UNIT 12 ORIGIN AND EVOLUTION OF LIFE

Structure

12.1 INTRODUCTION

You have already studied how and when our planet Earth was born. This unit proposes to take you back to a distant past when there was no life on our planet and helps you to imagine how life originated and how plants and animals came into existence. Naturally, in discussing things which must have happened billions of years ago, there is a certain amount of guess work and uncertainty. But the guess or conjecture has to conform to a good deal of available evidence as well as to basic laws of physical sciences. This creates a certain amount of confidence in the suggested theory of the origin of life on our planet. Thus, there is general agreement today that life originated about 4 billion years ago, from spontaneous chemical reactions whose ingredients were molecules of non-living substances. This theory is supported by the remarkable fact that all living organisms on the Earth have a similar composition and basic molecular structure.

Objectives

After studying this unit you should be able to:

- describe the various theories regarding the origin of life, and Pasteur's contribution in this context,
- explain the theory of chemical evolution and its scientific basis,
- discuss the theory of biological evolution and the diversity of life forms,
- describe systems view of life, the mechanism of feedback, information and control,
- discuss the concept of life cycles and aging,
- analyse the possibility of life beyond the Earth.

12.2 ORIGIN OF LIFE ON THE EARTH

Man has always wondered how he came into existence, who created him, and why he was created. Curiosity in this connection has been so strong that every ancient thinker, philosopher or "prophet", has tried to give some answer to this question and suggest some mechanism for the creation of life.

According to an ancient Greek idea, life was transferred from "cosmozoa" (life of outer space) to different planets in small units called "spores". These spores had a thick impenetrable covering which prevented loss of water and other necessary components. It was assumed that under favourable conditions of temperature and moisture, these spores gave birth to the initial living organisms on the, as yet uninhabited, planets. This

idea presumes a universal and eternal store house of spores of life, and thus indeed avoids answering the question as to how life anywhere originated in the first place. The Greeks, or anyone else at that time, of course, did not know that the travelling spores would encounter destructive radiations like the ultraviolet and gamma rays in space.

In addition to this, various other theories have been put forward from time to time about the origin of life. Some of them were mere speculations, whereas others have some scientific basis. Let us see briefly what some of these theories are.

12.2.1 Special Creation

One belief, common among people of all cultures, is that all the different forms of life, including human beings were suddenly created by a divine order about 10,000 years ago. These innumerable forms of life have always been the same and will last without change from generation to generation until the end of the world. As we shall see later in this Unit, such a theory of 'special creation' is unsound, because fossils of plants and animals which must have lived a hundred thousand or more years ago have been discovered. In fact, researches show that life existed on the Earth even 3.5 billion years ago. It seems that simple forms of life came into being from non-living matter, and that these forms grew more complex over a period of time.

12.2.2 Spontaneous Generation

If we look around at our everyday environment, we observe that straw, soil, mud, dirt, indeed any sort of refuse or rotting matter is infested with a wriggling, moving multitude of living organisms. Such observations led people to believe that life originated spontaneously from non-living matter. Aristotle (384-322 B.C.), known as the father of biology, maintained that not only worms and insects, but also fish, frogs and mice could spring from suitable breeding materials like filth and moist soil. Even man might have had a similar origin! This theory of spontaneous generation was disproved by the experiments of the French microbiologist Louis Pasteur as late as 1862. It was not easy to dislodge Aristotelian ideas. It took all the ingenuity and experimental skill of Louis Pasteur to disprove the theory of spontaneous generation. Pasteur performed his experiment before a gathering of well-known biologists of the time, who were commissioned by the Academy of Sciences of France to test his hypothesis, that only "life begets life".

For his experiment, Pasteur took two flasks, half filled them with yeast infusion containing a little bit of sugar and heated them so as to kill any living organisms. He sealed the mouth of one of the flasks and left the other open to the air. After a few days, he invited his friends to observe what had happened. To their surprise, they found that the closed flask was still free of any living organism while the open one was infested with living organisms. In fact one of these sealed flask is still kept at the Academy of Sciences in Paris. Even after more than a hundred years, there are no living organisms in it. However, to further remove any doubt that organisms did not grow in the sealed flask due to lack of oxygen, Pasteur repeated the experiment with swan necked flasks which were left open (Fig. 12.1). The gooswan-neck would enable the air to get in, but would prevent any living organisms from getting into the infusion. Again no organisms grew in these flasks.

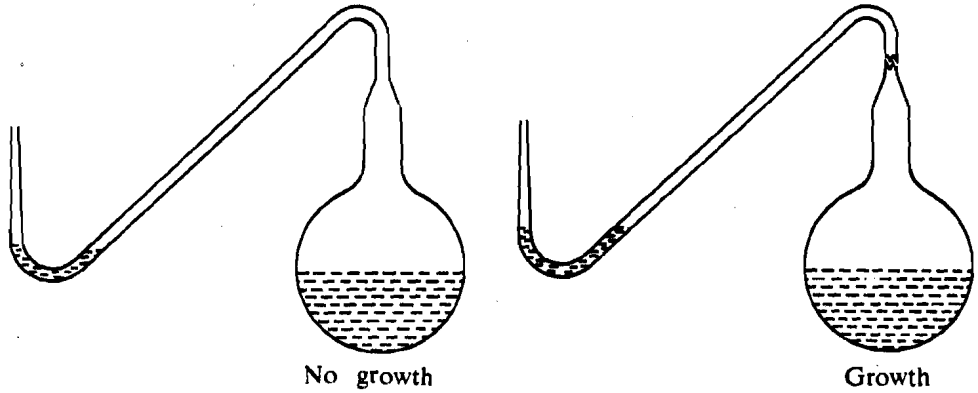

Fig. 12.1: Pasteur boiled broth in flasks with long "swan necks" that admitted air but not dust particles or micro-organisms. When cooled, his broth remained clear until the necks were broken off. Pasteur argued that these experiments disproved the existence of a vital substance in the air.

Pasteur had, thus, shown by these simple experiments that *living organisms do not arise spontaneously.*

Pasteur's studies helped to solve many problems related to brewing of wines. Wine making was an important industry in France at the time and 'souring of wine' or wine going bad was threatening this industry at that time. Pasteur showed that if certain harmful organisms could be kept out during the brewing process, wine would not sour. These studies had a profound effect in another area also, namely that of surgery. Surgical wounds and injuries used to get infected invariably. So much so, that if one did not die of injury, one would certainly die of infections caught from surgical instruments, bandages etc. Taking Pasteur's work as the basis, it was postulated that if the wounds could be kept 'clean', i.e. if disease producing germs could be prevented from getting into a wound, it would not get infected and would heal better.

12.2.3 Chemical Evolution

The question of how life came into being in the first place still remained unanswered. To find an answer to this question means looking back billions of years in time and trying to imagine what the conditions on the earth could have been like, when life first appeared. Soviet biochemist, Oparin, and the British biologist, Haldane, tried to do just that. They proposed that "life could have arisen from non-living organic molecules".

In other words, to understand the problem of origin of life, one must have a knowledge of the origin of 'organic molecules' on the earth. In the early stages of its development, with the hot gases condensing and molten matter which was solidifying to form what are rocks, today, the Earth acted as the huge factory, producing many kinds of compounds. The sources of energy available for the formation of numerous type of molecules were cosmic rays, ultraviolet radiations, electrical discharges such as lightning, radioactivity, and heat from volcanoes and hot springs. Molecules of all sorts were being continuously created and destroyed due to their state of agitation. The lighter gases of the atmosphere such as hydrogen, helium, oxygen, nitrogen, etc.. escaped into space unless they could combine with other elements to form liquids or solids. In such cases they remained on the earth. In particular, oxygen could not remain as free oxygen. It combined with other elements to form compounds. For example, hydrogen and oxygen combined to form water vapour, and remained in the Earth's atmosphere. Similarly, oxygen combined with calcium and carbon to form calcium carbonate, i.e. limestone. Again, nitrogen, hydrogen and oxygen combined together to form ammonium nitrate. Compounds of carbon and hydrogen were also formed sometimes along with nitrogen or oxygen. These compounds are, today, called "organic compounds".

The Earth had at the same time started cooling down. As the Earth cooled sufficiently, torrential and prolonged rains were caused due to condensation of steam. The rains began to accumulate in the depressions on the earth and so the oceans were formed. These hot bodies of water contained abundant and varied organic compounds washed down from the atmosphere. Continued interaction among these compounds in the warm waters resulted in the formation of yet more compounds. The waters of this stage of the Earth's development have been referred to as "hot dilute soup", which amongst other things also contained "amino acids" having a composition of carbon, hydrogen, nitrogen and oxygen. The molecules of amino acids combined together to form large complex molecules, the "proteins" which are the building blocks of life.

Self replicating molecule, i.e., they could make from chemical substances around them, other systems like themselves.

It is from this accumulation of complex organic molecules that the first extremely simple **self-replicating molecular systems** accidentally originated. Because of the property of self-replication, they are called living organisms. The Sun's deadly ultraviolet (UV) radiations would have killed any exposed living molecules unless they were under the protective cover of water. Such primitive life also had a very limited food supply, since it depended on the slow sinking of organic materials synthesised by radiation in the upper layers of water. Thus, for millions of years, life must have existed under these special conditions. Again, random combinations may have led to the formation of chlorophyll containing organisms which could produce their own food by a process called **photosynthesis**. Such organisms had a better chance of survival. During the process of photosynthesis, light from the Sun helps to synthesise carbohydrates like sugar and starch out of carbon dioxide and water. Oxygen is given off in the process. As such organisms grew and photosynthesis proceeded, the atmosphere grew richer in

free oxygen. As we shall see, this had a profound effect on the course of subsequent events.

The primitive earth's atmosphere was devoid of free oxygen and contained mostly carbon dioxide, methane, ammonia, water vapour etc. It was only the photosynthetic process initiated by cyanobacteria about 2 million years ago, that led to release of free oxygen in the universe.

Oxygen when acted upon by ultraviolet radiation, forms ozone, a gas through which ultraviolet radiation cannot pass. This happens at a height of about 25 km above the surface of the earth, giving a protective 'ozone layer'. We have, therefore, the happy chain of events—more photosynthesis, more oxygen produced. And in its turn, more ozone produced out of oxygen in the atmosphere, screens the earth from the ultraviolet radiation of the Sun. This allowed living organisms to come to the surface of water and to survive even on land, if they got thrown out of the swirling and splashing water. The oxygenation of Earth's atmosphere was very significant from biological point of view, as organisms of greater complexity and even intelligence could eventually arise.

12.2.4 Miller's Experiment

The above theory could be tested by recreating in the laboratory on a small scale, the conditions which must have existed when life originated on the earth.

Fig. 12.2: Stanley Miller shown with his apparatus which demonstrates amino acid synthesis in a condition that prevailed on the earth before life came into being.

Miller, an American biologist (Fig. 12.2) subjected a gaseous mixture of methane, ammonia, water vapour and hydrogen in a closed flask at 80°C to electric sparking, for a week. This mixture, with its temperature, and electric discharge through it, represented a situation that might have prevailed on the earth before life came into existence. When the contents of the flask (Fig. 12.3) were examined a week later, they were found to have amino acids which are essential for the formation of proteins. As we have said before, proteins are the essential building blocks for living organisms. With the making, in the laboratory, of molecules related to life, the credibility of the Oparin-Haldane theory of chemical evolution greatly increased. Many amino acids have been obtained, since by this method. So also some sugars and nitrogenous bases which are otherwise found in the nucleus of a cell, which is a unit of living organisms. Similar experiments have led to the production of various compounds which form many kinds of fats and important natural pigments. Miller's experiment thus forms a turning point in our approach to the problem of the origin of life.

The evidence, we get from Miller's experiment, is supported by evidence of similar chemical reactions occurring in space even today. Chemical analysis of a meteorite which fell near Murchi Murchison in Australia, in 1969, showed the presence of organic molecules. The types and relative proportions of these molecules were very similar to the products formed in Miller's experiment. The presence of organic molecules like methane, ethane, formaldehyde, acetylene etc. has been shown in interstellar space by radioastronomy also.

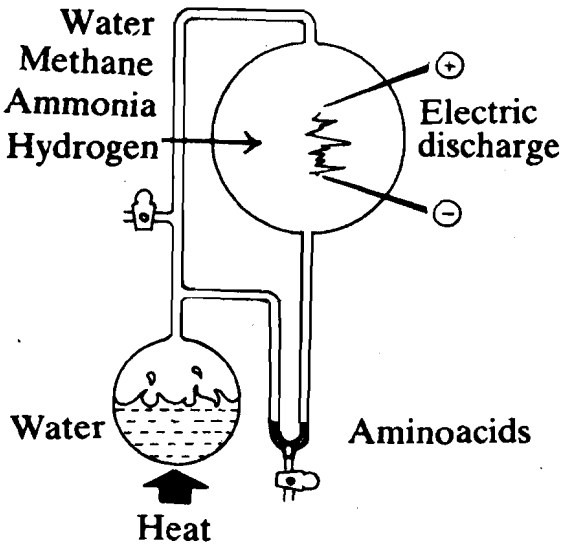

Fig. 12.3: A typical experiment simulating conditions on the primitive earth. Water is heated in a closed apparatus containing methane, ammonia and hydrogen and an electric discharge is passed through the vaporized mixture Organic compounds accumulate in the U-tube trap.

SAQ 1

i) In the table given below, we list some of the theories related to the origin of life and some features of the theories. Match the features with the corresponding theory.

Theories		Features	
a)	Theory of spontaneous generation	1	Cosmozoa or Spores were transferred to many planets from outer space.
b)	Theory of special creation	2	Oparin and Haldane gave independently the idea that life on the earth may have originated from preformed organic molecules.
c)	Theory of chemical evolution	3	Innumerable forms of life were created by the Divine Act.
d)	Ancient Greek idea	4	Living organism are produced from rotting food and other organic matter.

ii) Some incomplete statements regarding evolution of life on the earth are given below. Complete them by choosing the right word from the parenthesis.

a) A theory related to the origin of life such as the..... theory of chemical evolution could be verified experimentally.

b) Miller subjected a gaseous mixture of methane, ammonia, water vapour and hydrogen in a..... flask at 80°C.

c) When the contents of the flask were examined, they were found to have ..... which are essential for making of proteins.

d) Similar experiments in the laboratory led to the production of various ..... which form many kinds of fats and natural pigments.

(compounds, closed, amino acids, Oparin-Haldane)

12.3 BIOLOGICAL EVOLUTION

In the previous section you have seen how life could have originated on the Earth. You have also seen how, as the conditions on the Earth changed, more and more complex life forms evolved. We can presume that biological evolution began with the formation

of the first true cells. These must have been forms that did not require free oxygen and lived at the expense of organic molecules available in the waters that surrounded them. Eventually, as nutrients were depleted, the first cells capable of using carbon dioxide and energy from light, to make their own food through photosynthesis must have arisen. Today, the diversity of plant and animal forms we have, ranges from simple single celled organisms to many kinds of plants on one side and animals including man on the other. Today, we have millions of 'species' of living forms on our planet. There is evidence, that all the life forms are inter-related and also that the higher forms have evolved from the lower ones. We will study more about this in the next unit—Evolution of Man. The study of these millions of species, individually would be a cumbersome task. Therefore, it is necessary to classify them in groups according to their evolutionary relationships and similarities in form and function.

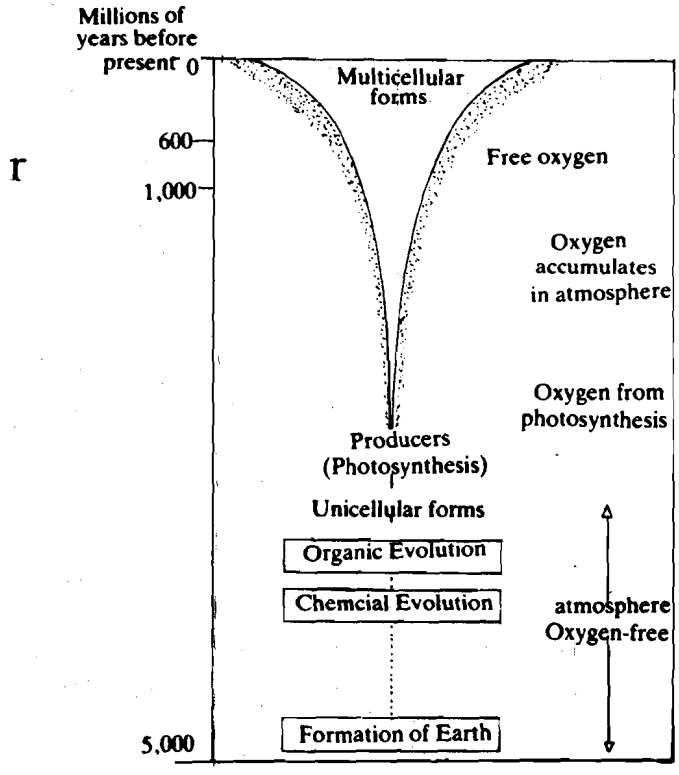

Fig. 12.4: Diagrammatic representation of major events in history of life on earth.

Today, most biologists recognise five categories or kingdoms of living organisms shown in Fig. 12.5. The first category, Monera, consists of the most primitive single celled organisms. These alone were present in the beginning for about 2 billion years. These cells do not have a nucleus and are represented today by the bacteria and cynobacteria (formerly known as blue green algae). The second, Protista evolved about 1.5 billion years ago and consists of single celled organisms containing a nucleus. Algae, protozoans and slime moulds belong to this kingdom.

You must have seen mushrooms sprouting under the trees during the rainy season. These, and the unicellular yeast are members of the Kingdom Fungi. They are placed in a separate kingdom because they are one of the most complex organisms that feed on decaying organic matter. Some fungi are also parasitic causing serious diseases in plants, animals and human beings while some fungi have given us the most useful group of medicines—antibiotics. You must have heard about penicillin, streptomycin etc., these are produced by fungi. The next two kingdoms, Plants and Animals, evolved later as a result of adaptations to the changing environment of the earth. Plants began to evolve about 600 million years ago and most of these organisms possess a green pigment, chlorophyll, which helps them in manufacturing their own food by the process of photosynthesis. They first appeared in the seas as unicellular algae. The green algae are believed to be ancestral links to the land plants like gymnosperms, i.e. nonflowering plants sand angiosperms or flowering plants. Today, these plants have diversified and increased in numbers tremendously.

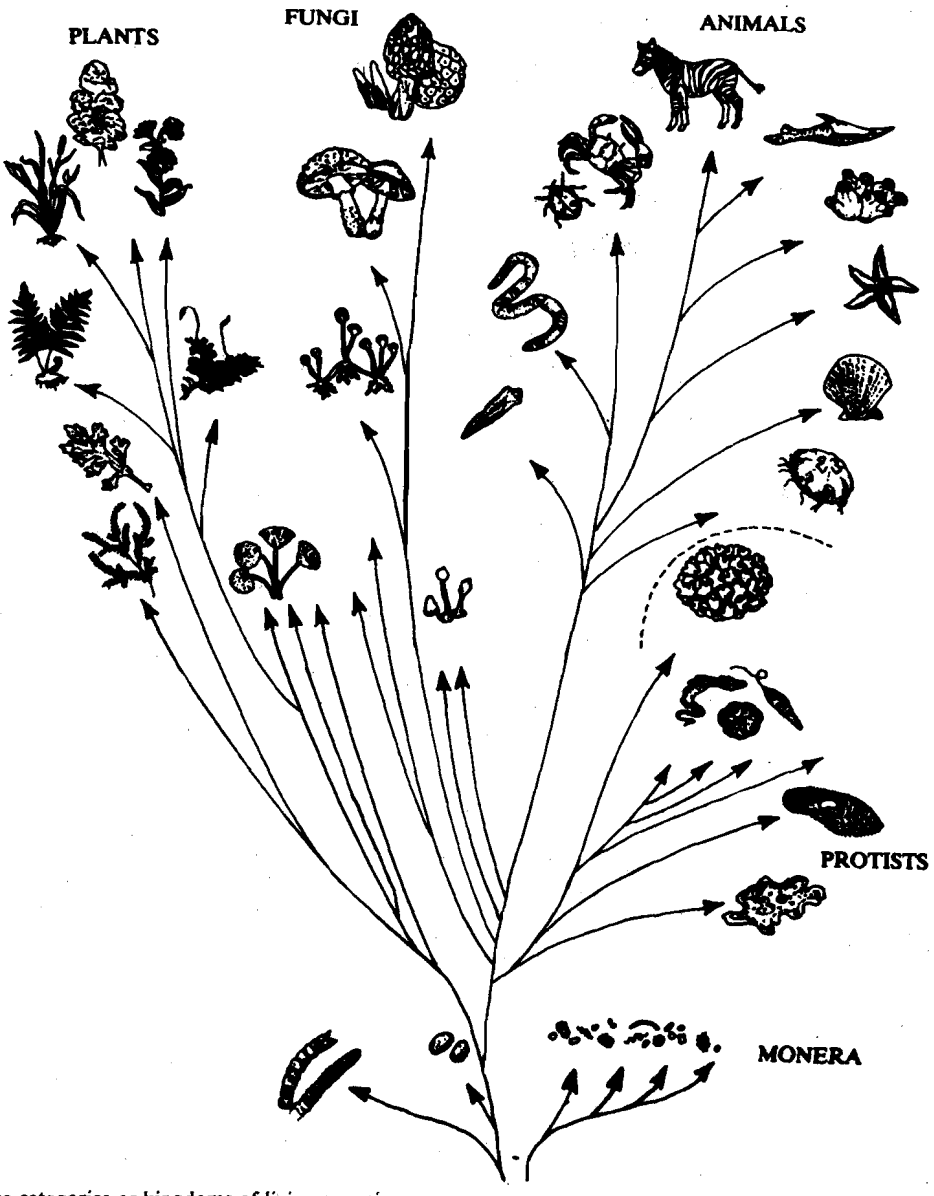

Fig. 12.5: Five categories or kingdoms of living organisms.

While plants are multicellular organisms which synthesise their food through photosynthesis, animals are multicellular organisms that survive on food produced by the plants. The animals are divided into invertebrates or animals without a backbone and vertebrates, i.e. animals with a backbone. It is possible to arrange the various animal groups so that one can see an increase in their complexity. The insects and worms are invertebrates, while the fishes, frogs, toads, snakes, birds, and mammals like cows, deer, horses, elephants, and even man, all belong to the group—vertebrates.

Thus, we see that organic evolution proceeds slowly and over these billions of years, various species have evolved and have adapted themselves to their environment.

SAQ 2

Some questions regarding the origin and evolution of plant and animal life are given below. Write your answer in the space provided.

i) What was lacking in the first cell?

.....

ii) List the names of some non-flowering plants found in your region or locality.

.....

iii) Name the pigment that plants possess for the manufacture of food.

.....

iv) What are the animals possessing a backbone called?

.....

12.4 SYSTEMS VIEW OF LIFE

You have seen above, that evolution has given rise to various types of life forms from single celled bacteria to organisms as complex as a human being. It may interest you to know, that even the simplest of these organisms is able to carry out various life processes like, taking in food, excreting waste material, reacting to stimuli and reproducing offsprings. It is able to survive in varied environments. Let us see how an organism is able to do this.

The characteristics, which we recognize as life, are in fact an expression of the coordinated working of various parts in the organism. Various parts in an organism, whether plant or animal are not haphazardly put together but are organised into systems.

A system is a set of some specific inter-related parts which are organized as one unit for some purpose. The parts work together and the entire combination forms one unit. A car producing company, which is organized to produce transport vehicles can be viewed as a system too. For the effective functioning of the company, all of its parts, such as the department that purchases raw materials, the factory, the management and the sales department must work in unison. An animal or a plant is also made up of numerous parts which represent a well defined system. For example, in an animal body, the parts concerned with the in-take of food and digesting it, the bones arranged as a skeleton to support the body, the heart circulating blood to different parts of the body through the arteries and veins and the brain receiving signals and giving orders of various kinds together compose the system.

The assemblage of all plants and animals in an environment provided by each other as well as by the land, air and water works collectively. The way these diverse forms of life depend on each other makes one imagine this planet itself as a huge system. Looking at it in another way, the life and environment of the earth are a well coordinated system, within which there are sub-systems like individual organisms. And within each of these sub-systems, a single plant or animal, one would find a complex multicellular system. Similarly, industrial, agricultural or educational systems can be visualised as the sub-systems in the society.

Organic systems maintain themselves in a given composite form and function. For example, a cat remains a cat, it prowls for food, it may lay kittens, but its internal system functions on the basis of physical principles with stability. How is this stability maintained by a system? Let us take a specific example; how does a man or woman maintain this internal stability while the environment around them changes. For instance, how do they maintain a fixed temperature of 37°C, or the composition of their blood or the blood pressure? It has been found that all organisms possess a kind of information and control network which directs them to adjust to various situations for survival, e.g., if you touch a snail, it withdraws into its shell. This is a kind of information and control device for protecting its life. If you sit in the Sun and you feel hot, a signal which is internally generated causes perspiration and produces cooling by evaporation of the sweat. This is another example of information and control for maintaining a fixed body temperature.

You will find that all organisms possess a network of information and control which may be very simple or at times quite complicated. Without it, neither the survival of an organism nor its existence in a stable physical condition is possible.

A whole science of "cybernetics" has developed to study information and control in a general way. This is because, even machines have to be so designed as to work with stability. You must be familiar with a device called a voltage regulator which is used with a television set or a refrigerator. If at any time the voltage becomes higher than a

fixed value the voltage regulator brings it back to that value. Thus, the voltage supplied to the TV or refrigerator remains stable.

Another example is prevention of fire in buildings particularly offices, hotels, etc. Here a technique is used to measure the temperature of the rooms and in case of a sudden rise in temperature in a particular room a valve opens to sprinkle water from the ceiling. This is automatic protection against fire.

If we just think about it, the basis of information and control is that any deviation or "difference" from some "normal" value is detected and this generates a signal to correct the difference. Thus, difference, deviation or error being used to correct the error, is at the heart of all stable systems. One can also call it a "feedback" arrangement, which means, feeding the error back into a control so as to reduce or correct the error.

Living organisms have remarkable capacity to regulate their own lives according to the changes around them. They maintain a normal external and internal structure and environment in spite of the change in the outside surroundings. This state of constancy which is vital for life is known as 'homeostasis'.

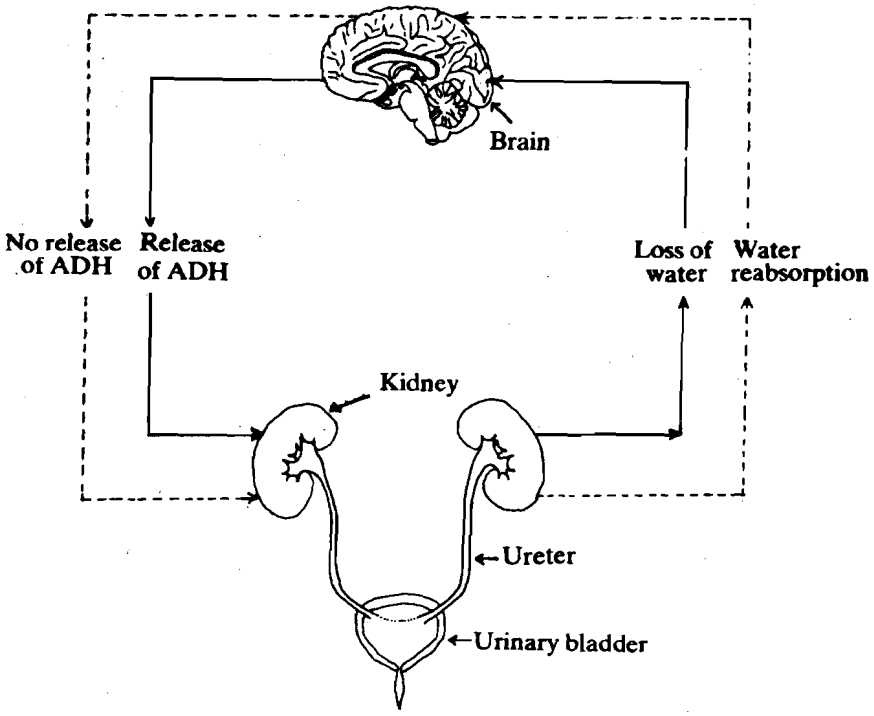

Fig. 12.6: Feedback mechanism which checks the loss of water from the kidneys.

We will give you just one example of the feedback system in the human body which maintains the right amount of water in the blood (Fig. 12.6). Kidneys are able to control or check the loss of water from our body. For this, water is reabsorbed by the collecting tubes in the kidneys so as to prevent its undue loss in the form of urine. This absorption of water is under the control of a chemical called anti-diuretic hormone (ADH), which is produced by specialized nerve cells in one of the parts of the fore brain. If more water begins to be lost by the body due to greater evaporation during summer, a decrease of water in the blood will take place, changing its internal environment for which our body is very sensitive. At the time of need a positive signal to the brain causes the production of this particular chemical (ADH) which increases the absorption of water in the kidneys and reduces excretion of urine. The absorbed water gets back into the blood to maintain the normal concentration of the fluid.

SAQ 3

Statements given below speak about life systems. Fill in the blanks by using words given in the parenthesis.

i) The various parts in an ..... whether plant or animal, are not put together haphazardly but are organized into .....

ii) All the organisms possess a kind of ..... and ..... network.

iii) Cybernetics is a study of information and control in a general .....

iv) Kidneys are able to control or check the ..... of water from our body.

v) They send a signal to the brain to cause the production of the particular chemical ..... which increases absorption of water in the ..... and reduces the flow of urine.

(ADH, organism, way, loss, information, control, kidneys, systems)

12.4.1 Life Cycle

The idea that an organism is a system, consisting of various parts, that function to maintain its internal environment throughout its life time is an important concept in biology. But how is this system formed?

In its life time an organism passes through certain recognizable stages like birth, growth, reproduction and death. We see around us plants sprouting from seeds, growing, bearing fruit and ultimately drying up. Children are born, grow to adulthood, marry, have children of their own, grow old and die. *The series of events which occur from the time an organism is born to the time it dies, constitute a life cycle.*

The parents die and disappear but the progenies continue to repeat the life cycle, generation after generation. This continuity of generations is made possible by reproduction. Primitive organisms like bacteria, algae, protozoa, etc. reproduce by simple division of the unicellular parent into smaller cells of approximately equal size, each of which then grows to the size of the parent. Some organisms develop a small outgrowth or 'bud' which gets separated from the parent body and develops into an individual. In some lower animals, the body of the parent breaks into several parts and each part develops into a complete organism.

The common feature of all the processes described above is that only a single parent is involved and as such all the offsprings produced are alike. This method of reproduction is called 'asexual reproduction'. Interestingly, asexual reproduction prevails only in the lower animals and in some plant groups. Man has used this to his advantage in plant breeding or horticulture. For instance, one can get a new rose plant by simply cutting a branch and growing it separately. This method is extensively used in growing some economically important plants, like several varieties of citrus fruits, lemons, oranges etc. It has been found, that plants produced in this way mature faster and bear fruit earlier than those grown from seeds.

Evolution, as we now know, is dependent upon individual variations due to interaction of heredity with environment. These variations are inherited by the process of sexual reproduction which involves two parents. Most animals and plants reproduce by this method. The male parent produces a highly specialized cell called 'sperm' and the female produces 'ovum' or 'egg'. These cells also called 'gametes' are different from other body cells in having half tl n''mber of 'chromosomes'. Chromosomes are the chemical structures which carry infoi..'tion for all the life processes. These two cells, sperm and ovum, unite b,' a process called fertilization, to form a new cell called 'zygote'. The general pattern of development from zygote to many-celled organism is basically the same for every animal and plant. In the first stage of development the single-celled zygote divides, and the subsequent cells continue to divide repeatedly while adhering to one another. These cells finally become specialized for the formation of various organs. For example during the course of development, a few cells become specialized for the formation of liver. These cells begin to multiply and give birth to millions of cells so as to form a liver. Likewise, differentiated brain cells give birth to complicated structure of brain in an organism. Other organs are also formed in a similar way and become different parts of the organism. After the organism obtains maturity, aging starts with the passing of time.

12.4.2 Aging

Aging simply means the process of growing old or the process of progressive deterioration in the structure and function of the cells and organs of the body.

Aging is an integral part of the life cycle of an organism. Even if an individual meets no fatal accident, or is not eaten up by other organisms or does not suffer a killing disease, death still comes as the natural final result of old age. We are all familiar with the symptoms of aging in man, some of which are dry and wrinkled skin, brittle bones, reduced blood circulation and thin shrivelled body. These outward signs of aging are the result of changes taking place within the cells and the loss of ability of cells to divide.

During a life time, millions of cells are destroyed and replaced rapidly by the process of cell division. When more cells are destroyed than are replaced, aging takes place. The ability of cells to divide is fixed and is always characteristic of an organism. This explains why some animals age more rapidly than others and have shorter life span than others.

The division rate of different body cells is also specific. In human beings, the cells forming the skin are continually destroyed and rebuilt, while the cells constituting the brain undergo no division at all from a time about 5-6 years after birth. Thus, the different cell types within the same individual age at different rates.

In recent years, much attention has been paid to study the process of aging, and how to slow it down. If this could be done and we could remain active physically and mentally for longer periods of life span, it would be wonderful. Wouldn't it? Physical exercises which counter sluggish blood circulation and other body processes are known to be of some help. Some drugs, which can slow down aging, are also being experimented with.

SAQ 4

Tick mark the right answer in the space provided.

i) Asexual reproduction is carried out by participation of
   a) both the parents ( )
   b) single parent ( )

ii) In sexual reproduction gametes are formed by
   a) doubling the number of chromosomes ( )
   b) reducing the number of chromosomes to half ( )
   c) no change in the number of chromosomes ( )

iii) Aging is caused by
   a) retardation of growth of brain cells ( )
   b) wrinkling of skin ( )
   c) defects in function of the cells ( )
   d) deterioration in structure and functions of the cells and organs of the body on the whole ( )

12.5 EXTRA-TERRESTRIAL LIFE

Just as we have been curious about how life originated on the Earth, we have also tried to explore whether there is life on any other planet in the Solar System or elsewhere in the universe.

Explorations of outer space carried out by spacecraft and ground based observatories, in recent years, have led us to the conclusion that in the entire Solar System, the planet Earth is, perhaps, the only place where there is life. The other planets are at such a distance from the Sun that they are either too hot or too cold for life to exist. The one close possibility is the planet Mars. Space probe Viking collected and analysed samples of rock and soil from Mars (Fig. 12.7) to detect the presence of life. But so far no conclusive evidence of any life, present or past, has been found on this planet.

Man is also looking for life beyond the Solar System. Two approaches are currently available to him; either to send a man or an instrument to a particular star in the Universe and examine local surface for life or to listen to the signals from outer space which may come in the form of radio waves. With our present technology, the first approach does not take us beyond the Solar System. The second approach is based on the assumption that there may be civilisations technically as advanced or even more advanced than our own. So we can exchange radio messages with them. We have

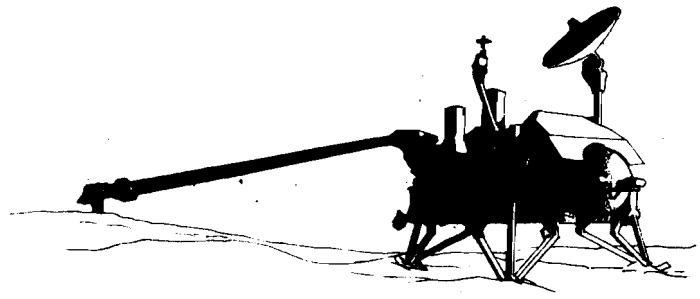

Fig. 12.7: A Viking Lander which analysed rock and soil samples from the planet Mars.

drawn a blank so far on this front. But it is quite possible that our galaxy, the entire system of dust, gases, and stars within which the Sun moves, is already filled with chatter between the far older and more advanced civilisations! These signals may have been transmitted by a technique still undiscovered on Earth, so we may be missing them altogether! Recently it has been reported that astronomers have found some other stars, like our Sun, which have planets. If this is proved to be true, there may be millions of planetary systems in the Universe, increasing the likelihood of life existing on some of them.

12.6 SUMMARY

In this unit you have learnt:

- about various theories which have been put forward to explain the origin of life on the Earth, and how Pasteur, through a well designed experiment showed that living organisms alone can produce other living organisms,
- the Oparin-Haldane theory of chemical evolution and the support it got from Miller's experiments,
- how biological evolution started with the formation of the first cells and the role photosynthesis played in the release of free oxygen and formation of ozone layer in the atmosphere. With this change in the earth's atmosphere tremendous diversification of life forms, both plants and animals became possible.
- the systems view of life and the ability of living organisms to maintain their form and function in changing environments,
- the life cycle or the various phases through which an organism passes from the time it is born to its death and the phenomenon of aging.

12.7 TERMINAL QUESTIONS

1) In what way the concept of spontaneous generation of life was discarded by the works of Louis Pasteur.

2) Explain briefly the impacts of Miller's experiment on the classical theories of origin of life.

3) Can the deviation in normal state of living being be corrected? Describe your answer in short.

4) Are there any devices known to obtain the information about extra-terrestrial life? What are they?

12.8 ANSWERS

Self Assessment Questions

1) i) a) 4 b) 3 c) 2 d) 1
   ii) a) Oparin-Haldane b) closed c) amino acids d) compounds
2) i) nucleus ii) cycas and pine trees iii) chlorophyll iv) vertebrates
3) i) organism, system ii) information, control iii) way iv) loss, ADH, kidney
4) i) a ii) b iii) d

Terminal Questions

1) Pasteur demonstrated by setting experiments that it is not the rotting food and other organic matter that produces living organisms but rather that the rotting and fermentation are caused by micro-organism.
2) Miller took a gaseous mixture of methane, ammonia, water vapour and hydrogen in a closed flask at 80°C subjecting the flask to electric discharge for a week. This represented the early atmosphere of the earth. Analysis of product formed thus revealed the formation of organic compounds known to occur in living organisms. This experiment supported the theory of chemical evolution given by Oparin-Haldane.
3) Living organisms are provided with mechanisms which conceive of changes from the normal state and once the change is detected, it is corrected through a mechanisms of feedback.
4) The other planets are so far away from the Sun and from one another that currently only two ways are available for man either to land a manned or unmanned space craft or to obtain signals from the outer space with the help of special instruments devised for this purpose.