









7

ORGANIC EVOLUTION

What we have learned earlier

-  Biosphere is the area on the earth where life exists. It includes about 20 kilometers upwards in the atmosphere and 11 kilometer downwards.
-  In the Biosphere different plants and animals are present. This diversity of life is an important charateristic of earth.
-  Each species of organism has adaptations to live in its environment.
-  The biosphere contains both unicellular organisms and multicellular organisms that have fully developed organs and organ systems.
-  The life processes of the higher organisms are far more complex. The related organs also begin to develop correspondingly.
-  Organisms are classified on the basis of similar and differing characteristics.
-  Human beings are classified on the basis of similarities and differences with other organisms.
-  The sum total of all the different genes in the population is known as the gene pool.

Many many different species of organism exist around us. Most of them were not present during earlier times. Similarly, many organisms present in ancient times are not seen today. Have you ever thought how this has happened? From ancient times organisms have undergone continuous changes and many of them have become extinct during the past millions of years. It is interesting to know how this has happened.

The origin of earth and life

How did the earth and life originate? The attempt to answer these questions has been made from early times since the origin of human beings.

It was formerly believed that all life forms that we see around us were created almost simultaneously. This view called "the special creation" is no longer considered to be valid in scientific circles as it cannot be proved scientifically.

There existed another theory about the origin of life (Theory of Spontaneous Generation). It was believed that living things like insects, worms, rat, etc. could arise spontaneously from mud, dung and earth. This theory was also rejected by later scientists like Francesco Redi and Louis Pasteur through well planned experiments. They established that living

things can arise only from similar living things.

If life originated from living things how did life originate at first?



Louis Pasteur
(1822-1895)

The answer to this is explained by the theory of chemical evolution. It states that inorganic

The very remote touch of life

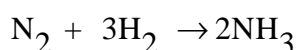
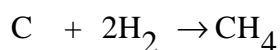
According to the theory known as cosmozoic theory 'life is immortal' and has come to this earth from some unknown region of the universe as spores or germs or some other simple particles. But the question is whether the temperature of outer space, uv rays and absence of air will permit these particles of life to reach the earth? Unless otherwise proved by Science, this theory will not be accepted by the scientific world.

molecules combined spontaneously in right proportion to give rise to organic molecules in the ancient earth.

How did chemical evolution happen on earth? You know conditions of our earth during that period?

The primordial earth

It is estimated that about 4600 million years ago earth originated. Can you imagine the conditions that existed on the earth during that period? It was a super hot, whirling mass of dust particles. The major share was composed of hydrogen. Oxygen was not present in free state. Hydrogen combined with oxygen as soon as it was formed to form steam. In addition to this, other compounds of hydrogen were also gradually formed. Some examples are



Nitrogen, hydrogen, gases of carbon and steam encircled the earth and these formed the atmosphere at that time. Gradually this atmosphere began to cool itself. Due to this cooling steam began to condense and rains began to fall and continued for thousands of years. In this way oceans, lakes and rivers were formed on the earth. Through the rain water aminoacids reached the earth from the atmosphere. It took thousand million years for life to originate on the earth.

The origin of life

After continuous chemical changes in the water, nitrogen bases were formed from inorganic substances. The nitrogen bases combined with other elements and nucleotides

were formed. These nucleotides joined together to form nucleic acids. The non living substances in the earth's atmosphere, methane, water vapour and, nitrogen joined together to produce amino acids. This reaction required energy. Which were the sources of energy for the ancient earth?

In 1953, Harold Urey and Stanley Miller succeeded in producing amino acids from inorganic gases in the laboratory, and provided proof for chemical origin of life. They created the conditions of the primitive earth in the laboratory. By analysing the figures 7.1(A) and 7.1(B) understand how this was done at that time.

Record your observations in the science diary.

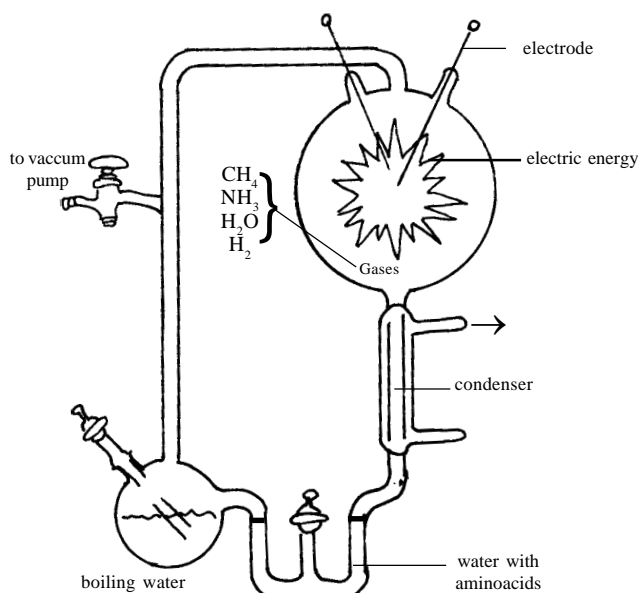


Figure 7.1 (A)

A.Satnley Miller and Harold Urey's Experiment

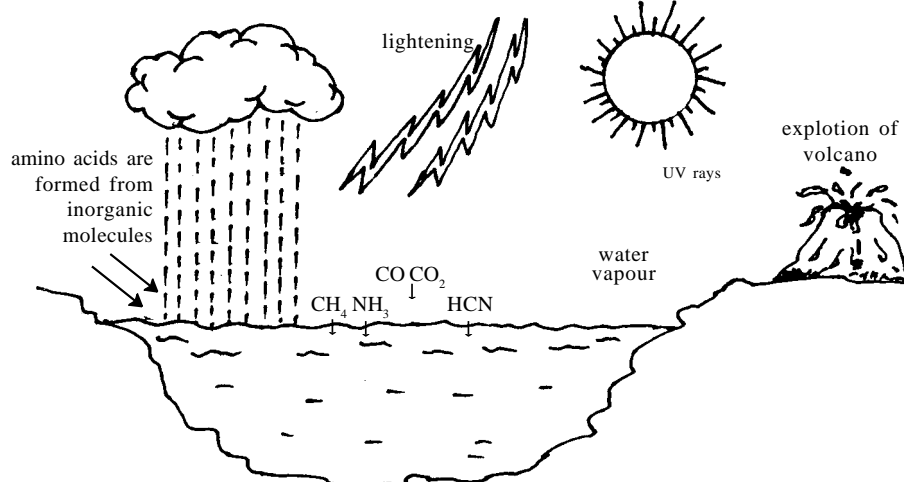


Figure 7.1 (B)

B Still water in ancient earth

Note down the similarities in the figures 7.1 (A&B).

- Substances responsible for chemical reaction
- Sources of energy
- Products formed

You know that aminoacids are the basic units of protein. Proteins are the important component of protoplasm that led to the origin of life. It is also proved that all these reactions do not require free

oxygen. Chemical evolution does not occur in the present day earth because of this.

Life does not evolve simply by the formation of these substances. How were these substances later converted into the cell? There was no substantive evidence for this complex process. But Oparin and Sydney Fox (1965) gave an explanation to this. The macromolecules had a tendency for aggregation and precipitation in the primitive oceans. They developed

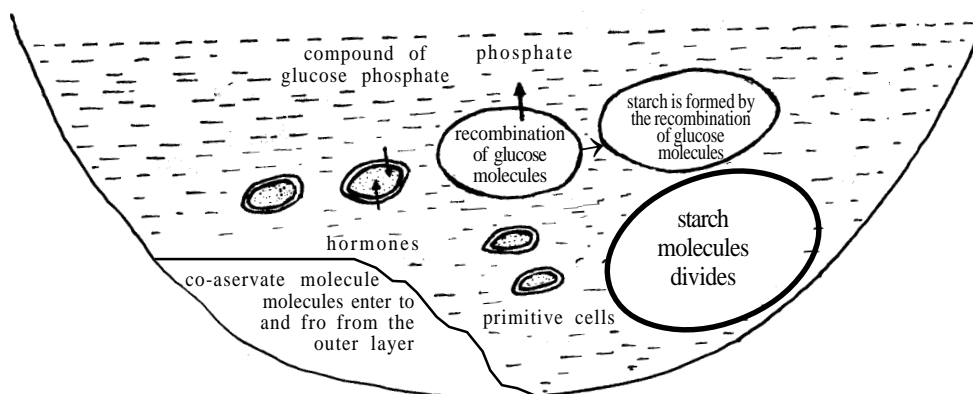


Figure 7.2 (A)

Oparin's Model

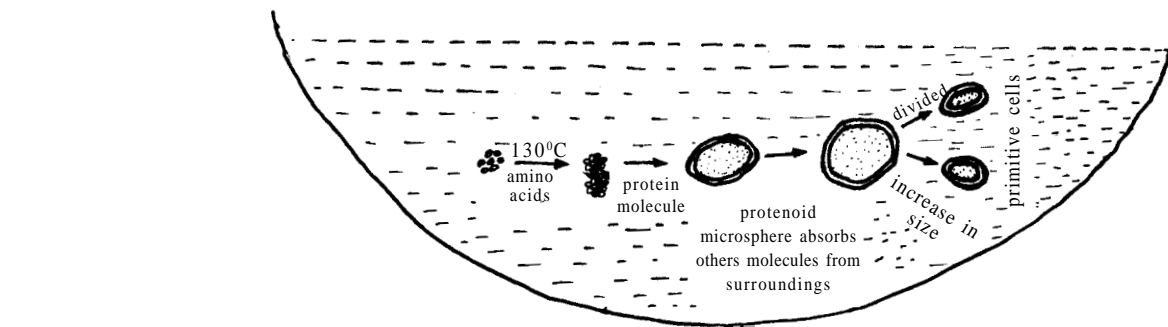


Figure 7.2 (B)
Model of Sidney Fox

the power of self duplication and they are considered the forerunners of the cell. These colloidal particles of organic materials were called by Oparin as coacervates. But Sydney Fox called them as protenoid microspheres.

Compare the figures below (fig.7.2.A&B) and make a note in the science diary.

What conclusions could you draw from this model?

- ✧ Different types of molecules were found in water of the primitive earth.
- ✧ They must have had different properties based on the components present in them.
- ✧ From the surrounding they absorbed

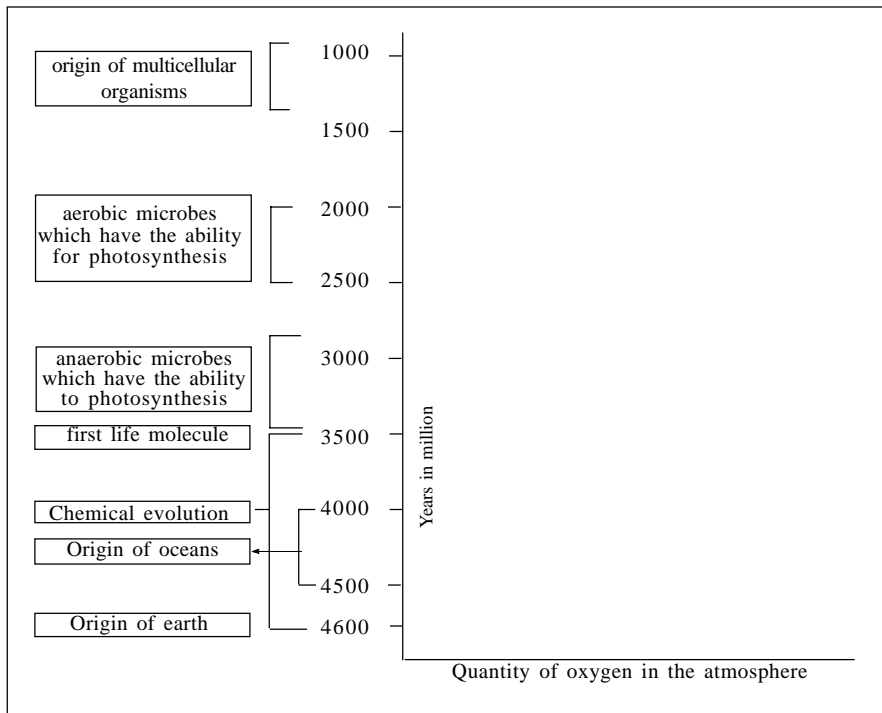


Illustration I

other molecules and underwent chemical reaction.

- ✧ Gradually they enlarged and attained the power of division and transformed themselves into protocells.

These protocells were covered by a fatty layer and this might have developed later into the plasma membrane.

Nucleic acids, capable of transmitting hereditary characters later entered into the protocell.

Science has not been able to suggest so far what type of cell was formed first. Was the protocell a complete cell? Or even much simpler than this? These questions remain unanswered. But the facts that life originated as a result of chemical evolution has been widely accepted.

Observe the illustration I. Discuss using the points given below and note down your conclusions in your science diary.

- How long did it take to form the first molecule of life through chemical evolution?
- The earliest organisms must have been anaerobic Why?
- What are the changes that happened to the earth's atmosphere after the formation of aerobic organisms?
- Which were formed first, plants or animals?

You have understood that it is from the simple unicellular organisms that complex multicellular organisms evolved. It is evident that constant changes are occurring in organisms since their origin. Evolution is the study of such slow changes occurring in organisms. This is the subject matter of organic evolution.

From the multicellular organisms there evolved four groups.

- Fungi
- Sponges
- Green plants
- Animals

The origin of green plants on earth resulted on the development of biodiversity on this earth.

The evolution of plants

The first green plants were algae present in water. Some of them began to

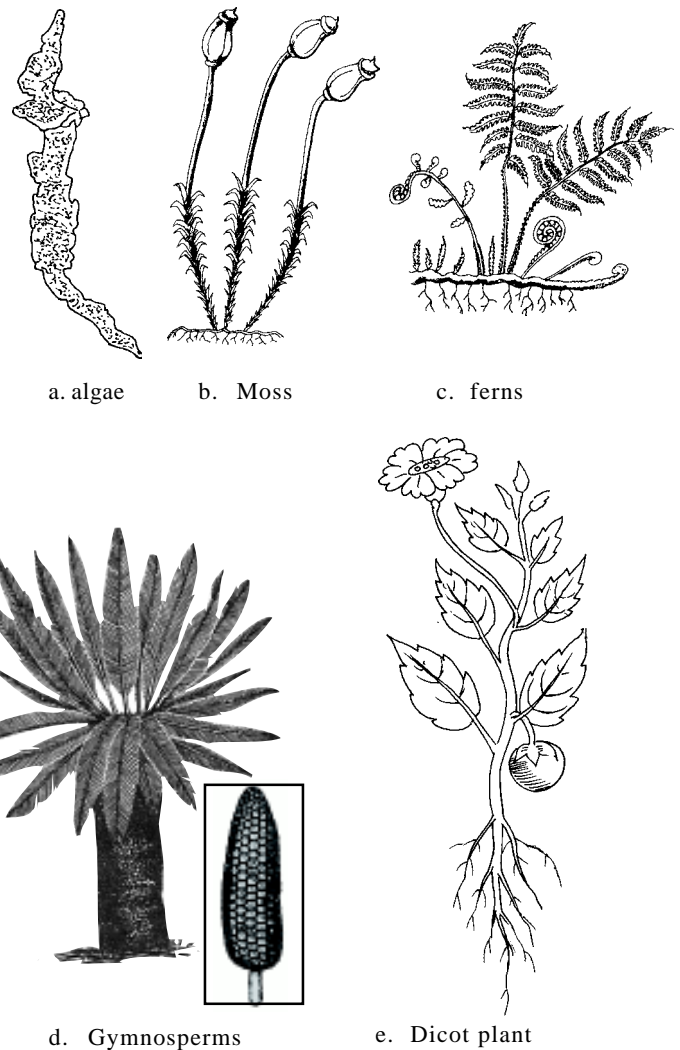


Figure 7.3
The evolution of plants

live on land after millions of years. Do you know about the mosses which get attached to wet rocks. They belong to bryophytes. From them came the pteridophytes (ferns) and then the gymnosperms. When the green plants moved from water to land the cells were covered by cell wall, to protect the loss of water from the plant body. Several other changes also occurred in their structure. Fig 7.3 (a,b,c,d,e)

- What were the changes that occurred to roots, stem and leaves during plant evolution.
- How did these changes help in the absorption of water and salts and conduction of materials?

Record your findings in the science diary.

The evolution of Animals

We have studied how organs for nutrition, respiration, excretion, circulation etc are complex as we proceed from the simple



Figure 7.4
Vertebrates without jaws (Lamprey)

organisms to higher organisms. Among multicellular organisms animals that evolved at first were the two layered or diploblastic organisms and they evolved into three layered or triploblastic organisms. Invertebrates

evolved into vertebrates. Among the vertebrates the first formed animals were agnatha (jaw less). They had no jaws. Fig 7.4. From these jaw-less vertebrates were evolved the cartilaginous fishes and then the bony fishes. Some bony fishes were able to breath atmospheric air. From these the amphibians evolved. They later gave rise to the reptiles and from reptiles birds and mammals evolved.

The important Mammals

About 70 million years ago the early mammals adapted themselves to live in the environment of that period. Among these one group had the ability to live on trees. These animals are called primates. Lemurs, Monkeys, Chimpanzees, Gorilla and man all belong to the primates. Examine the general characters of the primates.

- Fore and hind limbs have five digits each with flat nails
- Presence of opposible thumb
- A pair of eyes with binocular vision
- A pair of Mammary glands

The primates are classified on the basis of similarities and dissimilarities as shown in the following illustration II.

- Which are the types of primates present on the earth?
- Is man a primate like monkey or has evolved from monkey. Justify your opinion.

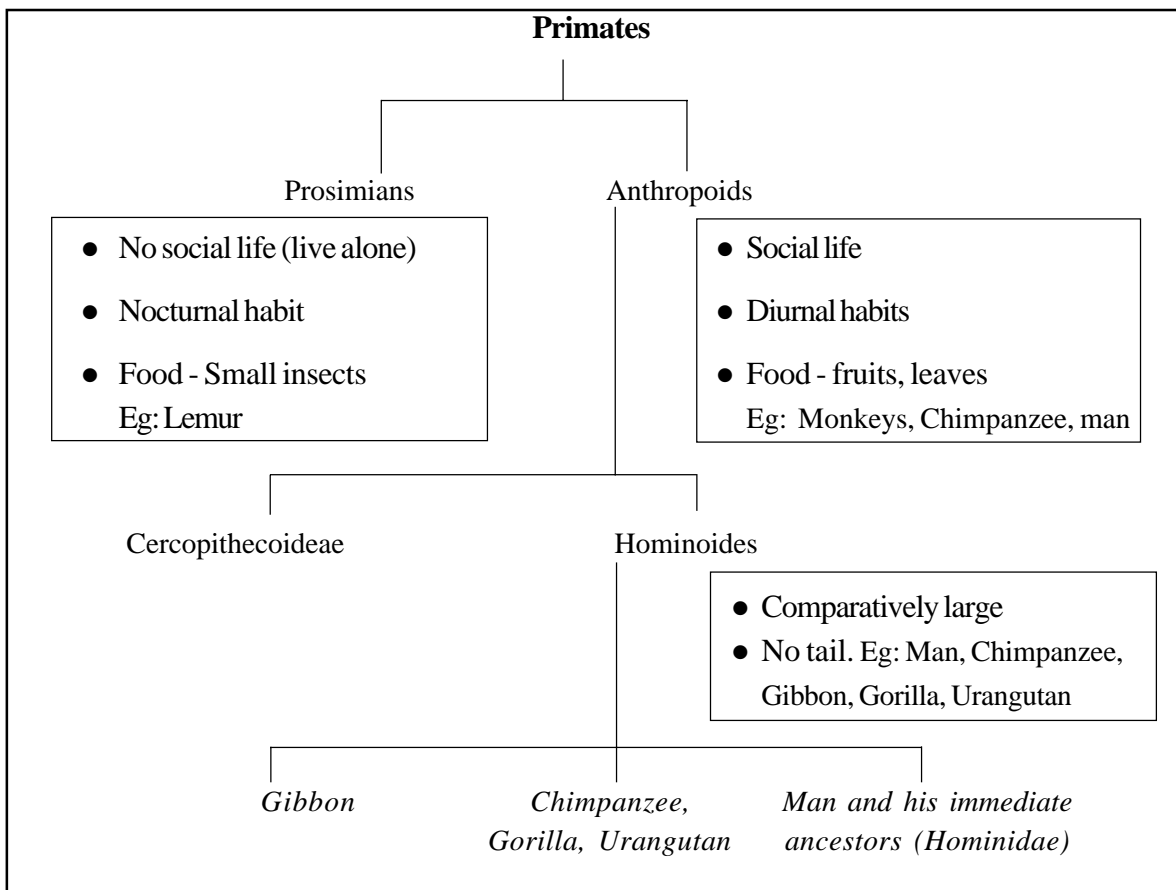


Illustration II

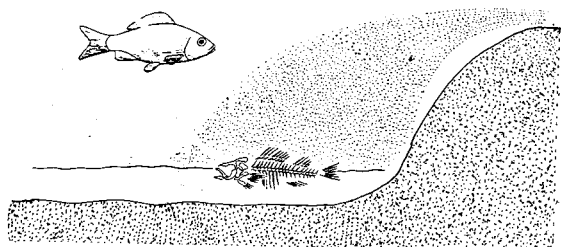
Evidences of Evolution

The evolution of life is a scientific theory and so it requires supporting proof. Like other theories, evolution also depends on evidences. Let us examine some of them.

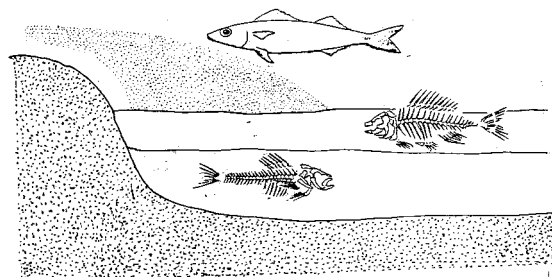
A. Fossils

Fossils are dead remains of very ancient organisms get protected on the earth, in the sedimentary rocks.

Observe fig 7.5 (A-D). Understand how fossils are formed.

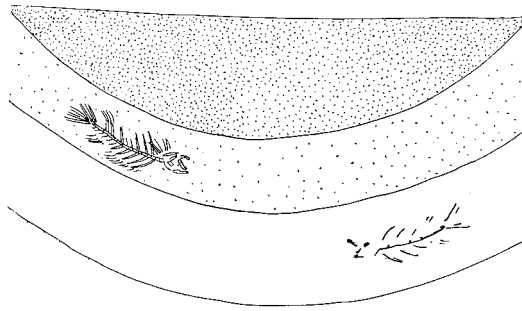


A. Animal trapped under soil

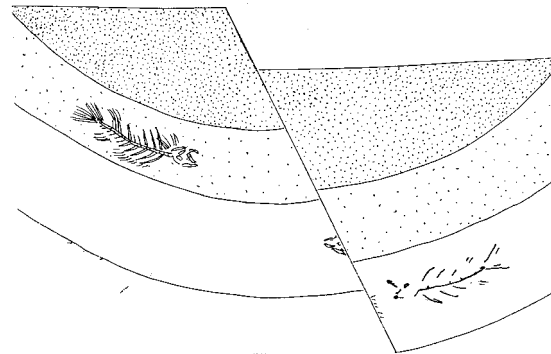


B. Soft body parts decay. Sand and clay fall in layers.

Figure 7.5



c. Due to pressure, the lower layers become sedimentary rocks. The hard parts of animals form part of the layer



(the years)

d. Over (the period of time,) layers are formed one above the other. The fossils of many organisms are formed in these layers.

Figure 7.5

Formation of fossils

Fossils obtained from which of the layers might be older? Why? Fossils are also obtained in many forms. Do you know what they are?

- Body of organism trapped between ice layers
- Animals which are trapped and well preserved in sticky amber
- Imprints of animals

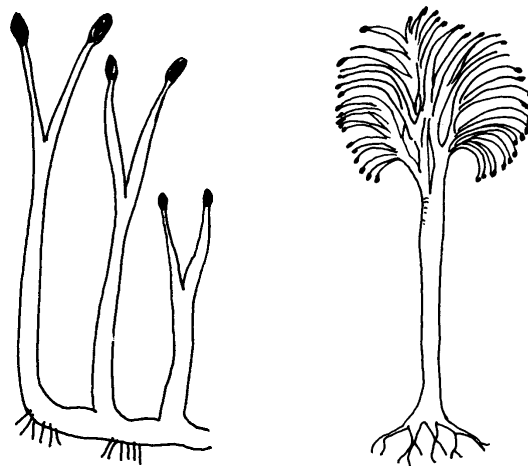
The study of fossils is known as Palaeontology. Palaeontologists can determine the age of fossils. Palaeontology provides the most direct evidence in favour of organic evolution. Let us examine.

From simple to more complex organisation

The study of oldest fossils reveal that they were simple in structure. Later fossils

exhibit more complex structures and organisations. From this what can we derive?

Observe the figure 7.6 and compare these ancient plants with our modern trees. Observe the changes that have occurred



Plants lived about 450 million years ago

Another plant lived about 300 million years ago

Figure 7.6

in leaf shape, stem, roots and record the major changes that have occurred.

Connecting link

Some fossils may link two different groups of organisms. The fossil of archeopteryx clearly indicates us that birds had originated from the reptiles.

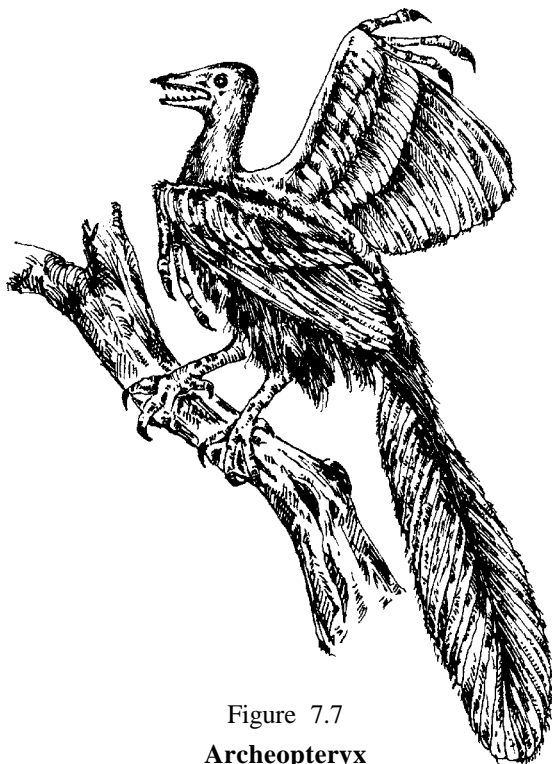


Figure 7.7
Archeopteryx

Observe the figure 7.7 of Archeopteryx and find out the characteristics in which it resembles reptiles and birds.

The evolution of the evolutionary history

The study of fossils has helped to know the complete history of evolution of some animals. The evolutionary history of the elephant and the horse has been studied in this way.

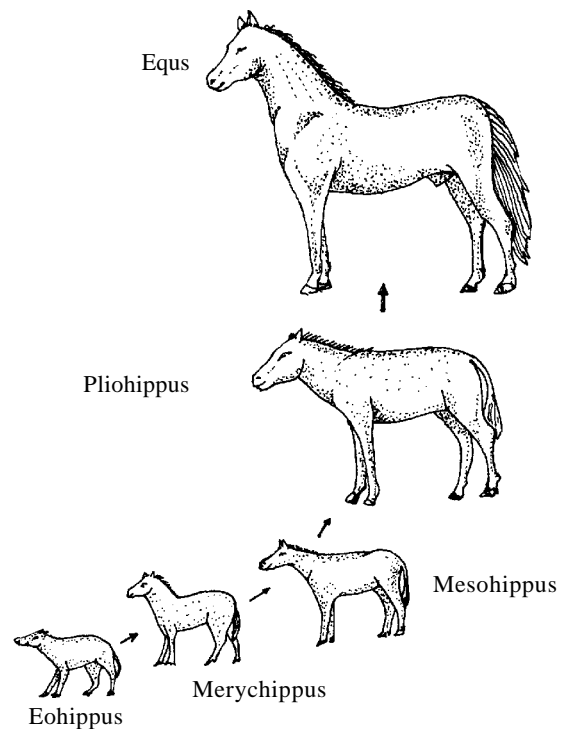


Figure 7.8
Evolution of the horse

Observe the fig 7.8. Prepare an account of the history of evolution of horse.

From this it is evident that the fossils provide real evidences of evolution .But all the fossils of organisms that lived in the past are not available to us. So the study of fossil history is incomplete. Hence you can understand why the continuity in the data available through study of fossils is broken. That is the reason why the study of fossil becomes incomplete. But by the discovery of new fossils, existing concepts also become modified. In this way the fossils make evolutionary studies true.

B Comparative morphology

You have learnt that the structure of organisms become more complex as we pass from simple organism to higher level. The

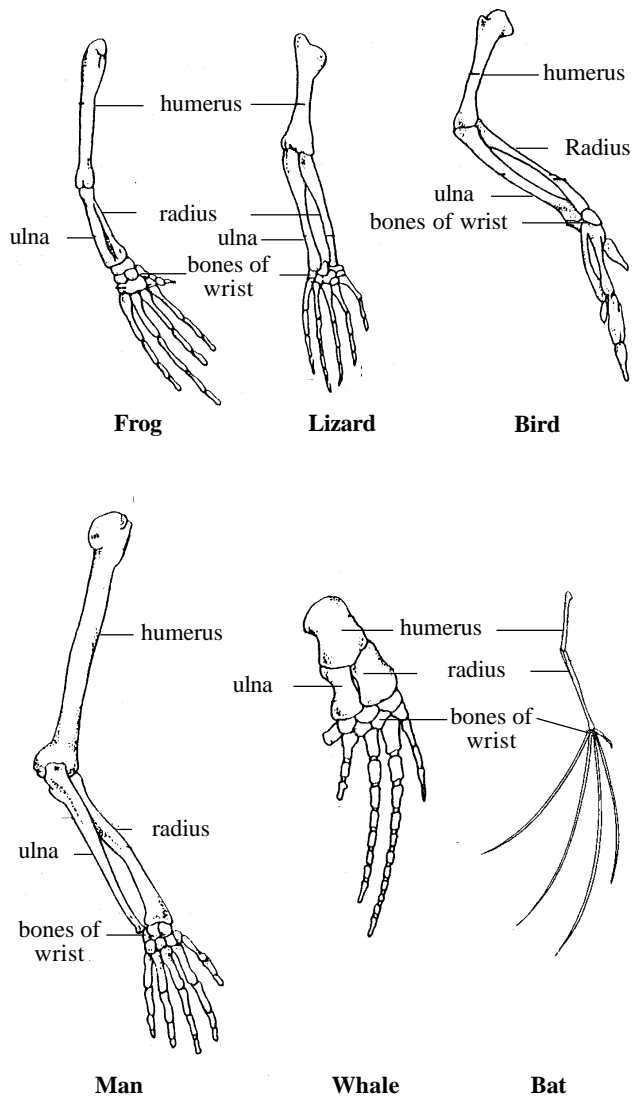


Figure 7.9

Comparison of the bones of the hand in different animals and their functional similarities

comparative study of external structure (Morphology) exhibits striking similarities between certain organs. Though they exhibit differences in external structure, their internal

structure shows similarities. Observe the figure 7.9 and based on the indications given prepare notes.

- structure and position of bones
- position and significance of bone - joints

Common internal characteristics exhibited by these animals show that all these had a common ancestor. Therefore comparative morphology also gives evidences for evolution. External structures of the organs are different in these animals based on their functions. Thus these differences help them in adapting to the environment.

C Evidence form embryology

Embryology is the study of the development of an organism from egg to adult stage. You have seen the tadpole of the frog. Which does it resemble more, the fish or

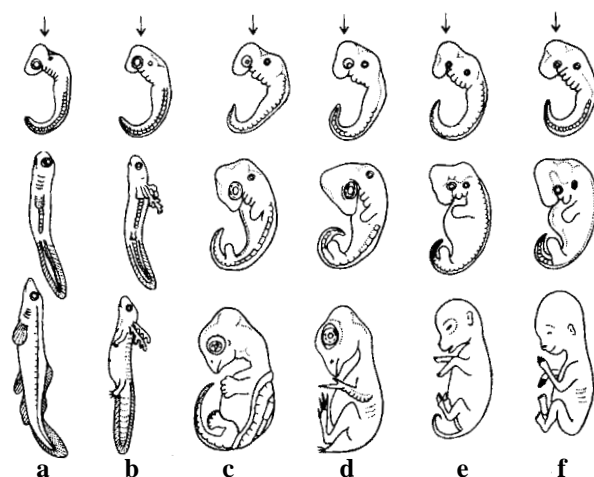


Figure 7.10

Development of vertebrate embryos

(a) Fish (b) Reptile (c) Amphibia (d) Bird (f) Man

frog? Why is this is so? Does it not indicate that frogs have evolved from fish ancestors?

There are remarkable similarities in the embryos of different animals from fish to man. The resemblance is so close that at an early stage, even an expert embryologist would find it difficult to distinguish one embryo from the other. Does it not indicate that in the life history of every individual, it exhibits the structural features of its ancestors? This strengthens the view of the existence of a common ancestor from which these have evolved?

Observe the figure 7.10(a,b,c,d,e,f), the different stages of development of vertebrate embryos and discuss the visible similarities and dissimilarities

D Classification

Have you considered how organisms could be classified. On the basis of similarities organisms are grouped into larger groups (taxon) and based on dissimilarities they are grouped into smaller groups. The meaning of evolution is that from a common ancestor, which undergo structural changes over amillions of years, new forms of organism evolve. This is what is understood by organic evolution. You know how human beings are classified. Man belongs to the family of Hominidae but also shows some characteristics of primates. Similar characteristics indicate the possibility of common ancestors and differences show the origin of a new species.

E Comparative Physiology

Have you ever considered the similarities in comparative physiology and bio chemistry of organisms?. Discuss and record in your science diary with the help of points given below.

- Building materials of our body
- Production, storage and supply of energy
- Genetic inheritance
- Different digestive glands

The protein content in different animals was analysed and the similarities and differences were studied. These findings also prove beyond doubt that organic evolution existed through several differences and deviations.

Theories of organic evolution

There was no agreement among the scientists about the origin of variation (differences) in animals. So there are different theories of organic evolution. The common theories are:

Inheritance of acquired characters

French biologist Jean Baptiste De Lamarck put forward the theory of inheritance of acquired characters. Constant use of an organ results in its better development while disuse causes its reduction and degeneration. These acquired characters will be carried over to the next

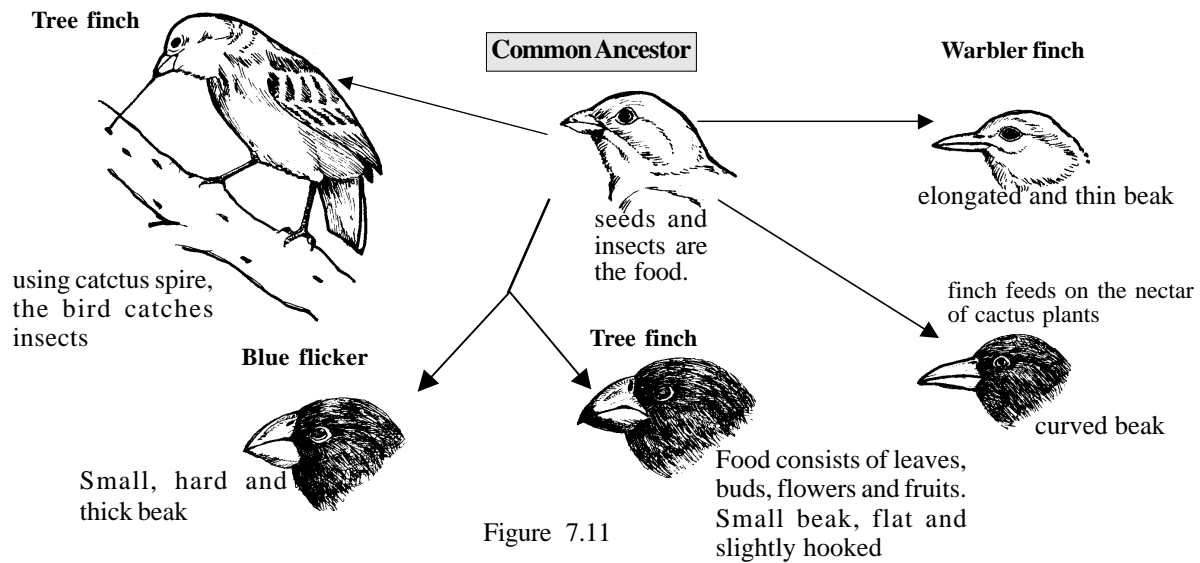


Figure 7.11

Peculiarities of Finches

generation. He cites examples like the long long neck of giraffe, the loss of limbs of snakes etc. for the acquired characteristics. The protein content in different animals was analysed and the similarities and differences were noted. These findings also prove beyond doubt that organic evolution occurred through several differences and deviations. But Lamarck's theory was criticised on the grounds that acquired characteristics do not affect the genetic material and that they are not transmitted to the next generation.

The theory of natural selection

Charles Robert Darwin clearly and convincingly set forth the concept of natural selection as the mechanism of evolution. Darwin gave the biological world a master key that unlocked the previous intricacies about evolution. Darwin's theory of natural selection is based on the following facts.

Galapagos - the laboratory of evolution

Galapagos - a group of small and large islands located in the Atlantic Ocean about 1000 kms away from the north-west region of South America. Studies on evolution and Galapagos islands are closely linked. Charles Darwin was attracted by the structural peculiarities of these islands. In his description "The sea voyage of the Beagle" he has stated: "A small group of clearly related birds exhibiting diversity in structure was noticed in these islands. This diversity gave the impression that at the beginning the birds were very few and that it would appear that one species was chosen by nature to produce such a diversity."

Darwin's theory of Evolution originated from the observation he made on the animals of the Galapagos islands. That too from area which is only $\frac{1}{5}$ th of the area of Kerala.

Variation of all kinds are produced among individuals and species in nature. Those variations which are useful are retained while those which are harmful are lost. This is called natural selection. Thus in a population there arises a struggle for existence and only the fittest shall survive (or the preservation of the favoured ones). This process over time leads to the formation of new species.

Fig 7.11 contains the common finches noticed by Darwin in Galapago's Islands. Examine the changes in the finches and how these changes enabled them to live successfully in the environment.

Darwin explained how nature favours useful variations. Each species produces a large number of offsprings. These compete with one another for space, food and mates. In this struggle for existence, only the fittest survive. They also reproduce. Over generations the best variants survive. This is called survival of the fittest. Over a long period of time this leads to the formation of new species. Darwin arrived at this conclusion. It was later discovered that genetic mutations are responsible for variations.

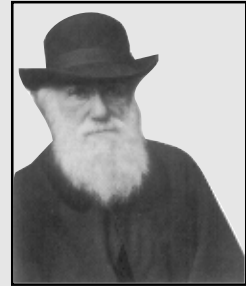
Mutation Theory

Sudden heritable changes are called mutations. The Dutch botanist, Hugo De Vries, one of the rediscoverers of Mendel's

From Darwin to Darwin



Erasmus Darwin



Charles Darwin

Erasmus Darwin (1794) grand father of Charles Darwin in his book "Sunomia" explained about the evolution, age of earth, origin of life from bio molecules, struggle for existence, and the survival of the fittest. But he could not give substantive evidences. Later in 1809, Jean Baptist Lamarck in his treatise 'Philosophie Zoologique' published his theory of organic evolution. In the same year Charles Robert Darwin, the grand son of the great Erasmus Darwin, was born in England in a small town known as Shrewsburg. Darwin had his early schooling in Shrewsburg. His father wanted Darwin to follow his footsteps as a medical student in Edinburgh in 1825. But he did not complete the medical education. His father wanted Darwin to be clergy man and enrolled him as a student. But Darwin did not complete his studies. However he got his degree as a clergy man. Later he joined as a young naturalist in the 'H.M.S. Beagle expedition' around the world. During this voyage, Darwin made innumerable observations, made critical notes on plants, animals and the lands he visited and returned in 1836. On 24 November 1859, Darwin elaborated his theory in a volume entitled "On the origin of species by Means of Natural Selection or the preservation of favoured races in the struggle for life". The books were sold out in a single day. He also published two more books on evolution. Darwin devoted his entire life in researches and studies. He died on April 19, 1882 at the age of 73.

Laws, proposed the mutation theory to explain the evolution of new species. It has been proved that x-rays, some chemicals, UV rays etc may cause mutations.

The new perspective of Darwin's Theory

Most of the biologists accept Darwin's theory of natural selection as the best general explanation of evolution. But the theory does not provide a complete answer to all the problems of evolution. The most serious weakness in Darwin's theory was his failure to identify correctly, the mechanism of inheritance. He had no idea about the origin of variations and their inheritance. But later the development of the science of genetics has provided answers to the causes of variations and how it occurs in the population. These provided scientific basis for Darwin's theory. We can examine how Darwin's theory got validity.

Chromosomes and genes are shuffled and reshuffled during meiosis and fertilization resulting in the production of offspings with different gene combinations.

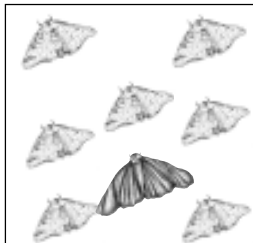
The synthesis of identical thoughts

In 1858, when Charles Darwin was formulating the theory of evolution in his mind, he received an article sent to

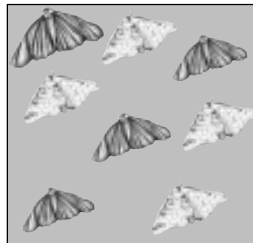


him by Alfred Russel Wallace (1823-1915) about his studies in the Indonesian islands - Natural selection was the subject matter of the article. Darwin was surprised on going through the article. Later in the same year, Charles Darwin and Alfred Wallace jointly published an article in the "Journal of the Linnaean Society" about natural selection. It was only after this that Darwin published his famous book. The studies made by the two scientists on evolution came to be the theory of natural selection.

Changes which occur in chromosome number, structure etc may also cause different changes in organisms. In addition there are also other factors that contribute to these changes. If a group organism happened to be isolated in deserts or islands over a period of time some changes may appear in them to adapt them to live that



Before the Industrial revolution while colour was helpful for escaping from enemies



After the industrial revolution the atmosphere become clouded with fumes and soot. Walls and tree trunks became black due to soot. In this black background the white coloured most were conspicuous and were easily attacked. Gradually black coloured moths began to appear and increase in numbers and white ones disappeared.

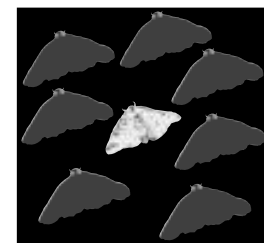
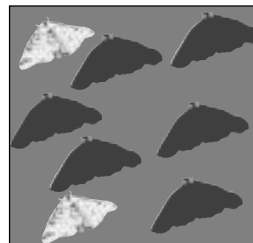


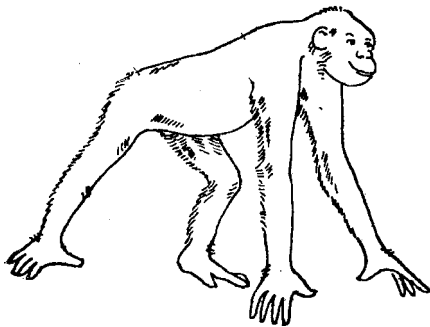
Figure 7.12
Natural selection in moths

environment. These changes may not be present in the same species living elsewhere. These changes may lead to the formation of new species. Food shortage, natural calamities etc. may lead to the mass disappearance of a species. The remaining organisms may develop changes which make them capable of withstanding the environmental conditions.

One of the most striking examples of natural selection in action was furnished by studies made by Kettle Well (1961) at London with regard to industrial melanism in peppered moth. Examine figure 7.12. How did the changes come about in the moths.

Justify natural selection. Record your observations in the science diary.

Darwins theory of Natural selection is accepted by the Scientific world,even today. Its limitations are modified and more explanations have been provided. Natural selection is not the primary factor in evolution. It is only a part of the full explanation of evolution. Most biologists regard it as a directing and controlling force rather than an initiating factor. The reason for the evolution of new species is the constant changes and visible differences appearing in organism. Such differences enabled the evolution of new species. Let us examine how through such processes modern man has evolved.

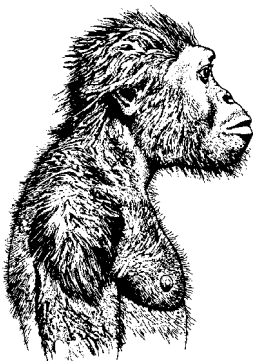


Dryopithecus

Forefather of hominidae and apes who lived in between 20-15 million years ago. After Dryopithecus, to clear evidence is available about what happened during the several lakhs of years. The non availability of Fossils is the reason.

Ardipithecus ramidus

- Lived about 4.4 million years ago, can be included under Hominidae
- Only thin layer of enamel on the teeth
- Short canine
- Walk on two legs



Australopithecus afarensis

- Lived about 2 million years ago
- Bipedal
- Short canine
- Small brain

The evolution of man

Science has to go further to make clear how evolution of man has occurred. But on the basis of available fossils it is possible to reach some conclusion about the evolution of man. Observe the figure given below.



Homo habilis

- Lived between 1.6 to 2 million years ago
- Cranial capacity 650-750 cc
- Ability in making weapons
- Ability in hunting

Homo erectus

- Lived about 1-1.80 million years ago
- Had a height of 1.70 meters
- Cranial capacity 800-1050 cc
- No forehead
- Projecting eye brows
- No chin
- Social animal
- Speaking ability

Homo sapiens neanderthalensis

- Appeared about 12.5 lakhs years ago
- Cranial capacity 1400 cc
- Skull bones thick
- Slanting and thick eyebrow ridges
- Short neck

Homo sapiens

- Appeared about 40000 years ago
- Cranial capacity 1400 cc
- Bones become thinner

- Eyebrows narrow
- Flat forehead
- Began to cultivate crops before 10,000 years.
- Made weapons using metals
- Ability to use language

We can conclude the evolution of man like this.

- ✧ Discarded the trees and built houses on the ground
- ✧ Ability to stand erect
- ✧ Walk on two legs
- ✧ The ability to oppose the big toe with the other toes was lost
- ✧ Development of prominent chin
- ✧ Greater development of the brain
- ✧ Size differences that appeared in incisors and canine

From the basic group of Primates, it is through a process of tree like branching that modern man evolved.

Prepare the evolutionary tree of man from Primates based on the above concept.

Have you ever thought about the position of man in the living world at present? Are we superior to all other animals.

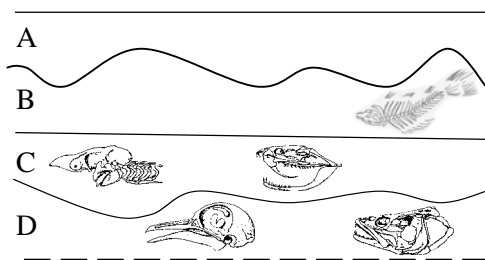
Compare our body structure with those of other animals. What are our limitations? How do we outlive these limitations? It is this process that leads organic evolution forwards.

SUMMARY

- ❖ Life originated on this earth due to the chance union of inorganic materials. This has been proved by the principles of chemical changes.
- ❖ It is believed that the modern cells have come from the early cells. The scientists Oparin, Sydney, Fox and others have explained the details regarding the origin of the early cells and how they could have been formed.
- ❖ Studies on fossils, comparative anatomy, embryology, taxonomy and biochemistry throw light on the fact that there was common ancestor for living organisms and that it is from simple organisms that complex organisms have come into being. This supports the theory of organic evolution.
- ❖ The theory proposed by Jean Baptiste Lamarck that acquired characteristics are inherited has been questioned.
- ❖ According to the theory of Natural selection proposed by Charles Darwin, production of a large number of offsprings, struggle for existence and survival of the fittest are the processes through which the desirable characters got evolved and new species came into being.
- ❖ According to Hugo De'Vries, mutations are responsible for the appearance of variation in the offsprings. With the growth of the science of genetics, it became clear how variations appear in the offsprings. This gave a new interpretation to the theory of natural selection
- ❖ Dryopithecus is considered as the common ancestor of the hominids and the apes. It triggered human evolution and Ardipithecus, which is considered as the earliest member in the line of human evolution, has been understood from fossil evidences.
- ❖ Though man has got many structural limitations, his brain capacity has enabled him to rectify these limitations especially with the help of scientific technology.

FURTHER ACTIVITIES

- ⇒ The earliest microorganisms must have had the ability to overcome the effects of UV rays. How?
- ⇒ If there were no oxygen in the atmosphere at present, most organisms could not live. But in the ancient earth if free oxygen had been present what could have been the result? Why?
- ⇒ Examine the illustration given below and observe a fossil obtained from a layer of sedimentary rocks and answer the following questions.



- Based on their age, rearrange the fossils according to their ascending order.
- Based on their complexity of structure, arrange the fossils in their descending order.
- What are your conclusions from this about the organic Evolution?

- ⇒ Can you find out any similarities in the early embryos of vertebrates? How is this phenomenon related to organic evolution?
- ⇒ "Even if concentrated pesticide is sprayed the pests do not die. Possibly the pesticide has been adulterated". This is the opinion expressed by a farmer. Discuss this problem on the basis of environmental stability.
- ⇒ The progress in knowledge gained through scientific technology has tended to reduce human activities considerably. How can it influence human evolution? After about 1000 years what will be the condition of humanity? Prepare a scientific note.
- ⇒ It is through the development of adaptation to suit the environment that organisms have undergone evolution. But man for his comfortable living is modifying his life style and his environment. How do you respond to this statement? Substantiate this.

