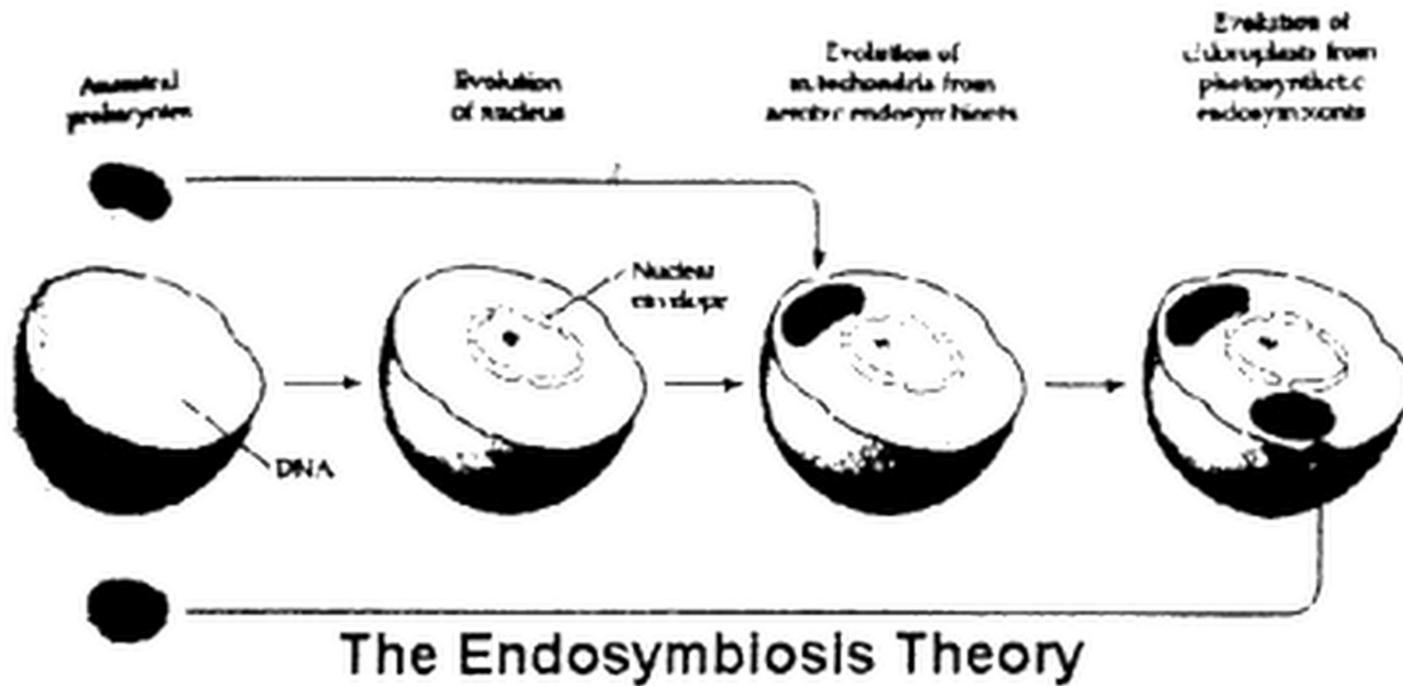


Figure: Showing endosymbiosis theory

Q6. Describe the Lamarck theory of inheritance of acquired characters. Why Lamarck is regarded as an early proponent of evolution?

Answer

Lamarckism

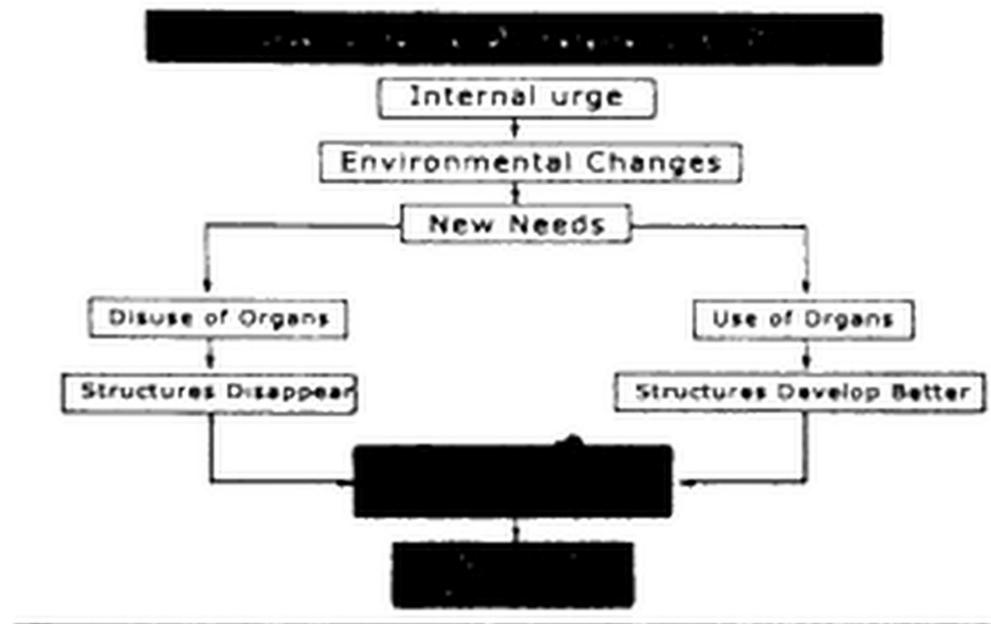
Jean-Baptiste Chevelier de La Marck, (1744-1829) is often known simply as Lamarck. He was a French naturalist, soldier and biologist. Lamarck was an early proponent of the idea that Evolution occurred and proceeded in accordance with the natural laws. Lamarck is regarded as a premier authority on invertebrate zoology. He is remembered, at least as a taxonomist of considerable stature. In 1809, he published a book *Philosophie Zoologique* (Zoological Philosophy).

Main Points of Lamarckism

The Ideas about evolution presented by Lamarck are known as Lamarckism. He pictured evolution as a ladder of life from simplest to the most complex animals. Man was the top rung of this ladder. Lamarck did little in way of explaining the origin of this ladder as a whole. However, he did offer an explanation for the origin of adaptations to the environment. Lamarck's contribution to science is important, because he was the first to propose that organisms undergo change over time as a result of some natural phenomena.



Lamarck's explanation of evolution revolved around two basic assumptions. The first one is the use and disuse of organs. Lamarck's second assumption is the inheritance of acquired characteristics.



Use and Disuse of Organs

Lamarck believed that some organs which are more frequently used by an organism are developed and become strong. organs which are not properly used by an organism are deteriorated, diminished and ultimately disappeared in successive generations. Among the example Lamarck cited were the blacksmith developing a bigger bicep in the arm that works the hammer, giraffe stretching its neck to increase length to eat leaves of the tree and the snakes which are living in small holes and crevices have lost their legs.

Inheritance of Acquired Characteristics

Lamarck believed that characteristics which individual acquired during its lifetime were passed on to the offspring of that individual. Such characteristics are called acquired characters which often emerged by the use or disuse of organs. According to Lamarck through several generations these acquired characters are continuously inherited and accumulated. Gradually a group of organisms would be produced which would be better able to cope with the environment due to inherited acquired characters. Evolution, in other words, would occur.

Q7. Outline the steps of evolution of the giraffe's neck as illustrated in Lamarckism and states the drawbacks in Lamarckism.

Answer

Evolution of Giraffe's Neck

An example often used to illustrate Lamarck's hypothesis involves the evolution of the giraffe's long neck from short necked ancestors. In Lamarckian terms, this process would have occurred as follows. Each giraffe, during its lifetime, would try to reach the leaves at the top of trees. Each animal would constantly stretch its neck to attain this goal. As these individuals reproduced, the results of neck stretching (an acquired characteristic) would be passed on to future generation. Each offspring would be born with a slightly longer neck than those of its parents. Thus long necked giraffes would be born with a slightly longer neck than those of its parents. Thus long necked giraffes gradually evolved.



Figure: Evolution of giraffe neck

Drawbacks of Lamarckism

The anatomical, biochemical and behavioral characteristics that individual organism displays as it develops through life is known as its phenotype. However, the phenotype that an individual actually develops is somewhat conditional and is based on two key factors:

- 1) The fixed genetic potential of the organism (or its genotype; this refers to specific qualities of its genetic material, or DNA).
- 2) The environment conditions which an organism experience as it grows.

The first point of Lamarckism i.e. use and disuse of organs may be acceptable but the characteristics which are acquired through this process during the life time have no genetic bases and therefore cannot be inherited to the next generation. Actually the sciences of that time were unaware of the mechanism of inheritance which was proposed by Mendel 1865.

Q8. Briefly describe the observations Darwin made during his voyage of HMS Beagle.

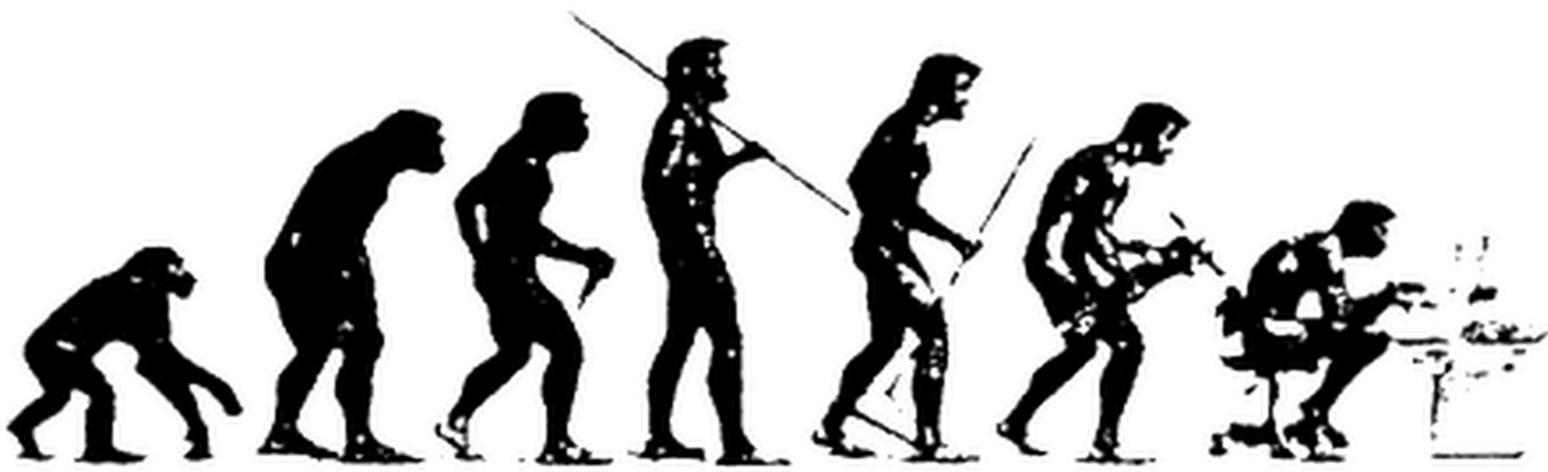
Answer

Darwinism

Charles Darwin was born in England in a wealthy family. His father was a prominent physician. He joined Cambridge University to study theology; even so attend many lectures in biology and geology. He was only 22 in 1831 when he accepted the position of naturalist aboard the HMS Beagle, a British Naval ship about to sail around the world. His major mission was to expand the navy's knowledge of natural resources e.g., water and food in foreign lands.



Figure Charles Darwin



Darwin's Observations During his Voyage

The Beagle left Plymouth, England and cruised slowly along the east and west coasts of South America. He collected and catalogued thousands of plants and animals specimens and kept notes of his observations. The Beagle spent almost two months at the Galapagos (means tortoise) Islands. The Islands are 950 kilometres west of Ecuador. Here Darwin made observations that were most important in the development of his ideas about evolution.

Observations about South America Mainland

He noticed that flora and fauna of different region of the continent had a definite South American stamp, very distinct from the life form of Europe. Further the South American fossils that Darwin found, though clearly different from modern species, were distinctly South American in their resemblance to the living plants and animals of the continent.



Figure: Map showing the journey of HMS Beagle around the world

Observation about Galapagos Island

He compared the animals and plants of the Galapagos with those of the South American mainland. He was particularly impressed by their similarities and wondered why the organisms of the Galapagos should resemble those from South America more than those from other in different parts of the world. Moreover, although there were similarities between Galapagos and South American species, there were also distinct differences. The common birds were those of South America. Closely related species had

beaks of very different sizes and shapes, adapted for feeding on completely different kinds of food. Darwin collected 13 types of finches on the Galapagos which are although quite similar but seemed to be different species. Some were unique to individual islands, while other species were distributed on two or more islands that were close together.

Darwin pondered these observations and tried to develop a satisfactory explanation for the distribution of species among the islands. Darwin perceived the origin of new species and adaptations as closely related processes. A new species would arise from an ancestral form by the gradual accumulation of adaptations to different environment, separated from original habitat by geographical barriers. Over many generations, the two populations could become dissimilar enough to be designated as separate species.

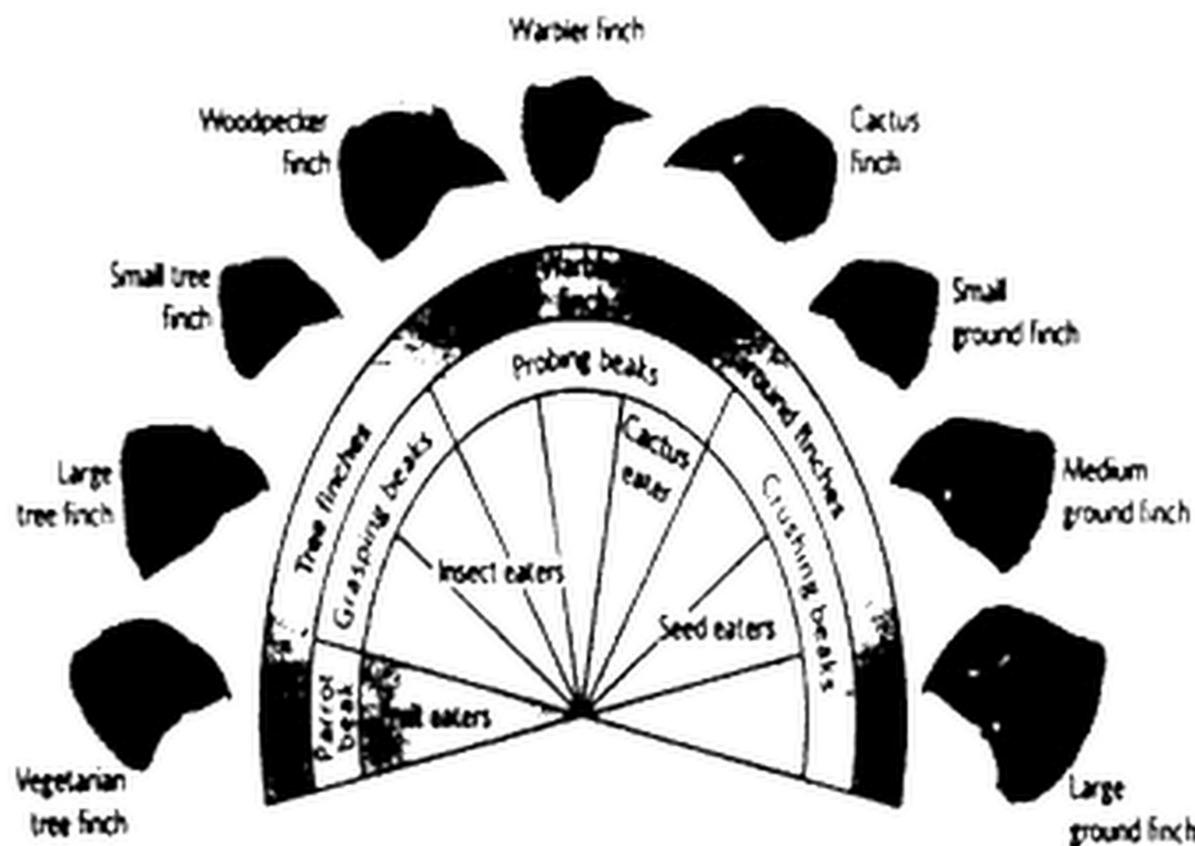


Figure: Darwin's theory of evolution of finches at Galapagos Island

Q9. Explain the main postulates of Darwin's theory of natural selection.

Answer

Darwin's Theory of Natural Selection:

Darwin in his book *The origin of Species* developed two points i.e.

- i) Decent with modification,
- ii) Natural selection and adaptation.

i) Decent with Modification

Darwin believed and perceived unity in life, with all organisms related through decent from some common ancestors and that adaptation to various environment results diversity. In the Darwinian view, the history of life is like a tree, with multiple branching and re-branching from a common trunk all the way from the tips of the living twigs, symbolic of current diversity of organisms. At each of the evolutionary

ii) Natural Selection and Adaptations

Natural selection refers to the differential reproductive capacities among the individuals of a population which indicates that some individuals of a population are capable to reproduce while others are not.

Darwin's mechanism of evolution by natural selection consists of four observations about natural world.

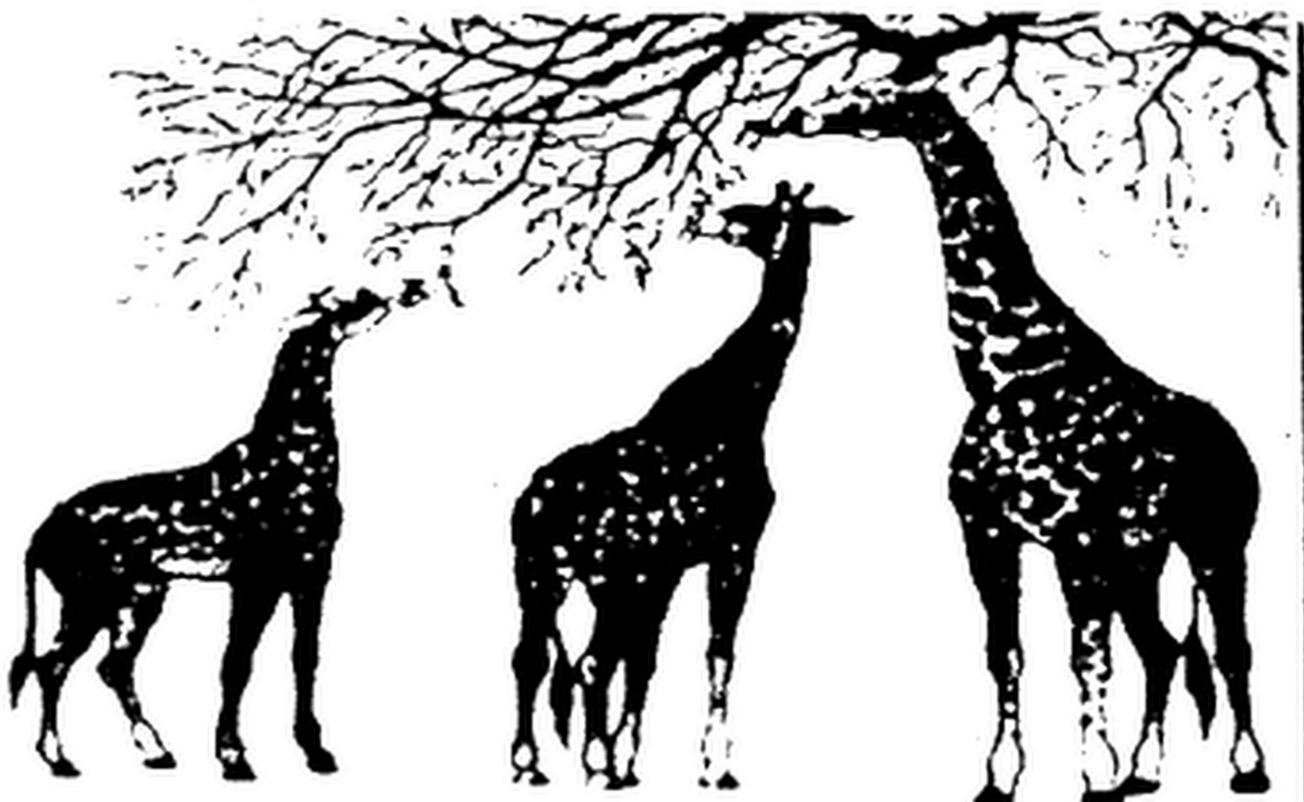
Over production: Each species has the capacity to produce more offspring than will survive to maturity. Through reproduction, natural populations may exponentially increase in number over time.

Variations: The individuals in a population exhibit variation in their traits. Some of these traits improve the chances of an individual's survival and reproductive success, whereas other traits do not.

Struggle for existence: Over production leads to the competition among the individuals of a population for the limited resources, food, water, light, growing space. Because there are more individuals than the environment can support, not all will survive to reproductive age. Other limits on population growth include predators and disease causing organisms. The struggle may be intraspecific and environmental.

Survival of the fittest: Those individuals that possess the most favorable combination of characteristics are most likely to survive and reproduce, passing their heritable traits on to the next generation. For example if there is sudden flood only those organisms that can swim or respire in water, have a better chance to survive and other will die or if there is an earthquake, the flying animals have a better chance of survival. This is called natural selection. It is also referred as the survival of the fittest. The fittest individuals are those that reproduce most successfully.

The processes of natural selection thus cause an increase of favorable alleles and a decrease of unfavorable alleles within the population. Over succeeding generations, individual members become better adapted to local conditions, thus, leading to the evolution of new species.



Neo-Darwinism:

When Lamarck and Darwin put forward their ideas, practically nothing was known about heredity. The emergence of population genetics has provided a clear understanding of inheritance and variation among the individuals of a population and firm support for Darwinian Theory. This reappraisal of the theory of natural selection in terms of modern population genetics is sometimes called Neo-Darwinism.

Q10. What is Hardy-Weinberg theorem? Describe the assumptions of Hardy-Weinberg theorem.

Answer

Hardy-Weinberg Theorem:

The mathematical relationship between the frequencies of alleles and genotypes in population was developed independently by Godfrey Hardy an English mathematician, and Wilhelm Weinberg, a German physician, in 1908. They pointed out that the frequencies of various genotypes in a population can be described mathematically which is now known as Hardy-Weinberg principle. According to the Hardy-Weinberg principle, both *the ratios of genotypes and the frequency of alleles remain constant from one generation to the next in a sexually reproducing population, provided other conditions are stable.*

Conditions / assumptions for Stability

As long as any population remains free of outside interference, it will remain in genetic equilibrium i.e., ratios and proportions of gene frequencies and genotype frequencies will remain same. Real populations like *Drosophila*, however, are rarely free from outside influences and they never totally meet the following five basic conditions for stability:

- a) Reproduction must be totally random.
- b) There must be no gene flow.
- c) Populations must be large.
- d) There must be no mutations.
- e) There must be no selection.

In an ideal population left undisturbed by any of the five conditions listed above, there would be complete genetic equilibrium. The population would contain the same type of genes represented in the same ratios within the same phenotypes.

Over long periods of time, this population would never change. Actually, in the real world, this does not happen. A definition of evolution, therefore, could be; *Deviations from genetic equilibrium leads to evolution.*

Factors that Change Allele Frequencies

The evolution of a species to occur, the gene frequencies of that population must undergo change but under certain conditions these frequencies may remain constant over time. However, a number of factors can lead to change in allele frequencies. They are as follows:

- a) Migration / gene flow:** It is the movement of individuals from one population to another. Whether it is movement of foreign individuals into the population (emigration) or it is outward movement of individuals from the population (immigration), in both cases allele frequencies will change accordingly.
- b) Mutation:** It is a major source of variations. New alleles are arisen due to mutation but it occurs so rarely that it alone does not change allele frequency much.
- c) Non-random mating:** It is mating among specific group of individuals in a large population. Although new alleles cannot be developed by non-random mating but it can cause an increase in homozygous genotypes.
- d) Selection:** Some individuals leave behind more progeny than others, and the rate at which they do so is affected by their inherited characteristics. This is called selection. It may be artificial selection or natural selection. In artificial selection breeder select for the desirable traits while in natural selection, the environment plays this role. In both cases frequencies of alleles can be affected.

Hardy-Weinberg Equation

A general formula called the Hardy-Weinberg equation can be used for calculating the frequencies of alleles and genotypes in a population which is genetic equilibrium or Hardy-Weinberg equilibrium. If all alleles of a given locus are the same in the population, the frequency of that allele is one. Such allele is called fixed allele. In fruit flies the allele for grey body B is dominant over the allele for black body colour b . Because only two alleles B and b exist for the locus, the sum of their frequencies must be equal to one. If we let p represent the frequency of the dominant B allele and q the frequency of the recessive b allele in the population, then we can summarize their relationship with a simple binomial equation, $p + q = 1$. (A binomial equation is an algebraic expression that consists of two quantities connected by plus or minus sign) When we know the value of either p or q , we can calculate the value of the other.

$p = 1 - q$ and $q = 1 - p$, because $p + q = 1$, then $(p + q)^2 = 1$. This binomial equation can be expanded to describe the relationship of the allele frequencies to the genotype in the population. When it is expanded, we obtain the frequency of the offspring genotypes:

$$(p + q)^2 = p^2 + 2pq + q^2$$

(Frequency of BB) (Frequency of Bb) (Frequency of bb) (All individuals in a population)

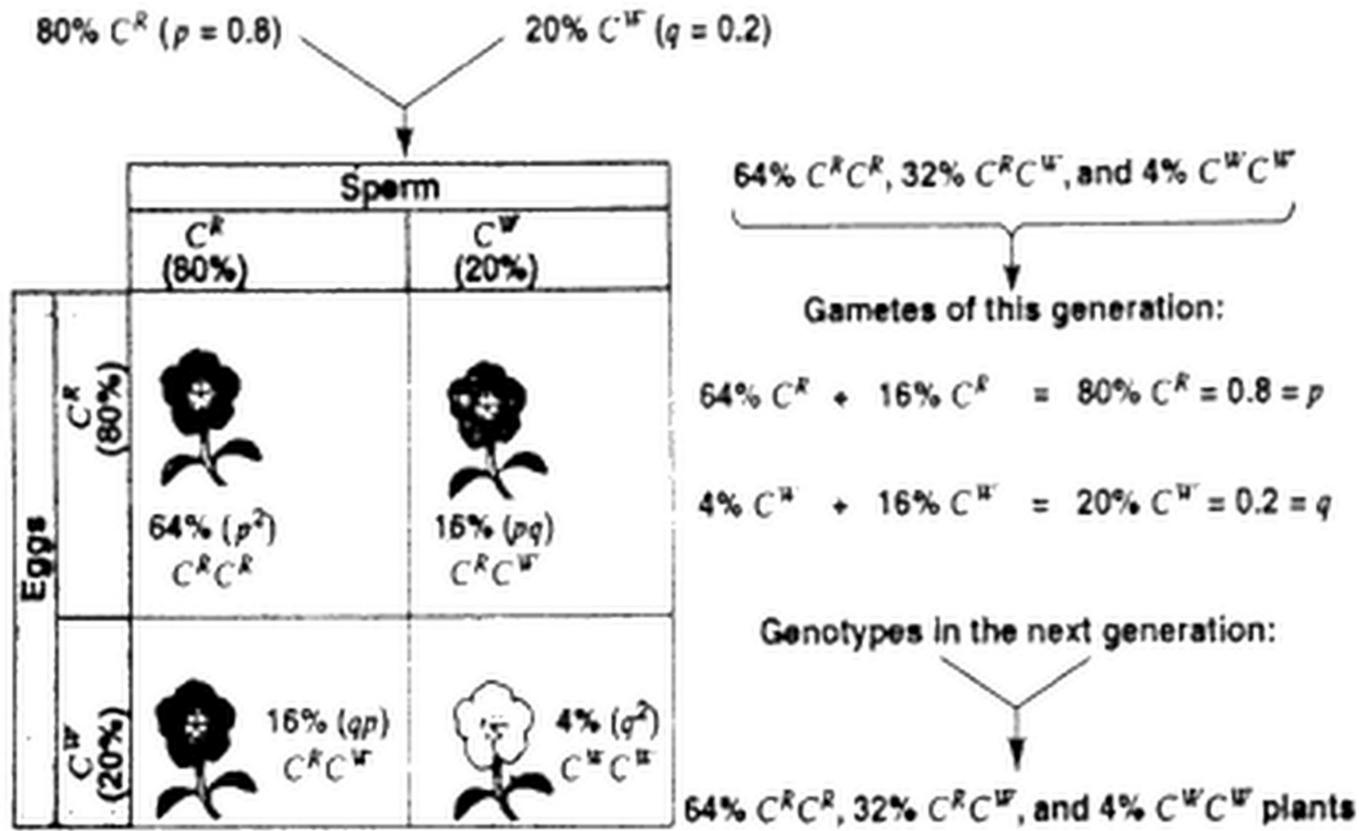


Figure: Example of Hardy Weinberg equilibrium in population

Q11. Explain genetic drift.

Answer

Genetic Drift (Natural Selection)

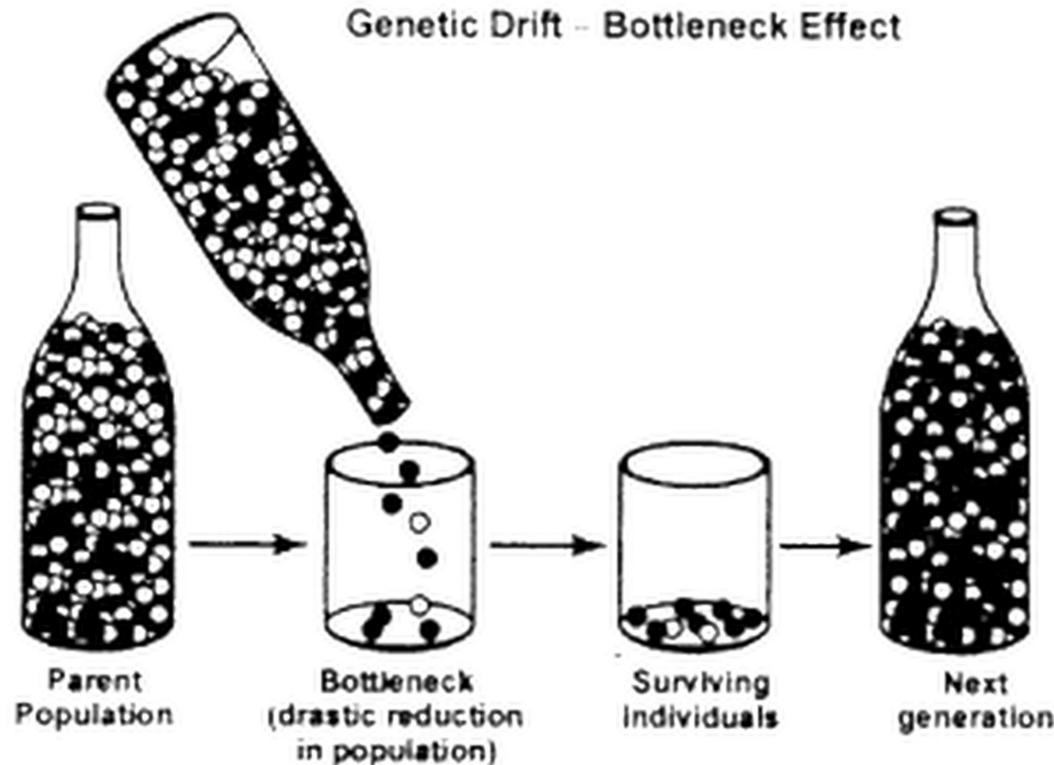
In each generation, some individuals may, just by chance, leave behind a few more descendants (and genes, of course!) than other individuals. The gene of the next generation will be the genes of "lucky" individuals, not necessarily the healthier or "better" individuals. That, in a nutshell, is genetic drift. It happens to all populations there is no avoiding the vagaries of chance. One allele may be eliminated from the population by chance, regardless of whether that allele is beneficial, harmful or of no particular advantage or disadvantage. Although genetic drift occurs in both large and small populations, a large population is expected to suffer less. When a population is small there is greater chance that some rare genotypes may be lost in the next generation, when if few individuals fail to reproduce. Genetic drift can decrease genetic variation within a population, although it tends to increase the genetic difference among different populations.



Figure: Genetic drift

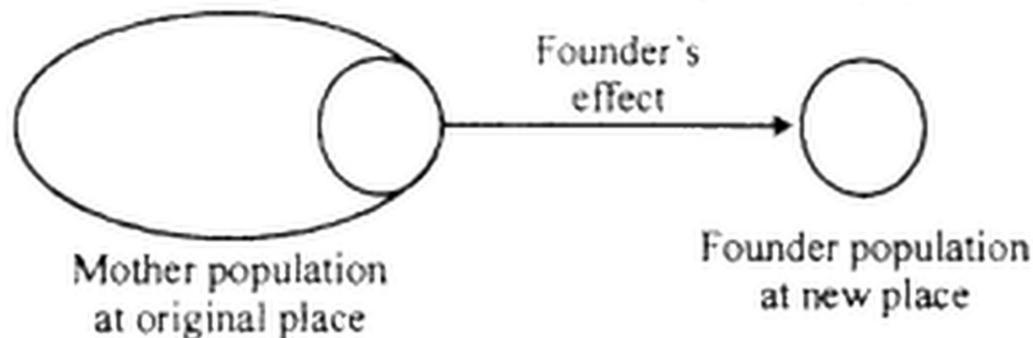
Bottleneck Effect

The reduction of population size with some specific allele and genotype due to natural disaster is called bottleneck effect. For example, events such as earthquake, floods, or fire may kill large numbers of individuals unselectively, producing a small surviving population that is unlikely to have the same genetic makeup as the original population but have different proportion and ratios of allele and genotype frequencies.



Founder Effect

The founder effect is a particularly example of the influence of random sampling. It was defined by Ernst Mayr as: "The establishment of a new population by a few original founders (in an extreme case by a single fertilized female) which carry only a small fraction of the total genetic variation of the parental population."



The founder effect can have two interesting consequences:

If a small sample of individuals is taken from a larger population, there is a chance that an allele will be lost. In the case of two alleles, *A* and *a*, if the founding population are all *a* homozygous then the *A* allele will be lost and the new population will be genetically monomorphic. In fact, the founding effect is quite ineffective at reducing genetic variations- even if the founding population is very small even less than 10, it will usually possess both alleles.

In a small sample, the frequencies of the genes may differ from the parental population. Isolated populations often have exceptionally high frequencies of otherwise rare alleles, and the most likely explanation is that the founding population had a disproportionate number of these rare alleles. The frequency of Huntington's disease in

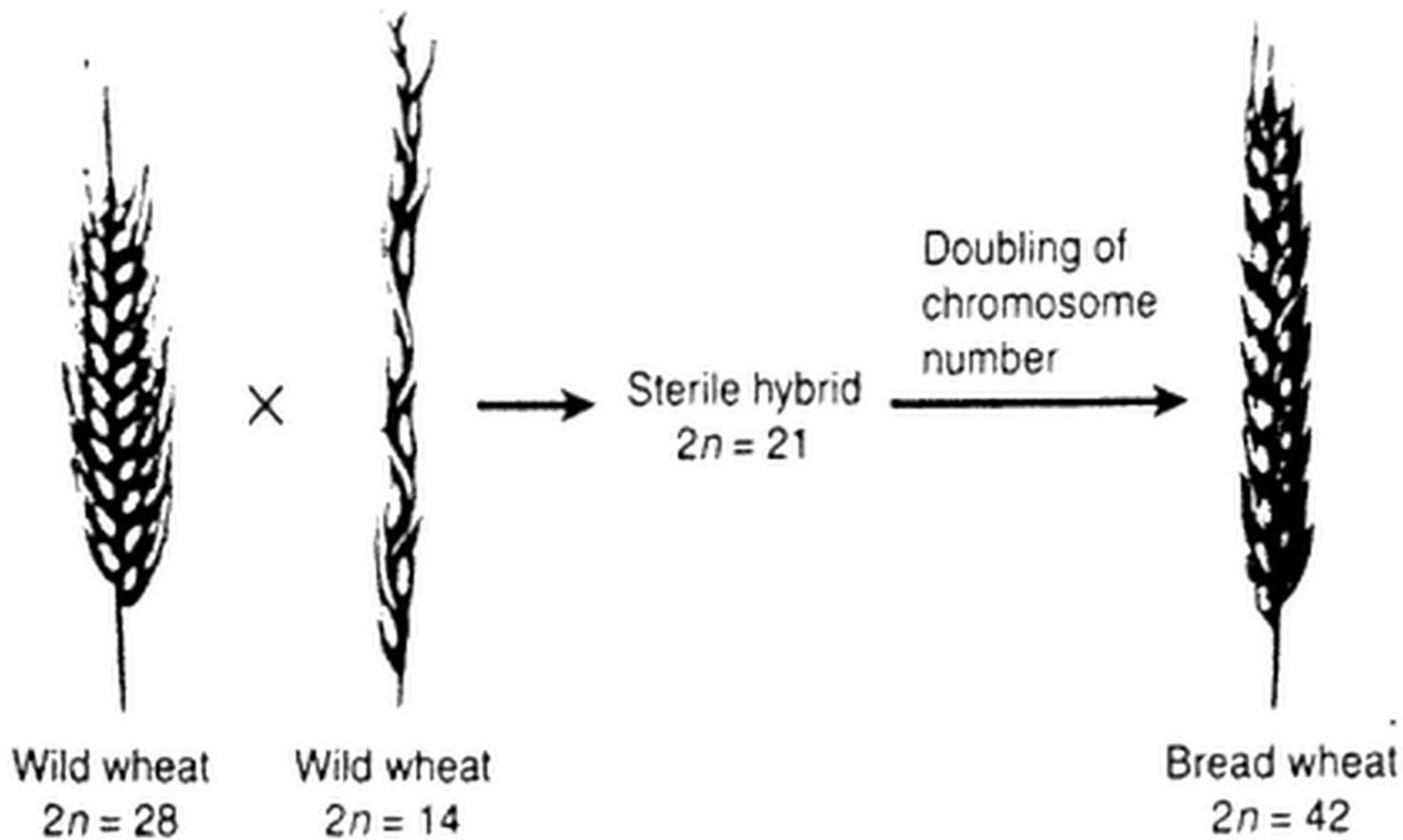
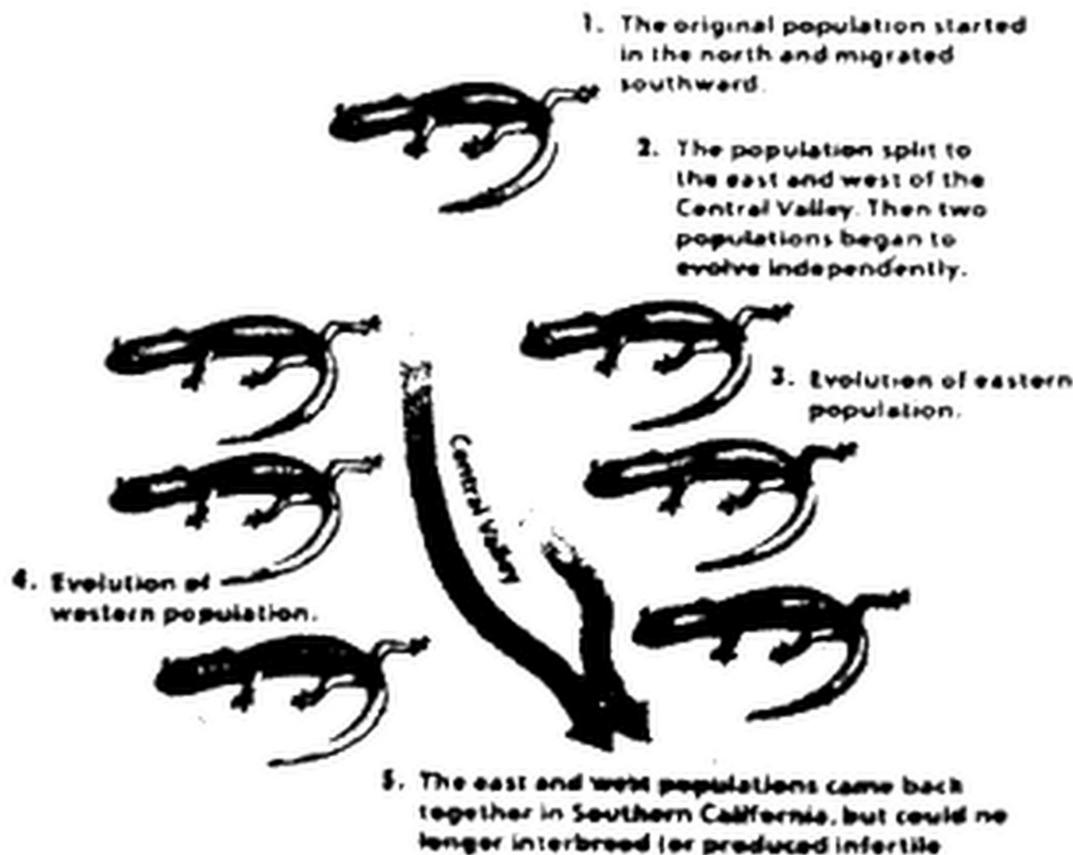


Figure: Sympatric speciation in wheat

Allopatric Speciation

It is the most common form of speciation. It occurs when populations of a species become geographically isolated. When populations become separated, gene flow between them ceases. Over time, the populations may become genetically different in response to the natural selection imposed by their different environments. If the populations are relatively small, they may experience a founder effect: the populations may have contained different allelic frequencies when they were separated. Selection and genetic drift will act differently on these two different genetic backgrounds, creating genetic differences between the two new species.



Parapatric Speciation

Parapatric speciation is extremely rare. It occurs when populations are separated not by a geographical barrier, such as a body of water, but an extreme change in habitat. While populations in these areas may interbreed, they often develop distinct characteristics and lifestyles. Reproductive isolation in these cases is not geographic but rather temporal or behavioral. For example, plants that live on boundaries between very distinct climates may flower at different times in response to their different environments, making them unable to interbreed.

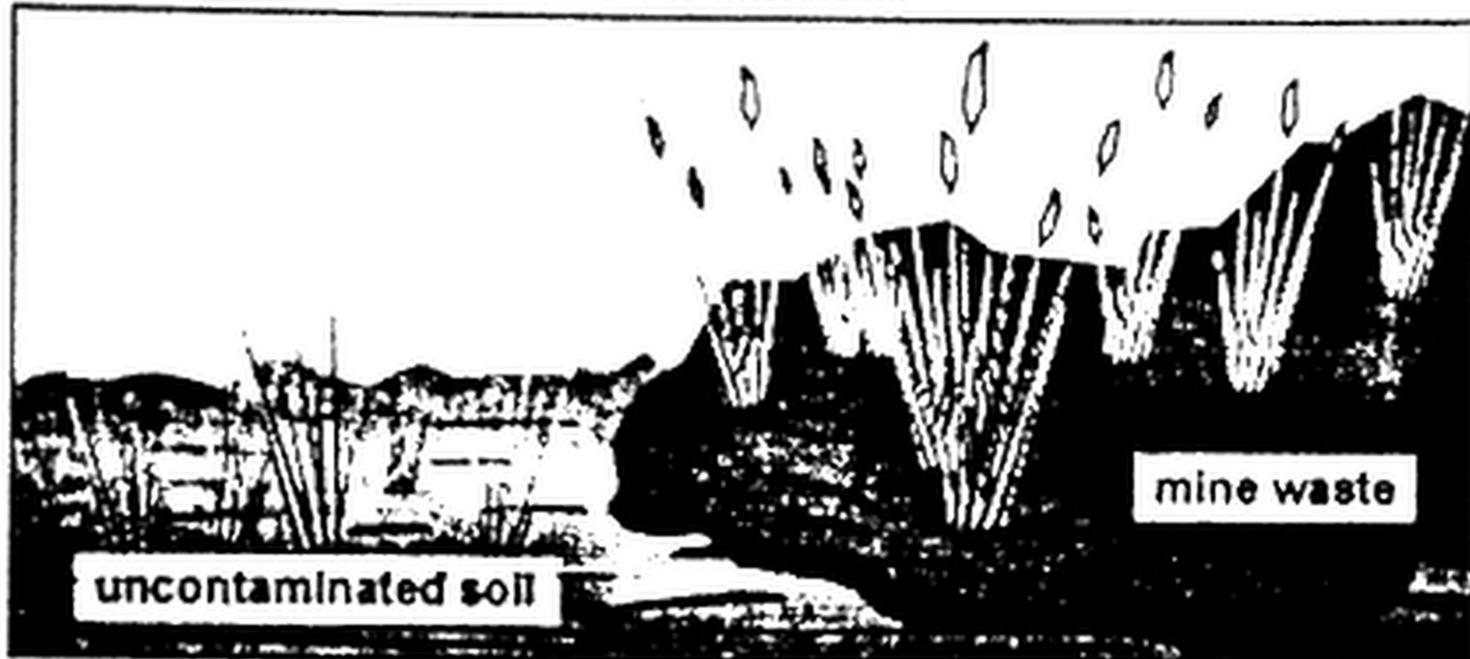


Figure: Parapatric speciation

Q13. What are the ideas that contributed in the early development of Darwinism?

Answer

In 1858, Charles Darwin and Alfred Russel Wallace published a new evolutionary theory that was explained in detail in Darwin's *On the Origin of Species* (1859). Unlike Lamarck, Darwin proposed common descent and a branching tree of life, meaning that two very different species could share a common ancestor. The theory was based on the idea of natural selection, and it synthesized a broad range of evidence from animal husbandry, biogeography, geology, morphology, and embryology.

Darwin began formulating his theory of natural selection in the late 1830s but he went on working quietly on it for many years. He wanted to amass a wealth of evidence before publicly presenting his idea. In 1842, Darwin wrote for himself, a brief 35-page sketch of his theory. Two years later he enlarged this into an essay of 230 pages, which he showed to his friends, but did not published it. For the next fifteen years, Darwin continued to collect facts to support his ideas.

The bases for the development of Darwin's theory of evolution were not only his observations about unique distribution of organisms in different regions of the world but he was also inspired by the work of many other scientists of that time. Therefore, the ideas of these scientists also contributed in the early development of Darwinism.

Q14. Describe and analyze examples of technology that have extended

contribution of radiometric dating to the paleontological analysis of fossils)

Answer

Geologists and paleontologists, use techniques to determine the actual ages of rocks and the fossils they contain. The most common method is called radiometric dating or often called radioactive dating, is based on the fact that living organisms contain certain radioactive isotopes in certain ratio. For instance, living organisms have the same constant ratio ^{14}C , a radioactive isotope to ^{12}C , a stable isotope, as does Earth's atmosphere. However, when an organism dies, its ratio of ^{14}C to ^{12}C starts to drop, because ^{14}C decays to other chemical elements, and the organisms no longer obtains any ^{14}C from the atmosphere. Each radioactive isotope has a fixed rate of decay known as half-life. The half - life is the amount of time it takes for one half of the initial amount of the parent radioactive isotope, to decay to the daughter isotope. For example, ^{14}C has a half-life of 5600 years, meaning that half of the ^{14}C in a specimen decays in about 5600 years, half remaining ^{14}C decays in the next 5600 years and so on, until all the ^{14}C is gone. Knowing both the half-life of a radioactive isotope and the ratio of radioactive to stable isotope in a fossil enables us to tell how old the fossil is. For instance, if a fossil has a ^{14}C to ^{12}C ratio half that of atmosphere, it is about 5600 years old; a fossil with one-fourth the atmospheres ratio is about 11,200 years old.

Q15. List the vestigial structures found in man and categorize them in homologous or analogous structure.

Answer

Human vestigial organs are those organs that have lost all or most of their original functions through Evolution. There are about 90 such structures present in our body.

- 1) **Vermiform appendix** is a vestige of the cecum.
- 2) **Coccyx or tailbone** is the remnant of a lost tail.
- 3) The **wisdom teeth** are vestigial third molars that human ancestors used to help in grinding down plant tissue.
- 4) Humans have ear muscles that are minimally developed and non-functional, but some people are able move their ears in various directions.
- 5) **Nictitating membrane**: membrane present in the eyes to clean membrane

Q16. What factors have contributed to the dilemma that pharmaceutical companies face in trying to develop new antibiotics because so many micro-organisms are resistant to existing antibiotics?

Answer

Antibiotic resistance a type of drug resistance where a microorganism is able to survive exposure to an antibiotic. While a spontaneous or induced genetic mutation in bacteria may confer resistance to antimicrobial drugs, genes that confer resistance can be retransferred between bacteria. Thus a gene for antibiotic resistance which had evolved

