3.0 VIRUSES

Viruses are acellular entities. They are genetic elements that cannot replicate independently of a living cell called the host cell. Viruses have extracellular forms which enable them to exist outside the host for long periods. But to multiply, they have to enter a cell in which they can replicate causing infection. Viruses are the most numerous microorganisms on earth and infect all types of cellular organisms. The study of viruses is known as virology.

3.1 General Characteristics of Viruses

i. They are the smallest microorganisms. They range in size from 10 to 400µm in diameter and can only be viewed using an electron microscope.

ii. They are acellular, i.e. not cellular and non living.

iii. They only reproduce when present within living cells.

iv. They are infectious agents.

v. A complex virus particle or virion consists of one or more molecules of DNA or RNA enclosed in a protein coat.

vi. Viruses can exist in two phases: extracellular and intracellular.

The **extracellular phase** known as virion possesses few if any enzymes and cannot reproduce independent of living cells. It is metabolically inert and does not carry out respiration.

In the **intracellular phase**, viruses exist primarily as replicating nucleic acids in the host cells that induce host metabolism to synthesize virion components which are later released.

Viruses differ from living cells in three ways:

i. They have simple acellular organisation.

ii. The presence of either DNA or RNA but not both in almost all virions.

iii. They do not have the ability to reproduce independent of cells and carry out cell division as procaryotes and eukaryotes do.

3.2 Structure of Viruses

A virus is made up of a central genetic **nucleic acid** molecule surrounded by a protein coat called a **capsid**. The combination of both is called the **nucleocapsid**. The capsid surrounds and protects the viral nucleic acid. The capsid also gives the virus a characteristic shape and help to establish the specificity of the virus for a particular host cells. Capsids are large macromolecular structures that self assemble from many copies of one or a few types of proteins. The protein used to build the capsids is called protomers. The simplest virus is a naked virus (nucleocapsid) or non-enveloped virus consisting of a geometric capsid assembled around a nucleic acid. On the other hand, we can have a virus made up of a nucleocapsid surrounded by a flexible membrane called an **envelope**. This type of virus is called an envelope virus.

The various morphology types of viruses results from the combination of a particular type of capsid symmetry with the presence or absence of an envelope which is a lipid layer external to the nucleocapsid.

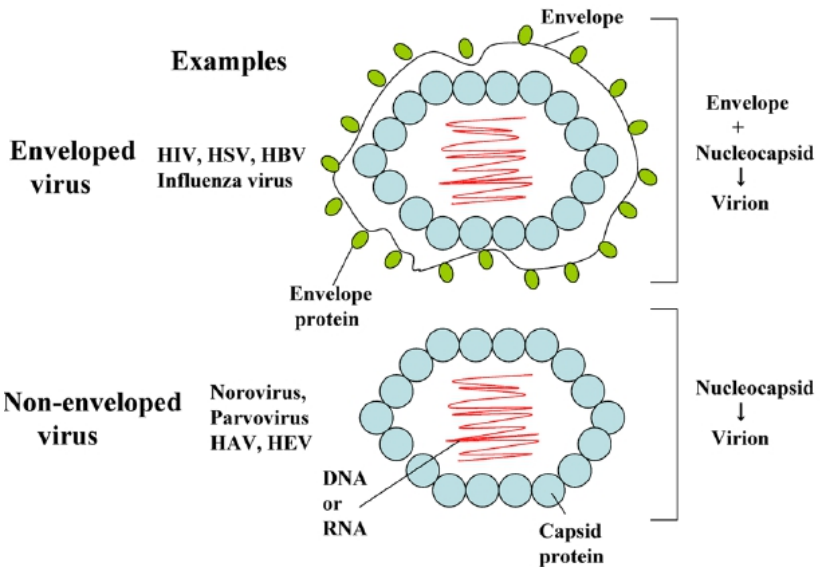

Fig 3.1: Structure of Virus

3.3 Reproduction in Virus

Viruses need a host cell in which to reproduce; hence the first step in the life cycle of a virus is attachment to a susceptible host. This is followed by entry of either the nucleocapsid or the viral nucleic acid into the host. If the nucleocapsid enters uncoating of the genome usually occurs before further steps can occur. Once free in the cell cytoplasm, genes encoded by the viral genome are expressed, i.e. the viral genes are transcribed and translated. This allows the virus to control the host cell's biosynthetic machinery so that new virions can be made. The viral genome is then replicated and viral proteins are synthesised. New virions are constructed by self assembly of coat proteins with the nucleic acids and finally, the matured virions are released from the host.

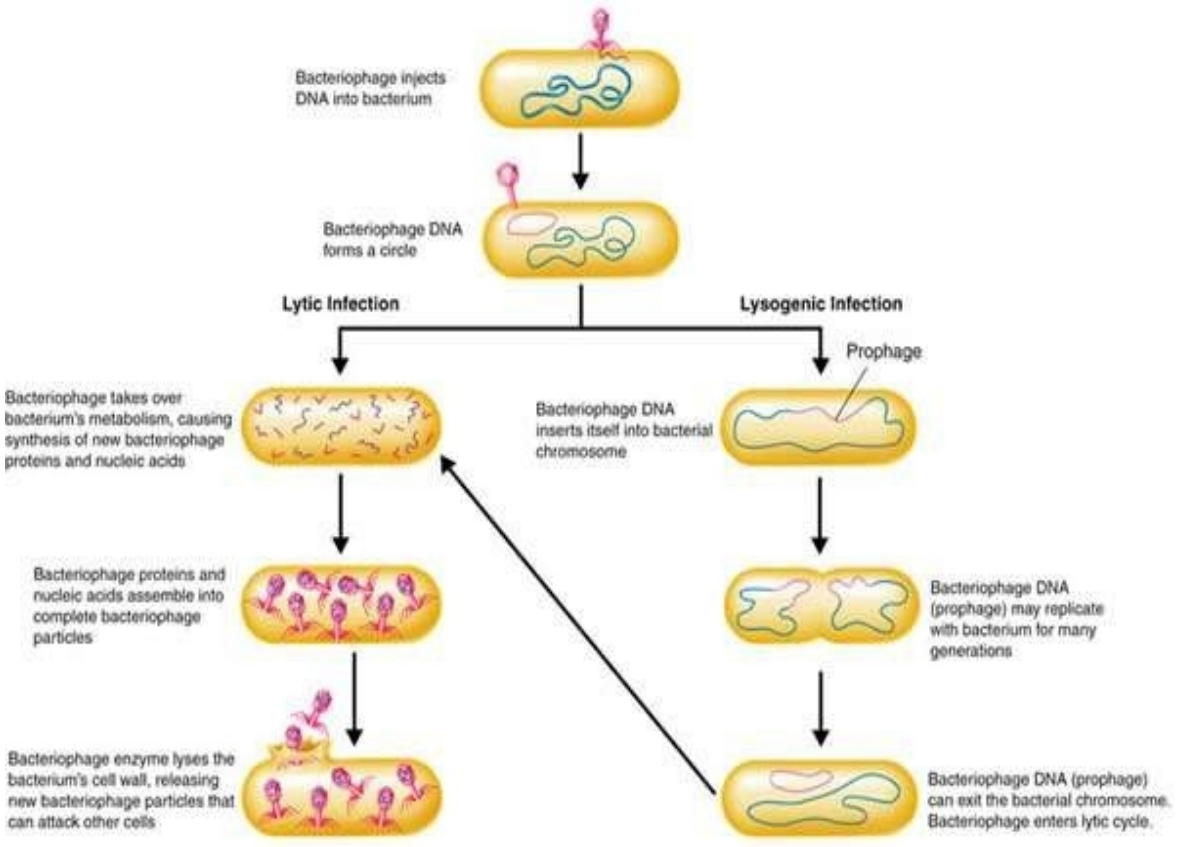

Fig 3.2: Generalised Illustration of Virus Reproduction

Summarily, the steps involved in viral replication or reproduction are:

- attachment of the virion to a susceptible host
- penetration or entry of the virion or its nucleic acid into the host
- synthesis of virus nucleic acid and protein by cell metabolism as directed by the virus.
- assembly of capsids and packaging of viral genomes into new virions.
- release of mature virions from the cell.

However, there is great variation in the details of virus reproduction for individual virus species.

4.0 ALGAE

Algae (singular, alga) are unicellular microorganisms that have chlorophyll and are photosynthetic. Algae are heterogeneous and range from microscopic unicellular forms to macroscopic seaweeds. They are different from green plants due to their simple reproductive structure for sexual reproduction. Many live in aquatic environments but many also thrive as subterranean algae. Algae are of great importance to biologist because single algal cells are complete organisms capable of photosynthesis and the synthesis of other compounds which constitute the cell. The study of algae is known as phycology.

4.1 General Characteristics of Algae

i. Algae are eukaryotic microorganisms.

ii. They are photosynthetic microorganisms.

iii. They contain chlorophyll and utilise light energy to generate their chemical energy.

iv. Chlorophyll and other pigments are found in membrane bound organelles known as chloroplasts.

v. Algae contain a discrete nucleus. Other inclusions are starch grains, oil droplets and vacuoles.

vi. They have a wide range of sizes and shapes. Many species occur as single cells that may be spherical, rod shaped, club-shaped or spindle-shaped. Others are multicellular and appear in every conceivable form, shape and degree of complexity.

vii. In most species the cell wall is thin and rigid cell walls of diatoms are impregnated with silica making them thick and very rigid.

viii. The motile algae such as euglena have flexible cell membrane called periplasts.

ix. They are also able to produce oxygen from water.

4.2 Occurrence and Distribution

Algae are found in many places on earth. They occur in great abundance in the ocean, seas, salt lakes, fresh water lakes ponds and streams. Many are found in damp soil, on rocks, stones and tree barks. Some are found on plants and animals. Small aquatic forms make up a large part of the free-floating microscopic life in water called plankton which is the principal food for aquatic animals including such large ones as whales. Plankton is generally considered to be composed of both algae and microscopic animal forms. Phytoplankton is made up of plants, i.e. algal forms and zooplankton is composed of animal organisms. Algae are found where there are sufficient light, moisture and simple nutrients to sustain them. Some species of algae grow on the snow and ice of Polar Regions and mountain peaks, sometimes

occurring in such abundance that the landscape becomes coloured by the red pigments in their cells.

A very common green alga is **spirogyra**; a filamentous alga found on the scum that cover ponds are slow moving water. The motile algae also called the swimming algae have flagella occurring singly or in clusters at the anterior or posterior ends of the cells. Some algae have no means of locomotion and are carried by tides, waves and currents. Some attach themselves to the substrate in the body of water where they live and are occasionally broken loose by currents which move them to new locations. In some forms, only the zoospores, the asexual reproductive cells are motile.

4.3 Reproduction

Algae may reproduce either asexually or sexually. Some species are limited to one of these processes. However, they have complicated life cycles involving both asexual and sexual means of reproduction.

4.3.1 Asexual Reproduction

Asexual reproduction processes in algae include:

i. purely vegetative binary fission.

ii. production of unicellular spores, many of which, especially in the aquatic forms have flagella and are motile, these are called **zoospores**. In terrestrial types of algae, non-motile spores or **aplanospores** are formed; however, some aplanospores can develop into zoospores.

4.3.2 Sexual Reproduction

All forms of sexual reproduction are found among the algae. In this processes there is a fusion (conjugation) of sex cells called gametes to form a zygote. If the gametes are identical, i.e., there is no visible sex differentiation. The fusion process is called

isogamous. However, if two gametes are different, the process is called heterogamous. In higher algae, the sex cells are differentiated into male and female. The female egg cell (ovum) is large and non motile, while the male gametes (sperm cell) is small and are actively motile. This type of sexual reproduction is called oogamy.

5.0 PROTOZOA

Protozoa are unicellular, non-photosynthetic eukaryotic organisms. They are distinguished from other eukaryotic protists by their ability to move at some stage of their life cycle and by their lack of cell walls. Some protozoa are free living while some are parasitic. Some protozoa form colonies, in a colony, the individual cells are joined by cytoplasmic thread or embedded in a common matrix, hence colonies of protozoa are essentially a cluster of independent cells. The study of protozoa is called Protozoology.

5.1 General Characteristics of Protozoa

- ❖ They are unicellular, non-photosynthetic microorganisms.
- ❖ They are predominantly microscopic in size.
- ❖ They occur generally as single cells.
- ❖ They lack cell walls.
- ❖ They have ability to move at some stages of their life cycle.
- ❖ Many are motile.
- ❖ The majority of protozoa are between 5 and 250μm in diameter.
- ❖ They occur in colonies with each colony having independent individual cells.
- ❖ Protozoa may be divided into free-living forms and those living on or in other organisms.

5.2 Occurrence/Distribution of Protozoa

Protozoa are found in all moist habitats. They are common in the sea, in soil and freshwater. Free-living protozoa have even been found in the Polar Regions and at very high altitudes. Parasitic protozoa may be found in association with most animal groups. Most protozoa survive dry conditions by the formation of a resistant cyst or dormant stage.

5.2.1 Free-Living Protozoa

Free-living protozoa are found in a variety of habitats. The factors which influence the distribution and number of free-living protozoa in a habitat are: moisture, temperature, light, available nutrients, and other physical and chemical conditions.

5.2.2 Symbiotic Protozoa

This is a type of co-existence between protozoa and other organisms which differ in many ways and include:

1. Commensalism: In which the host is neither injured nor benefitted but the commensal (protozoa) is benefitted, e.g. the protozoa living in the lumen of the alimentary tract.

2. Mutualism in which some flagellates are present in the gut of termites and help to digest the woody materials eaten by termite to a form which can be used by the host cells. If deprived of these flagellates, the termite dies, if the flagellates are removed from the termite gut, they also die.

3. Some protozoa are parasites, they live at the expense of other organisms, and an example is **Plasmodium** which is a parasite of man and causes malaria in man.

5.2.3 Locomotory Organelles

Protozoa may move by three types of specialised organelles: pseudopodia, flagella and cilia. In addition, a few protozoa without such organelles can carry out a gliding movement by body flexion.

1. **Pseudopodia:** A pseudopodium is a temporary projection of part of the cytoplasm of those protozoa which do not have a rigid pellicle. Pseudopodia are therefore characteristic of the amoebas (sarcodina). These organelles are also used for capturing food substances.

2. **Flagella:** The flagellum is an extremely fine filamentous extension of the cell. As a rule, the number of flagella present in an individual protozoan varies from one to eight; one or two is the most frequent number. Examples include; Trypanosomes, Leishmania and Trichomonas species

3. **Cilia:** are fine and short threadlike extensions from the cell. In addition to their locomotory function, also aid in the ingestion of food and serve often as a tactile organelle, e.g. Paramecium.

5.3 Reproduction of Protozoa

Protozoa general multiply by asexual reproduction. Many protozoa are able to carry out both asexual and sexual processes. Some parasitic forms may have an asexual phase in one host and a sexual phase in another host.

Asexual Reproduction occurs by simple cell division, which can be equal or unequal the daughter cells are of equal or unequal sizes, respectively. If two daughter cells are formed, then the process is called **binary fission**. If many daughter cells are formed, it is called **multiple fission**. Budding is a variation of unequal cell division.

Sexual Reproduction: Various types of sexual reproduction have been observed among protozoa. Sexual fusion of two gametes (syngamy or gametogamy) occurs in various groups of protozoa. They include:

Conjugation, sexual process found exclusively in the ciliates. After exchange of nuclei, the conjugants separate and each of them gives rise to its respective progency by fission or budding. When the gametes (which develop from trophozoites) are morphologically alike, they are called isogametes. When they are unlike in morphology (as well as physiology), they are anisogametes and can be either microgametes or macrogametes.

6.0 The Role of Microorganisms in Nature

Microbes are everywhere in the biosphere, and their presence invariably affects the environment. The effects of microorganisms on the environment can be beneficial or harmful or in-apparent with regard to human measure or observation.

6.1 Beneficial Roles on Microorganisms

The beneficial effects of microbes derive from their metabolic activities in the environment, their associations with plants and animals, and from their use in food production and biotechnological processes.

1. Nutrient Cycling and the Cycles of Elements that Make Up Living Systems

The most significant effect of the microorganisms on earth is their ability to recycle the primary elements that make up all living systems, especially carbon (C), oxygen (O) and nitrogen (N). Different forms of carbon and nitrogen are needed as nutrients by different types of organisms. The diversity of metabolism that exists in the microbes ensures that these elements will be available in their proper form for every type of life. The most important aspects of microbial metabolism that are involved in the cycles of nutrients are discussed below.

- **Primary production** involves photosynthetic organisms which take up CO_2 in the atmosphere and convert it to organic (cellular) material. The process is also called CO_2 fixation.

- **Decomposition** or **biodegradation** results in the breakdown of complex organic materials to forms of carbon that can be used by other organisms.

- **Nitrogen fixation** is a process found only in some bacteria which removes N_2 from the atmosphere and converts it to ammonia (NH_3), for use by plants and animals. Nitrogen fixation also results in replenishment of soil nitrogen removed by agricultural processes. Some bacteria fix nitrogen in symbiotic associations in plants. Other Nitrogen-fixing bacteria are free-living in soil and aquatic habitats.

- **Production of Oxygen -** Photosynthesis results in the production of O_2 in the atmosphere. **At least 50 percent of the O_2 on earth is produced by photosynthetic microorganisms (algae and cyanobacteria),** and for at least a billion years before plants evolved, microbes were the only organisms producing O_2 on earth. O_2 is required by many types of organisms, including animals, in their respiratory processes.

2. Symbiosis with Animals and Plants

Microbes invariably enter into beneficial, sometimes essential, associations with all higher forms of organisms, including insects, invertebrates, fish, animals and plants. For example, bacteria and other microbes in the intestines of animals and insects digest nutrients and produce vitamins and growth factors. In the plant world, leguminous plants live in intimate associations with bacteria that extract nitrogen from the atmosphere and supply it to the plant for growth.

The microbes that normally live in associations with humans on the various surfaces of the body (called the normal flora) are known to protect their hosts from infections, and otherwise promote nutrition and health.

3. Production of Foods

In the home and in industry, microbes are used in the production of fermented foods. Yeasts are used in the manufacture of beer and wine and for the leavening of breads, while some bacteria are used to make yoghurt, cheese, sour cream, buttermilk and other fermented milk products.

4. Medical, Pharmaceutical and Biotechnological Applications

In human and veterinary medicine, for the treatment and prevention of infectious diseases, microbes are a source of antibiotics and vaccines.

- **Antibiotics** are substances produced by microorganisms that kill or inhibit other microbes which are used in the treatment of infectious disease. Antibiotics are produced in nature by molds such as *Penicillium* and bacteria such as *Streptomyces* and *Bacillus*.

- **Vaccines** are substances derived from microorganisms used to immunize against disease. The microbes that are the cause of infectious disease are usually the ultimate source of vaccines.

- **Biotechnology** - Microbiology makes an important contribution to biotechnology, an area of science that applies microbial genetics to biological processes for the production of useful substances. This opens the possibility for microbial production of foods, fuels, enzymes, hormones, diagnostic agents, medicines, antibiotics, vaccines, antibodies, natural insecticides and fertilizers, and all sorts of substances useful in our civilization and society.

6.2 Harmful Role of Microorganisms

The primary harmful effects of microbes upon our existence and civilization is that they are an important cause of disease in animals and crop plants, and they are agents of spoilage and decomposition of our foods, textiles and dwellings.

1. Microbes Cause Infectious Disease

A microbe which is capable of causing infectious disease in an animal or plant is called a pathogen. Pathogens are the cause of infectious diseases. Historically, infectious diseases are the most significant cause of death in humans. Microbes are also the cause of many diseases in plants, which, if crop plants or forest resources, may have important economic or social consequences.

2. Microbes Cause Food Spoilage and Decomposition

Microbes are the agents of food spoilage and decomposition of clothing and sheltering materials. The factors that allow microbes to accomplish biodegradation and carbon cycling are at work on everything organic, which includes stored foods and grains, as well as natural structural materials and textiles used for our shelters and clothing. Fungi and bacteria are the major microbial agents of decomposition in the environments.