314en01

1

ORIGIN AND EVOLUTION OF LIFE AND INTRODUCTION TO CLASSIFICATION

The planet earth came into existence sometime between 4 and 5 billion years ago. Life evolved on planet earth about 3.5 billion years ago. Since then, approximately 15 million different species of organisms have evolved. But only about two million have been identified so far. In this lesson we will learn how life of these, at first originated on earth and how such a vast variety of organisms, popularly known as biodiversity, evolved through variation and natural selection.

The study of such a wide variety of organisms becomes convenient only when they are grouped according to similarities and differences, named, and their evolutionary relationships established. We will also learn about the importance and method of classification of organisms in this lesson and understand the position of viruses and viroids vis-a-vis the web of the living world.

OBJECTIVES

After completing this lesson, you will be able to :

- *describe the widely accepted 'theory of origin of life';*
- *explain what is organic evolution;*
- *give morphological, palaeontological, embryological and molecular evidences in favour of organic evolution;*
- *state modern theory of evolution;*
- *explain the sources of organic variations (gene and chromosomal mutations, recombination, gene flow and genetic drift);*
- *explain natural selection with examples;*
- *explain the role of isolation in evolution;*
- *list the various isolating mechanisms;*
- *explain speciation;*
- *understand Hardy–Weinberg Equilibrium to relate genetics and evolution.*
- *define classification;*

- *justify the need for classification of organisms;*
- *list the bases of classification;*
- *trace the changes in bases of classification from morphotaxonomy to systematics.*
- *State the position of virus and differentiate between virus and viroids.*

1.1 ORIGIN OF LIFE

The earth was formed about five billion years ago. At that time it was extremely hot. The existence of life in any form at that high temperature was not possible. As such, two questions arise pertaining to life:

1. How did life originate on earth?
2. How did primitive organisms evolve into new forms resulting in the evolution of a variety of organisms on earth.

Origin of life means the appearance of simplest primordial life from non-living matter.

Evolution of life means the gradual formation of complex organisms from simpler ones.

1.1.1 Chemosynthetic Theory of Origin of Life

Several theories have been put forth to explain the origin of life. The widely accepted theory is the Chemosynthetic theory of origin of life, proposed by A.I. Oparin. Other theories such as the theory of Spontaneous Generation are of historical importance only.

Chemosynthetic Theory

Life might have originated at first on earth through a series of combinations of chemical substances in the distant past and it all happened in water.

- The earth originated about 5 billion years ago.
- It was initially made up of hot gases and vapours of various chemicals.
- Gradually it cooled down and a solid crust was formed.
- The early atmosphere contained ammonia (NH_3), water vapour (H_2O), hydrogen (H_2), methane (CH_4). At that time there was no free oxygen. This sort of atmosphere (with methane, ammonia and hydrogen) is still found on Jupiter and Saturn (Fig. 1.1).
- Heavy rains fell on the hot surface of earth, and over a very very long period the water bodies appeared that still contained hot water.
- Methane and ammonia from the atmosphere dissolved in the water of the seas.
- In this water, chemical reactions occurred and gave rise to amino acids, nitrogenous bases, sugars and fatty acids which further reacted and combined to give rise to biomolecules of life such as proteins and nucleic acids.

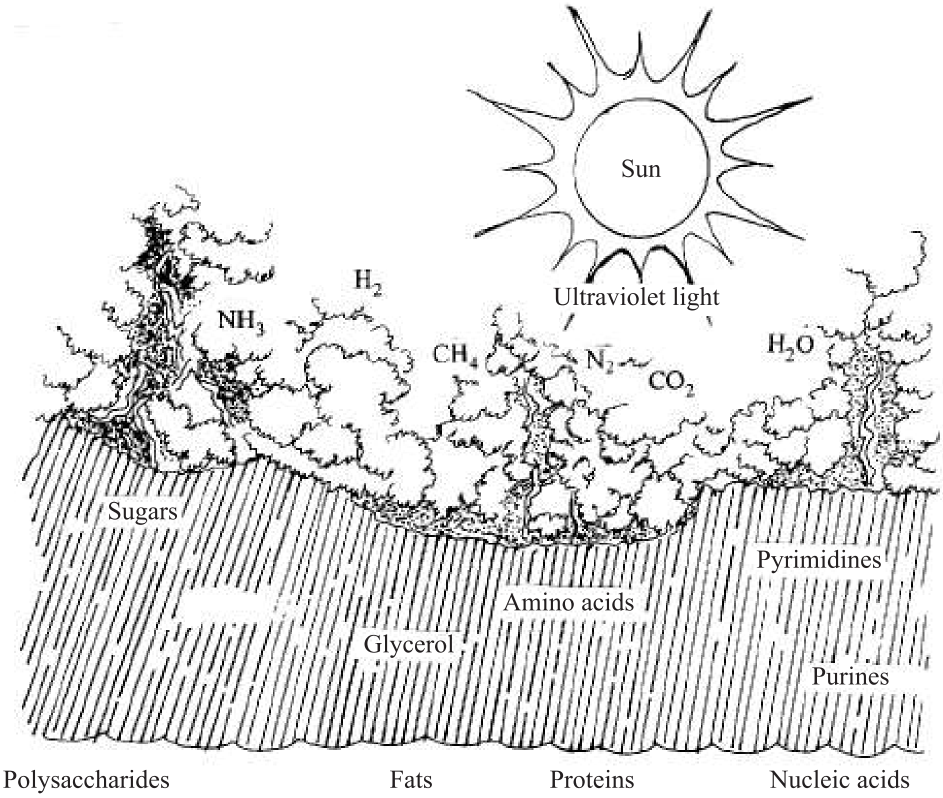


Fig. 1.1 Primitive conditions on earth

1.1.2 Probable stages in the origin of life

First stage

The sources of energy were the ultraviolet rays or electric discharge (lightening) or heat. Either alone or a combination of these energy sources caused reactions that produced complex organic compounds (including amino acids) from a mixture of ammonia (NH_3), methane (CH_4), water (H_2O) and hydrogen (H_2). The amino acids are the building blocks of proteins which are the main components of protoplasm.

> Stanley Miller and Harold C. Urey in 1953 set up an experiment with an air-tight apparatus (Fig. 1.2) in which four gases (NH_4, CH_4, H_2 and H_2O) were subjected to an electric discharge for one week. On analyzing the liquid, they found a variety of organic substances in it, such as amino acids, urea, acetic acid, and lactic acid (Fig. 1.2).

Second Stage

Simple organic molecules combined to form large molecules which included peptides (leading to the formation of proteins), sugars, starch and fat molecules.

Third stage

The large molecules of different kinds combined together to form multi-molecular heaps or complexes. Some simple fat molecules arranged themselves around this molecular complex in a sort of membrane. It was observed in the laboratory experiments that when such complexes reached a certain size they separated from the surrounding solution in the form of what were termed "**coacervate drops**" of microscopic size, moving in the liquid with a definite boundary (**coacervate means "heap"** referring to the combining together of the molecules).

Coacervate like aggregates were probably the precursors of the first living cells.

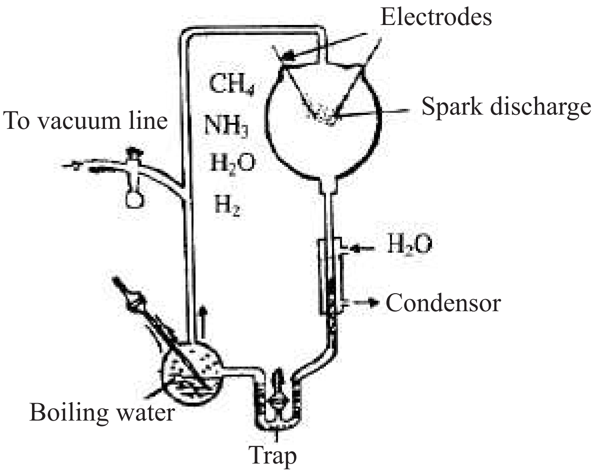


Fig.1.2 The apparatus used by Stanley Miller and Harold C. Urey to demonstrate the synthesis of amino acids under conditions that existed on the primitive earth

Now, some sort of "metabolism" could occur within these coacervates with synthesis of certain substances and breakdown of others. The latter (i.e. breakdown reactions) could provide energy.

Some of the earliest formed proteins might have acted like enzymes and would have affected the rates of reactions. It is also believed that RNA molecules might have shown enzymatic activity in the "primordial soup" of chemical compounds. Such molecules have been termed **ribozymes.**

Fourth stage

Some sort of nucleoproteins or nucleic acids may have evolved by random combinations which have provided two more properties to coacervate–like bodies. These include :

(i) chemical reactions from the nucleic acids, and

(ii) the capacity to reproduce through duplication of the nucleic acids (Fig. 1.3).

Thus, cells were produced that could be called the simplest primordial life. Figure 1.3 depicts the probable stages of origin and evolution of living beings.

The primitive "drop"–like forms of life were all heterotrophs, unable to manufacture their own food but derived it from environment.

One of the innumerable changes in genetic make up of the primitive heterotrophs led to the formation of chlorophyll (green colouring matter of the leaves) molecules.

– The chlorophyll–bearing units of life for the first time started using solar energy for production of food as well as for the first time started liberating free oxygen into the atmosphere.

> Early atmosphere of earth had no free oxygen, the forms until then could at best be only "anaerobic". Chlorophyll–bearing organisms later released free oxygen which gave greater possibilities for life to evolve.

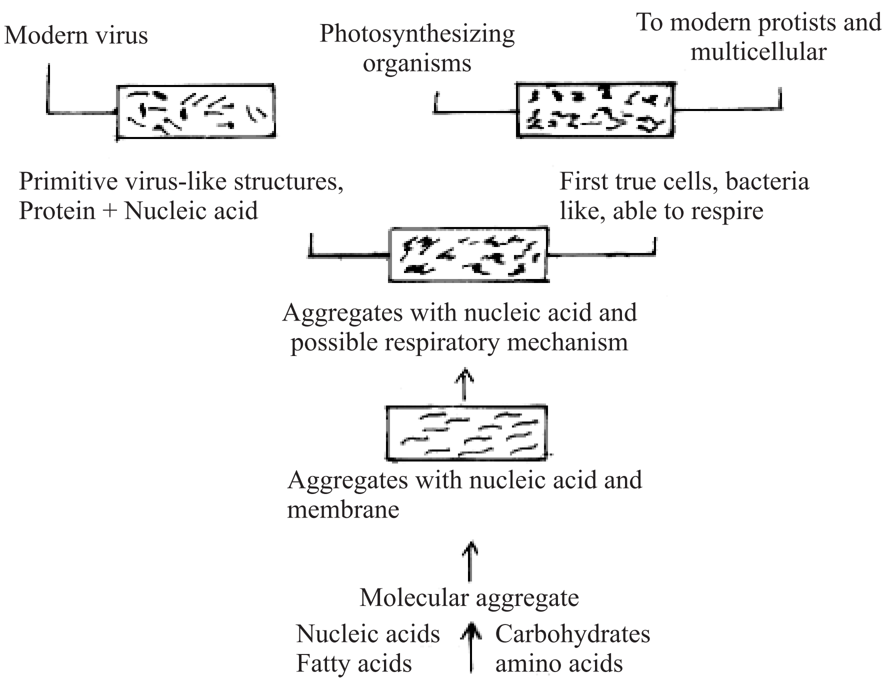


Fig. 1.3 Steps of the events which led to the origin of life

Thus, the simplest form of life originated through four main stages. Thereafter, a wide variety of organisms came into existence through **biological evolution**.

INTEXT QUESTIONS 1.1

1. Approximately how many years ago was the earth formed?

   ....

2. Who gave the Chemosynthetic Theory for origin of life?

   ....

3. Name the four gases present in the primitive atmosphere of the earth.

   ....

4. Name one source of energy which was used for chemical combination in primitive atmosphere.

   ....

5. Where did life originate in water or on land?

   ....

6. What are 'coacervates'?

   ....

7. In the origin of life, first large molecules were formed from inorganic compounds. Name any two such large molecules.

   ....

8. Name the two scientists who experimentally tried to verify Oparin's hypothesis.

   ....

1.2 ORGANIC EVOLUTION

1.2.1 What is Evolution ?

The formation of complex organisms through 'gradual change' from simple ancestral types over the course of geological time is termed Evolution or Organic Evolution.

According to the Theory of Organic Evolution

- The various present day organisms were not created in the same form in which they exist today, but have gradually evolved from much simple ancestral forms from a common ancestor.
- The characteristics of organisms had been changing in the past; they are changing even today, and will continue to do so in the future as well. This is due to the fact that the environment in which organisms live also changes and organisms need to adapt to the changed environment in order to survive.
- Several living organisms of the past have become extinct.
- The origin of the various forms (species) found on earth has been a gradual and extremely slow process, requiring hundreds or even thousands of years. However, the evolution of black peppered moth or polyploid varieties of some crops or pesticide resistant mosquitoes happened in much shorter periods of time.

This process of slow and gradual change is called Organic Evolution.

> The theory of organic evolution states that "All living things on earth are here as a result of descent, with modifications from a common ancestor".

1.2.2 Evidences of organic evolution

The evidences supporting organic evolution are derived from a number of fields of Biology. Those discussed here are :

1. Morphological evidences
2. Embryological evidences
3. Palaeontological evidences
4. Molecular evidences

1. Evidences from Morphology

Though organisms of different species and groups are quite different from each other, they still retain certain common features. Morphological evidences for evolution are derived from -

(i) Homologous and analogous organs (Fig. 1.4 and Fig. 1.5)

(ii) Vestigial organs

(iii) Connecting links

The comparative study of various organs in different groups of vertebrates exhibit common features which show that they evolved from a common ancestor. Take for example the heart of the vertebrates (Fig. 1.4).

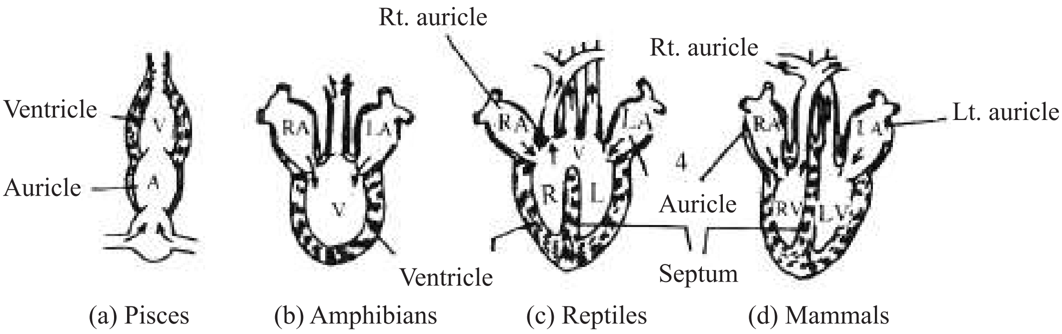


Fig. 1.4 Comparative study of heart of different groups of vertebrates

(ii) Homologous Organs

Homologous organs are the organs which are similar in structure and origin but may look very different and perform different functions.

– Forelimbs of vertebrates are a good example of homologous organs. They are built on the same fundamental plan yet they appear different and perform different functions (Fig. 1.5).

– In each case the forelimb consists of humerus, radius and ulna, carpals, metacarpals and phalanges. This basic similarity in the structure of the apparently different forelimbs of different kinds of vertebrates is due to the fact that all these limbs have evolved from a common type called the **pentadactyl** (five-fingered) limb.

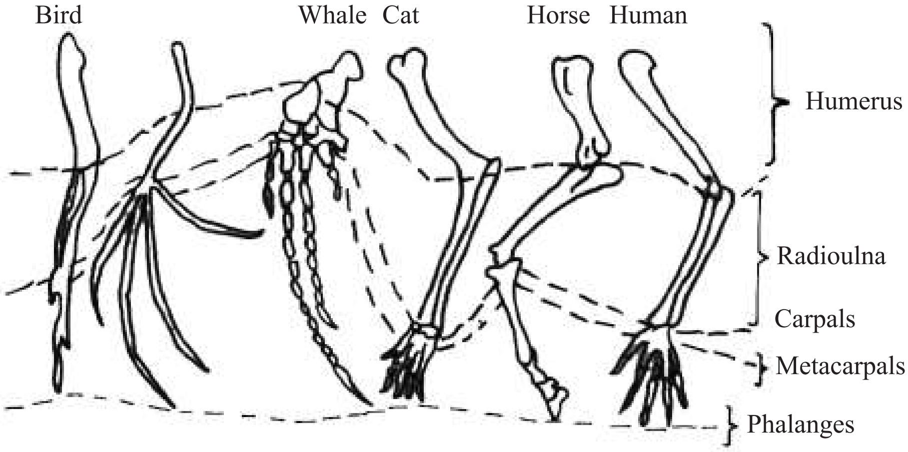


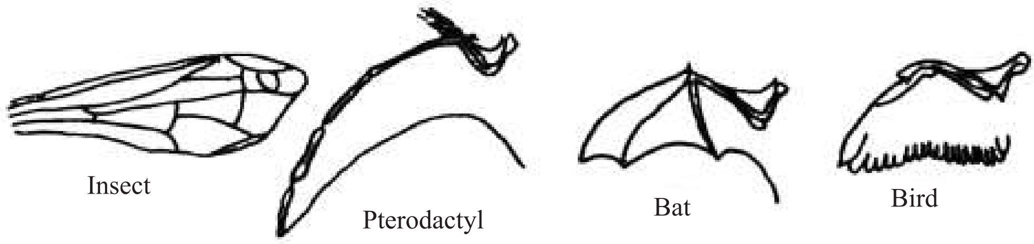
Fig. 1.5 Homology and adaptation in bones of the forelimbs of some vertebrates

The homologous organs, therefore, prove that different kinds of organisms came into existence through evolution.

Analogous organs

The structures which are functionally similar but structurally different are called analogous organs.

The wing of an insect, and that of a bird or bat or pterodactyl are examples of analogous organs (Fig. 1.6). The function of the wing is the same (for flying) but the insect wing has no structural resemblance with that of the vertebrates.



(a) Wing of insect (b) Wing of bird

Fig. 1.6 Analogy between wings of insects and of different vertebrates

(iii) Vestigial Organs

Vestigial organ is any small degenerate or imperfectly developed (non-functional) organ or part which may have been complete and functional in some ancestor.

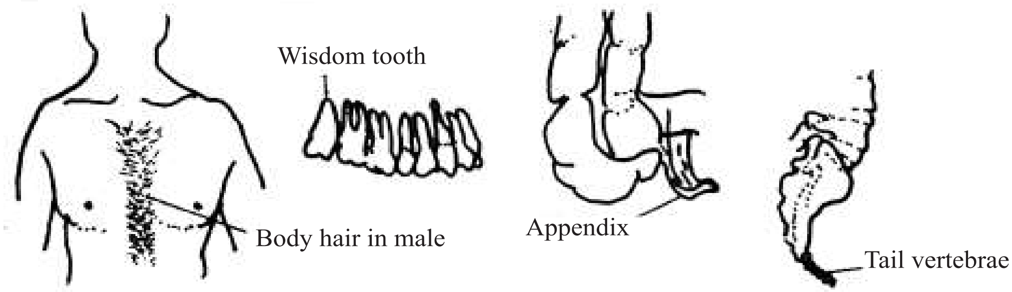


Fig. 1.7 Some vestigial organs in human body

The only rational explanation for the presence of these non-functional organs is that they have been inherited from ancestors in which they were functional. Fig. 1.7 shows some of the vestigial structures in the human body.

(iv) Connecting Links

The animals or plants which possess characters of two different groups of organisms are known as connecting links. The **connecting links** establish continuity in the series of organisms by proving that one group has evolved from the other. A good example is that of a fossil bird *Archaeopteryx*, which was a connecting link between reptiles and birds. This bird had a beak with teeth and a long tail (with bones) like the lizards. It had feathers on the wings and on the body like the birds. (Fig. 1.8).

Fig. 1.8 An extinct bird - *Archeopteryx*

2. Evidences from Embryology

Embryology is the study of development of an organism

The aspects of embryology which support the doctrine of organic evolution are :

- similar stages of early development (morula, blastula or gastrula) in all the animals;
- the embryos of all vertebrates are similar in shape and structure in their early stages.

This resemblance is so close that it is difficult to tell them apart (Fig. 1.9).

- All the vertebrates start their life from a single cell, the zygote.
- All of them during their life history, pass through two-layered blastula and three layered gastrula stage and then through fish like stage with gill-slits.

All the different aspects of embryology strongly support the fact that the different classes of vertebrates had common ancestors.

3. Evidences from Paleontology

Paleontology is the study of **fossils**. Fossils are the remains or traces of animal and plant life of the past, found embedded in rock either as petrified hard parts or as moulds, casts or tracks.

The fossils of the earliest era in the geological time scale were those of bacteria, then invertebrates and then successively of fishes, amphibians, reptiles and lastly of birds and mammals and among mammals primitive fossils of humans are the most recent.

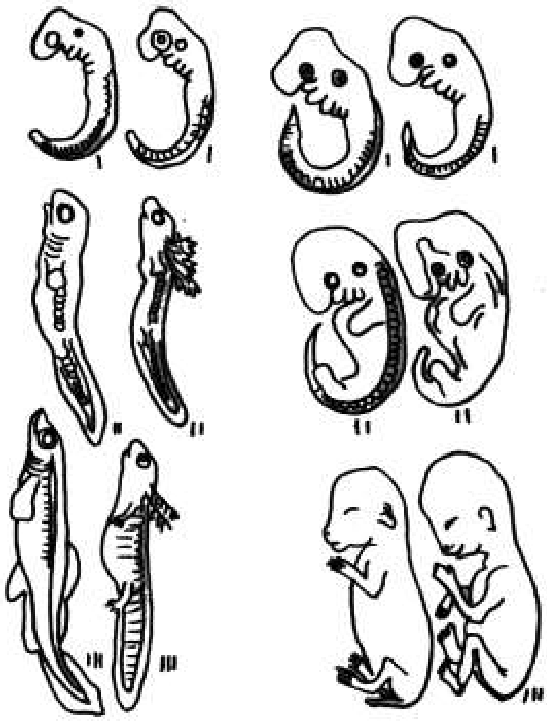


Fig. 1.9 Series of vertebrate embryos in comparable stages of their development a-Fish, b-Chick, c-Man

The discovered fossils of the horse, elephant, camels, and humans provide their ancestral history (Fig. 1.10). The number of toes decreased for greater speed, size gradually increased and teeth adapted to eat grass.

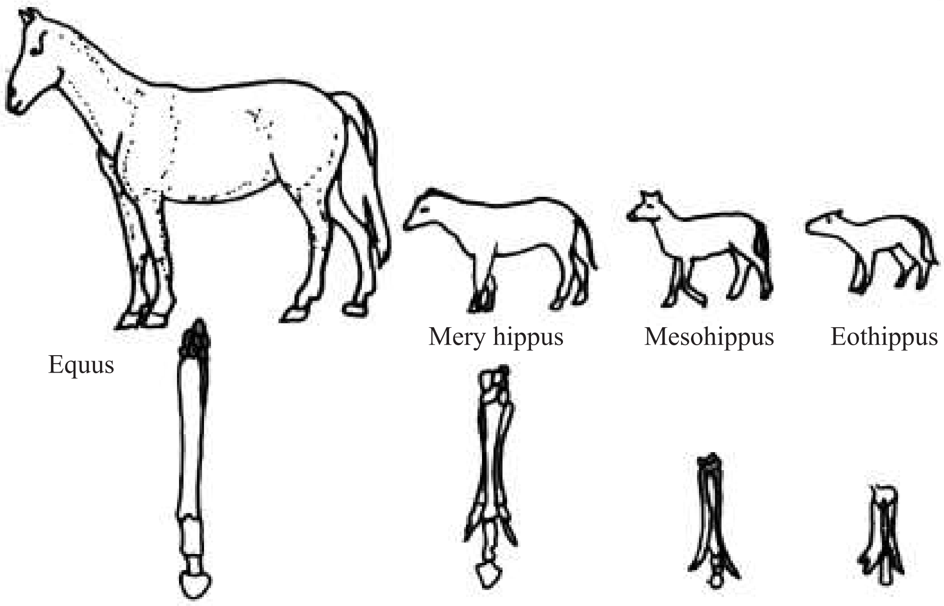


Fig. 1.10 Fossil record of bone of hind legs of horses from *Eohippus* to *Equus* showing decrease in the number of toes

4. Molecular Evidence of Evolution

- All organisms have cell as the basic unit of life. The cell is made of **biomolecules** common to all organisms.
- Ribosomes, the cellular organelles are of universal occurrence in organisms.
- DNA is the hereditary material of all organisms, except for some viruses.
- ATP is the molecule which stores and releases energy for biological processes.
- The same 22 amino acids form the constituents of proteins of almost all organisms.
- The genetic code is universal (exceptions are very few).
- The central dogma which deals with the transfer of genetic information in cells is the same.
- The basic steps of transcription and translation for protein synthesis are similar in all organisms.
- The sequence of nucleotides such as that for the promoter gene (TATA box) is common to all organisms.

However, organisms sharing same chemical characteristics show closer evolutionary relationships. For example (i) human blood proteins are most similar to those of the chimpanzee among all apes, or (ii) only plants and some algae have chlorophyll so they are more closely related. Similarity in chemical constituents between organisms is termed **molecular homology** or **biochemical homology** and are used in recent times, to establish evolutionary relationships and form the basis of systematics.

INTEXT QUESTIONS 1.2

1. Define organic evolution.

   ....

2. Name one fossil animal which forms a connecting link between reptiles and aves.

   ....

3. Which organ of man is homologous to the wings of birds?.

   ....

4. Define vestigial organ.

   ....

5. Give one example of a connecting link among the living beings.

   ....

6. Give two examples from molecular biology which support organic evolution.

   ....

1.2.3 Mechanism of Evolution

Various theories about the mechanism of evolution have been proposed; some of them such as Lamarck's theory of "Inheritance of acquired characters" and De Vries' theory of 'mutation' are now of historical importance only.

Darwin's theory of Natural selection still holds ground but was modified with progress in genetics and developed into the **Modern synthetic theory** which is regarded as the most valid theory of evolution.

Darwin's Theory of Natural Selection

An English Scientist, Charles Darwin (1809-1882) explained the mechanism of evolution through his theory of natural selection. He is still regarded as 'the father of evolution' because of two very significant contributions. He suggested (i) that all kind of organisms are related through ancestry and (ii) he suggested a mechanism for evolution and named it **natural selection.**

According to Darwin, organisms produce more offspring than can survive. Because environmental resources are limited there ensues struggle for existence. Organisms with advantageous variations are protected and allowed to reproduce while the disadvantageous variants are eliminated from nature. This is what was termed **natural selection** by Darwin.

According to Darwin when the environment changes, new adaptations get selected in nature and after many generations sufficient characteristics will have been changed so as to alter the species into a new one (origin of species).

Darwin talked about variation but did not know about the sources of variation. With progress in genetics the sources of variation were discovered and Darwin's original theory of Natural Selection modified. This new theory was termed **Neo-Darwinism** or **Modern Synthetic Theory**.

According to this theory :

1. The unit of evolution is 'population' which has its own gene pool. Gene pool is the group of all different genes of a population.
2. Heritable genetic changes appear in the individuals of a population.
   These heritable changes or variations occur due to small mutations in the genes or in the chromosomes and their recombinations.
3. Natural selection selects the variations which helps in adapting to the environment.
4. A change in the genetic constitution of a population selected by natural selection is responsible for evolution of a new species, since through interaction of variation and **Natural Selection** more offsprings with favourable genetic changes are born. This is called 'differential reproduction'.
5. Once evolved, **Reproductive Isolation** helps in keeping species distinct.

INTEXT QUESTIONS 1.3

1. Who gave the theory of natural selection?

   ....

2. What is the modern interpretation of Darwin's theory of evolution called?

   ....

3. What are the two major contributions of Charles Darwin regarding evolution?

   ....

4. Give two main features of Neo-Darwinism.

   (i) ....

   (ii) ....

5. What do you mean by "differential reproduction"?

   ....

1.2.4 Elemental Forces of Organic Evolution

Evolution is caused by action of forces on **Natural Selection** of **Variation**. Reproductive Isolation keeps the species distinct therefore the elemental forces of Organic Evolution are: (i) Variation (ii) Natural Selection (iii) Isolation.

(i) Sources of organic variation

Variation arises in an individual member of a population, and if favourable, spreads into the population through "differential reproduction" by the action of natural selection. Variations may occur by

1. **Mutation,** which is a sudden genetic change. It may be a change in a single gene (genic mutation or point mutation) or may affect many genes (chromosomal mutation).

2. **Genetic recombination**, which occurs in sexually reproducing organisms at every reproduction. The chromosomes and thus genes of the parents mix at random during zygote formation. That is why offspring of same parents are different from each other as they have different combinations of parental genes. Variation is also brought about when crossing over occurs during gamete formation.

3. **Gene flow** is when there is chance mixing of genes of closely related species through sexual reproduction.

4. **Genetic drift** occurs in small populations when a part breaks off from a large population. Only representative genes of the large population are present which undergo change at a right time and the small population may evolve into a new subspecies or species.

(ii) Natural Selection

Natural selection considered to be responsible for "differential reproduction of genes" which means that more of favourable genes get reproduced in a population.

Many examples of natural selection in action are available now. Given below are three such examples.

Example 1 : DDT resistant mosquitoes

About 50 years back, the mosquito population had been kept in control with the help of DDT. Thereafter, it was found that mosquitoes could not be killed with DDT any longer. There appeared DDT-resistant mosquitoes. What had happened was that a **gene mutation** (variation) had conferred (given) on the mosquito, the ability to resist the effect of DDT. While DDT killed other mosquitoes, those with the gene mutation survived and slowly within a few generations DDT resistant mosquitoes replaced the DDT-sensitive ones. In other words, the DDT resistant mosquitoes 'reproduced differentially' by the action of natural selection.

Example 2 : Metal tolerance in grasses

Certain metal residues sometimes collect in the soil near some industries using heavy metals. Being poisonous they kill the grasses. However, resistant grasses are found to evolve after some time through the action of genetic variation and natural selection.

From the above example, can you explain the evolution of the heavy metal-tolerant grasses?

Example 3 : Industrial melanism

A commonly quoted example of natural selection in action is that of the peppered moth, *Biston betularia*. The moth with its light coloured wings dotted with spots blended well with the lichens growing on the houses and trees on which it rested. Once in a while if a mutated form of the moth which was black in colour appeared, it was eaten up by birds as it was conspicuous because of its black wings. This was observed in the British Isles before the industrial revolution. After the industrial revolution, the genes for black wings proved favourable on the soot covered lichens growing on the walls of houses. Natural selection acted through the agency of the birds which now ate up the conspicuous light coloured winged peppered moth. These were therefore, soon replaced by the black variety (Fig. 1.10).

There are several such examples in which human activities have changed the environment and natural selection has been observed to play its role. But it is an established fact now that all of biodiversity over these millions of years have also evolved through the interaction of variation and natural selection.

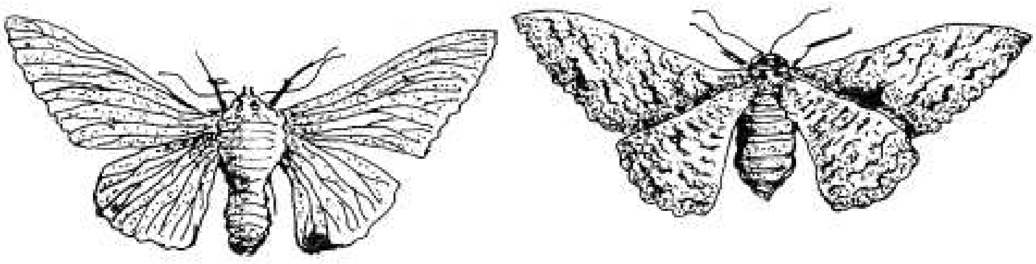


Fig. 1.11 Light and dark forms of *Biston betularia*

(iii) Role of Reproductive Isolation

Once new species arise from the parental species due to the effect of variation and natural selection, reproductive barriers prevent the two species from exchanging genes through reproduction.

Thus two related species cannot mate with each other and remain distinct. Isolation means separation and reproductive isolation simply means that the two species are prevented from successful reproduction and kept genetically distinct from each other. Reproductive isolation operates in the following ways:

Ecological isolation	:	The two species are unable to mate as they live in geographically different areas.
Seasonal isolation	:	Mating is prevented because the reproductive organs mature at different times.
Ethological (Behavioural) isolation	:	The songs in birds of two species or the colouration of two fishes are so different that female of one species is able to recognise only the male of its own species.
Mechanical isolation	:	The male and female organs for mating differ in different species and prevent their union.
Physiological isolation	:	The sperms of one species are not able to survive in the female tract of another species.
Zygotic and developmental Isolation	:	If all the above mechanisms fail and a "hybrid zygote" (zygote from mating of two different species) is formed, it dies after some time. If the hybrid zygote survives it dies during development.

Hybrid sterility	:	Mule, the offspring of a female horse and male donkey is a good example. It leads a normal life but is sterile and cannot reproduce.
F_2 breakdown	:	In rare cases, all the above mechanisms fail and a hybrid (offspring of parents belonging to different species) is fertile, it can reproduce only for one generation.

1.2.4 Speciation

The evolution of new species is termed **speciation.** Speciation occurs in the following ways and is termed accordingly.

Allopatric speciation takes place when a part of the population becomes geographically separated (geographical isolation) from the parental population. For example a group of birds lives at the base of the mountain, some members fly up and get geographically isolated. Variation and natural selection act differently on the two because the environment in which the two live is different. Gradually genetic changes render them to be reproductively isolated.

Sympatric speciation

Sometimes a genetic barrier (reproductive barrier) prevents reproduction between a section of a population of a species with other members. Such a section of population usually arises in plants because of polyploidy. **Polyploidy** is a mutation in which the normal diploid number of chromosomes become doubled or trebled (2n becomes 3n, 4n, 5n etc) in a section of the population of a species due to certain irregularities during cell division. The polyploid section of the population is then unable to interbreed (mate and reproduce) with their diploid ancestors and becomes a new species.

Models of speciation

There are two accepted models of speciation that have given rise to the biodiversity

1. Phyletic Gradualism model

Two species from common ancestor gradually become more and more structurally different acquiring adaptations unique to each other (Fig. 1.12a). Darwin also believed that evolution is a slow and gradual process.

2. Punctuated equilibrium

A new species arises through major changes in the beginning and then remain constant for long periods before changing again. (Fig. 1.12b). This model was suggested by palaeontologists (scientists who study fossils), Niles Eldredge and Stephen Jay Gould.

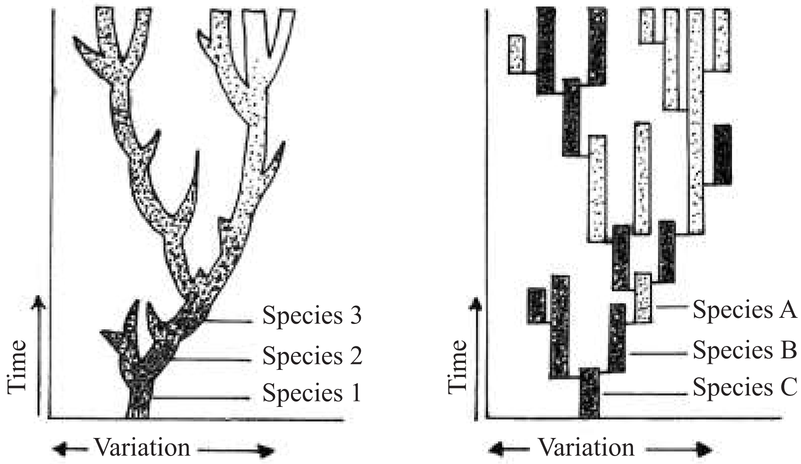
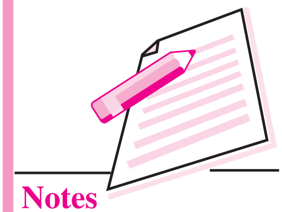


Fig. 1.12 Models of speciation (a) Phyletic gradualism, (b) Punctuated equilibrium



1.2.5 Hardy-Weinberg Equilibrium

This is a concept related to both genetics and evolution and was proposed by G. H. Hardy and W. Weinberg.

A population of sexually reproducing organisms in which genes combine at random due to random mating is called **panmictic**. In other words, a panmictic population is one in which mating partners are not specifically selected. For example, we humans usually do not look for specific blood group when a marriage is arranged so we are panmictic with respect to blood types.

The Hardy Weinberg Principle states that in a panmictic population if there is no pressure of mutation, selection, genetic drift etc. then the relative frequency of any pair of genes remains constant, generation after generation. For example, a gene has two alleles, p and q in the population and no mutation or selection etc. takes place, then the frequency of these two alleles will remain constant generation after generation. This can be mathematically represented as:

$$(p+q)^2 = 1 \text{ or } p^2 + 2pq + q^2 = 1$$

INTEXT QUESTIONS 1.3

1. List the sources of organic variation.

   ....

2. What is 'industrial melanism' about? Answer in one or two sentences.

   ....

3. State one point of difference between (a) allopatric & sympatric speciation (b) Ecological and Ethological Isolation

   ....

4. What is a panmictic population?

   ....

5. According to Hardy Weinberg Principle, $(p + q)^2 = 1$. Explain this mathematical expression.

....

1.3 CLASSIFICATION

1.3.1 Meaning of Classification

Classification means identifying similarities and differences between different kinds of organisms and then placing similar organisms in one group and different kinds of organisms in different groups.

Taxonomy, may thus be defined as the science of classification of organisms into categories, maintaining certain rules. Early taxonomists classified organisms according to **morphological features** only. Once the concept of organic evolution was accepted, taxonomists began to draw evolutionary relationships between different kinds of organisms. This was termed **systematics.** Today taxonomy and systematics are treated as synonymous, since for classification, both morphological and biochemical resemblances and even those between molecules such as DNA and RNA are studied to establish evolutionary relationships.

1.3.2 Taxonomic categories

While classifying an organism, it is assigned to categories which show its evolutionary relationship with other groups of organisms. Each level or category is termed **taxon** (plural-taxa). The lowermost category of classification or taxon is **species**. Other categories are arranged above the species so that there is a hierarchy of categories. The various taxonomic categories are given below :

Species : Group of individuals of one kind which can interbreed to produce fertile offsprings.

Genus : Group of species resembling each other in several features indicating common ancestry.

Family : Group of genera (singular-genus) resembling each other. e.g. *Felis domestica* (the cat) and *Panthera tigris* (the tiger), both belong to the family Felidae.

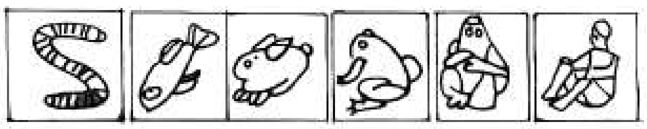
Order : Includes families showing similar characteristics.

Class : Includes related orders.

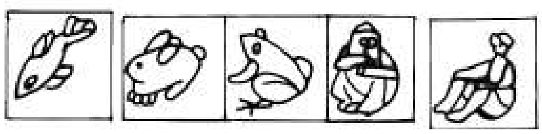
Phylum : Includes related classes. (See Fig. 1.13)

The various phyla belong to their respective **kingdoms**. There are **five kingdoms** about which you will learn later. Humans belong to the kingdom Animalae and classification of humans is given as an example to describe the manner in which living organisms are classified.

Kingdom : Animalae (Animals)



Phylum : Chordata (Animals with notochord/ backbone)



Notes

Class : Mammalia (Animals that suckle their young ones.)

Order : Primates (Mammals with larger brains and binocular vision)

Family : Hominidae (Humans and human like ancestors)

Genus : *Homo* (Fossilmen and modern man)

Species : *H.sapiens* (Modern man)

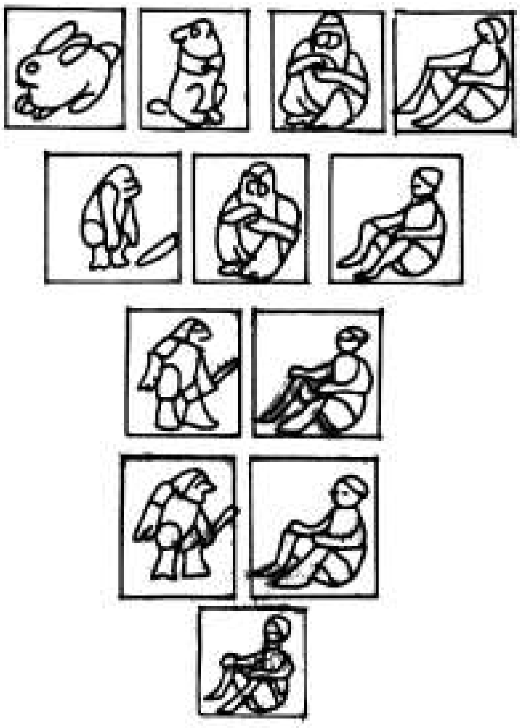


Fig. 1.13 Classification of Human species

1.3.3 Scientific naming of organisms

Different plants and animals have different common names. A cat is called 'billi' in Hindi, 'biral' in Bengali, 'punai' in Tamil and 'manjar' in Marathi. There are different words for cat in French or German. Thus, there arose the need to give organisms names which could be understood throughout the world. Therefore, scientific names which are understood all over the world were given to organisms.

A simplified system of naming organisms called **binomial nomenclature** has been the standard for more than two centuries now. It was proposed by the Swedish biologist, **Carolus Linnaeus (1707-1778)**. Binomial nomenclature simply means **two-name** system of naming. The name of every category of organism has two parts, that of the **genus** followed by that of **species**. The generic name is written with a capital letter and the specific name with a small letter. e.g. ***Homo sapiens*** is the scientific name of modern man, ***Mangifera indica*** is the boctnical name of mango.

Three main features of biological naming are as follows :

1. A scientific name, by convention, is printed in **italics** or **underlined** when hand written.
2. Scientific naming is according to a set of scientific rules of nomenclature.
3. Scientific names are mostly in *Greek* and *Latin*. They are uniformely understood all over the world and have made communication about organisms easier.

1.3.4 Prokaryotes and Eukaryotes

The organisms that are most primitive or the first to evolve on earth are the bacteria. They do not possess a nuclear membrane around their single chromosome. Absence of a well-defined nucleus or in other words a primitive nucleus terms them **prokaryotes** (pro = primitive, karyon = nucleus). **All bacteria including blue-green algae (Cyanobacteria) are prokaryotes**. As a constrast, **organisms other than bacteria** possessing a well-defined nucleus are **eukaryotes** (eu = true; karyon = nucleus). There are other differences between prokaryotes and eukaryotes which are given below in Table 1.1.

Table 1.1 Differences between Prokaryotes and Eukaryotes

Characteristics	Prokaryotes	Eukaryotes
1. Size	0.1-10 µm	10-100 µm (larger volume)
2. Genetic material	Circular DNA, no linear DNA, no histones associated with DNA, nucleoid form, no nuclear membrane	Histones present on which DNA molecule wrapped, well defined linear chromosomes, with free terminal end nuclear membrane present
3. Site of nuclear material	DNA in cytoplasm	DNA inside distinct nucleus
4. Organelles	No membrane bound organelles	Mitochondria, golgi body, lysosomes present in the cell
5. Cell wall	Always present, Contains peptidoglycan	None in (animals) and made of cellulose/chitin in plants and fungi
6. Respiration	By mesosomes	By mitochondria
7. Reproduction	Mostly asexual e.g. bacteria and cyanobacteria (blue-green algae)	Asexual and sexual e.g. Protoctista, fungi, plants Animals

1.3.5 The Five Kingdoms of Organisms

Till recently there were only two kingdoms for classification - **Plantae** and **Animalae**. Such a two kingdom classification had several drawbacks, e.g. bacteria and fungi were kept alongwith plants although they are very different.

R.H. Whittaker in 1969 suggested the five kingdom classification which is based on the following three criteria.

(i) The presence or absence of a well-defined nucleus.

(ii) Unicellular or multicellular

(iii) Mode of nutrition

The five kingdoms are Monera, Protista or Protoctista and Fungi, Plantae and Animalae. Based on the three criteria mentioned above, (Fig. 1.13) the five kingdom classification is explained as under.

Table 1.2 **The five kingdom classification of organisms**

Names of Kingdoms	Nature of nucleus	Whether unicells or multicells	Kinds of nutrition
1. **MONERA** (Blue green algae and bacteria)	Prokaryotic	Unicellular (except some cyanobacteria that are filamentous or multicellular and sometimes branched.	Diverse types of nutrition
2. **PROTOCTISTA** (some Algae and Protozoa)	Eukaryotic	Unicellular	Diverse kinds of nutrition
3. **FUNGI** (Moulds, etc.)	Eukaryotic	Unicellular or Multicellular	**Saprophytic** (Feed on dead, organic matter)
4. **PLANTAE** (All green plants)	Eukaryotic	Multicellular	**Autotrophic** (Synthesize food by photosynthesis)
5. **ANIMALAE** (Animals)	Eukaryotic	Multicellular	**Heterotrophic** (Depend on other organisms for food)

The five kingdoms are shown below in Fig. 1.14

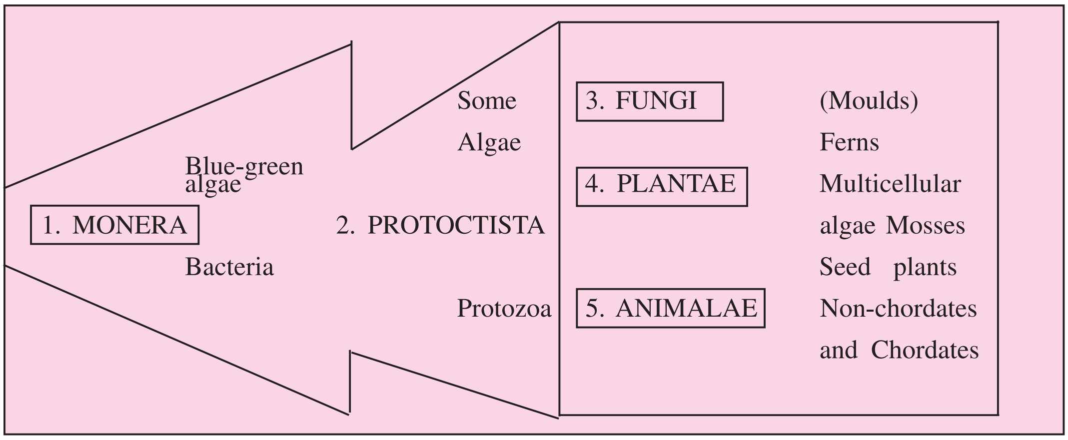


Fig. 1.14 The Five Kingdoms of Life

INTEXT QUESTIONS 1.4

1. Name the scientists who proposed :

   (a) Binomial nomenclature ....

   (b) Five Kingdom Classification ....

2. Which were the first organisms to appear on earth?

   ....

3. Name the taxonomic categories which come before and after family.

   ....

4. Name the categories above order level in a correct sequence.

   ....

5. Rewrite the following in correct form –

   (a) Mangifera Indica ....

   (b) Homo Sapiens ....

   (c) Felis leo ....

6. Place the following in their respective kingdoms

   (a) Bacteria which curdle the milk ....

   (b) Cow ....

   (c) Grass ....

   (d) Amoeba ....

   (e) Bread mould ....

1.4 VIRUSES - AN INTRODUCTION

- You have heard about diseases such as influenza, polio, mumps, rabies, small-pox, AIDS and dengue are caused by viruses.
- They are non-living and made up of DNA or RNA surrounded by a protein coat. They can replicate. However, they cannot reproduce on their own. They reproduce when inside a living cell. Therefore viruses pose a special classification problem.
- Logically, therefore, they cannot be placed in any of the five kingdoms because they can multiply in their host cells, and can mutate – like living organisms but, can be crystallised exhibiting a non-living feature.

Discovery of Viruses

In 1892, the Russian botanist Iwanowsky prepared an extract from tobacco plants suffering from tobacco mosaic disease. The extract was filtered to keep back bacteria in the residue. The filtrate was still infectious. Dutchman Beijerinck gave the term virus in 1898 (Virus - poison in Latin) to these infective particles.

Size

- Viruses are extremely small and can be seen only under the electron microscope.
- They are smaller than the smallest bacteria.
- Can pass through fiters which retain bacteria.
- Their size is indicated in nanometres (nm). Their size ranges from 10 nm to 300 nm in diameter.

Nanometre (nm)

It is a unit of microscopic measurement, equal to 10^{-9} m. It was formerly called millimicron

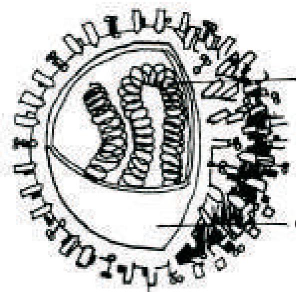


Fig. 1.15(a) Influenza virus

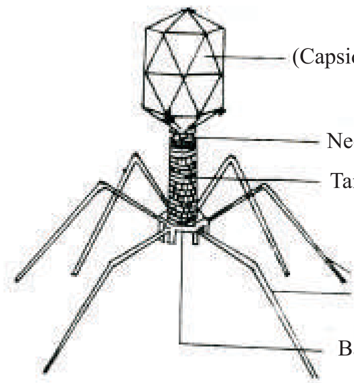


Fig. 1.15(b) T. Bacteriophage

1.4.1 Structure of virus

Virus has a simple structure consisting of a core and a cover. The core particle is the genetic material, either DNA or RNA. The cover is a protein coat called **capsid** (Fig. 1.16).

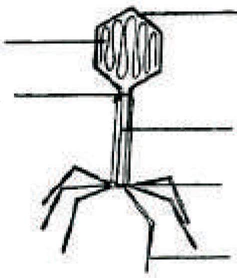


Fig. 1.15 Structure of Virus

Virus can reproduce only when inside the living cells.

A virus cannot reproduce by itself. For its reproduction it needs to enter the cell of some organism. From the host cell, it uses the raw material and enzymes and energy generating machinery of the host cell to produce its own DNA. A number of virus particles are thus formed inside the host cell. The host cell bursts to release the new virus particles.

Virus — living or non-living?

Though viruses possess nucleic acids as genetic material like the living organisms, they cannot make copies of DNA for reproduction on their own. They can make copies of themselves to reproduce only inside a living cell. And because their genetic material is DNA or RNA, they exhibit mutations followed by variations in their infective properties. Further, they are considered non-living because they are non-cellular, they have no enzymes of their own and they can be crystallised

1.4.2 Infective properties of virus

Viruses are known to attack bacteria, plants or animals. Viruses which invade bacteria are called **bacteriophages.**

Viruses are highly specific in their relationship with the host and tissue. For example – Polio virus attacks particular nerves; mumps virus attacks the particular pair of salivary glands (parotid glands) of humans.

Viruses keep on 'mutating'!

Mutation means change in genetic material. For example – Influenza virus which has RNA as its genetic material, mutates and so every year flu is caused by a different virus and scientists find it difficult to find a cure for influenza or flu.

1.4.3 Viruses and diseases

Table 1.3 indicates the names of certain viruses, their hosts and diseases and modes of their transmission

Certain cancers are also known to be caused by viruses. These viruses have RNA as genetic material and are called ***retroviruses***.

Table 1.3 Certain viruses, their hosts, diseases caused by them and mode of transmission.

	Virus	Host	Disease	Mode of Tranmission
Plants	Potato roll virus	Potato	Potato leaf roll	Air borne contact
	Tomato stunt virus	Tomato	Tomato bushy stunt	Air borne, contact
	Tobacco mosaic virus	Tobacco	Mosaic	Air borne, contact
Human	Herpes virus	Humans	Herpes	Air borne,, contact
	Pox virus	Humans	Small Pox	Air borne, contact
	HIV	Humans	AIDS	(i) Sexual contact (ii) Lactating mother to child (iii) Blood transfusion
	Dengue	Humans	Dengue	Bite of infected *Aedes* mosquito
	Hepatitis B	Humans	Hepatitis	Infected water

1.4.4 Viroids

Viroids are circular RNA molecules, consisting of several hundred nucleotides. They infect plants and even kill them. In plants, they use enzymes of the plant cells to replicate like the viruses do. When they infect plants, these RNA molecules cause defects in the regulatory systems controlling plant growth. Hence viroid infected plants show stunted growth and abnormal development.

INTEXT QUESTIONS 1.6

1. With reference to viruses fill in the blanks (1, 2 and 3) in the following table :

1. ...	Tobacco	Tobacco Mosaic Disease
HIV	2. ...	AIDS
Herpes	human	3. ...

2. Give one feature because of which viruses are considered non-livng.

   ....

3. Name one chemical common to viruses and all other organisms.

   ....

4. Complete the following :

   (a) Core particle of virus contains ....

   (b) Coat of virus is made of ....

5. In what way is viroid structurally different from a vrius?

   ....

   (Refer Module 1, Lesson 1 page 22)

6. Why are viroids considered a menace for plants that they attack?

   ....

WHAT YOU HAVE LEARNT

- The most accepted theory about origin of life is the chemosynthetic theory.
- Earth's early environment was favourable for the formation of organic molecules from simple inorganic materials.
- Coacervates are believed to have been membrane–bound molecular aggregates capable of growth and budding.
- It is believed that life originated some 3.5 billion years ago on this earth.
- The environment and the forms of life of the past were quite different from those of today.
- Evolution is the gradual unfolding of living forms from the earlier simpler forms into the complex ones. It was in operation in the past, it is operating at present and will continue do so in the future.
- Chief evidences in favour of organic evolution come from comparative anatomy, embryology, palaeontology and molecular biology.

- Darwin's theory of 'Origin of Species' by natural selection', explains the process of evolution through useful variation and natural selection.
- Neo-Darwinism is the modern interpretation of Darwinism based on natural selection, mutation and reproductive isolation. This is also called the modern synthetic theory.
- Sources of variation are mutation, recombination, geneflow and genetic drift.
- Natural selection acts upon variation through "differential reproduction" which means greater reproduction of favourable genes.
- Isolation helps in formation of new species and also in keeping species distinct.
- The reproductive isolating mechanisms are ecological isolation, seasonal, ethological, mechanical and physiological isolation, zygote inviability, hybrid sterility and F_2 breakdown.
- Evolution of new species is termed speciation.
- Speciation occurs through (a) geographical isolation, or (b) polyploidy.
- Gradualism and punctuated equilibrium are suggested modes of speciation.
- Hardy Weinberg equilibrium relates to genetic variation during evolution. According to this theory, 'in a panmictic population, frequency of two alleles remains same for generations in the absence of Mutation and Natural Selection.
- Classification is essential for studying organisms and communicating about them. Classification means grouping on the basis of similarities and differences.
- There are hierarchical taxonomic categories which reveal evoulutionary relationships of an organism.
- The scientific naming of organisms is according to the Linnaean system of binomial nomenclature.
- The five kingdoms of life are Monera, Protoctista, Fungi, Plantae and Animalae.
- Viruses are nucleoprotein particles which have DNA or RNA molecules present as core particles, surrounded by a protein coat.
- Viruses were discovered by Ivanowsky and named by Beijerinck.
- Viruses are very small and can be observed only through electron microscope.
- Viruses cannot reproduce except when inside living cells.
- Viruses share properties of living and nonliving.
- Viruses infect bacteria, plants and animals.
- Viruses attacking bacteria are called bacteriophages.
- Viruses cause several human diseases like herpes, small pox, AIDS, dengue and influenza.
- Viroids are RNA particles that attack plants.

TERMINAL EXERCISES

1. Explain the most valid theory about origin of life on earth. How did Miller and Urey verify the chemosynthesis theory of evolution?
2. Differentiate between Darwinism and Neo-darwinism.
3. Explain the synthetic theory of evolution.

5. Substantiate the idea of evolution through molecular evidence.
6. Classify the following animals : earthworm, roundworm, frog and human-beings.
7. Write the scientific names of
   (i) Mango (ii) Man (iii) Cat (iv) Tiger
8 How does a virus increase in number? Show only by explanatory diagrams.
9. Give a schematic diagram of the five Kingdom classification.
10. State the criteria on which the five kingdom classification is based.

ANSWERS TO INTEXT QUESTIONS

1.1
1. 5 billion years
2. A.I. Oparin
3. NH_3, CH_4, CO_2, water vapour
4. Lightening/geothermal energy/UV rays (any one)
5. Water
6. aggregates of (life-like) molecules
7. amino acids, fatty acids, sugars (any two)
8. Miller and Urey

1.2
1. The process of slow and gradual change as a result of descent with modification, from a common ancestor.
2. *Archaeopteryx*
3. Fore-limb/arm
4. Functionless organs of the body
5. (i) Lungfish between fish and amphibia
   (ii) Egg laying mammals between reptiles and mammals.
6. See sub-section on evidence of evolution from molecular biology

1.3
1. Mutation, Recombination, gene flow, genetic drift,
2. It is about the evolution of a variety of peppered moth during industrial revolution, through mutation and Natural Selection.
3. Allopatric speciation leads to differences in population of a species due to physical isolating barriers. Reproductive barriers separate sympatric species which may live in the same geographical area.
4. Both are isolating mechanisms, Ecological Isolation by barriers of season or habital and Ethological Isolation by barriers of behavioural differences.
5. Randomly mating population.
6. $(q + q)^2 = 1$ means frequencies of allelic genes p + q remain same for generation after generation if there is no force of evolution like variation, natural selection etc.

1.4
1. Charles Darwin
2. Neo-Darwinism/synthetic theory
3. All organisms are related through ancestry he suggested natural selection as the probable mechanism for evolution.
4. (i) Variation in population forms the basis of evolution

   (ii) Differential reproduction
5. Reproduction of favourable genes is greater

1.5
1. (a) Carolus Linnaeus

   (b) R.H. Whittaker
2. Bacteria
3. Genus
4. Kingdom, phylum, class, order
5. (i) *Mangifera indica* (ii) *Homo sapiens* (iii) *Felis leo*
6. Kingdom, phylum, class, order, family, genus, species
7. (i) Monera (ii) Animalae (iii) Plantae (iv) Protoctista (v) Fungi

1.6
1. 1. Tobacco mosaic virus, 2. humans, 3. Herpes.
2. They cannot reproduce on their own / they can be crystallised (any one)
3. Nucleic acid/protein (any one)
4. (a) DNA or RNA (b) Protein
5. A virus has a DNA or RNA molecule surrounded by a protein coat, whereas a viroid is only an RNA molecule.
6. They infect plants and when inside the plant cells, use the host plants' enzymes to replicate & increase in number resulting in stunted and abnormal growth of plant.