ORGANIC EVOLUTION

Evolutionary Concepts and Origin of Life

Very Short Answer Questions

1. What is abiogenesis?

Ans. The life originated from nonliving substances is called abiogenesis.

2. Explain the theory of panspermia.?

Ans. According to Richter and Arrhenius, life is distributed over cosmos in the form of resistant spores. It is also known as cosmozoic theory.

3. What does theory of catastrophism explain about the evolution?

Ans. Cuvier and Orbinge advocated this theory. The earth was subjected to periodic catastrophes. Catastrophes destroyed the life form time-to-time and created new and special form of life after each destruction.

4. What is biogenesis theory?

Ans. Lois Pasteur proposed biogenesis theory by conducting Swan-neck flask experiment.. According to this theory the living organisms originated from the pre-existing living organisms.

5. Define evolution?

Ans. The study or origin of life and the diversity among living organisms through ages and the gradual changes occurred in it according to the geological time scale is known as Evolution.

6. What does theory of organic evolution say about the origin of life?

Ans. According to the theory of organic evolution origin of life is a phenomenon of abiogenesis (chemical evolution) and then diversity of organisms is a biogenesis.

7. What is the significance of swan neck flask experiment conducted by Pasteur?

Ans. Louis Pasteur confirmed the theory of biogenesis by his swan neck flask experiment.

8. Distinguish between reducing atmosphere and oxidizing atmosphere.

Ans. **Reducing atmosphere:** The primitive atmosphere which contained the free hydrogen and without free oxygen.

Oxidising atmosphere: Present Atmosphere with free oxygen.

9. What is hot dilute soup?

Ans. Haldane called ocean as prebiotic soup. All the reactions which lead to the formation of molecules occurred in the ocean, so it was described as the hot dilute soup or prebiotic soup.

10. What are protobionts?

Ans. Protobionts are the molecules with limited metabolic activity and these protobionts evolved into early living organisms. E.g. Coacervates or microspheres.

11. What are free genes?

Ans. Self-reproducing molecules are called free genes or replicates.

12. Distinguish between coacervates and microspheres.

Ans. Coacervates are the suspended colloidal systems in the hot dilute soup. They later acquired the lipids to form the membrane.

Microspheres were membrane bound molecules and self multiplied by budding.

13. What are chemo heterotrophic organisms?

Ans. These are heterotrophs which cannot synthesize their own food but depend on others mainly for their chemical requirements.

14. What are chemoautotrophs?

Ans. Autotrophs, which used organic molecules for their energy and CO_2 as the source of carbon. They are mainly Iron and sulphur bacteria.

$$6CO_2 + 12H_2S \xrightarrow{\text{Chemical energy}} C_6H_{12}O_6 + 6H_2O + 12S$$

15. Who conducted simulation experiment? What is the significance of this experiment?

Ans. Simulation experiments were conducted by Urey and Miller. The significance of these experiments is experimental verification of the chemical origin of life.

16. Why is equilibrium shifted to the polymerized compounds in the origin of life?

Ans. Stable polymers shifted the chemical equilibrium form unstable monomers to stable polymers.

17. Does the life have beginning? If yes, when did it begin?

Ans. The free genes started absorbing the organic compounds from the prebiotic soup and evolved into anaerobic heterotrphs. It begins three to four billion years ago.

Short Answer Questions

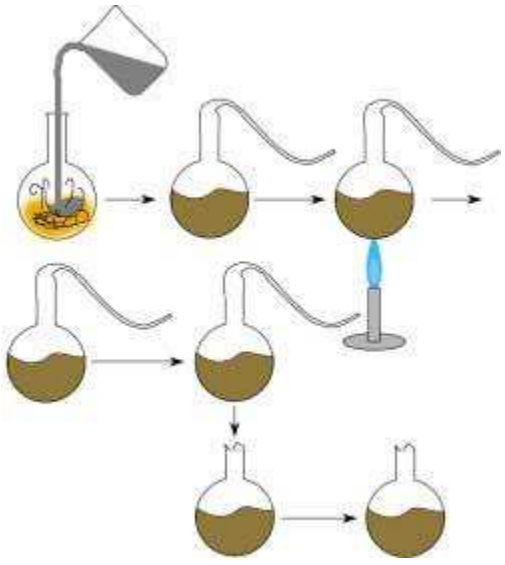
1. How is abiogenesis theory disproved experimentally?

Ans. Abiogenesis theory was disproved experimentally by Louis Pasteur by conducting Swan-neck flask experiment.

He created a swan-neck flask and placed a boiled meat broth in it. Flask was left unsealed. The broth remained free of microbial contamination for several months. The microbes present in the air were trapped in the neck and they did not reach the solution.

When the neck of the flask was broken, the solution of flask had shown the thick growth of microbes. In this case microbes directly reached the solution.

From this experiment it is clear that life existed from the pre-existing living organism. Hence abiogenesis theory was disproved.



2. Explain the origin of the earth and atmosphere.

Ans. The earth originated 4.5 to 5 billion years ago along with other planets in the following phases.

- Fragmentation of an interstellar cloud.
- Contraction and flattening of the solar nebula.
- Condensation of nebular material into meteorites and protoplanetry bodies.
- Solidification of planets.

The initial temperature of earth is very high and was estimated as 5000°C to 6000°C. It as cooled down to a core surrounded by mantle and crust.

The lightest elements like Helium, Hydrogen, Nitrogen, and Carbon flowed to the surface and formed the earth's atmosphere. The primitive atmosphere was hot and rapidly rotating ball of gases. Among all the amount of Hydrogen was very high. There was no free oxygen hence the atmosphere is a reducing atmosphere.

3. Describe the evolution of molecules.

Ans. The primordial earth has reducing atmosphere and Carbon is found in the form of metal carbides. Nitrogen as metal nitrides. Temperature is very high but it was reduced as the time passed. Hence, liquids solidified steam condensed into water resulting in rain. Rain drops on reaching to hot earth surface evaporated. This resulted in cooling the earth.

Water mass were formed. Mineral rocks were also dissolved and accumulated in the sea water.

The chemical substances like ammonia, hydrocarbons and water under went condensation, oxidation, reduction and polymerization and give rise to complex molecules like sugars, amino acids and resulted in hot dilute soup or prebiotic soup.

The pre-biotic soup contains simple organic molecules which later produced new complex polymer molecules like polysaccharides, proteins fats, nucleosides and nucleotides.

4. Discuss the origin of living organisms from the molecules.

Ans. The large polymers which are present in hot dilute soup.

The large polymers originated into life under three conditions like

1) Self-reproducing molecules called free genes or replicates.
2) Errors during the copying of replicators i.e. mutations.
3) A continuous supply of free energy and partial isolation of the molecule from the environment.

The partial isolation had been attained with in aggregates of artificially produced prebiotic protobionts like coacervates and microspheres. The microspheres were membrane bound molecules and self multiplied by budding. Some of the proteins inside the protobionts acquired the property of enzymes resulting in the fast multiplication of molecules.

Formation of living Organisms: The free genes started absorbing the organic compounds from the prebiotic soup and evolved into anaerobic heterotrophs, protocells, three billion years ago.

The earliest living organisms had clumps of nucleoproteins containing one or two DNA molecules. Which are similar to organisms of Monera. During the course of evolution prokaryotes have evolved. These prokaryotes because chemoautotrophic. From these photoautotrophic organism and Heterotrophs have been evolved.

5. Explain the simulation experiment conducted to explain the origin of complex organic molecules from simple molecules.

Ans. Simulation experiments were conducted by Stanley miller and Harold Urey. They had taken a mixture of water vapour, methane, ammonia and hydrogen (simulation for primeval atmosphere) in the spark chamber which has provided with electrodes for electric charge.(simulation of lightning)

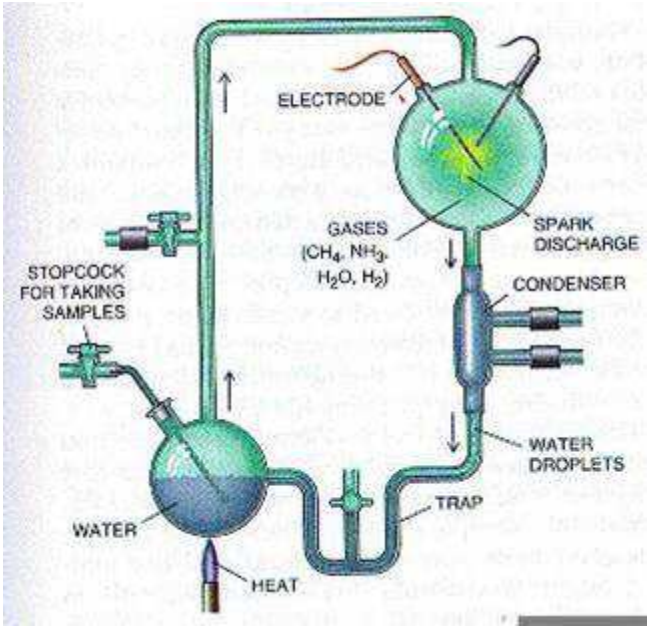
The spark chamber was connected to another flask with the provision for boiling (simulation of evaporation).

The spark chamber was connected on the other end to a trap by a tube that passed through condenser (simulation of rain and condensation of Haldane's oup).

The trap was also connected to the boiling flask for circulation.

They noticed the simple organic molecules like amino acids, peptide chains in the aqueous solution after a few days.

Glycine, alanine, aspartic acid were produced. Later all amino acids were produced. Even adenine and other nitrogen bases were produced by using hydrogen cyanide..



Long Answer Questions

1. Discuss the biological evolution of living organisms. ?

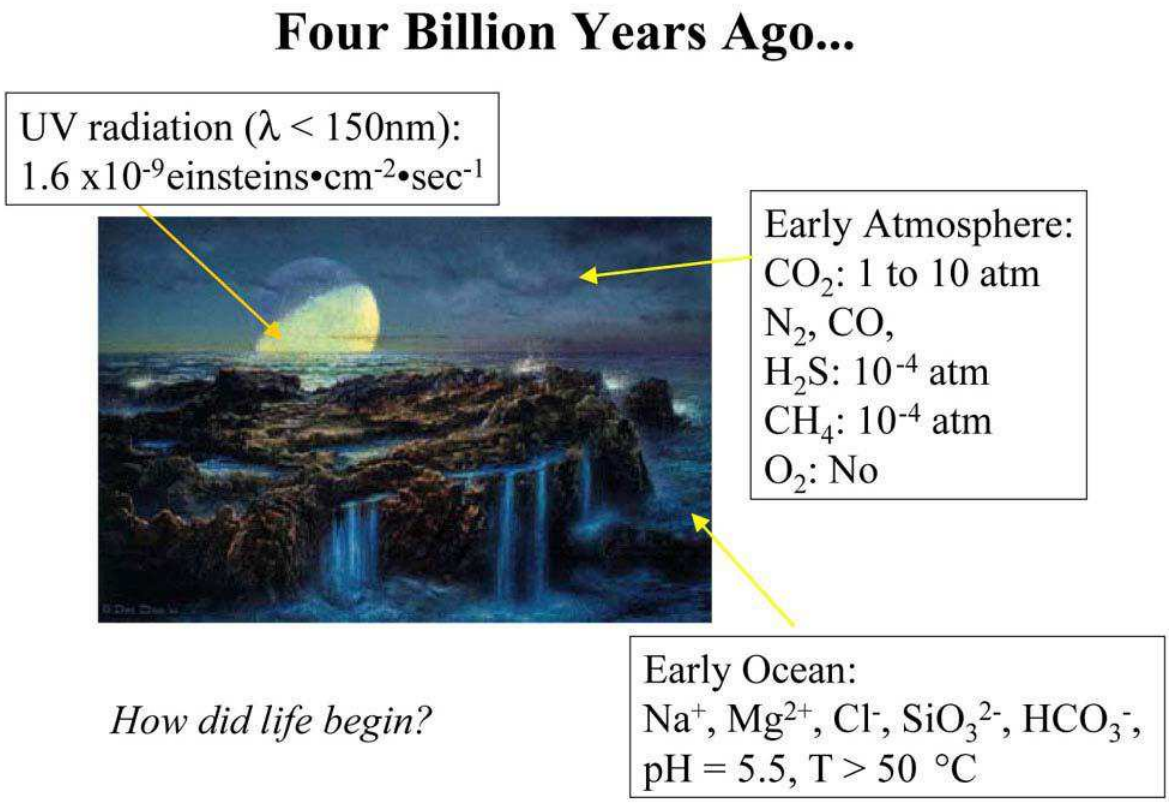
Ans. a) **Origin of earth:** The earth originated 4.5 to 5 billion years ago along with other planets in the following phases.

- Fragmentation of an interstellar cloud.
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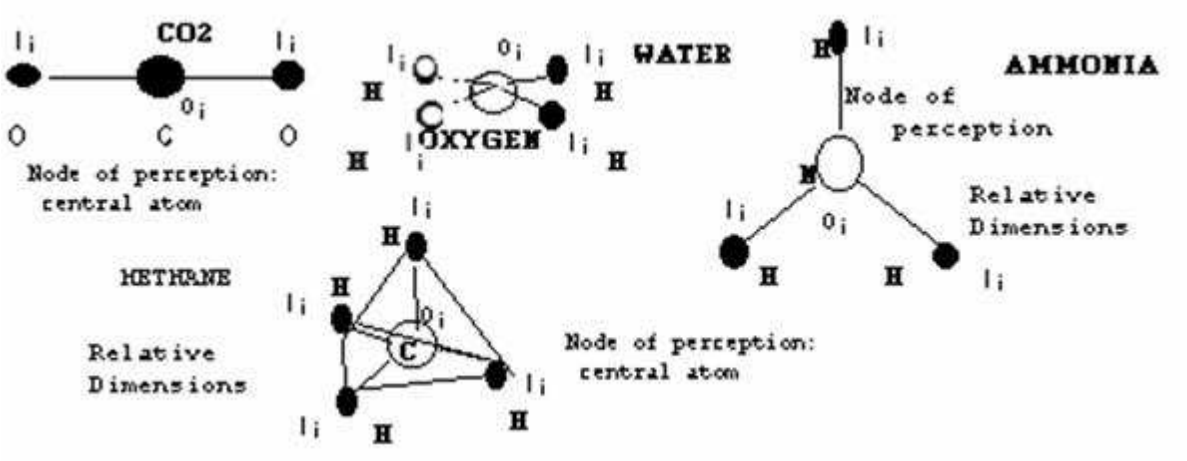
rotating ball of gases. Among all the amount of Hydrogen ws very high. There was no free oxygen hence the atmosphere is a reducing atmosphere.



b) **Evolution of Molecules:** The primordial earth has reducing atmosphere and carbon is found in the form of Meta carbides, Nitrogen as metal nitrides. Temperature is very high but it was reduced as the time passed. Hence liquids solidified, steam condensed into water resulting in rain. Rain drops on reaching to hot earth surface evaporated. This resulted in cooling the earth.

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The prebiotic soup contains simple organic molecules which layer produced new complex polymer molecules like polysaccharides, proteins, fats, nucleosides and nucleotides.

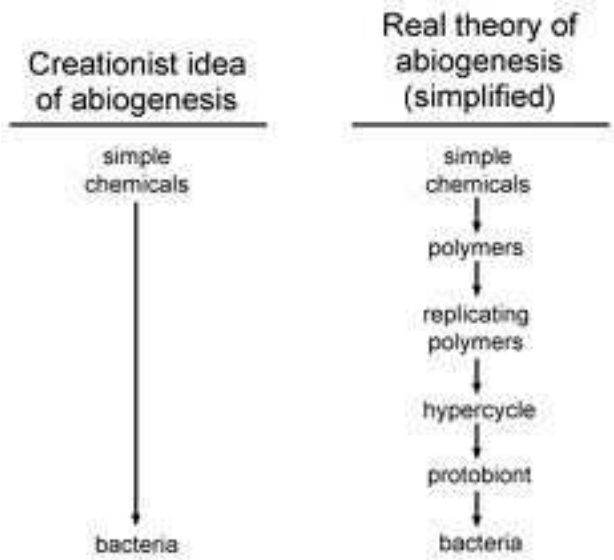
Evolution of Living Organisms: The large polymers which are present in hot dilute soup. The large polymer originated into life by under three conditions like

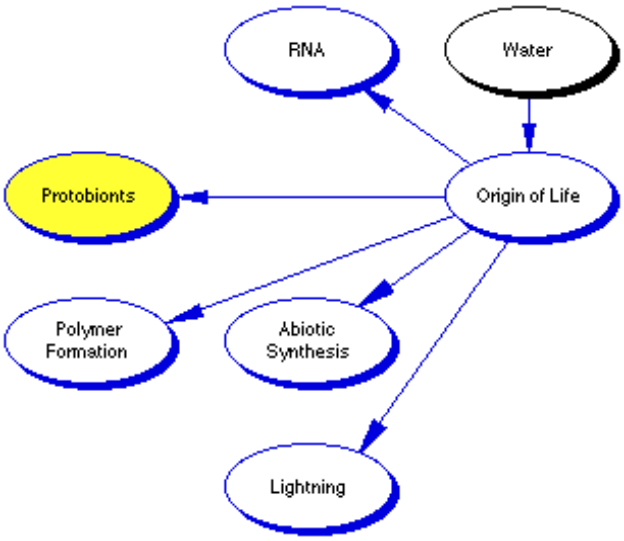
1) Self-reproducing molecules called free genes or replicators.

2) Errors during the copying of replicators i.e., mutations.

3) A continuous supply of free energy and partial isolation of the molecule from the environment.

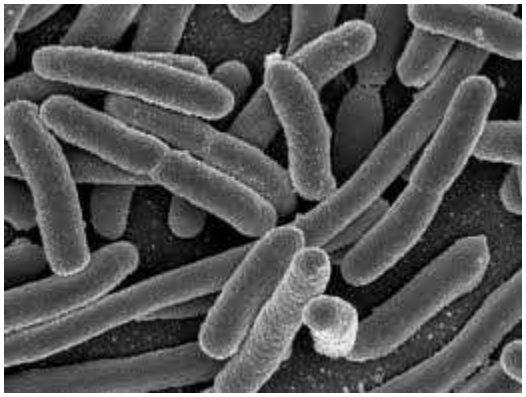
The partial isolation had been attained with in aggregates of artificially produced prebiotic protobionts like coacervates and microspheres. The microspheres were membrane bound molecules and self multiplied by budding. Some of the proteins inside the protobionts acquired the property of enzymes resulting in the fast multiplication of molecules.





c) Formation of living Organisms: The free genes started absorbing the organic compounds from the prebiotic soup and evolved into anaerobic heterotrophs, protocells, three billion years ago.

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$$C_6H_{12}O_6 + 2ADP + 2Pi \xrightarrow{\text{Fermentation enzyme}} 2C_2H_5OH + 2CO_2 + 2ATP$$

During the course of evolution early prokaryotes acquired the carbohydrate synthesis catalyzing enzymes. Thus early chemoautotrophic organisms evolved. A unique feature of these organisms is that they thrive at high temperature.

$$6CO_2 + 12H_2S \xrightarrow{\text{Chemical energy}} C_6H_{12}O_6 + 6H_2O + 12S$$



Mean while some bacteria synthesized bacterial chlorophyll from the metalloporphyrin of ocean waters. Thus oxygenic photoautotrophic organisms were evolved.

$$6CO_2 + 12H_2S \xrightarrow{\text{Solar energy}} C_6H_{12}O_6 + 6H_2O + 12S$$

Later oxygenic photoautrotrophic organisms like blue green algae were evolved. The bacterial chlorophyll evolved into true chlorophyll. More oxygen is released into atmosphere due to the evolution of true chlorophyll. These events transformed the reducing atmosphere into modern oxidizing atmosphere.

$$6CO_2 + 6H_2O \xrightarrow{\text{Solar energy}} C_6H_{12}O_6 + 6O_2$$

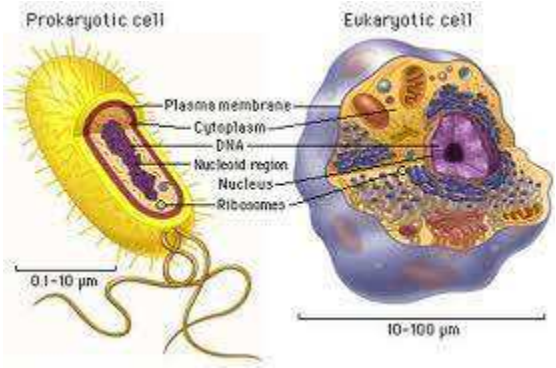
$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

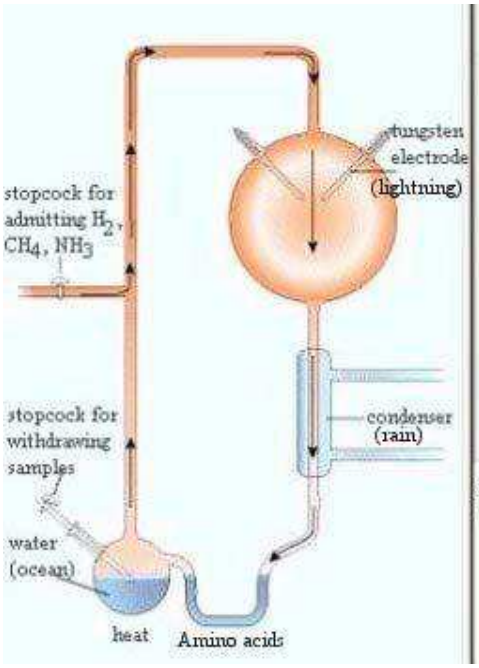
$$6NH_4 + 6O_2 \longrightarrow 2N_2 + 2H_2O$$

With the availability of free oxygen finally aerobic mode of respiration is evolved. CO_2 is released in this mode of respiration.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy}$$

Eukaryotes are evolved by two processes. Endomembrane system of eukaryotes including nuclear membrane might have evolved by infolding of the plasma membrane of ancestral prokaryotes. Prokaryotes lived symbiotically in the ancestral eukaryotes and evolved into organelles like mitochondria and plastids.





Some Products Formed under Prebiotic Conditions

Carboxylic acids	Nucleic acid bases	Amino acids
Formic acid	Adenine	Glycine
Acetic acid	Guanine	Alanine
Propionic acid	Xanthine	α-Aminobutyric acid
Straight and branched fatty acids (C_4–C_{10})	Hypoxanthine	Valine
Glycolic acid	Cytosine	Leucine
Lactic acid	Uracil	Isoleucine
Succinic acid	**Sugars**	Proline
	Straight and branched pentoses and hexoses	Aspartic acid
		Glutamic acid
		Serine
		Threonine

Source: From Miller, S.L. (1987) Which organic compounds could have occurred on the prebiotic earth? *Cold Spring Harb. Symp. Quant. Biol.* **52**, 17–27.

Theories of Evolution

Very Short Answer Questions

1. What are acquired characters?

Ans. Characters that are developed by the organisms in order to meet the need of the new want after their birth are known as acquired characters.

e.g. Increase in the length of neck in Giraffe.

Losing of limbs in snakes.

2. Give two examples of use and disuse, one for each.

Ans. Use examples: Increasing the height of fore legs and neck in Giraffe.

Disuse examples: Loosing of limbs in snakes.

3. Trace the evolution of giraffe according to Lamarkism.

Ans. Deer like ancestor of Giraffe found the supply of grass and herbs inadequate. In the process of reaching the leaves of higher branches of trees, its neck got stretched and forelegs were raised. As a result the neck became longer along with that fore limbs. Lamarck cited this example for the use of an organ.

4. Distinguish between germplasm and somatoplasm.

Ans. Protoplasm appears in two forms. They are…….

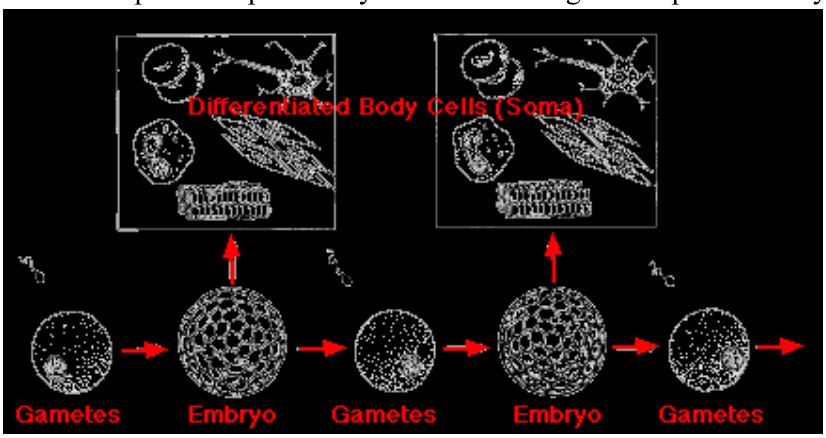
Germplasm : It is the protoplasm of sex cells.

It plays an important role in heredity.

Somatoplasm : It is the protoplasm of somatic cells.

It does not play any role in heredity.

This concept was explained by Weisman through Germplasm theory.



5. What is Weisman famous for?

Ans. Weismann is the main critic to Lamarch's principle of inheritance of acquired characters.

He performed decaudalisation experiment in mice and disproved the Lamarck's principle and also pangenesis theory of Darwin.

7. What is meant by inheritance of acquired characters?

Ans. Every new character that has been acquired in the life of an individual is preserved and transmitted to the next generation is the inheritance of acquired characters proposed by Lamarck.

8. What is natural selection?

Ans. Nature removes the organisms with unfit characters from competition is known as natural selection.

9. Who influenced Darwin much in formulating the idea of natural selection?

Ans. Three scientists influenced Darwin, they are

1) T.R. Malthus – On the principles of populations.

2) Sir Charles Lyell – Principles of Geology

3) Alfred Russel Wallace – On the tendency of varieties to depart from original types.

10. Name the ship in which Darwin toured as a naturalist. Where did he observe the adaptive radiation of Finch birds?

Ans. Darwin traveled on the ship H.M.S. Beagle for five years (1831-1836).

He observed the adaptive radiation of Finch birds in Galapagos islands.

11. Justify the statement "Galapagos islands are the living laboratories of Evolution".

Ans. Darwin has found the adaptive radiation of Finch birds in the Galapagos and explored the fauna and flora in that island, so these were considered as the living laboratories of evolution.



12. What is prodigality of production?

Ans. Over production of enormous power of fertility as result ever organism reproduces and produce off springs enormously.

13. What is natural selection according to Darwin?

Ans. According to Darwin during the struggle for existence, the organisms with beneficial variations alone with survive and selected by the nature to survive and to be continue..

14. What is common to Darwinism and Lamarckism?

Ans. Presence of variations is common to Darwinism and Lamarckism.

15. What is adaptive radiation?

Ans. Emergence of many new species from a common ancestor is known as adaptive radiation or divergent evolution.

16. What is artificial selection?

Ans. Artificial selection is one of the three types of selections proposed by Darwin.

Artificial selection is a man made selection in which man selects only certain races, which are useful for him.

Artificial selection focuses on one trait rather than overall fitness of the animal.

17. What is sexual selection?

Ans. It is an evolutionary consequence related to the adaptation of sexual mode of reproduction.

It includes the competition among the males for mates. So animals develop secondary sexual characters.

18. How does artificial selection differ from natural selection?

Ans. Artificial selection is a man made selection. Natural selection is done by the nature.

19. How does sexual selection differ from natural selection?

Ans. Sexual selection is related to the adaptation to sexual mode of reproduction. By which secondary sexual characters developed to attract the other sex.

Natural selection selects the fittest organisms in all aspects to survive and to win in the struggle for existence.

20. Which theory states that "Permanent racial change is a product of fluctuating variations"? What does it mean?

Ans. It was said by Darwin in which any change occurred in the body is due to a continuously occurring variations by which new species is formed.

21. Which theory states, that "Permanent racial change is not a product of fluctuating variations"? What does it mean?

Ans. De Vries said this. According to him any markable change occurred in the organisms is due to a sudden change but not by a continuous change. It is due to a large, discontinuous change.

22. How does natural selection differ from mutation theory in explaining evolution?

Ans. Natural selection selects the organisms with fittest characters and eliminates the members with less fit characters.

Mutation theory explains how the fitness has occurred by that organism. In this aspect it differs from theory of natural selection.

23. What is Hardy-Weinberg equilibrium?

Ans. The frequency of dominant and recessive alleles in a population will remain constant from generation to generation under certain conditions..

Changes in gene frequencies are significant in producing variations which lead to evolution.

24. Write the Hardy-Weinberg equation.

Ans. $p + q = 1$

Where p = dominant allelic frequency

q = recessive allelic frequency

$(p + q)^2 = 1$

$p^2 + 2pq + q^2 = 1$

where p^2 = Genotypic frequency of homozygous dominant phenotype.

q^2 = Genotypic frequency of recessive phenotype.

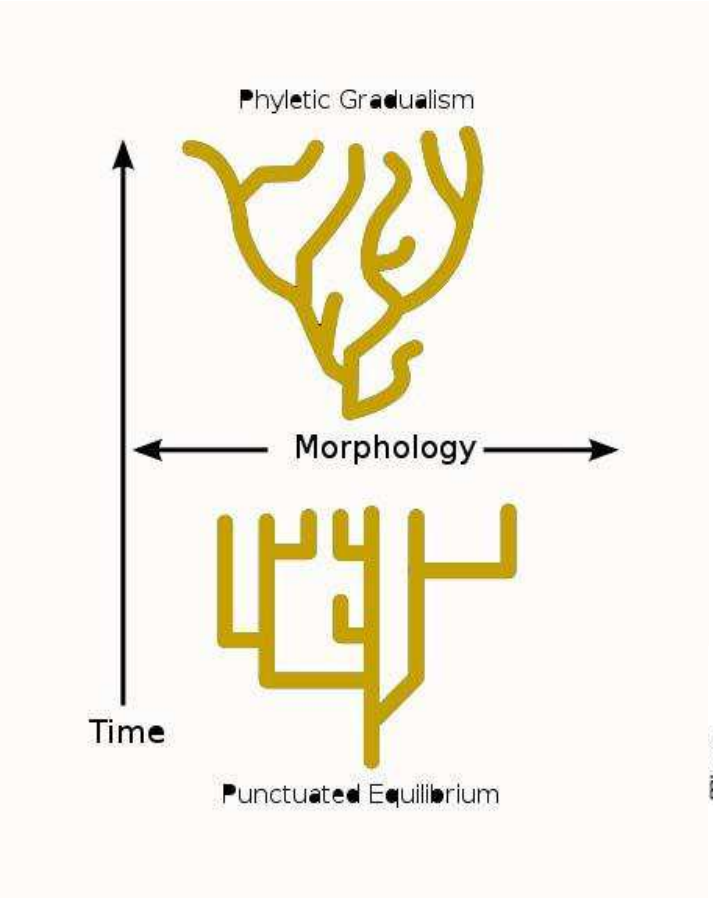
2pq = Genotypic frequency of heterozygous dominant phenotype.

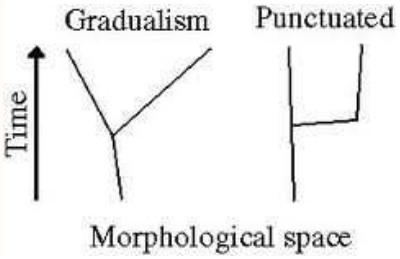
25. What is genetic drift?

Ans. Any deviation due to chance variations is called random genetic drift or Sewall Wright effect.

26. What is phylogenetic evolution?

Ans. It is also known as anagenesis It is the evolution of new species in a single lineage.





27. What is the significance of assortative mating in evolution?

Ans. It is a non-random & preferential mating between male and female of a species.

It is one of the evolutionary forces where alters genotypic frequencies only.

28. What is significance of random mating in evolution?

Ans. Mating within the species in which there is no selection of the mate. Any male can mates with any female is random mating.

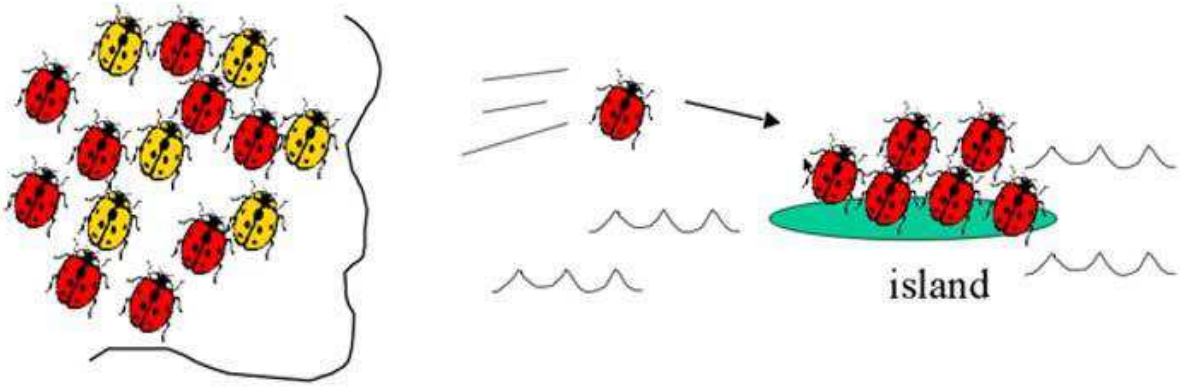
29. What is fitness or adaptive value?

Ans. Fitness is the degree of the adaptation of a character by which it is selected by nature.

30. Define founder effect.

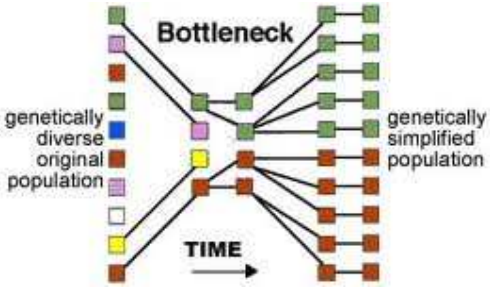
Ans. It is a form of genetic drift. It is the derivation of a new population from a small isolated group of individuals (founders) that is genetically different from the parent population.

- **founder effect**: a few individuals from a population start a new population with a different allele frequency than the original population



31. Define bottleneck effect.?

Ans. Bottlenecks are natural calamities. After bottlenecks, the parents of next generation are reduced to a small number and may be genetically different from the original population.



32. What is gene flow?

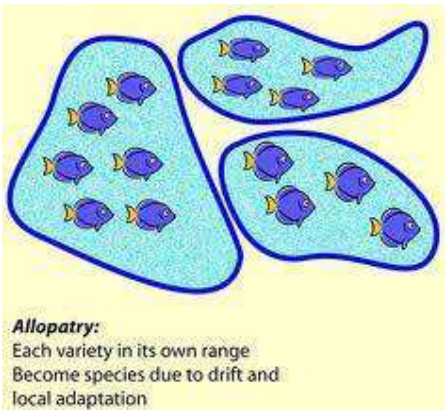
Ans. The movement of alleles from one copulation to another because of the interbreeding between members of the two populations.

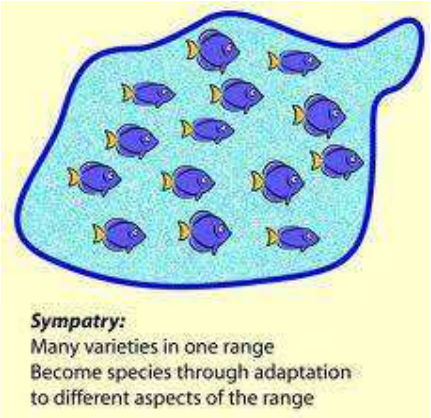
33. What is genetic load?

Ans. Existence of deleterious genes within the population is called genetic load.

34. Distinguish between allopatric and sympatric speciations.?

Ans. **Allopatric speciation:** Speciation occurring in which first geographical isolation occurs, then secondly reproductive isolation occurs.



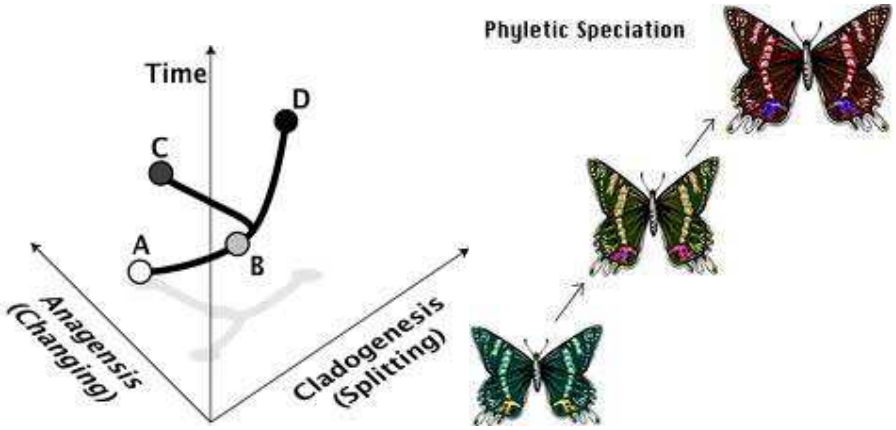


Sympatric speciation: reproduction isolation occurs without geographical isolation.

35. What is reproductive isolation?

Ans. In the absence of gene exchange between the populations, organisms of two populations cannot breed. These two populations are reproductively isolated.

36. Distinguish between anagenesis and cladogenesis.?



Ans. **Anagenesis :** Evolution of new species in single lineage. It is known as phyletic evolution. E.g., Evolution of *Limulus polyphemus* of recent epoch from *Aflasis etoni* of Cambrian eriod through different species.

Cladogenesis : Evolutionary process where one species diverges into two or more species.

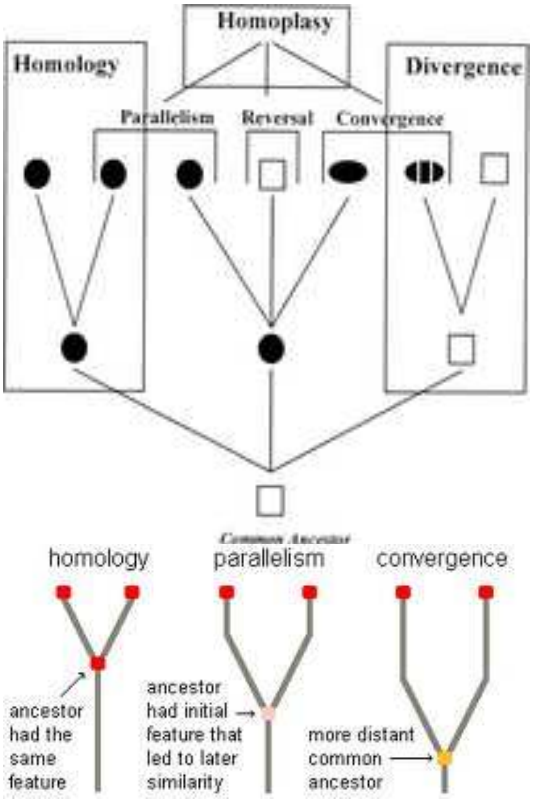
37. Compare parallelism and homoplasy.

Ans. Parallelism: The evolution of similar characters in a related lineages whose common ancestor was phenotypically different, called parallelism.

e.g. Echidna, Myrmicobius and Myrmicophaga.

Homoplasy or Convergence: The evolution of similar characters in genetically unrelated lineages, because they have been subjected to similar environmental selective pressure, called homoplasy.

e.g. Shark, *Ichthyosaur (*Dinosaur) and *Porpoise* (Mammal) adapt to sea life.

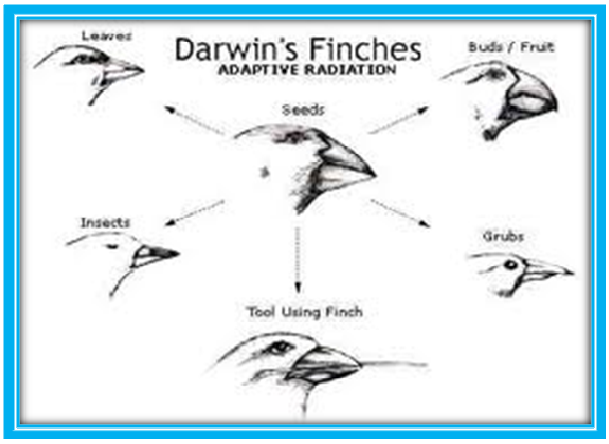


38. What is divergence?

Ans. Diversification of a group into a large variety of groups is called divergence.

39. Explain adaptive radiation.

Ans. Adaptive radiation is the diversification of a group into a large variety of groups based on adaptations to changes in surroundings.



40. Distinguish between macroevolution and microevolution.

Ans. The evolutionary changes occur in the evolution of taxa higher than the level of species is called macroevolution.

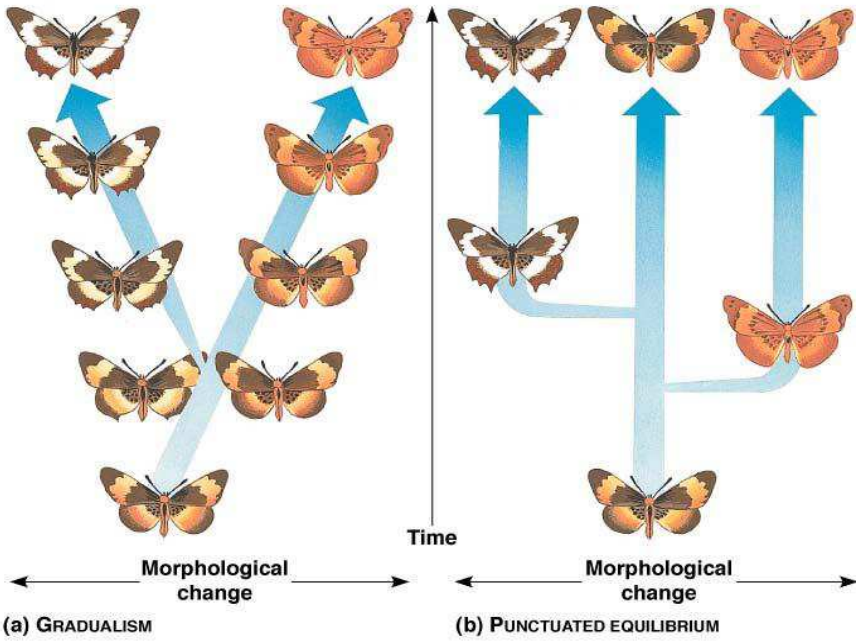
The evolutionary changes commonly that occur in populations causing differences in populations of a species are called microevolution.

41. What is reproductive success?

Ans. The proportion of fertile off spring produced a genotype relative to the other genotypes is called reproductive success.

42. What is punctuated equilibrium?

Ans. Evolutionary lineage follows a long-term intervals in which there is relatively little change and punctuated by bursts of speciation is called punctuated



equilibrium.

43. Distinguish between K-selection and r-selection.?

Ans. The selection in a population at or near carrying capacity of a habitat is K-selection. It is for improved competitive ability rather than the numbers.

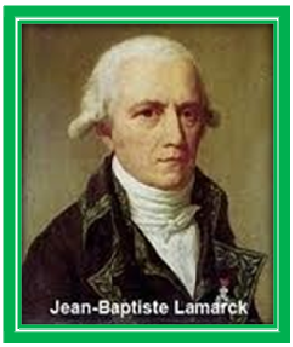
The selection in a population to rapidly changing environments with highly fluctuating food sources is called r selection. It emphasises rapid growth in population rather than competition

44. However the organism is fit, the selection depends on the reproductive success. Why?

Ans. The proportion of reproductively fertile off spring produced a genotype relative to the other genotypes is the reproductive success.

The organism that fails to reproduce cannot be represented in future generations, however fit it may be in the struggle for existence.

Short Answer Questions

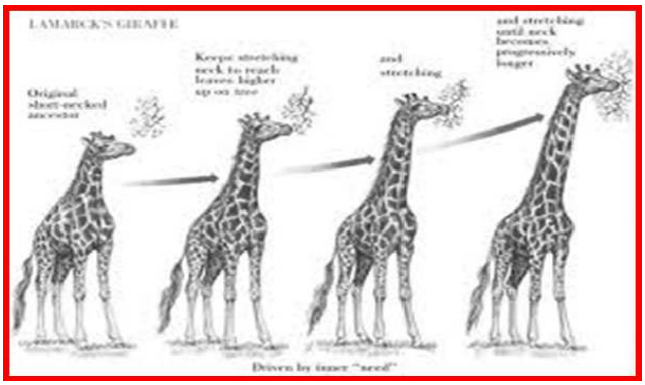


1. Explain Lamarck's theory of use and disuse?

- The development of organs and their use are proportional to the activities of these organs.

- ❖ Use and disuse or organs result in variations.
- ❖ According to theory of use and disuse of organs, Organs that are used more, increase in their size and organs which are not used continuously, degenerate.

Example for Use of Organs: The present day Giraffe with long neck has originated from the deer like ancestor. The deer like ancestors found the supply of grass and herbs inadequate. They started feeding on the leaves of trees in the process of reaching the leaves of higher branches, their necks got stretched and forelegs were raised. As a result the neck became longer along with their forelimbs.



Example for disuse of organs. : The ancestors of snakes were four limbed animals. They were adapted to burrowing habit. Due to burrowing habit of life the limbs were lost gradually. Thus the present day snakes are without limbs.

2. Explain Weismann's theory of Germplasm?

Ans. August Weismann performed decaudalisation experiments on mice, by these experiments he had disproved the Lamarckism and pangenesis theory of Darwin.

- ❖ He had cut the tails of white mice for mor than 20 generations and observed the effect on the length of tain lin coming generations..
- ❖ In all generations, the length of the tail was found to be normal.
- ❖ Hence he believed that all the acquired characters are not inherited.
- ❖ Weismann proposed the theory of germplasm or germinal selection ….

a) He differentiated protoplasm into somatoplasm and germplasm.
b) Somatoplasm is present in somatic cells and does not play any role in heredity.
c) Germplasm is in sex cells and plays an important role in heredity.
d) The changes occur in somatic cells or non reproductive cells are not transmitted but the changes that occur in reproductive cells are inherited.

3. Discuss the objections to the Darwin's theory of Natural selection.

Ans. **The objections to Darwin's Natural Selection are:**

1) He did not distinguish between heritable and non heritable variations and he did not distinguish between somatic and Germinal variations.
2) Natural selection can not explain the occurrence of vestigial organs as they have no selection value.
3) Darwinism explained the survival of the fittest, but did not explain the arrival of the fittest (origin of the fittest).
4) It does not explain the over specialization of some organs like antlers of extinct Irish deer and large special tusks of Jefferson mammoths.
5) It does not explain the organs formed by co-adaptations like electric organs in electric rays.

6) Darwin did not consider the importance of macro variations in evolution. He called them as sports of nature.

7) Natural selection does not account for how an organ can be successful in its initial stages of formation.

4. Explain Darwin's theory of natural selection with industrial melanism.



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- A classical example for natural selection is Industrial melanism.
- Pepperd moths, *Biston betularia*, generally appear in two phenotypes, Grey and Black.
- Grey moths were abundant before industrial revolution all over England.
- The reason for the existence of large number of grey moths during that period was their camouflage the light trunks of trees.
- But after the establishment of industries in England (industrial revolution), Black colored moths were more and grey forms were less. This is due to pollution form industries in the form of soot turned barks of trees into black. So grey moths wre easily identified and were more predated by birds. Thus grey moths decreased in number dark moths increased in the population.
- Thus natural selection favoured the melanic moths to reproduce more successfully.
- Natural selection of darker forms in response to industrial pollution is known as industrial melanism.
- This hypothesis was tested experimentally by Bernard Kettlewell.

5. Critically examine de Vries theory of Mutations.?

- Mutation is a sudden, random, discontinuous and heritable change independent of the environment in the genetic make up of an individual.
- The term mutation was coined by Hugo De Vries.
- Darwin called such variations as ports, or saltatiion.
- Bateson called them as discontinuous variations.
- Hugo de Vries observed this phenomenon in the evening prime rose plant *Oenothera Lamarckiana* in different forms like …

a) *O.brevistylis* – with small style

b) *O.Levifolia* – with smooth leaves

c) *O.gigas* – the giant form

d) *O.nanella* – the dwarf form





- ► These characters are inherited to the progeny.
- ► According to this theory, new full- fledged species originate at once as a result of large discontinuous variations, which appear suddenly.

Salient features of mutation theory:

1) Mutations arise from time to time in the individuals of a naturally breeding population.
2) Mutants are markedly different from parents.
3) Mutations are subjected to natural selection.
4) Mutations are large, quantitative or qualitative, sudden, random and heritable.
5) As Mutations are random, evolution is also random, which occurs in any direction..
6) Mutations are discontinuous, not cumulated over generations.
7) As they are full-fledged, there are no intermediate stages in the course of evolution.

6. Explain Hardy-Weinberg equilibrium.

- ❖ **Hardy-Weinberg equilibrium explains the genetic equilibrium. It is concerned with the frequencies of genes in a population os sexually reproducing diploid individuals.**
- ❖ **The frequency of dominant and recessive alleles in a population will remain constant from generation to generation in certain conditions like**

a) Size of population is large.

b) Biparental mode of reproduction and the mating is random (panmictic)

c) No differential reproductive rate. All genotypes are equally fertile.

d) No evolutionary force. It means there is no effect of selection, mutations or large scale migrations.

e) Population is homogenous in age.

In the above conditions

1) Equilibrium of allelic frequency: In a diploid population the frequency of alleles at an autosomal locus will not change over generations.
2) Genotypic frequencies: they are determined by allelic frequencies in a predictable way.
3) The equilibrium is neutral: Any disturbance occurs, it wil be reestablished within one generation of random mating at the new frequencies.

In mathematical formula

$P + q = 1$ so $(p + q)^2 = 1$

Where p = dominant allelic frequency

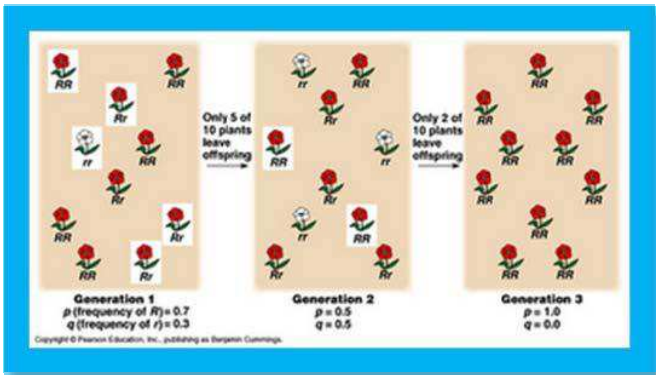
q = recessive allelic frequency

p^2 = Homozygous dominant genotype frequency

2pq = Heterozygous dominant genotype frequency

q^2 = Recessive genotype frequency.

7. Discuss the role of genetic drift in evolution.



- Variations which occur by chance in a small population cause deviations from Hardy-Weinberg equilibrium.
- Any deviation due to chance variations is known as Random genetic drift or Sewall Wright effect. Chance plays an important role in genetic drift.
- The probability of reaching the end point (fixation or loss) depends on the size of the population.
- Genetic drift can be explained by Founder effect and Bottle neck effect.

i) **Founder effect:** It is the derivation of a new population from a small isolated group of individuals (founders) that is genetically different from the parent population.

The allelic frequencies of the new population re similar to the founders rather than to the ancestral parent population.

e.g., Human population founded on Pitcairn Island is a good example of founder effect. Pitcairn island population is resulted from the small numbers of founders of Caucasian and Polynesian members.

The gene frequencies in population of Pitcairn island is neither similar to the Caucasian parent populations or Polynesian parent population, but similar to the founder of Pitcairn islands.



ii) **Bottle neck effect:** It is another form of genetic drift. Bottle necks are the natural calamities like earthquakes and volcanic eruptions, floods etc.

After bottle necks, the parents of the next generation are reduced to a small number and are genetically different from the original population.

Thus a genetically different population arises from the parent population that is left after bottle necks.

E.g. Poly dactylic dwarf individuals are more in old order Amish population of Lancaster in USA.

9. Discuss the role of different patterns of selections in evolution.

► Natural selection is a process by which the organism which are physically, physiologically and behaviorally better adapted to the environment, survive and reproduce.

► Selection is an operative process that occurs in a population whenever there is difference in reproductive success of individuals.

► A measure of the reproductive success is the fitness or adaptive value of a genotype. Genotype that produces more fertile offspring has higher fitness.

Selections are of three types. :

(1) Stabilizing selection,

(2) Directional selection,

(3) Diversifying selection.

A) **STABILIZING SELECTION (CENTRIPETAL)**

❖ It operates in a stable environment.

❖ Extreme members from both ends of phenotypic distribution are eliminated.

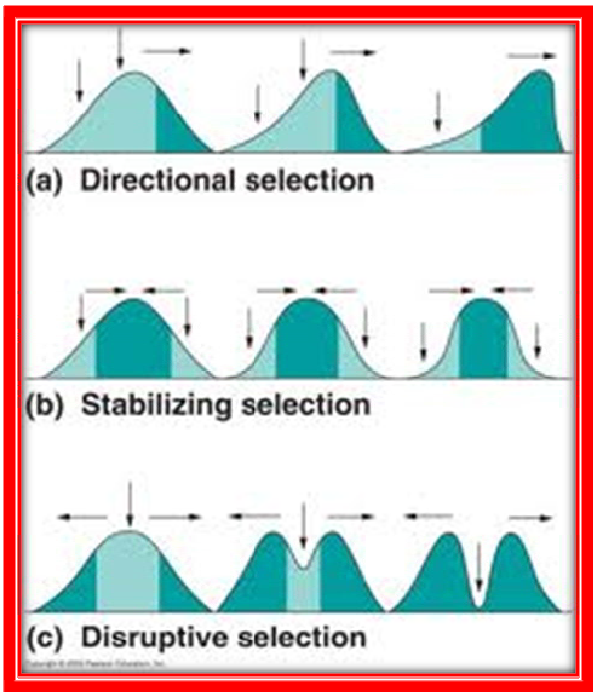
❖ The organism which is in the average of the phenotypic distribution re preserved.

❖ It does not promote evolutionary changes that lead to speciation, but tends to maintain phenotypic stability within the populations.

❖ So over a time the same average value of the phenotypic distribution is maintained.

❖ It removes deleterious genotypes from the population for which reproductive success is zero.

❖ E.g., In England, weights of babies in large sample were take. It was found that greater mortality (death rate) in the babies was when the weight was greater or lesser than the average weight 8 lbs.



B) DIRECTIONAL SELECTION:

- ❖ This selection operates in response to gradual changes in environmental conditions.
- ❖ Directional selection works by constantly removing the individuals from one end of the phenotypic distribution.
- ❖ Thus average value of fitness is constantly shifting towards the other end of the phenotypic distribution.

e.g. In case of the long-necked giraffes , the average value of neck shifted towards the long-neck. When the mean value of phenotype coincided with the new optimum conditions, stabilizing selection takeovers.

ii) Development of resistance to DDT by mosquitoes

C) Disruptive selection (CENTRIGUGAL SELECTION) :

- ► It is the rare form of selection but very important in bringing about evolutionary change.
- ► It operates in the changing conditions within environment (heterogenous).
- ► Heterogenous conditions increase the competition in the population.
- ► Increased competition leads to selection pressure. It removes the average of the phenotypic distribution in the population.
- ► So phenotypes move away from the average towards the ends of the population distribution. It can split the population in to two or more subpopulations, known as species populations.
- ► If the gene flow between the species populations is prevented, each population may give rise to a new species. It is known as adaptive radiation.

e.g., In California, the sunflower population was divided into two subpopulations. One was adapted to dry area and the other was adapted to wet area..

10. Explain the concept of artificial selection and sexual selection.

Ans. **Artificial Selection:** It is a man made selection. According to Darwin it is the commonest method of producing new races of animals by man. This process is adopted for producing the better races of domestic animals by man.

Man selects the economically favoured races and their progeny.

So artificial selection focuses on one trait rather than the over all fitness of animal.

Sexual selection: It is one of the evolutionary consequences related to the adaptation of sexual mode of reproduction.

This includes the competition among the individuals for mates. Animals develop secondary sexual characters.

For the sake of reproduction the animals develop secondary sexual characters by which the opposite sex is attracted. Hence that organism with good characters is selected. Hence it is known as sexual selection.

Sexual selection cannot be explained on the basis of natural selection, because these are not useful in the struggle with the environment.

11. In human beings, persons carrying dominant allele(s) of a gene can taste a chemical called phenylthiocarbamide and are called tasters. These who cannot taste it are called non-tasters. In a random-mating human population in Hardy-Weinberg equilibrium there are 64% non-tasters. What is the percentage of homozygous tasters in that population?

Ans. $Q^2 = 0.64 \Rightarrow Q = \sqrt{0.64} = 0.8$

$P = 1.0 - 0.8 = 0.2$

$P^2 = 0.2 \times 0.2 = 0.04$

The percentage of homozygous tasters in that population = $100 \times 0.04 = 4\%$.

12. In a population of 100 rabbits, which is in Hardy-Weinberg equilibrium, 24 are homozygous long-eared. Short ears are recessive to long ears. There are only two alleles for this gene. Find out the frequency of recessive allele in the population.

Ans. Number of rabbits in the population with H.W. equilibrium = 100

Number of dominant homozygous long eared rabbit = 24

Frequency of homozygous dominant long eared rabbits $p^2 = \frac{1}{100} \times 24 = 0.24$

Frequency of dominant allele = p = 0.49

Frequency of recessive allele = q = 1 – 0.49 = 0.51.

13. The ability of certain people to taste the chemically phenylthiocarbamide (PTC) is governed by a dominant allele T and the inability to taste PTC by its recessive allele t. In a population of 1600 individuals, 384 are homozygous tasters and 640 are heterozygous tasters. What is the frequency of t?

Ans. Number of individuals in the population = 1600

Number of dominant homozygous tasters = 384

Number of dominant heterozygous tasters = 640

Total number of tasters in population = 1024

Number of non-tasters in the population = 576

Frequency of non-tasters $q^2 = \frac{1 \times 576}{1600} = 0.36$

Recessive allele t frequency $q = \sqrt{0.36} = 0.6$

14. In a diploid population which is in Hardy-Weinberg equilibrium one out of 10,000 in the population is recessive, which is a deleterious phenotype. What percent of that population is heterozygous?

Ans. Number of individuals in the populations = 10,000

Number of recessive individuals in the population = 1

Frequency of recessive individuals in population $= q^2 = \frac{1 \times 1}{10000} = 0.0001$

Frequency of recessive allele in the population $= q = \sqrt{0.0001} = 0.01$

Frequency of dominant allele in population p = 1 – 0.01 = 0.09

Frequency of heterozygous individuals in population, 2pq $= 2 \times 0.99 \times 0.01 = 0.0198$

Percentage of heterozygous individuals in population $= 0.0198 \times 100 = 1.98\ \%$

