LESSON
EVOLUTION

Introduction

Evolutionary Biology is the study of history of life forms on earth. To understand the changes in flora and fauna that have occurred over millions of years on earth, we must have an understanding of the concept of origin of life, i.e., evolution of earth, of stars and of the universe itself.

Origin of Life

The origin of life is considered a unique event in the history of universe. The universe is very vast, and the earth itself is almost only a speck. Very old – almost 20 billion years old. Huge clusters of galaxies comprise the universe. Galaxies contain stars and clouds of gas and dust.

Theories of origin of Life

1. **Big Bang Theory:**
   - The Big Bang theory attempts to explain the origin of universe.
   - It talks of a singular huge explosion unimaginable in physical terms, the universe expanded and hence, the temperature came down.
   - Hydrogen and Helium formed sometime later, the gases condensed under gravitation and formed the galaxies of the present day universe.
   - In the solar system of the milky way galaxy, earth was supposed to have been formed about 4.5 billion years back.
   - There was no atmosphere on early earth. Water vapour, methane, carbondioxide and ammonia released from molten mass covered the surface. The UV rays from the sun broke up water into Hydrogen and Oxygen and the lighter H_2 escaped. Oxygen combined with ammonia and ethane to form water, CO_2 and others. The ozone layer was formed. As it cooled, the water vapour fell as rain, to fill all the depressions and formed oceans.
   - Life appeared 500 million years after the formation of earth, i.e., almost four billion years back.
2. **Theory of spontaneous generation**
   - It was also believed that living organisms (life) arose from decaying matter like straw.
   - But **Louis Pasteur** demonstrated that life can arise only from **'pre-existing'** life.
   - He showed that no life arose from the heat-killed yeast broth that was kept in a pre-sterilised flask kept closed, while new living organisms arose from the heat-killed yeast that was kept in the flask left open in the air.
3. **Theory of Panspermia/cosmozoic theory**
   - Some scientists believe that life arose on earth from other planets or outer space.
   - Early greek philosophers thought units called **'spores'** or **'pansperms'** came on the earth along with meteorites and they might have evolved into the present day forms.
4. **Theory of chemical evolution**
   - This theory was proposed by **Oparin** and **Haldane**.
   - They proposed that the first life form could have come from the pre-existing, non-living organic molecules (like RNA, proteins, etc.) and that formation of life was preceded by chemical evolution i.e., formation of diverse organic molecules from inorganic constituents.
   - The conditions on the earth that favoured chemical evolution were: Very high temperature, volcanic storms, reducing atomsphere that contained methane, ammonia, water vapour, etc.

Experimental Proof for chemical Evolution of Life

- Stanley Miller and Urey created conditions similar to the primitive atmosphere in the laboratory using glass apparatus and tubes.
- They created electric discharge using electrodes in a closed flask containing methane, ammonia, hydrogen and water vapour at 800^o C.
- The water-containing chamber was heated to provide water vapour.
- After a week, they observed the formation of a number of complex organic molecules like some sugars, nitrogen bases, amino acids and lipids.
- Analysis of the meteorites also revealed the presence of similar compounds, indicating the occurrence of similar processes elsewhere in the space.
- The chemical evolution of life was more or less accepted.

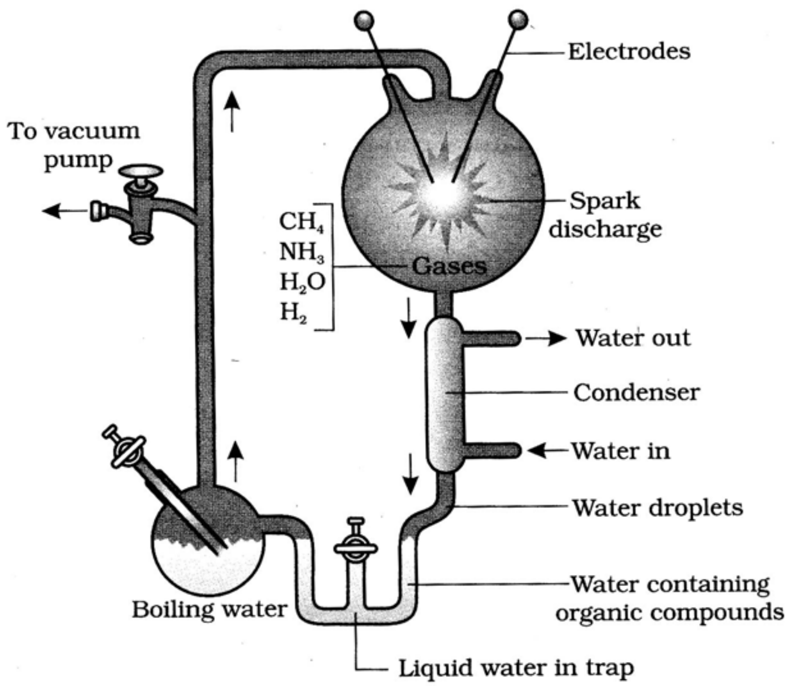


Fig.1 Diagrammatic representation of Miller's experiment

5. Biogenesis

The first non-cellular forms of life could have originated 3 billion years back. They would have been giant molecules (RNA, Protein, Polysaccharides, etc.). These capsules reproduced their molecules perhaps.
The first cellular form of life did not possibly originate till about 2000 million years ago. These were probably single-cells, and originated in water environment only.
This version of a biogenesis, i.e., the first form of life arose slowly through evolutionary forces from non-living molecules is accepted by majority. Once formed, the first cellular forms of life evolved into the complex biodiversity of today.

Evolution of Life forms—A Theory

- The word **evolution (L.evolviere)** means to unfold or to reveal the hidden potentialities.
- In its broadest sense, evolution simply means an orderly 'change' from one condition to the other.
- Biological or organic evolution refers to the changes in the properties of organisms or groups of such populations over a number of generations.

- It is the process of cumulative change of living populations and in the descendent populations of organisms, i.e., descent with modifications.

Conventional religious literature tells us about the **Theory of Special Creation**. This theory has three connotations:

(a) All living organisms (species or types) that we see, today were created as such.
(b) The diversity was always the same since creation and will be the same in future also.
(c) Earth is about 4000 years old.

Natural Selection as a Mechanism of Evolution

- Darwin made a sea voyage round the world in a sail ship H. M.S Beagle.
- Based on the observations he made during this voyage, he concluded the following:
  (i) The existing living organisms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago.
  (ii) There has been gradual evolution of life forms.
  (iii) Any population has built in variations in characteristics.
  (iv) Individuals with those characteristics which enable them to survive better (fitness of the individual) in the natural conditions, would outnumber the other, who are less adapted under the same natural conditions.
- This fitness of the individual, according to Darwin, refers ultimately to **'reproductive fitness'.**
- Such fit individuals leave more progeny (with more fit individuals) than others.
- They are selected by nature to survive and reproduce **'natural selection'.**
- In due course of time new life forms arise and evolve.
- Darwin considered natural selection as a mechanism of evolution.
- Alfred Wallace, a naturalist who worked in Malay Archipelago had also arrived at similar conclusions at about the same time.
- Natural selection is based on certain observations, which are factual; they are as follows:
  (i) Natural resources are limited so populations are stable in size except for seasonal fluctuations.
  (ii) Members of a population show variation of every characteristic–no two members of a populations are identical, even though they show similarities.
  (iii) Theoretically population size will grow exponentially, if everybody reproduces to the maximum capacity–it is seen in growing bacterial/microbial populations.
  (iv) The population size in reality is limited–it is due to competition among the individuals for resources and only those which are better adapted can survive and reproduce at the cost of others who are less adapted to that habitat.
- The brilliant insight of Darwin was that he asserted that the heritable variations which make resource utilisation better in some individuals will enable them to reproduce and leave more progeny over a period of time, over many generations, there would be a change in the population characteristics leading to origin of new forms (species) i.e speciation.

Examples of Natural Selection

Following three examples can be cited in support of the theory of natural selection:

1. **Industrial Melanism:** It is an adaptation where the moths living in the industrial areas developed melanin pigments to match their body to the soot-covered surroundings. The problem of industrial melanism in moths has been originally studied by **R.A. Fischer** and **E.B. Ford**; and in recent items, by **H.B.D. Kettlewell**. This phenomenon provides an excellent instance of operation of selection in natural conditions. The occurrence of industrial melanism is closely

associated with the progress of the industrial revolution in Great Britain, during the nineteenth century. It has occurred in several species of moths. Of these, **Peppered moth (Biston betularia)** is the most intensely studied one. The first melanic form (entirely black form) of peppered moth has been observed in 1845, and till that period all known moths were light coloured. The frequency of this melanic form, at any rate, was not more than 1 percent. By 1895, the melanic moths inhabiting an industrial centre of Manchester, accounted for 99 percent of the total population. These melanic forms are mainly distributed in and around large industrial cities, where the environment has been altered by the pollution of the atmosphere; and is manifested by the appearance of dark colour of lichen-covered tree trunks, on which the moths rest during the day time, which is their period of inactivity. Kettlewell (1858) has reported about 70 other species of moths in Great Britain alone, having melanic forms in greater frequencies, in their populations. Such melanic forms have also been recorded from European and American industrial cities.

(i) Thus the peppered moth exists in two strains (forms): light coloured (white) and melanic (black).
(ii) In the past, bark of trees was covered by whitish lichens, so white moths escaped unnoticed from predatory birds.
(iii) After industrialization barks got covered by smoke, so the white moths were selectively picked up by birds.
(iv) But black moths escaped unnoticed so they managed to survive resulting in more population of black moths and less population of white moths.

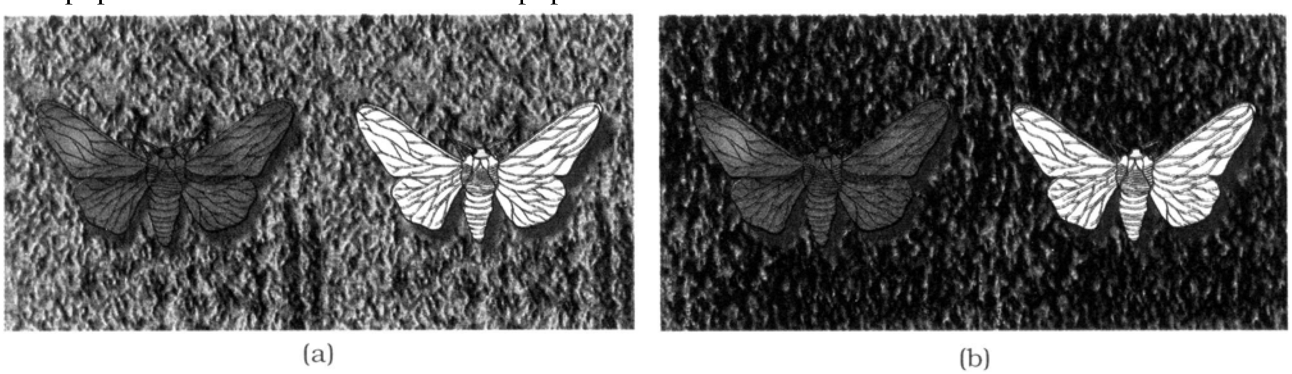


Fig.4 Figure showing white – winged moth and dark – winged moth (melanised) on a tree trunk (a) In unpolluted area (b) In polluted area

2. **Resistance of Mosquitoes to Pesticides:** The DDT, which came to use in later 1945, was thought to be an effective insecticide against household pests, such as mosquitoes, houseflies, body lice, etc. But within two to three years of the introduction of this insecticide, DDT- resistant flies appeared in the population. These mutant strains, which were resistant to DDT, soon became well established in the population, and to a great extent, replaced the original DDT-sensitive flies.

3. **Sickle Cell Anaemia:** One of the best examples, has been discovered in the human populations inhabiting in tropical and subtropical Africa. The sickle cell gene produces a variant form of the protein haemoglobin, which differes from the normal haemoglobin by a single amino acid. In people, homozygous for this abnormal haemoglobin, the red blood cells (RBCs) become sickle-shaped, and this condition is described as sickle cell anaemia. The people affected by this disease usually die before reproductive age, due to a severe haemolytic anaemia. Inspite of its disadvantageous nature, the gene has a high frequency in some parts of Africa, where malaria is

also in high frequency. Subsequently, it has been discovered that the heterozygotes for the sickle cell trait are exceptionally resistant to malaria. Thus in some parts of Africa, people homozygous for the normal gene tend to die of malaria, and those homozygous for sickle cell anaemia tend to die of severe anaemia; while the heterozygous individuals survive and have the selective advantage over either of homozygotes.

Similarly, excess use of herbicides, pesticides, etc., has only resulted in selection of resistant varieties in a much lesser time scale. This is also true for microbes against which we employ antibiotics or drugs against eukaryotic organisms/cell. Hence, resistant organisms/cells are appearing in a time scale of months or years and not centuries. These are examples of evolution by anthropogenic action. This also tells us that evolution is not a direct process in the sense of determinism. It is a stochastic process based on chance events in nature and chance mutation in the organisms.

Evidences for evolution

Evidence that evolution of life forms has indeed taken place in earth has come from many quarters, and many sources such as: (i) Palaeontology (ii) Comparative anatomy and morphology (iii) Molecular homology and (vi) Biogeography.

1. Palaeontology

- Fossils found in the rocks support organic evolution.
- Rocks are formed by sedimentation and a cross-section of the earth's crust indicates the arrangement of the sediments one over the other during the long history of earth.
- Different sediments (of different ages) contain different life forms which probably died during the formation of the particular sediment.
- Certain organisms (like dinosaurs) have become extinct.
- Those found towards the upper layers resemble modern organisms, while other do not resemble modern organisms.
- Some are found only after a certain period of earth's formation/history.
- Thus it can be concluded that new life forms have appeared in the history of the earth.

2. **Evidences from comparative anatomy and morphology:**

Comparative anatomy and morphology shows both similarities and differences among present day organisms and those existed long before.

(a) Homology

- **Homology is the relationship among organs of different groups of organisms, that show similarity in the basic structure and embryonic development, but perform different functions.**
- Homology of organs of different organisms indicates their common ancestry.
- Homology is found in the bones of forelimbs of whales, bat, birds amphibians and humans; they have similar basic anatomical structure with bones humerus, radius, ulna, carpals, metacarpals and phalanges.
- Among plants, the thorn of bougainvillea and tendrils of Cucurbita represent homology.
- **Divergent Evolution** (Adaptive Radiation) Development of different functional structures from a common ancestral form is called divergent evolution.
  Example: forelimbs of mammals are adapted to different functions in various groups – running in horse dimbing in squirrel, burrowing in rabbit, flying in bat, swimming in whale and grasping in humans etc.

All mammals of different radiating lines have evolved from pentadactylous form. Thus, homologous organs show divergent evolution.

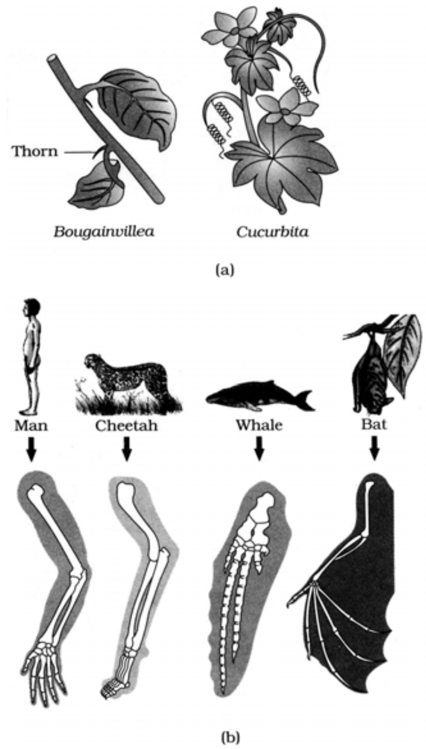
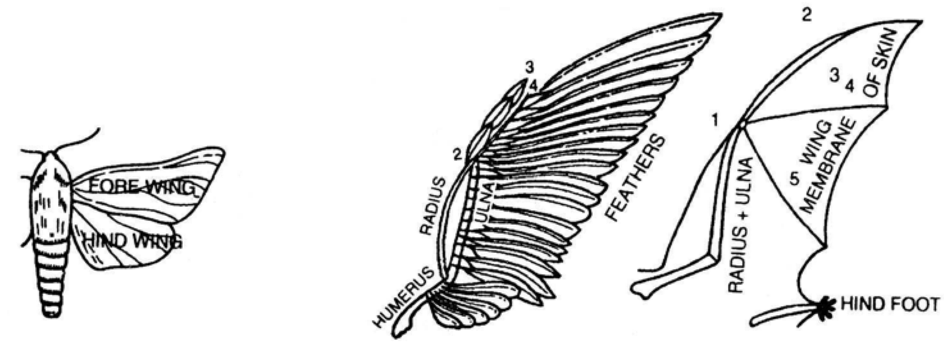


Fig.2 Example of homologous organs in (a) Plants and (b) Animals

(b) Analogy

- **Analogy is the relationship among organs of different groups of organisms performing the same function, irrespective of structural differences.**
- Some examples of organs showing analogy are:
  (i) Eyes of octopus and those of mammals.
  (ii) Wings of a butterfly (insect) and those of birds.
  (iii) Flippers of whales and those of Penguins.
  (iv) Tubers of sweet potato (root modified) and those of potato (stem modified) fins of fishes.
- Analogy is the result of convergent evolution, where similar habitat conditions have selected similar adaptive features in different groups of organisms, towards, the same function.
- **Convergent Evolution (Adaptive convergence):** Development of similar adaptive functional structures in unrelated groups of organisms is called – convergent evolution.
  Eample: Wings of insect, bird and bat Thus, analogous organs show convergent evolution.



(A) Insect **(B) Bird** **(C) BAT**

Fig.3 Analogous organs. The wings of (A) an insect (B) Bird, (C) bat

(c) Molecular homology

- Molecular homology refers to the similarities in the biomolecules of different groups of organisms.
- The biochemical similarities point to the same/common ancestry of diverse organisms.

3. <u>Evidence from Biogeography</u>

- The differential geographical distribution of different groups of organisms also indicate common shared ancestry in that restricted region.
- Habitat isolation has probably restricted these organisms to a particular geography on the earth.

4. <u>Evidence of evolution by Natural selection</u>

- **Rate of Reproduction:** Rate of reproduction is many times higher than the rate of survival in all organisms.
- **Limitation of Resources:** Food, space and other resources are limited.
- **Struggle for Existence:** Competition or struggle for existence is seen in all organisms.
- **Abundance of Variations:** Variations are so abundant in nature that no two individuals of a species are similar, not even the monozygotic twins (they possess some dissimilarities due to their environment).
- **Production of New Varieties of Plants and Animals by Sexual Selection:** When man can produce various new varieties of plants and animals in a short period, nature with its vast resources and long time at its disposal can easily produce new species by selection.
- **Mimicry and Protective Colouration**: They are found in certain animals and are products of natural selection.
- **Correlation between Nectaries of Flowers and proboscis of Insects (Entomophily):** The position of nectary in a flower and the length of proboscis in pollinating insects are wonderfully correlated.
- **Pedigrees of Some Animals:** Pedigrees of horses, camels and elephants also support the Natural Selection Theory.

Adaptive Radiation

Adaptive radiation is an evolutionary process in which an ancestral stock gives rise to new species adapted to new habitats and new ways of life. Examples of Adaptive Ratiation:

1. <u>Darwin's finches</u>

- These were small black birds which Darwin observed in Galapagos islands.
- These were many varieties in the same island.

- He reasoned that after originating from a common ancestral seed-eating stock, the finches must have radiated to different geographical areas and undergone adaptive changes, especially in the type of beak.
- Living in isolation for long, the new kinds of finches emerged that could function and survive in the new habitats.

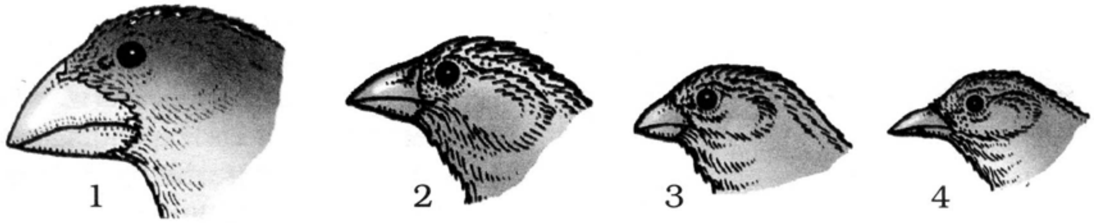


Fig.5 Variety of beaks of finches that Darwin found in Galapagos Island

2. **<u>Australian marsupials</u>**
    - A number of marsupials (pouched mammals) each different from the other, evolved from an ancestral stock within Australia.
    - When more than one adaptive radiation appeared to have occurred in an isolated geographical area with different habitats, it can be called as convergent evolution.
    - Natural selection can also lead to similar adaptations in different organisms for survival in similar habitats; such an evolutionary process is called convergent evolution.

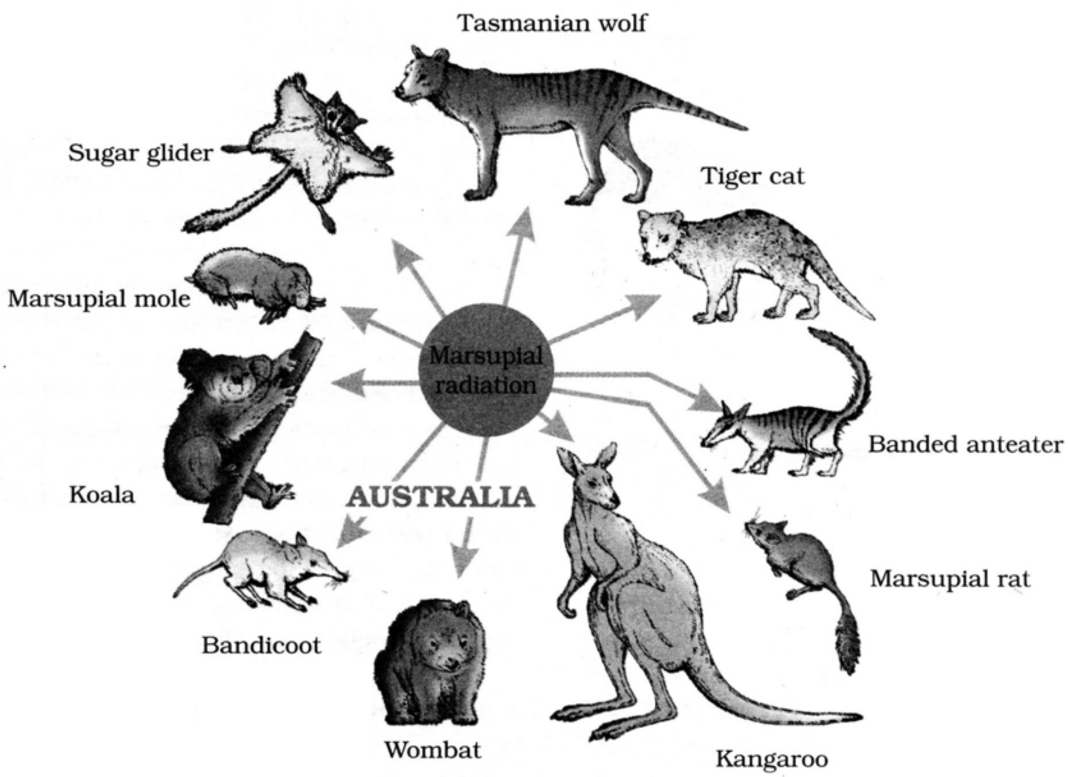


Fig.6 Adaptive radiation of marsupials of Australia

Biological Evolution

1. **<u>Lamarckism</u>**

    Lamarckism is the first theory of evolution, which was proposed by Jean Baptiste de Lamarck (1744-1829), a French biologist.

Lamarck's Theory of Evolution

- According to Lamarck, the evolution of life forms had occured by the use and disuse of organs.
- Organs that are used more develop more while those that are not used become vestigeal in the long run.
- The character/adaptation developed by an organism during its life time is passed on to the progeny.
- He gave the **long neck of giraffe as an example;** according to him, it is an outcome of the attempt to stretch their neck continuously to eat leaves from tall trees.
- As they passed on this acquired character of long neck to succeding generations, giraffes came to acquire long neck over a long period of time.

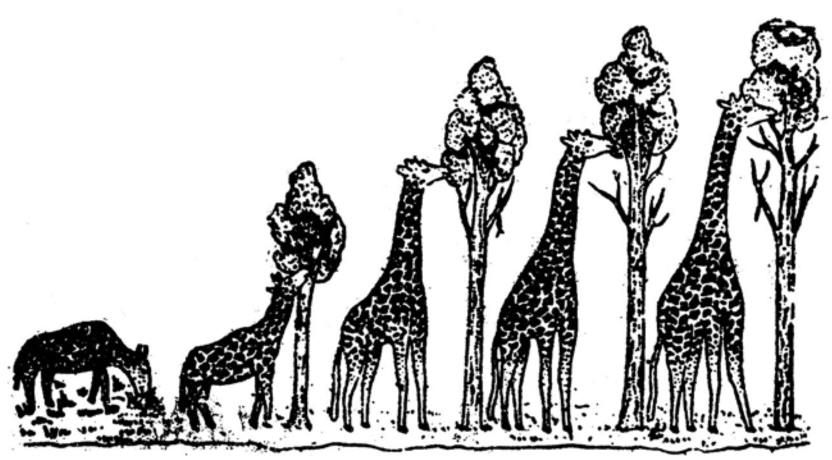


Fig.7 Diagram showing elongation of neck in giraffe according to Lamarck

2. **Natural selection**
   - The essence of Darwinian theory about evolution is natural selection.
   - The rate of appearance of new forms is linked to the life cycle or the life span.
   - Microbes that divide fast have the ability to multiply and become millions of individuals within hours. A colony of bacteria (say A) growing on a given medium has builtin variation in terms of ability to utilise a feed component. A change in the medium composition would bring out only that part of the population (say B) that can survive under the new conditions. In due course of time this variant population outgrows the others and appears as new species. This would happen within days.
   - For the same thing to happen in a fish or fowl would take million of years as life spans of these animals are in years.
   - Here we say that fitness of B is better than that of A under the new conditions, thus nature selects for fitness.
   - One must remember that the so-called fitness is based on characteristics which are inherited. Hence, there must be a genetic basis for getting selected and to evolve.

3. **Speciation**
   - All new species develop from the pre-existing species. The phenomenon of development of a new species from pre-existing one is called speciation. A species is a collection of demes. The deme is a group of populations with a common gene pool.

- **Factors Influencing speciation:** Following factors influence the speciation: (i) Mutation (ii) Recombination (iii) Natural selection (iv) Hybridization (v) Genetic drift (vi) Polyploidy (to be described) and (vii) Isolation

Mechanism of Evolution – Hugo de Vries Mutation Theory

Mutations-The cause of Evolution

- Hugo de Vries proposed the mutation theory of evolution.
- He defined mutation as large heritable change in the characteristics of a population that arise suddenly.
- According to him mutation caused speciation and he called it as **saltation**, i.e., single step large mutation.
- He differed from Darwin in the following way:
  (i) De Vries' Mutations are random and directionless, while Darwinian variations are small and directional.
  (ii) De Vries believed that mutation caused speciation in a single step, but evolution for Darwin was a gradual process and occurs over a number of generations.

Hardy-Weinberg Principle

- In a given population one can find out the frequency of occurrence of alleles of a gene or a locus. This frequency is supposed to remain fixed and even remain the same through generations. Hardy-Weinberg principle stated it using algebraic equations.
- This principle says that allele frequencies in a population are stable and is constant from generation to generation. The gene pool (total genes and their alleles in a population) remains a constant. This is called **genetic equilibrium**. Sum total of all the allelic frequencies is 1.
- Individual frequencies, for example, can be named p, q, etc. In a diploid, p and q represent the frequency of allele *A* and allele *a*. 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 is 2pq. Hence, $p^2 + 2pq + q^2 = 1$. This is a binomial expansion of $(p+q)^2$.
- When frequency measured, differs from expected values, the difference (direction) indicates the extent of evolutionary change. Disturbance in genetic equilibrium, or Hardy- Weinberg equilibrium, i.e., change of frequency of alleles in a population would then be interpreted as resulting in evolution.

Five factors are known to affect Hardy-Weinberg equilibrium. These are gene migration or gene flow, genetic drift, mutation, genetic recombination and natural selection.

(i) <u>Gene migration</u>

- When some individuals of a population migrate to other populations, or when certain individuals come into a population, the gene frequencies of the given population change, i.e., some genes are lost (in the first case and added in the second).
- If this migration occurs a number of times, **gene flow** occurs.

(ii) <u>Genetic drift</u>

- Random changes in the allele frequencies of a population occurring only by chance, constitute genetic drift.
- The change in allele frequency may become so drastically different that they form a new species.

- The original drifted population becomes the **founder** and the changes in the phenotype and genotype of the progeny, constitute the **founder effect**.
- This is clear with microbial experiments where the pre-existing advantageous mutants get selected and over a few generations, speciation occurs.

(iii) Mutation

- Though mutations are random and occur at very slow rates, they are sufficient to create considerable genetic variation for speciation to occur.

(iv) Recombination

- New combinations of genes occur due to crossing over in meiosis during gametogenesis.

(v) Natural selection

- Natural selection is the most critical evolutionary process that leads to changes in allele frequencies and favours or promotes adaptation as a product of evolution.
- Coupled to increased reproductive success, natural selection makes the population look entirely different from the original population, i.e., speciation.

A critical analysis makes us believe that variation due to mutation or variation due to recombination during gametogenesis, or due to gene flow or genetic drift results in changed frequency of genes and alleles in future generation.

- Depending upon the traits favoured, natural selection can produce one of the three following effects.
  (i) **Stabilisation:** in which more individuals acquire mean character value, i.e. variation is much reduced.
  (ii) **Directional change:** in which more individuals acquire value other than the mean character value.
  (iii) **Disruption:** in which more individuals acquire peripheral character value at both ends of the distribution curve.

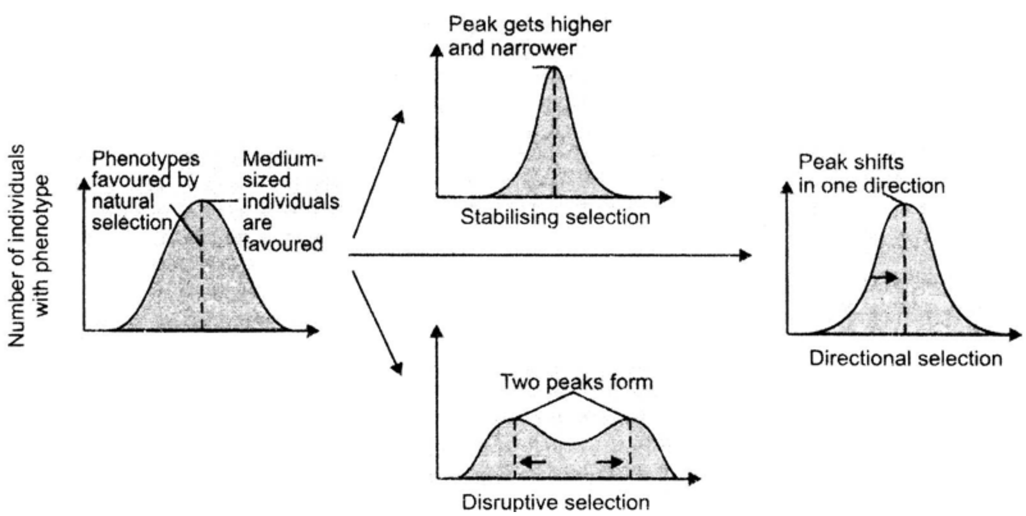


Fig.8 Effects of Natural Selection

An Account of Evolution

- About 2000 million years ago (mya) the first cellular forms of life appeared on earth.
- The mechanism of how non-cellular aggregates of giant macromolecules could evolve into cells with membranous envelope is not known. Some of these cells had the ability to release O_2. The reaction could have been similar to the light reaction in photosynthesis where water is split with the help of solar energy captured and channelised by appropriate light harvesting pigments. Slowly single-celled organisms became multi-cellular life forms.

- By the time of 500 mya, invertebrates were formed and became active.
- Jawless fish probably evolved around 350 mya.
- The first organisms that invaded land were plants. They were widespread on land when animals invaded land. Fish with stout and strong fins could move on land and go back to water, about 350 mya.
- The Coelacanth or lobefin fishes evolved into the first amphibians that lived on both land and water. There are no specimens of these left with us. However, these were ancestors of modern day frogs and salamanders.

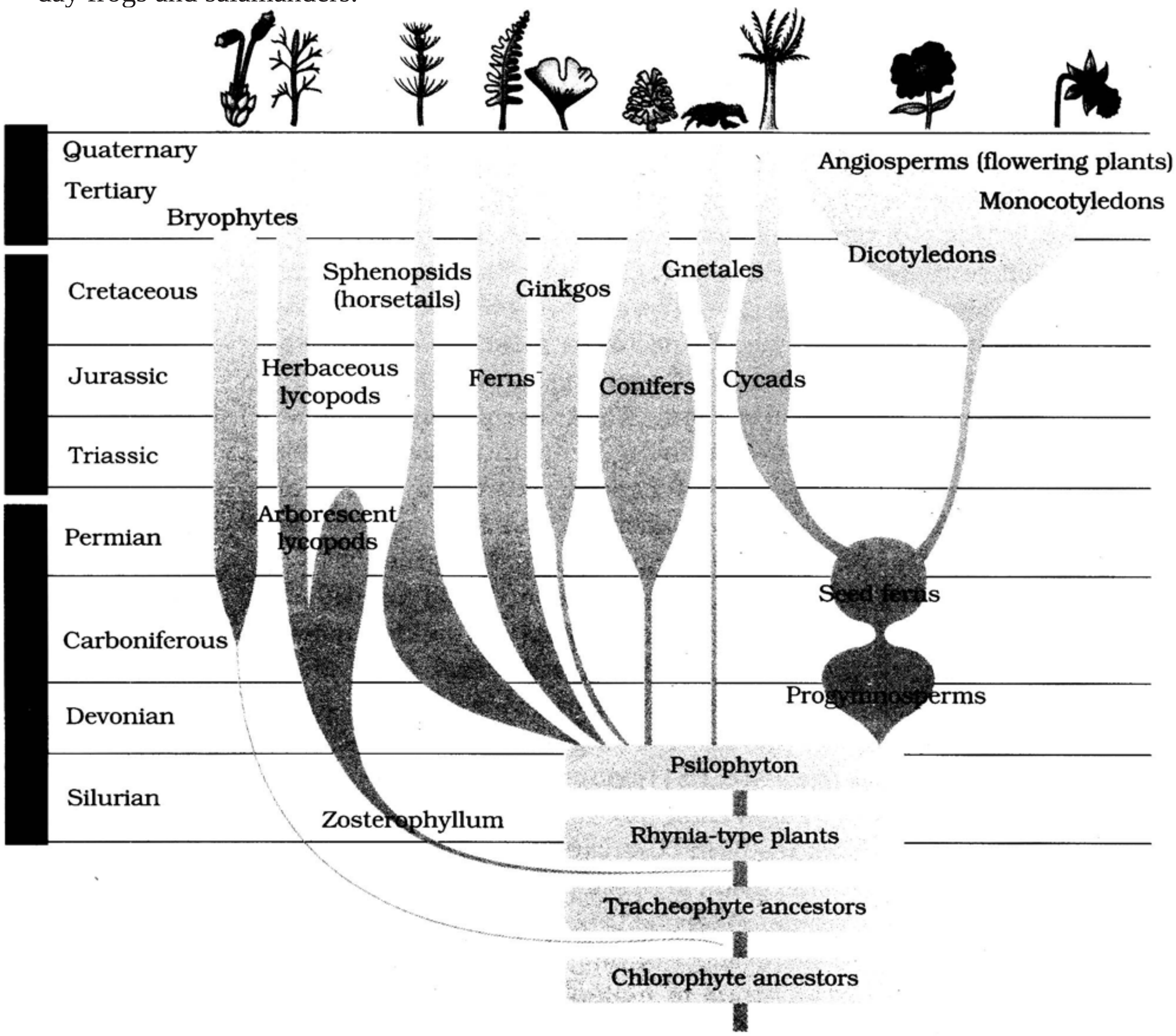


Fig.9 A sketch of the evolution of plant forms through geological periods

- The amphibians evolved into reptiles. They lay thickshelled eggs which do not dry up in sun unlike those of amphibians. We can see their modern day descendents, the turtles, tortoises and crocodiles.
- In the next 200 millions years or so, reptiles of different shapes and sizes dominated on earth.
- Some of these land reptiles went back into water to evolve into fish like reptiles probably 200 mya (e.g. *Ichthyosaurs*).
- The land reptiles were, of course, the dinosaurs. The biggest of them, i.e., *Tyrannosaurus rex* was about 20 feet in height and had huge fearsome dagger like teeth. About 65 mya, the

dinosaurs suddenly disappeared from the earth due to climatic changes. Small sized reptiles of that era still exist today.

- The first mammals were like shrews. Their fossils are small sized. Mammals were viviparous and protected their unborn young inside the mother's body. Mammals were more intelligent in sensing and avoiding danger. When reptiles came down mammals took over this earth. There were in South America mammals resembling horse, hippopotamus, bear, rabbit, etc. Due to continental drift, when South America joined North America, these animals were overridden by North American fauna. Due to the same continental drift pouched mammals of Australia survived because of lack of competition from any other mammal.

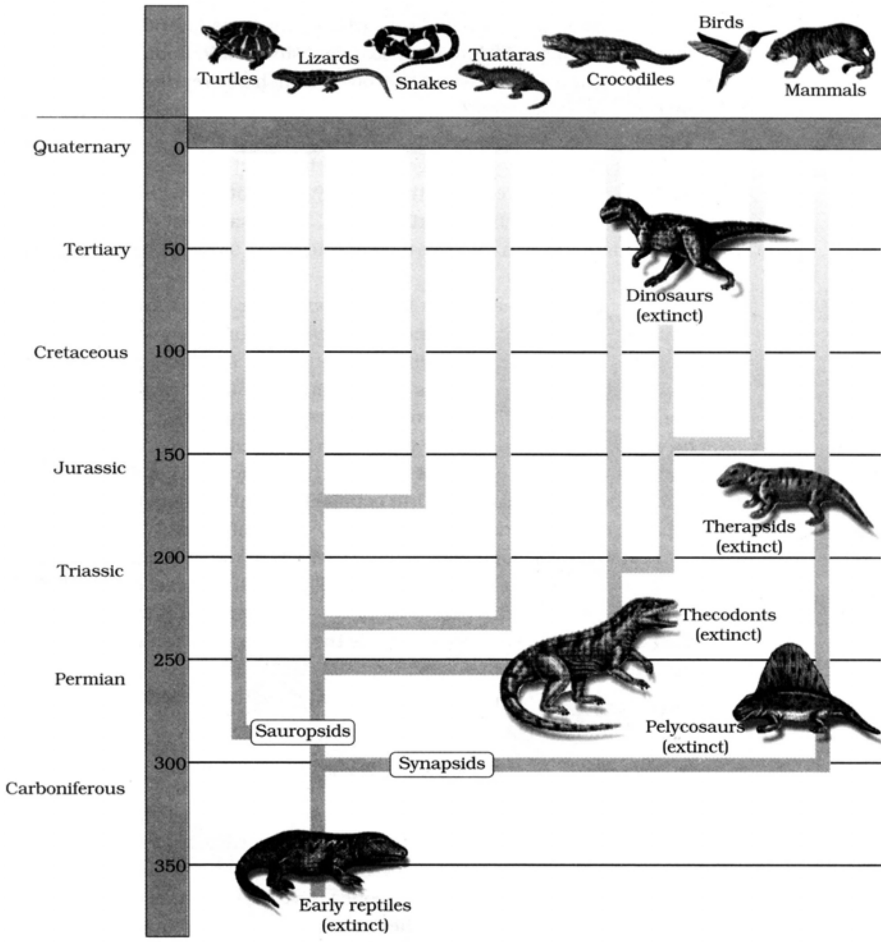


Fig.10 Representative evolutionary history of vertebrates through geological period

- Some mammals live wholly in water, Whales, dolphins, seals are some examples.
- Evolution of horse, elephant, dog, etc., are special stories of evolution. The most successful story is the evolution of man with language skills and self-consciousness. A rough sketch of the evolution of life forms, their times on a geological scale are indicated in (Figure 10).

Origin and Evolution of Man

- The common ancestor of apes and man is a primate **Dryopithecus**, that lived 15 million years ago.
- The next stage in the hominid evolution is **Ramapithecus**.
- Both Dryopithecus and Ramapithecus were hairy and walked like gorillas and chimpanzees, but Ramapithecus was more man-like and is the forerunner of hominid evolution.
- The human evolution is as follows:

(i) Australopithecus

- Their fossils were found in Tanzania and Ethiopia.
- They had a brain capacity of 450-600 cc.
- They were probably about four feet tall and walked nearly upright.
- They hunted with stone weapons but essentially ate fruits.

(ii) Homo habilis

- They lived in East African grasslands.
- They had a brain capacity of 650-800 cc.
- They probably did not eat meat.

(iii) Homo erectus

- Their fossils were found in Java (Java man).
- They had a brain capacity of about 900cc.
- They probably ate meat

(iv) Home sapiens (Primitive man)

- The fossils were found in east and central Asia.
- Neanderthal man (Homo sapiens neanderthalensis) had a brain capacity of about 1400 cc.
- He must have lived between 1,00,000–40,000 years before.
- They used hides to protect the body and buried the dead.
- They became extinct 25000 years before.

(v) Homo sapiens (Modern Man)

- Home sapiens sapiens arose during the ice age between 7500–10000 years ago.
- He spread all over the globe and learned to cultivate plants and domesticate animals.
- Pre – historic cave art developed about 18, 000 years before.
- Agriculture started around 10, 000 years back.
- Human settlements and civilizations started.

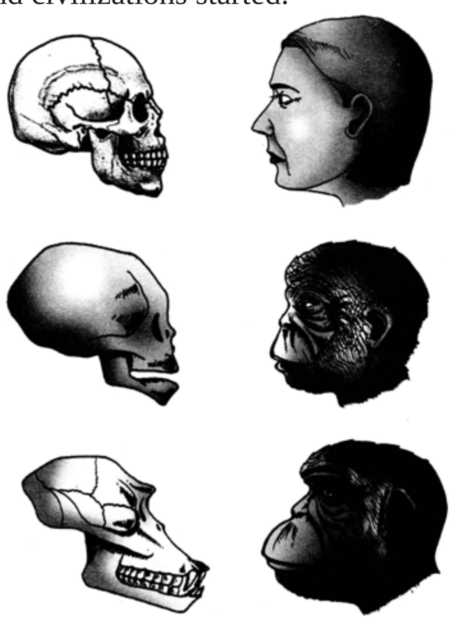


Fig.11 A comparison of the skulls of adult modern human beings, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

PROBLEMS

Exercise I

Q.1 Explain antibiotic resistance observed in bacteria in light of Darwinian selection theory.

Q.2 Find out from newspapers and popular science articles any new fossil discoveries or controversies about evolution.

Q.3 Attempt giving a clear definition of the term species.

Q.4 Try to trace the various components of human evolution (hint: brain size and function, skeletal structure, dietary preference, etc.)

Q.5 Find out through internet and popular science articles whether animals other than man has self-consciousness.

Q.6 List 10 modern-day animals and using the internet resources link it to a corresponding ancient fossil. Name both.

Q.7 Practise drawing various animals and plants.

Q.8 Describe one example of adaptive radiation.

Q.9 Can we call human evolution as adaptive radiation?

Q.10 Using various resources such as your school Library or the internet and discussions with your teacher, trace the evolutionary stages of any one animal say horse.

Exercise II

Q.1 Which one of the following is homologous to the wing of a bat?
(a) Tail of a kangaroo (b) Wing of butter fly
(c) Tail fin of a fish (c) Arm of a human

Q.2 Which of the following structures are analogous?
(a) Legs of a cockroach and the legs of a cat
(b) Forelegs of a dog and the wings of a bat
(c) Wings of a bat and the flippers of a whale
(d) Pectoral fin of a fish and the forelimb of a frog

Q.3 Anatomical Structures that show similar function, but are dissimilar embryonically are called
(a) homologous (b) primitive
(c) analogous (c) vestigial

Q.4 In which form/forms did Urey-Miller supply energy in their experiment?

Q.5 Who provided experimental support for Oparin-Haldane hypothesis?

Q.6 Who proposed the theory of origin of Life?

Q.7 What is evolutionary biology?

Q.8 Name the theory that describes the formation of universe.

Q.9 What is 'fitness' according to Darwin?

Q.10 What is meant by divergent evolution?

Q.11 What are Darwin's finches?

Q.12 Mention the two key concepts of Darwinism.

Q.13 What is saltation?

Q.14 State Hardy-Weinberg's principle.

Q.15 What is meant by genetic equilibrium?

Q.16 What is founder effect?

Q.17 Define gene migration.

Q.18 What is genetic drift?

Q.19 What were the first mammals like?

Q.20 Name the forerunner of hominid evolution.

Q.21 How do you consider tendrils of cucumber and thorns of Bougainvillea as homologous structures?

Q.22 DDT was known to be highly effective insecticide in the past. Why did it not wipe out all mosquito populations?

Q.23 What is speciation? List any two events leading to speciation.

Q.24 Define the following giving one example each
(i) Homologous organs.
(ii) Analogous organs

Q.25 What is the study of fossils called? Mention any three points how the fossils throw light on past life?

Q.26 What was Lamarck's theory of evolution? Explain the theory by quoting an example.

Q.27 What is the role of variation in evolution?

Q.28 Define natural selection. Who else along with Charles Darwin proposed it as a mechanism of evolution?

Q.29 How does theory of Panspermia explain origin of life?

Q.30 Differentiate between convergent and divergent evolution.

Q.31 Bring out the differences between de Vries' mutations and Darwinian variations.

Q.32 Differentiate between gene flow and genetic drift.

Q.33 Who put forth the theory of Natural selection? How does industrial melanism explain this theory?

Q.34 Mention the three connotations of the theory of special creation.

Q.35 Name and describe the factors that affect Hardy-Weinberg's equilibrium.

Q.36 Trace the evolution of man from the first man like hominid.

Flashback

CBSE 2000

Q.1 What are Homologous organs? How do they differ from amalogous organs? How does the study of comparative anatomy provide evidence in favour of organic evolution?

(5 out of 70)

CBSE 2001

Q.1 Which organic can pound did Miller and Urey find in their experiments stimulating conditions on the Primitive earth.

(1 out of 70)

CBSE 2002

Q.1 What was the kind of atmosphere on the Primitive earth?

(2 out of 70)

Q.2 Why has natural selection not eliminated sickle cell aneamia “

(2 out of 70)

Q.3 What is coacervates?

(2 out of 70)

Q.4 How does natural selection operate according to Darwin's theory of evolution?

(3 out of 70)

CBSE 2003

Q.1 Which statement is correct regarding Bision bitularia, a species of moth (pepper moth) found in Eng and during the late 19th century ?

(a) The black colouration of moth was caused by pollution from burning coal.
(b) Black moths were covered with soot from coal burning factories.
(c) These moths were killed by devastating fungus Phytophpthora.
(d) An occasional mutation caused black moths to be born.

(1 out of 70)

Q.2 List the gases used in the experiment performed by Urey & Miller.

(2 out of 70)

Q.3 What is reproductive isolation? What is its significance?

(2 out of 70)

Q.4 A biogeographical evidence in favour of organic evolution is provide by

(a) Archeopteryx (b) Modern horse

(c) Darwin's finches (d) Python

(1 out of 70)

Q.5 Which one of the following is homologous to the wing of a bat?

(a) Tail of a kangaroo (b) Wing of a butterfly

(c) Tail fin of a fish (d) Arm of a human

(1 out of 70)

Q.6 Which of the following structures are analogous?

(a) Legs of cockroach and the legs of a cat

(b) Forelegs of a dog and the wings of a bat

(c) Wings of a bat and the flipper of a whale

(d) Pectoral fin of a fish and the forelimb of a frog

(1 out of 70)

CBSE 2004

Q.1 How does natural selection operate according to Darwin's the ory of natural selection?

(3 out of 70)

Q.2 Who finally disapproved the theory of spontaneous generation?

(1 out of 70)

Q.3 What is the nature of component of bacterial chromosomes?

(1 out of 70)

CBSE 2005

Q.1 Which type of UV radiations can be lethal to organisms?

(2 out of 70)

CBSE 2006

Q.1 What was the kind of atmosphere in the primitive earth?

(1 out of 70)

CBSE 2007

Q.1 What was the kind of atmosphere in the Primitive earth?

(1 out of 70)

CBSE 2008

Q.1 Name any two vertebrate body parts that are homologous to human forelimbs.

(1 out of 70)

Q.2 How do Darwin's finches illustrate adaptive radiation ?

(2 out of 70)

CBSE 2009

Q.1

1 2 3 4

(a) Write your observations on the variations seen in the Darwin's finches shown above.

(b) How did Darwin explain the existence of different varieties of finches on Galapagos Islands? **(3 out of 70)**

Q.2 According to Hardy-Weinberg's principle the allele frequency of a population remains constant. How do you interpret the change of frequency of alleles in a population?

(1 out of 70)

CBSE 2010

Q.1 (a) How does the Hardy – Weinberg's expression ($p^2 + 2pq + q^2 = 1$) explain that genetic equilibrium is maintained in a population?

(b) List any two factors that can disturb genetic equilibrium.

(3 out of 70)

CBSE 2011

Q.1 Name the common ancestor of the great apes and man.

(1 out of 70)

Q.2 Branching descent and natural selection are the two key concepts of Darwinian Theory of Evolution. Explain each concept with the help of a suitable example.

(3 out of 70)