

BIOLOGY

Chapter 7: Evolution



Evolution

Origin of Life:

- The origin of life is considered unique events in the history of universe. Huge cluster of galaxies comprises the universe. Galaxies contain stars and clouds of dust and smoke.
- Big Bang Theory attempts to explain the origin of universe. According to this theory, a huge explosion occurs that forms the different galaxies.
- In solar system of Milky Way galaxies, earth has been supposed to be formed about 4.5 billion years ago. There was no atmosphere in early earth. Water vapour, methane, carbon dioxide and ammonia released from molten mass covered the earth surface.
- UV rays from sun splits the water into hydrogen and oxygen. Life appeared 500 million years after the formation of earth.

There are different theories regarding the origin of life on earth:

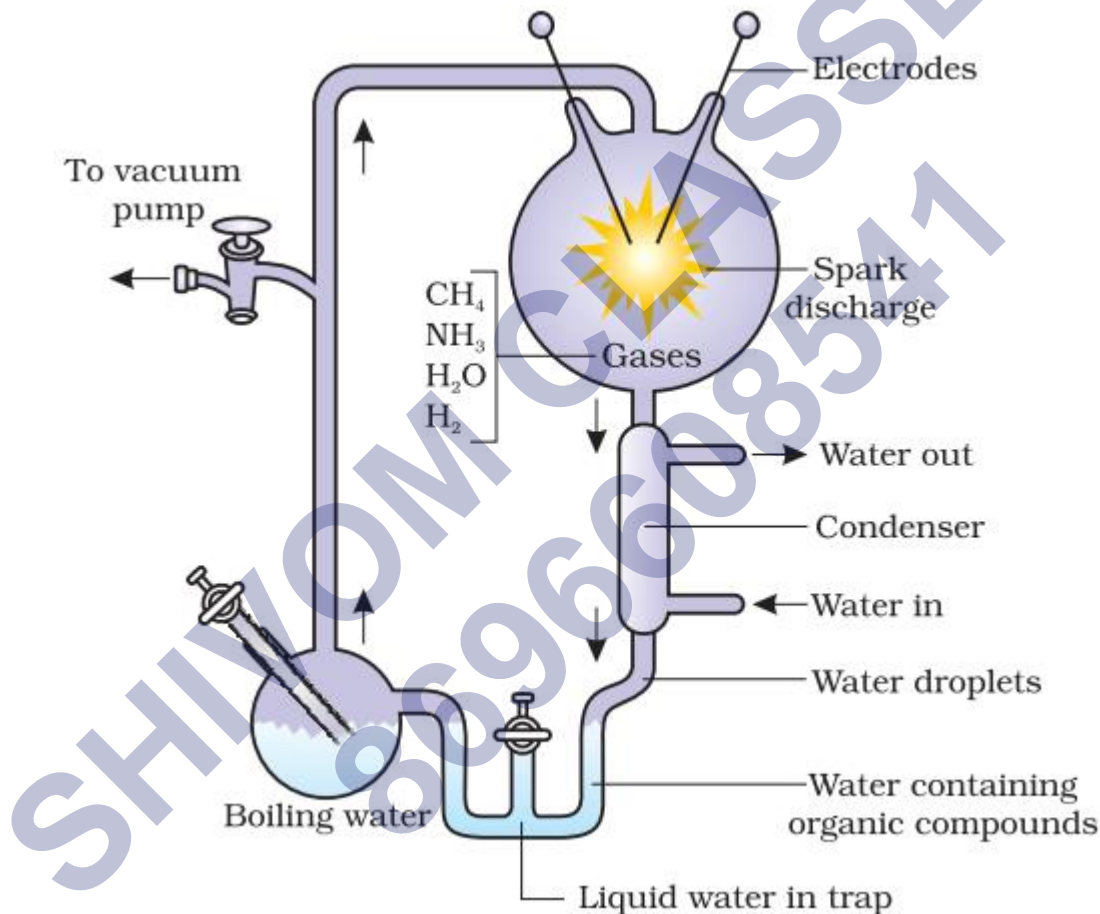
- Some scientist believes that life comes from other planets. Early Greek thinker thoughts that unit of life is called spores transferred from other planets.
- According to other theory, life comes out of dead and decaying matters like straw and mud. This theory is called theory of spontaneous origin.
- Louis Pasteur experimentally proved that life arises only from pre-existing life. Spontaneous theory of origin of life is dismissed after that.
- Oparin and Haldane proposed that the first form of life could have come from pre-existing non-living organic molecules like RNA and protein etc. The formation of life preceded by chemical evolution. At that time condition on earth were- high temperature, volcanic eruption, reducing atmosphere containing CH_4 and NH_3 .

Experimental representation of Miller's experiment:

- Miller experiment of Origin of Life- S.L. Miller in 1953, conducted an experiment to show the origin of life on earth in the physical environment similar to condition prevails at that time.
- Miller created similar condition of temperature and pressure in laboratory scale. He created electric discharge in a flask containing CH_4 , H_2 and NH_3 and water vapour at 8000C.
- He observed formation of amino acids in flask after 15 days of electric discharge. Similar experiment by other scientist found formation of sugars, nitrogen bases,

pigments and fats.

- Analysis of meteorite content also reveals similar compounds that reveal that similar process are occurring elsewhere in the space. This experimental evidence about the origin of life is called chemical evolution of life.
- The first non-cellular forms of life could have originated 3 billion years back. They could have been giant molecules like RNA, Protein, and Polysaccharide etc.
- The cellular form of life was probably single cell and originates in water medium. The theory that first form of life arose slowly through evolutionary forces from non-living molecules is called biogenesis.



Darwin Theory & Natural Selection:

Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago. Many such life forms do not exist anymore. There has been gradual evolution of life forms. according to Darwin, refers ultimately and only to reproductive fitness. those who are better fit in an environment, leave more progeny than others. will survive more and hence are selected by nature. He called it natural selection Alfred Wallace, a naturalist who worked in Malay Archipelago had also come to similar conclusions around the same time. All the existing life forms share similarities and share common ancestors. The geological

history of earth closely correlates with the biological history of earth.

Evidence of Evolution:

Evidence that evolution of life forms has taken place on earth have many proofs as mentioned below:

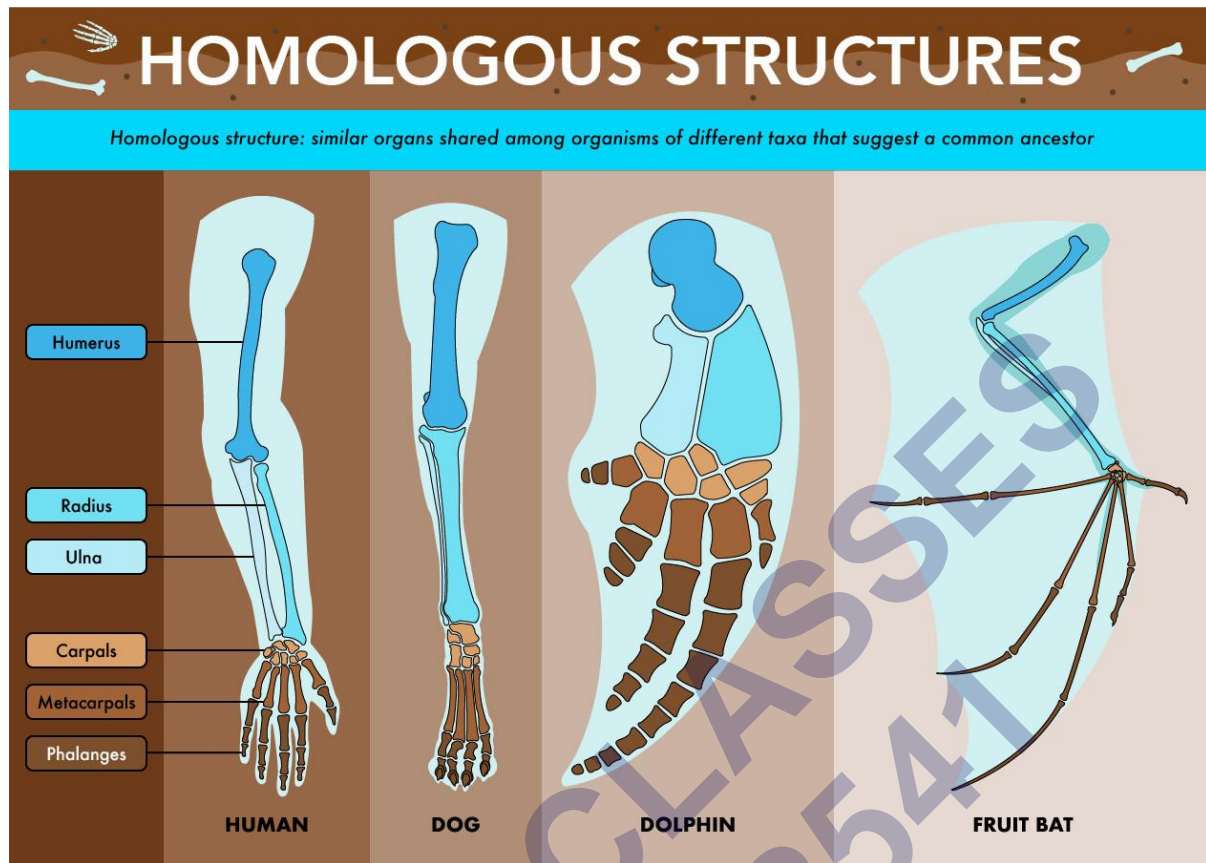
Paleontological evidence:

Paleontological evidence different aged rock sediments contain fossils of different life forms that probably died during the formation of particular sediment. Fossils are remains of hard parts of life-forms found in rocks. The study showed that different form varied over time and certain life forms are restricted geological time span. Hence, new forms of life have arisen at different times in history of earth.

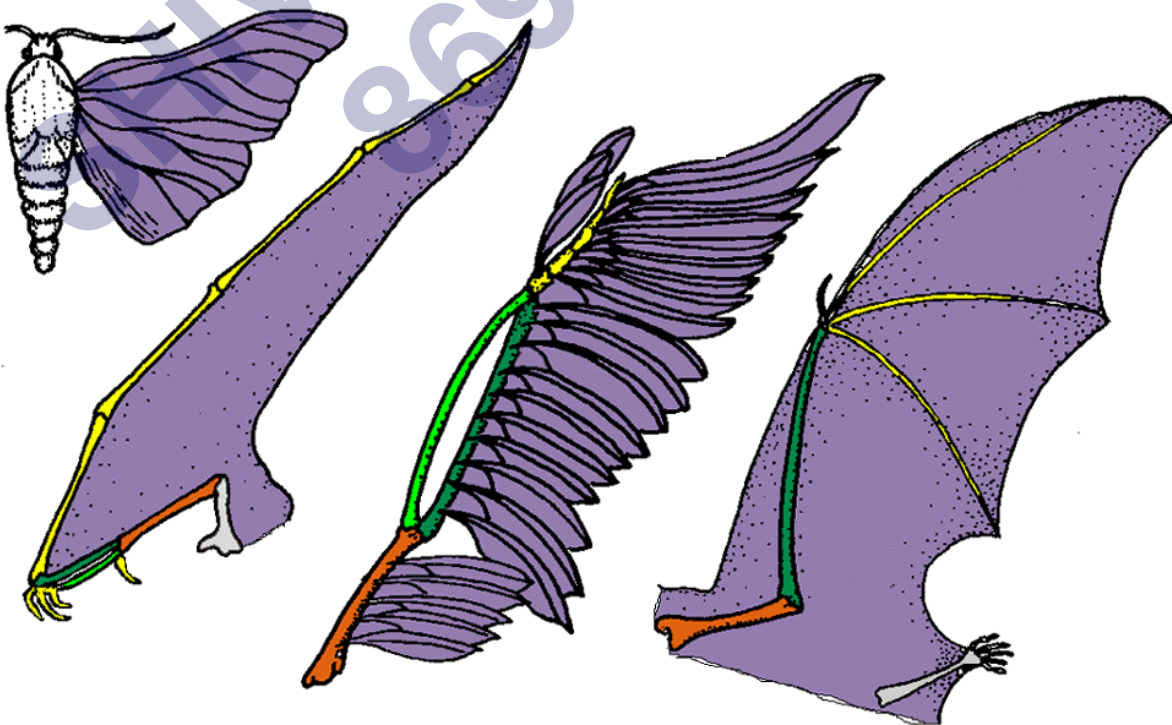


Homologous organs: Homologous organs those organs that perform different function but have similar origin and structure are called homologous organs. For e.g. human, cheetah, bat and whales share similarities in pattern of bones of forelimbs although these forelimbs perform different functions in these animals. In these animal similar structure developed along different directions due to adaptation of different needs. This is called divergent evolution.

Homologous structures: Homologous structures are organs or skeletal elements of animals and organisms that, by virtue of their similarity, suggest their connection to a common ancestor. These structures do not have to look exactly the same, or have the same function. The most important part, as hinted by their name, is that they are structurally similar.



Analogous Structures: Bird, Insect and Bat Wings. Unlike creatures with homologous structures, where organisms' shared traits can determine a Fish and Penguin Fins/ Flippers. Fish and penguins are both vertebrates that use fins to swim in deep waters. However, Duck and Platypus Bills. The duck-billed platypus, which is a mammal, seems like a perplexing example of evolution.



Biochemical evidences:

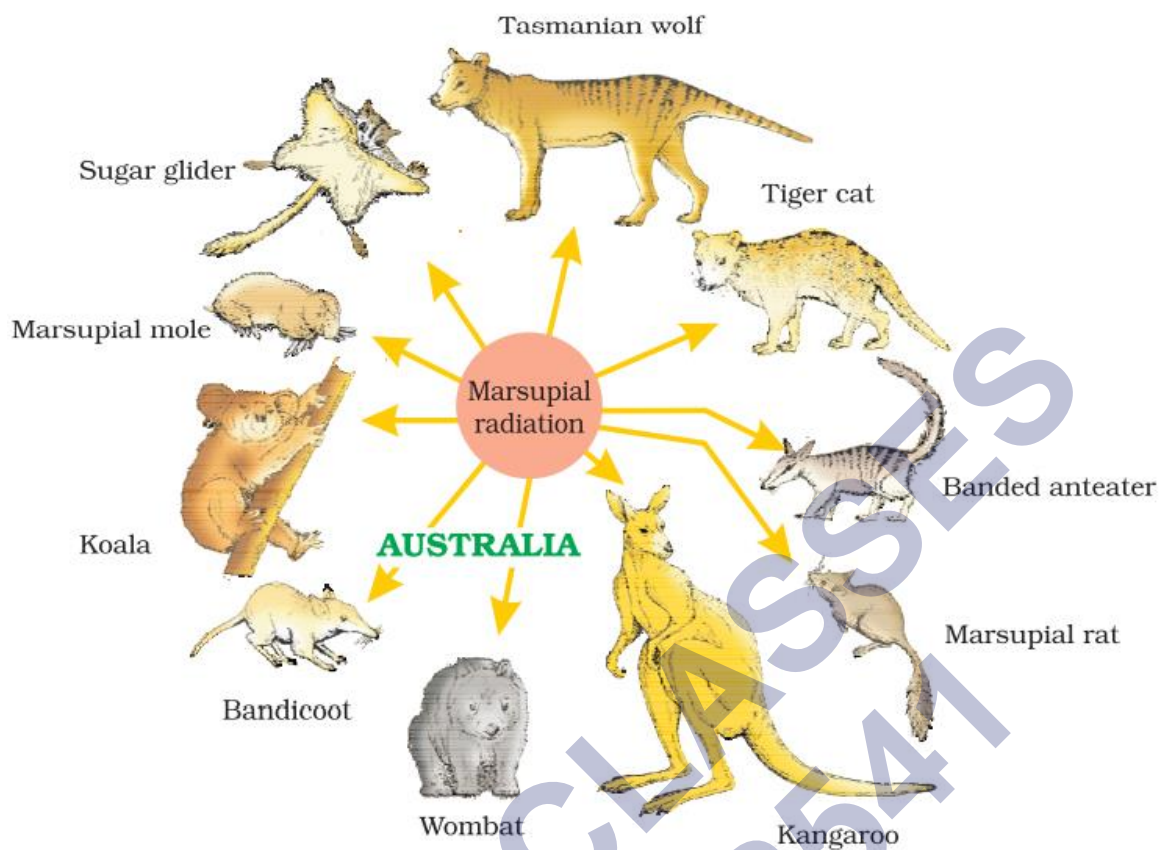
Similarities in proteins and genes performing a given function among diverse organisms give hints to common ancestry. These biochemical similarities point to the same shared ancestry as structural similarities among diverse organisms.

Divergent Evolution: Development of different functional structures from a common ancestral form is called divergent evolution. Homologous organs show divergent evolution. Examples: Darwin's Finches, Australian Marsupials, locomotion in mammals.

Convergent Evolution: Development of similar adaptive functional structures in unrelated groups of organisms is called convergent evolution. Analogous organs show convergent evolution. Examples: Australian Marsupials and Placental mammals, various aquatic vertebrate and wings of insect bird and bat.

Adaptive Radiation:

The process of evolution of different species in given geographical area starting from a point and radiating to other areas of geography (habitat) is called adaptive radiation. Darwin's finches represent one of the best examples of adaptive radiation. Australian marsupials, each with different from other evolved from one ancestral stock, but all within Australian island continents.



Adaptive radiation of marsupials of

When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats), we can call this convergent evolution e.g. Placental mammals and Australian marsupials.

Biological Evolution:

The nature select for fittest and fitness is based on characteristics which are inherited. Some organisms are better adapted to survive in otherwise hostile environment. Fitness is the end result of the ability to adapt and get selected by nature.

Lamarck had said that evolution of life form had occurred but driven by use and disuse of organs. He gave the example of giraffe to evolve their neck by foraging leaves on tall trees and had to adapt by elongation of their necks.

Branching descent and natural selection are the two key concepts of Darwinian Theory of Evolution.

Darwin theory of natural selection was based on certain observations like:

- Limited natural resources.
- Over population
- Competition for resources

- Struggle for existence
- Survival of the fittest.

Mechanism of Evolution:

Hugo DeVries based on his work on evening primrose brought forth the idea of mutation. Mutation is the large difference arising suddenly in a population.

Mutations are random and directionless while Darwin variations are small and directional. Hugo DeVries believed that mutation causes speciation and hence called saltation (single step large mutation).

Hardy Weinberg Principle:

Hardy Weinberg Principle in a given population, frequency of occurrence of alleles or genes can be finding out. These frequencies remains fixed and even remain the same through generation. This fact was represented by Hardy-Weinberg principles using algebraic equation.

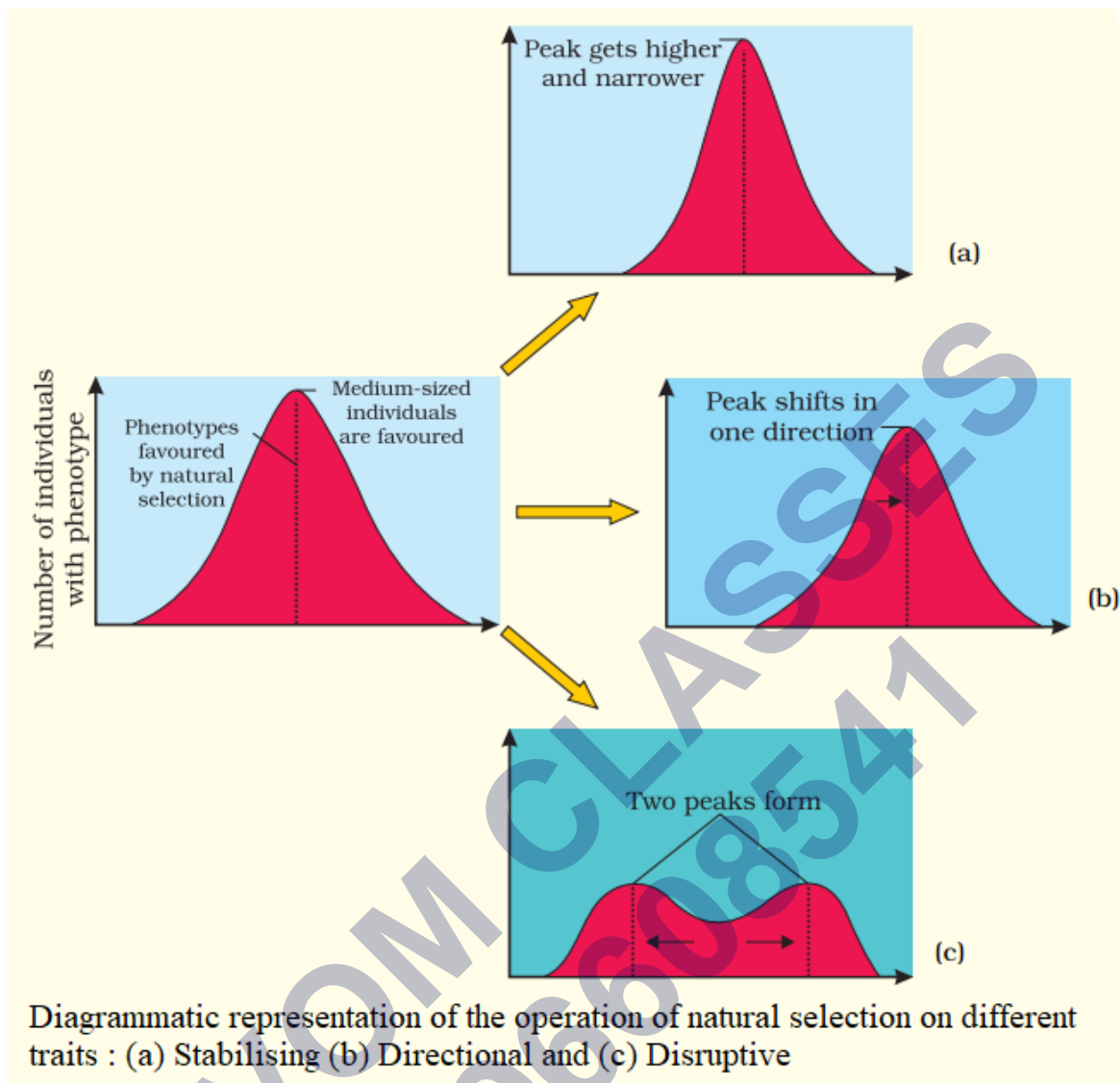
This principle states that allele frequencies in a population are stable and is constant from generation to generation. The gene pool remains constant. This is called genetic equilibrium and sum total of all the allelic frequencies is 1.

Binomial expansion of $(p + q)^2 = p^2 + 2pq + q^2 = 1$ where p and q represent the frequency of allele A and allele a in a population. The frequency of AA individuals in a population is simply p^2 . This is simply stated in another ways, i.e., the probability that an allele A with a frequency of p appear on both the chromosomes of a diploid individual is simply the product of the probabilities, i.e., p^2 . Similarly of aa is q^2 , of Aa $2pq$. Hence, $p^2 + 2pq + q^2 = 1$.

When frequency is measured, the actual value varies that indicates the extent of evolutionary changes. Change of frequency in a allele (Hardy-Weinberg equilibrium) in a population resulted due to evolution.

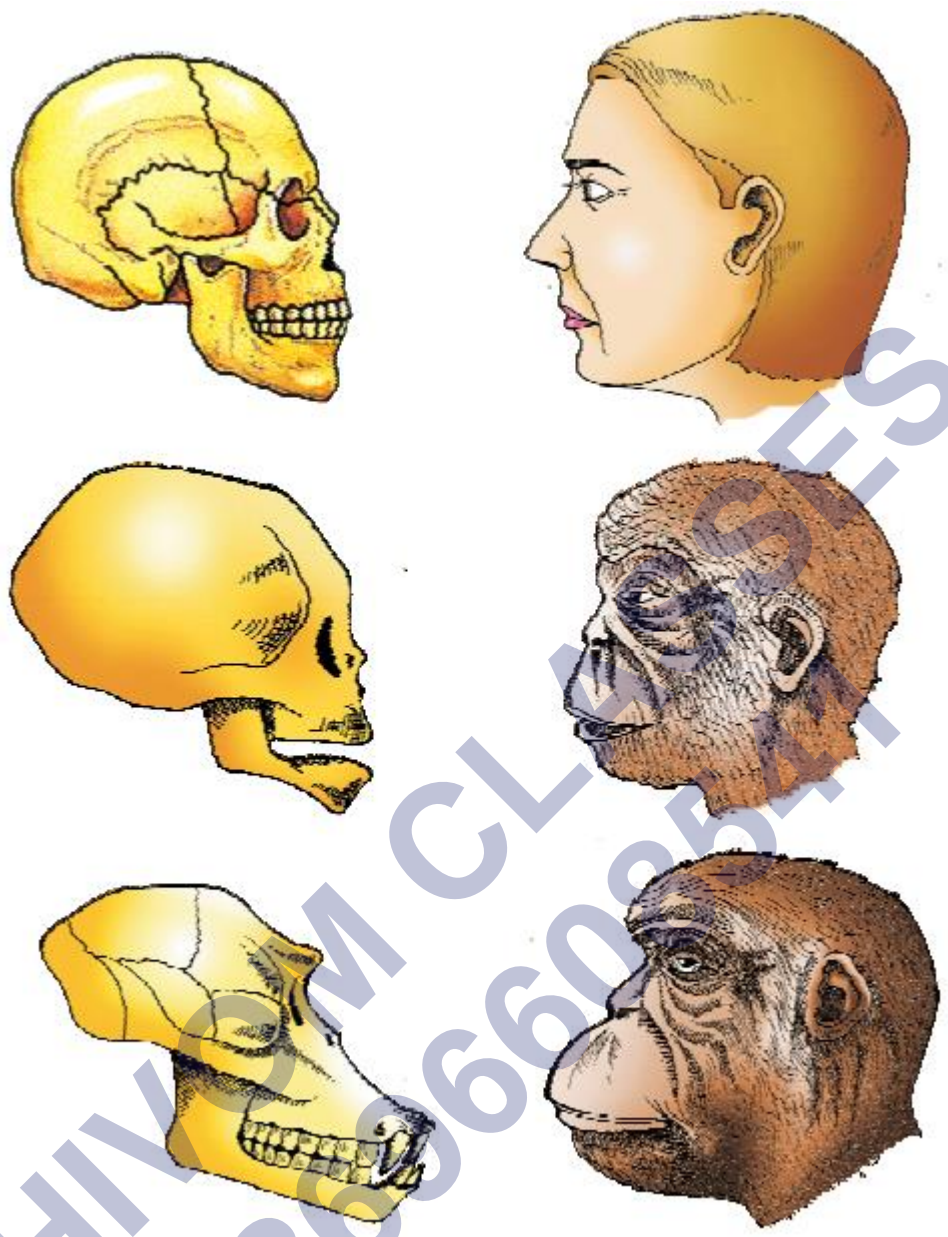
The factors that affect Hardy-Weinberg equilibrium are:

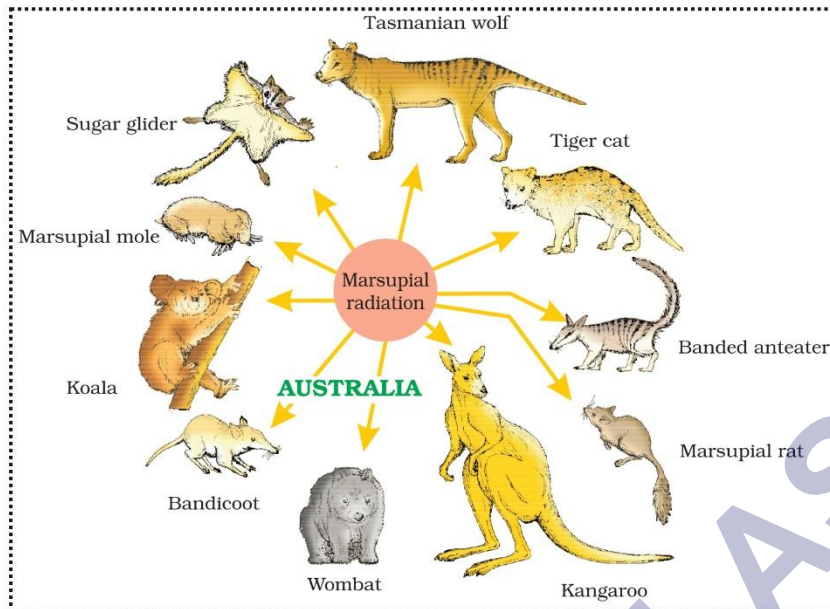
- Gene migration or gene flow.
- Genetic drift
- Mutation
- Genetic recombination
- Natural selection.
- During genetic drift, sometimes change in alleles frequency is so different in a sample of population that they become a different species. The original drifted population becomes founder and that effect is called founder effect.



Origin and evolution of man:

About 15 mya, primates called Dryopithecus and Ramapithecus were existing. Hairy walk like gorillas Ramapithecus was more man-like while Dryopithecus was more ape-like. about 3-4 mya, man-like primates walked in eastern Africa taller than 4 feet walked right Australopithecines probably lived in East African ate fruit. This creature was called the first human-like brain capacities 650-800cc. Homo erectus large brain around 900cc ate meat. Homo sapiens brain size of 1400cc.





Marsupial Radiation

- Human hand, Whale's flippers, Bat's wing, and Cheetah's foot.
- Thorns of Bougainvillea and tendrils of Cucurbita.

Homologous Organ

Analogous Organ

- Wings of insects and wings of birds.
- Eyes of Octopus and mammals - Flipper of Penguins and Dolphins.
- Sweet potato (modified root) and Potato (modified stem)

Analogous Organ

Palentological Evidence

- By study of fossils
- Fossils help to study phylogeny, connecting link and about extinct animals



Evidences

- Morphological & Anatomical
- Palentological Evidence
- Bio Geographical, Adaptive Radiation

Bio-Chemical

- Similarities in proteins and genes.

Embryological

- Similarities in embryo development.

Placental Mammals

E.g. Placental wolf and Tasmanian wolf-marsupial.

Evolution

Lamarckism

- Proposed by Lamarck.
- E.g. Long neck of giraffe.

Darwinism

- Proposed by Charles Darwin as Theory of Natural Selection

Human Evolution

Theories

- Theory of Panspermia
- Theory of Spontaneous Generation
- Theory of Chemical Evolution
- Theory of Biogenesis

Hardy Weinberg

Mechanism

Origin of Life- Urey and Miller's Experiment

Human ancestors	Origin period
Dryopithecus	20-25 mya
Ramapithecus	14-15 mya
Australopithecus	3-4 mya
Homo habilis	2 mya
Homo erectus (java man)	1.5 mya
Homo sapiens neanderthalensis (primitive man)	1,00,000-40,000 years ago
Homo sapiens sapiens (modern man)	75,000-10,000 years ago

Factors affecting

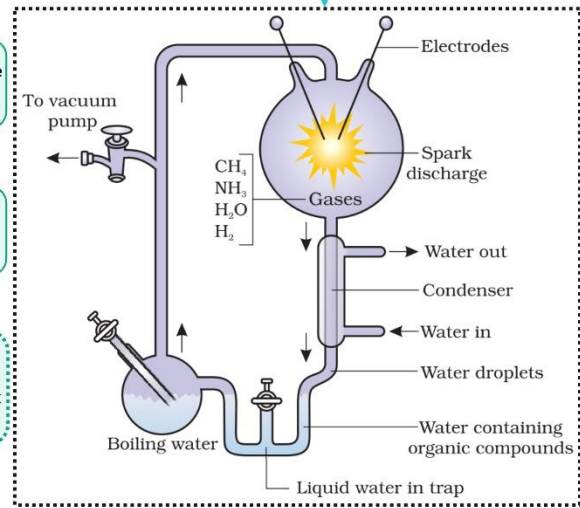
- Gene Migration
- Genetic drift
- Mutation
- Genetic recombination
- Natural Selection

Saltation by De Vries

Single Step Mutation

Proposed by Lamarck.

- E.g. Long neck of giraffe.



Important Questions

➤ Multiple Choice Questions:

- Which of the following is used as an atmospheric pollution indicator?
 - Lepidoptera
 - Lichens
 - Lycopersicon
 - Lycopodium.
- The theory of spontaneous generation stated that
 - life arose from living forms only
 - life can arise from both living and non-living
 - life can arise from non-living things only
 - life arises spontaneously, neither from living nor from the non-living.
- Animal husbandry and plant breeding programmes are the examples of
 - reverse evolution
 - artificial selection
 - mutation
 - natural selection.
- Palaeontological evidences for evolution refer to the
 - development of embryo
 - homologous organs
 - fossils
 - analogous organs.
- The bones of forelimbs of whale, bat, cheetah and man are similar in structure, because
 - one organism has given rise to another
 - they share a common ancestor
 - they perform the same function
 - they have biochemical similarities.
- Analogous organs arise due to
 - divergent evolution
 - artificial selection
 - genetic drift
 - convergent evolution.
- $(p + q)^2 = p^2 + 2pq + q^2 = 1$ represents an equation used in
 - population genetics

- (b) Mendelian genetics
 - (c) biometrics
 - (d) molecular genetics.
8. Appearance of antibiotic-resistant bacteria is an example of
- (a) adaptive radiation
 - (b) transduction
 - (c) pre-existing variation in the population
 - (d) divergent evolution.
9. Evolution of life shows that life forms had a trend of moving from
- (a) land to water
 - (b) dry land to wet land
 - (c) fresh water to sea water
 - (d) water to land.
10. Viviparity is considered to be more evolved because
- (a) the young ones are left on their own
 - (b) the young ones are protected by a thick shell
 - (c) the young ones are protected inside the mother's body and are looked after they are born leading to more chances of survival
 - (d) the embryo takes a long time to develop.
11. Fossils are generally found in
- (a) Sedimentary rocks
 - (b) Igneous rocks
 - (c) Metamorphic rocks
 - (d) Any type of rock.
12. For the MN-blood group system, the frequencies of M and N alleles are 0.7 and 0.3, respectively. The expected frequency of MN-blood group bearing organisms is likely to be
- (a) 42%
 - (b) 49%
 - (c) 9%
 - (d) 58%.
13. Which type of selection industrial melanism observed in moth *Biston betularia*?
- (a) Stabilising
 - (b) Directional
 - (c) Disruptive

(d) Artificial.

14. The most accepted line of descent in human evolution is

- (a) Australopithecus → Ramapithecus → Homo sapiens → Homo habilis
- (b) Homo erectus → Homo habilis → Homo sapiens
- (c) Ramapithecus → Homo habilis → Homo erectus → Homo sapiens
- (d) Australopithecus → Ramapithecus → Homo erectus → Homo habilis → Homo sapiens.

15. Which of the following is an example for connecting link species?

- (a) Lobe fish
- (b) Dodo bird
- (c) Sea weed
- (d) Tyrannosaurus rex.

➤ Very Short Question:

1. Name one fish like reptile that evolved from land reptile about 200 million years ago?
2. For a long time, it was believed that life originated from decaying matter. What is this theory known as? Name the scientist who experimentally disproved this theory.
3. If abiotic origin of life is in progress on a planet other than earth, what should be the conditions there?
4. Name the person who proposed that population tends to increase geometrically while food production increases arithmetically.
5. Name the scientist who had also come to similar conclusion as that of Darwin about natural selection as a mechanism of evolution. Which place did he visit to come to conclusions?
6. Name any two vestigial organs found in human body?
7. What is the cause of speciation according to Hugo De Vries?
8. Name the phenomenon by which rapid speciation takes place?
9. Name the two scientists who set up a special experiment to prove Oparin's theory of origin of life?
10. Name the common ancestor of apes & man?

➤ Short Questions:

1. Explain Oparin-Haldane theory of chemical evolution of life.
2. Distinguish between convergent and divergent evolution giving one example of each.
3. What is adaptive radiation? Explain with an example.

4. How did Louis Pasteur disprove spontaneous generation theory?
5. Define homologous organs? Give one example of organ homologous to hand of man?
6. What is the role of variation in evolution?
7. Describe one evidence which decisively proves that birds have evolved from reptiles?
8. Why has natural selection not eliminated sickle – cell anaemia?

➤ Long Questions:

1. What are homologous organs? Give similar or different functions are catted examples.
2. How has the study of fossils helped in convincing scientists that organisms have come into existence through evolution?
3. Explain antibiotic resistance observed in light of Darwinian selection theory.

➤ Assertion & Reason Questions:

1. For two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.
 - a. Both assertion and reason are true, and reason is the correct explanation of assertion.
 - b. Both assertion and reason are true, but reason is not the correct explanation of assertion.
 - c. Assertion is true, but reason is false.
 - d. Both assertion and reason are false.

Assertion: Organic compounds first evolved in earth required for origin of life were protein and nucleic acid.

Reason: All life forms were in water environment only.

2. For two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.
 - a. Both assertion and reason are true, and reason is the correct explanation of assertion.
 - b. Both assertion and reason are true, but reason is not the correct explanation of assertion.
 - c. Assertion is true, but reason is false.
 - d. Both assertion and reason are false.

Assertion: Primitive atmosphere was of reducing type.

Reason: First hydrogen atoms combined with all oxygen.

✓ Answer Key-

➤ Multiple Choice Answers:

1. (b) Lichens
2. (c) life can arise from non-living things only
3. (b) artificial selection
4. (c) fossils
5. (b) they share a common ancestor
6. (d) convergent evolution.
7. (a) population genetics
8. (c) pre-existing variation in the population
9. (d) water to land.
10. (c) the young ones are protected inside the mother's body and are looked after they are born leading to more chances of survival
11. (a) Sedimentary rocks
12. (a) 42%
13. (b) Directional
14. (c) Ramapithecus → Homo habilis → Homo erectus → Homo sapiens
15. (a) Lobe fish

➤ Very Short Answers:

1. Ichthyosaurs.
2. Theory of Spontaneous generation; Louis Pasteur.
3. Very high temperature, volcanic storms, Reducing atmosphere containing CH_4 , NH_3 , H_2 and water vapours.
4. Thomas Malthus
5. Alfred Wallace, Malay Archipelago
6. Vermiform appendix, wisdom teeth.
7. Mutations.
8. Genetic Drift.
9. Urey & Miller.
10. Dryopithecus.

➤ Short Answer:

1. The first life form could have come from the pre-existing, non-living organic molecules (like RNA, Proteins, etc.) and the formation of life was preceded by chemical evolution.

2. Divergent Evolution – Development of different functional structures from a common ancestral form is called divergent evolution.

Homologous organs show divergent evolution.

Examples: Darwin's Finches, Australian Marsupials, locomotion in mammals.

Convergent Evolution – Development of similar adaptive functional structures in unrelated groups of organisms is called convergent evolution.

Analogous organs show convergent evolution.

Examples: Australian Marsupials and Placental mammals, various aquatic vertebrate and wings of insect, bird and bat.

3. Adaptive radiation is an evolutionary process that produces new species from a single, rapidly diversifying lineage. This process occurs due to natural selection. An example of adaptive radiation is Darwin finches, found in Galapagos Island. A large variety of finches is present in Galapagos Island that arose from a single species, which reached this land accidentally. As a result, many new species have evolved, diverged, and adapted to occupy new habitats. These finches have developed different eating habits and different types of beaks to suit their feeding habits. The insectivorous, blood sucking, and other species of finches with varied dietary habits have evolved from a single seed eating finch ancestor.
4. Louis Pasteur showed that in pre-sterilized flasks, life did not come from killed yeast while in another flask open to air, new organisms arose from 'killed yeast.
5. Homologous organs are those organs which are similar in basic structure & embryonic developments but perform different functions. e.g. bones of forelimbs of whales, bat, birds and human beings.
6. Variations are useful for survival of species in changed environmental situations. If a population of reproducing organisms are suited to a particular niche & if the niche is drastically altered the population could be wiped out however if some variations were to be present in few individuals, there would be some chances for them to survive.
7. Missing link between birds & reptiles called. Archaeopteryx showed that "Birds have evolved from reptiles". These are organisms which show the characters of both birds (e.g. presence of wings & feathers in the body) as well as of reptiles (e.g. long tail & jaws with identical teeth).
8. Sickle cell anaemia is not eliminated during natural selection because in some cases, sickle cell anaemia is beneficial as it provides natural defense against malarial parasite.

➤ Long Answer:

1. Homologous organs: Organs that have a common origin, embryonic development, and the same fundamental structure but perform similar or different functions are called homologous organs.

Examples of homologous organs:

- i. The wings of bird and bat, flipper embryonic development, and same (fin) of whale and human forearm are fundamental structures but perform differently in forms because these have to perform different functions. Studies of the bones forming the skeleton of these organs would reveal similarity in construction. In fact, these are the forms of forearms that have originated from pentadactyl forms and due to the different functions they are performing, they transformed into different forms.
 - ii. In plants, the homologous organs may be a thorn of Bougainvillea or a tendril of Cucurbita both arising in axillary position. Both have different forms depending on their function to perform.
2. Fossils are important for man because of many reasons:
- i. They provide evidence of past life.
 - ii. They furnish direct and most convincing proofs in favor of organic evolution.
 - iii. They afford some information of ancient environment and climate.
 - iv. The most primitive forms of life are in the oldest rocks.
 - v. Ancient forms were simpler than those found today.
 - vi. None of the plants and animals of the past were exactly similar to those found today.
 - vii. A complete fossil record has been found in the evolution of horses.
3. Antibiotics were considered to be very effective against diseases caused by bacteria. But within two or three years of the introduction of antibiotics, new antibiotic-resistant bacteria appeared in the population. Sometimes a bacterial population happens to contain one or a few bacteria having mutations that make them resistant to the antibiotic. Such resistant bacteria survive and multiply quickly as the competing bacteria have died. Soon the resistance-providing genes become widespread and the entire bacterial population becomes resistant. Some hospitals harbor antibiotic-resistant bacteria due to the extensive use of antibiotics.

➤ Assertion and Reason Answers:

1) b) Both assertion and reason are true, but reason is not the correct explanation of assertion.

Explanation:

Organic compounds that first evolved in earth which required for origin of life were protein and nucleic acid. All life forms were in aquatic environment only.

2) a) Both assertion and reason are true, but the reason is correct explanation of assertion.

Explanation:

The interstellar dust from which earth originated was especially rich in hydrogen. It readily combine with nitrogen forming ammonia, with carbon forming methane, and with oxygen forming water leaving no free oxygen. Thus, early atmosphere of primitive earth was strongly reducing, it contains hydrogen, methane, ammonia and water vapours.

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