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NSC 106

Medical Mircobiology and Parasitology

Module 2

NSC 106 Medical Microbiology and Parasitology) Module 2

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Module 2: Introduction

As a practice nurse, you are aware of some characteristics features of microrgansims such as reproduction, movement etc. Microorganisms have different characteristics features which will be discussed in this module. The microranisms that will be discussed are those that have direct link with man. This module deals with general characteristics of bacteria, fungi and virus.

At the end of this module, you should be able to:

- describe the general characteristics of microorganisms and their links and usefulness to humans.

Unit 1 General Characteristics of Bacteria

1.0 Introduction

Bacteria are characterised based on the cell shape, size and structure cell arrangement, occurrence of special structures and developmental forms, staining reactions and motility and flagella arrangement. They are also characterised by the cell wall component, Gram stain reaction, cellular respiration and mode of nutrition. This unit examines the general characteristics of bacteria, shapes and forms of bacteria, structures external and internal in bacteria among other things.

2.0 Objectives

At the end of this unit, you should be able to:

- describe the general characteristics of basic bacteria
- identify and name the general shapes and forms of bacteria
- describe the external and internal structures of bacteria
- explain the significance of the cell wall structure and composition
- explain the modes of nutrition and energy source in bacteria
- explain the modes of cellular respiration in bacteria
- explain the modes of reproduction in bacteria.

3.0 Main Content

3.1 General Characteristics of Bacteria

- They are prokaryotic

- They are simplest of all microbial cells
- Bacteria are single celled organisms
- They have distinctive cell wall which contain peptidoglycan
- They are measured in unit called micrometer
- Bacteria lack a true nucleus but have a region called the nucleroid region, i.e. DNA is free floating
- They may have additional DNA called a plasmid
- Their reproduction is by binary fission
- They are extremely diverse and numerous in soils and waters.

3.2 Size, Shape and Arrangement of Bacterial Cell Size

Bacteria are very small, 0.5 to 1.0µm in diameter. Because of their small size, they have high surface area/volume ratio which results in a high growth and metabolism rate. No circulatory mechanism is needed for nutrients taken in because the mass of cell substance to be nourished is very close to the surface. Examinations of a microbial cell require the use of a high power microscope usually of about 1,000 diameters.

Fig.1: A Basic Bacterium Cell
Source: Microorganisms in our World by Atlas (1995)

Shape and Arrangement

The shape of a bacterium is governed by its rigid cell wall which gives it a definite shape.

Typical shapes of bacteria are:

- Cocci (Singular: Coccus), e.g. *Staphylococcus*
- Bacilli (rods) (Singular: rod, bacillus), e.g. Bacillus subtilis
- Vibrios (Singular: Vibrio)
- Spirilla (Singular: Sprillum)
- Spirochaetes (Singular: Spirochaete), e.g. Treponema pallidum.

Some species of bacteria are pleomorphic, i.e. they are able to change their forms especially when grown on artificial media.

1. **Cocci:** They are round, oval or spherical in diameter characteristic arrangement when multiplying is based on arrangement of cells, they are called:

- Diplococci: cocci in pairs, e.g. meningococci and gonococci.
- Streptococci cocci in chains.
- Staphylococci: cocci in irregular clusters (like a bunch of grapes).
- Tetracocci: cocci in a group of four cells.
- Sarcinae: cocci in regular clusters.

2. **Bacilli (Rod):** These are stick like bacteria with rounded, square, tapered or swollen ends. They measure 1-10µm in length by 0.3-1.0µm in width.

Bacilli are not arranged in patterns as complex as cocci. Most occur singly. Other arrangements are:

- Diplobacilli: Rods in pairs.
- Streptobacilli: Rods in chains.
- Trichomes: Similar to chains but have larger area of contact between adjacent cells.
- Mass together, e.g. Mycobacterium leprae.
- Palisade arrangement cells are lined side by side like matchsticks and at angles to each other like Chinese lecters, e.g. Corynebacterium diptheriae.

3. Vibrios: These are small slightly curved rods, or comma shaped 3-4µm in length by 0.5µm in width. Most are motile with a single flagellum at one end, e.g. Vibrio cholerae.

4. Spirilla: These are helical bacteria, small, regularly coiled, rigid, organisms measuring 3-4µm in length. Each coil measures about 1µm, e.g. Spirillum minus.

5. Spirochaetes: They are helical, (complete twist), flexible, coiled organisms, can twist and contort their shapes. Spirochaeters are divided into three main groups.

Treponemes: Tiny and delicate with regular tight coils, measuring 6-15µm by 0.2µm in width, e.g. Treponema pallidum and Treponema pertenue.

Borreliae: Large spirochaetes with irregular open coils 10-20µm in length by 0.5µm in width, e.g. Borella., duttoni and Borrelia vinceti.

Leptospires: Tiny spirochaetes with many tightly packed coils that are difficult to distinguish; 6-20µm in length by 0.1µM in width and have hooked ends, e.g. Leptospira, interrigans.

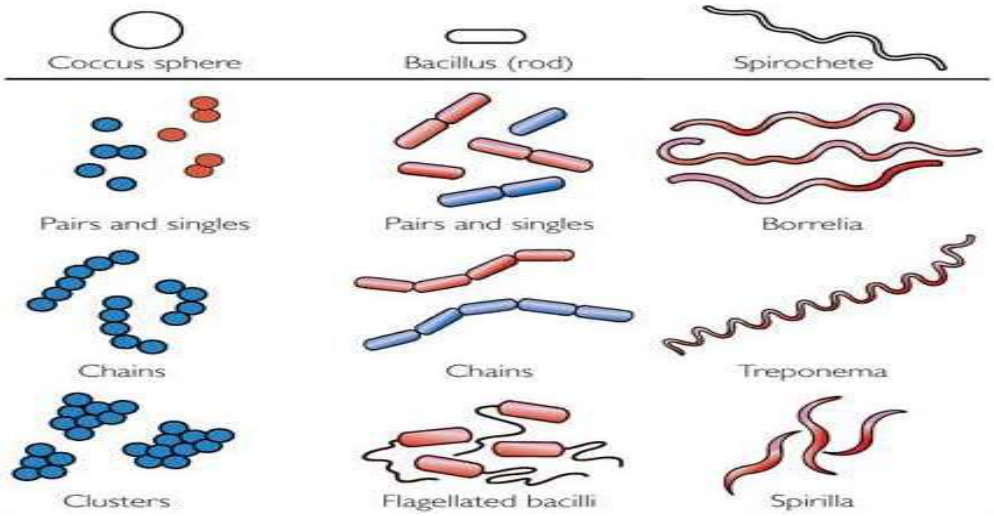

Fig. 2: Common Shapes of Bacteria
Source: Microorganisms in our World by Atlas (1995)

In addition to the common bacterial shapes, many others also occur in different shapes, which include:

- Pear Shaped cells, e.g. pasteuri
- Lobed Spheres, e.g. sulfolobus
- Rods with squared ends, e.g. bacillus anthracis
- Disk arranged stacks of coins, e.g. caryophanon
- Rods with helically sculptured surfaces, e.g. seliberia and many others.

The shape of a cell affects its survival and activity in the environment.

3.3 Bacterial Structures

Examination of a bacterial cell will reveal several components and structures. Some are external to the cell wall while others are internal to the cell wall.

Structure External to the Cell Wall
1. Flagella (Singular: Flagellum): These are hair like, helical appendages that protrude through the cell wall, 0.01 – 0.02µm in diameter and simple in structure. Based on their location on the cell, flagella may be polar or lateral.

- Polar: At one or both ends of bacterium.
- Lateral: Along the sides of the bacterium.

A flagellum is composed of three parts:

- A based body associated with the cytoplasmic, membrane and cell wall.
- A short hook and a helical filament which is usually several times as long as the cell.
- A flagellum grows at the tip rather than at the base.

Types of Flagella
Monotrichous: A single polar flagellum. Many that appears and functions as monopolar or bipolar flagella consist of bundles of 2 to 50 single units (polytrichous). eg Vibrio cholerae

Lophotrichous: A cluster of polar flagella or multiple polar flagella eg Bartonella baciliformis

Amphitrichous: Flagella, either single or clusters at both cell poles or single bipolar flagella eg Spirillum serpens

Peritrichous: Cell surrounded by lateral flagella or flagella distributed over the entire cell eg Escherichia coli

Function of Flagella
Bacteria propel themselves by rotating their helical flagella.

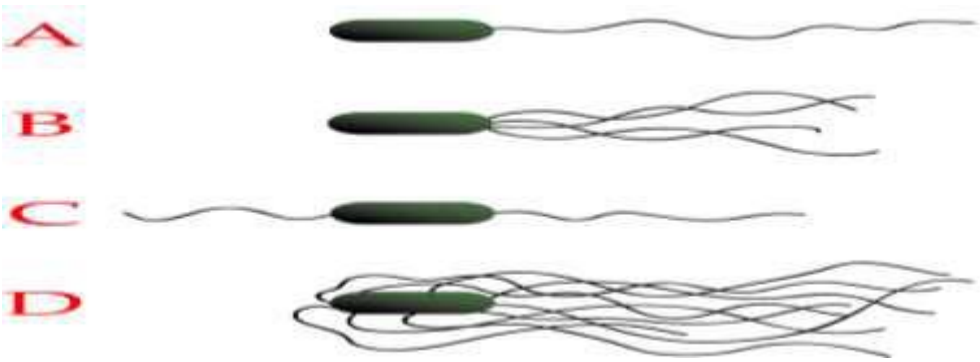

Fig. 3: Types of Flagella
Source: bioweb.uwlax.edu

2. Pili (Singular: Pilus): They are also called fimbriae. They are hollow, non-helical filamentous appendages that are thinner, shorter and more numerous than flagella: long, thin, straight threads 3-25µm in diameter and 12µm in length. They do not function in motility since they are found on non-motile and motile species. Several functions are associated with different types of pili.

F pilus (Sex pilus) serves as the path of entry of genetic material during bacterial mating. Some play major role in human infection by allowing pathogenic bacteria to attach to the epithehal cells lining the respiratory, intestinal or genitourinary tracts, this prevents the bacteria from being washed away by the flow of mucous or body fluids and permits infections to be established.

3. Capsules: This is a viscous substance forming a covering layer or envelope around the cell wall of some bacteria. Capsules are known to confer resistance to phagocytosis because complement cannot penetrate it, hence protecting bacteria against host defense to invasion. Also protects the bacteria from desiccation. Capsules are usually antigenic for identification. Capsules can be categorised into three based on their visualisation by light microscope using special staining methods.

If the covering layer can be visualised by light microscope using special staining methods, it is termed capsule.

Microcapsule: If the layer is too thin to be seen by light microscope.

Slime: If it is so abundant that many cells are embedded in a common matrix.

Most bacterial capsules consist of polysaccharides which can be homopolysaccharides or heteropolysaccharides.

Homopolysaccharides: Capsule made up of/composed of a single kind of sugar usually synthesised outside the cell by exocellular enzymes, e.g. glucan (a polymer of glucose) from sucrose by S. mutans.

Heteropolysaccharides: Composed of several kinds of sugars. A few capsules are polypeptide, e.g. bacillus anthracis has a capsule made up of a polymer of glutamic acid.

Functions

- They may provide protection against temporary drying by binding water molecules.
- They may block attachment of bacteriophages.
- They may be antiphagocytuc, i.e. they may inhibit the engulfment of pathogenic bacteria by white blood cells. Hence contribute to invasive or infective ability (virulence).
- Promote attachment of bacteria to surfaces.

Example of capsulated bacteria include; neisseria gonorhoeae, streptococcus pneumonia, hemophilus influenza.

Sheaths: Some bacterial species form chains or trichomes enclosed by a hollow tube called sheaths. These sheaths consist of a heteropolysaccharides containing glucose, glucuronic acid, galactose and fucose.

Functions

- In a few bacteria, they facilitate moderate change of position.
- Sheaths enable individual cells to stay associated in cell colonies.

Prosthecae and Stalks

Prosthecae: They are semi rigid extensions of the cell wall and cytoplasmic membrane and have a diameter less than that of the cell. Found in some aerobic bacteria from fresh water and marine environment.

Functions

- Increase surface area of the cell for nutrient absorption.
- Some have adhesive substances that aid attachment to surfaces.

Stalks: They are non-living ribbon, and like tubular appendages excreted by some bacterial cells, e.g. found in Gallionella or lanctomyces.

Functions

They aid in attachment of the cells to surfaces.

Some bacteria possess oval structures called endospores (these are not appendages) formed within certain bacteria specie that represent a dormant stage in the growth cycle of the organism. They are formed in response to nutritional deprivation within the vegetative bacterial cell. Highly resistant to injurious effects of heat, drying, pressure and many chemical disinfectants. Seen in Bacillus and Clostridium spp. And can reverse to vegetative form when environmentally convenient.

The Cell Wall

This provides structural rigidity and forms barrier against the outside environment. It has a high tensile strength conferred on it by a layer composed of a substance called peptidoglycan (aka murein or mucopeptide).

Bacteria are classified as Gram +ve or Gram –ve according to their response to Gram staining procedure i.e based on the propensity of their cell wall to hold fast to the primary dye (crystal violet) or otherwise when exposed to a decolorizing agent such as acetone or 95% alcohol.

It is the site of antigenic determinant of the cell surface. Lipopolysaccharide component of the Gram -ve wall is responsible for non specific endotoxin activity. The cell wall also Shows differences in Gram reaction thereby gives basis for classifying bacteria.

Gram positive cell wall

About 80nm thick with several layers of peptidoglycan(40-80% dry weight). Trapped within this peptidoglycan matrix are a variety of proteins, polysaccharides and unique molecules called teichoic acids which stabilize the wall, chelate small ions necessary for cell function and participate in cellular interaction and adherence to mucosal surfaces and are antigenic forming basis for antigenic grouping in some organisms.

The enzymatic biosynthesis of peptidoglycan form target sites for inhibition of cell wall synthesis by specific antibiotics.

Inhibitors of cell wall synthesis

- Beta lactams- they possess lactam rings. They are penicillins, cephalosporins, monobactams and cabapenems.
- Vancomycin …….. Glycopeptides
- Teicoplanin ……. Glycopeptides
- Fosfomycin
- Bacitracin
- Cycloserine.

Beta lactamase inhibitors- clavulinic acid, sulbactam, tazobactam.

Gram negative cell wall

It is thinner but highly complex and multilayered of about 5-10nm thickness Composed of:

- A peptidoglycan layer- relatively thinner than that of Gram +ve wall i.e about 2nm thick (5-10% of dry mass)

- Outer membrane- A bilayered structure, inner and outer leaflets are asymmetrical. Contains numerous proteins, up to 50% by mass. Lipopolysaccharides is attached by a weak cohesive forces (ionic and hydrophobic interractions) to the outer leaflet.
- Lipopolysaccharides (LPS) – attached to outer leaflet of the outer membrane. LPS is responsible for endotoxin activity of GN organisms in GN sepsis.

LPS has three components-

1. Lipid A- much of endotoxin effect.
2. Core polysaccharide region.
3. O-specific (somatic antigen) polysaccharide- for much identification.
    - Lipoprotein – cross-link outer membrane and peptidoglycan layer. Function to stabilize outer membrane and anchor it to the peptidoglycan layer.
    - Periplasmic space – seen immediately outside the cytplasmic membrane. Contains peptidoglycan layer and gel-like solution of proteins. Periplasmic proteins include substrates-binding proteins (for sugars,amino acids, vitamins and ions); hydrolytic enzymes; detoxifying enzymes(e.g β-lactamase and aminoglycoside phosphorylase). Detoxifying enzymes cause antibiotic resistance.

Gram Staining

This staining technique makes use of properties in the cell wall of the bacteria I.e. the peptidoglycan content in the cell wall. For gram positive bacteria that has higher peptidoglycan content, they retain the primary stain(crystal violet) despite decolourisation by acetone thereby appearing purple or blue but gram negative will quickly lose the primary stain after brief decolourisation due to reduced content of peptidoglycan in their cell wall thereby taking the colour of the counterstain(neutral red/safranin) and appearing red. Stains in gram staining are- Crystal violet (primary stain), lugol's iodine (mordant), acetone (decolouriser), neutral red/safranin (counterstain).

Structures Internal to the Cell

1. Cytoplasmic Membranes

- This lies immediately beneath the cell wall.
- It is approximately 7.5µm (0.0075µm) thick and composed primarily of phospholipids (20 to 30 percent) and protein (60 to 70 percent).
- It serves as a barrier to most water soluble molecules.
- It contains various enzymes involved in respiration, and metabolism and in synthesis of capsular and cell wall component.
- Proteins are also synthesised in the cytoplasm.

2. Protoplast

A protoplast is the portion of a bacterial, all made up of the cytplasmic membrane and the cell material bounded by it.

3. The Cytoplasm

This is the cell material bounded by the cytoplasmic membrane and it may be divided into:

- The cytoplasmic area, granular in appearance and rich in the macromolecular RNA-protein bodies called Ribosomes on which proteins are synthesised.
- The chromatin area rich in DNA and
- The fluid portion with dissolved substances.

4. Nuclear Material

Unlike eucaryotic cells bacterial cells do not have a distinct membrane enclosed nucleus but they have an area near the centre of the cell that is regarded as the nuclear structure, the DNA of the cell is confined to this area. The DNA is circular and bears the genes of the cell.

5. Spores and Cysts
Certain bacteria produce spores either within the cells (endospores) or external to the cell (exospores). The spore is metabolically dormant form which under appropriate condition can germinate to form a vegetative cell. Endospores are extremely resistant to desiccation, staining, disinfecting chemicals, radiation and heat.

Cysts are also dormant, thick walled desiccation resistant forms that can germinate also under favourable conditioning.

Nutrition
The nutrition requirements of bacteria vary widely. Based on their source of energy, they are classified as:

- Phototrophs: These are bacteria that use light energy as their energy sources.
- Chemotrophs: They obtain their energy by oxidizing inorganic or organic – chemical compounds.

Based on the source of carbon which is the major source of nutrient for all cells bacteria can be classified as:

- Heterotrophs: These are bacteria that derive carbon from preformed organic nutrients such as sugar or carbohydrate.
- Autotrophs: They derive carbon from inorganic sources such as carbon dioxide.

Cellular Respiration
Based on whether they need oxygen to survive or not, bacteria may be:

- Aerobic or strict aerobes: these require oxygen, e.g. Bacillus cereus.
- Anaerobic bacteria or strict anaerobes: they cannot tolerate oxygen, e.g. Clostridium spp.
- Facultative anaerobes: These are generally aerobes but have the capacity to grow in the absence of oxygen, e.g. Staphylococcus spp.

Reproduction
Bacteria reproduce mainly by asexual method which most of the time is transverse binary fission. This is a process in which a bacterial cell divides to give two daughter cells after developing a transverse septum (cross wall).

4.0 Conclusion

In this unit, we have learnt that Bacteria are prokaryotic single celled organisms that lack membrane-bound organelles. They are very small, with sizes ranging from 0.5 to 1.0nm in diameter. Also discussed were structures external to bacterial cell wall such as flagella, pili, capsules, sheaths, prosthecae and stalks.

5.0 Summary

In this unit, you have learnt about the following:

- General characteristics of bacteria
- Size, shape and arrangement of bacterial cell
- Bacterial structures.

6.0 Self-Assessment Exercise

Activity: Differentiate the cell walls of gram positive and gram negative bacteria. Also mention the stains in gram staining technique

1. Describe the general characteristics of basic bacteria (LO1)
2. What are the general shapes and forms of bacteria (LO2)
3. List four different structures external to the cell wall of bacteria and state one function of each. (LO3)
4. Explain the term gram positive and gram negative cell wall (LO4)
5. Describe the structures internal to bacteria cell (LO3)
6. Explain the modes of nutrition and energy source in bacteria (LO5)
7. Explain the modes of cellular respiration in bacteria (LO6)
8. Explain the modes of reproduction in bacteria. (LO7)

7.0 References/ Further Reading

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Unit 2 General Characteristics of Fungi

1.0 Introduction

Fungi are eukaryotic spore bearing organisms that lack chlorophyll and generally reproduce both sexually and asexually. They are of great practical and scientific importance. One of the reasons for this is that many fungi are of microscopic cellular dimensions. Fungi have a diversity of morphological appearances depending on the species. Fungi comprise the molds, mushrooms and yeasts. Molds are filamentous and multicellular while yeasts are unicellular. They are widely distributed and found wherever moisture is present. They are of great importance to man in both beneficial and harmful ways. This unit examines the general characteristics of fungi, the distribution, morphology, nutrition and reproduction of fungi.

2.0 Objectives

At the end of this unit, you should be able to:

- define a fungus
- state the general characteristics of fungi
- describe the structure of a yeast
- describe the structure of a mold
- explain the mode of nutrition in fungi
- explain the methods of asexual reproduction and sexual reproduction in fungi.

3.0 Main Content

Definition of Fungi
Fungi are eukaryotic spore bearing organisms that lack chlorophyll and generally reproduce both sexually and asexually.

3.1 Distinguishing Characteristics of Fungi

They are large, diverse and widespread group of organisms, the molds, mushrooms and yeasts.

- Fungi are Eucaryotic. They are members of the domain Eucarya.
- They contain a membrane-enclosed nucleus and several other organelles.
- They have no chlorophyll.
- They are chemo organotrophic organisms.
- The body of the fungi is called thallus.
- The thallus may consist of a single cell as found in yeasts.

- The thallus may consist of filaments, 5 to 10µm across which are commonly branched as found in molds.
- The yeast cell or mold filament is surrounded by a true cell wall (exception is the slime mould which have a thallus consisting of a naked amoeboid mass of protoplasm).
- Some fungi are dimorphic, that is they exist in two forms. Some pathogenic fungi of humans and other animals have a unicellular and yeast like form in their host but when growing saprobically in soil or on a laboratory medium they have a filamentous mold form.
- Habitat distribution of fungi is diverse. Some are aquatic, living primarily in fresh water and a few marine fungi are terrestrial. They inhabit soil and dead plant. Some are parasitic, inhabiting and infecting living hosts either plants or animals. Some form beneficial relationships with other organisms as mycorrhisae.
- The study of fungi is known as mycology.

3.2 Structure and Forms of Fungi

The body or vegetative structure of a fungus is called a thallus (plural thalli). It varies in complexity and size ranging from the single cell microscopic yeasts to multicellular moulds and mushrooms. The fungal cell is usually enclosed in a cell wall of chitin.

Yeasts

- They are unicellular fungi that have a single nucleus.
- They are commonly egg-shaped but some are elongated and some spherical. Yeasts have no flagella or other organelles of locomotion.
- They possess most of the other eukaryotic organelles.
- Yeast cells are larger than most bacteria. Yeasts vary considerably in size ranging from 1 to 5µm in width and from 5 to 30µm or more in length.
- They reproduce asexually by budding and traverse division or sexually through spore formation.

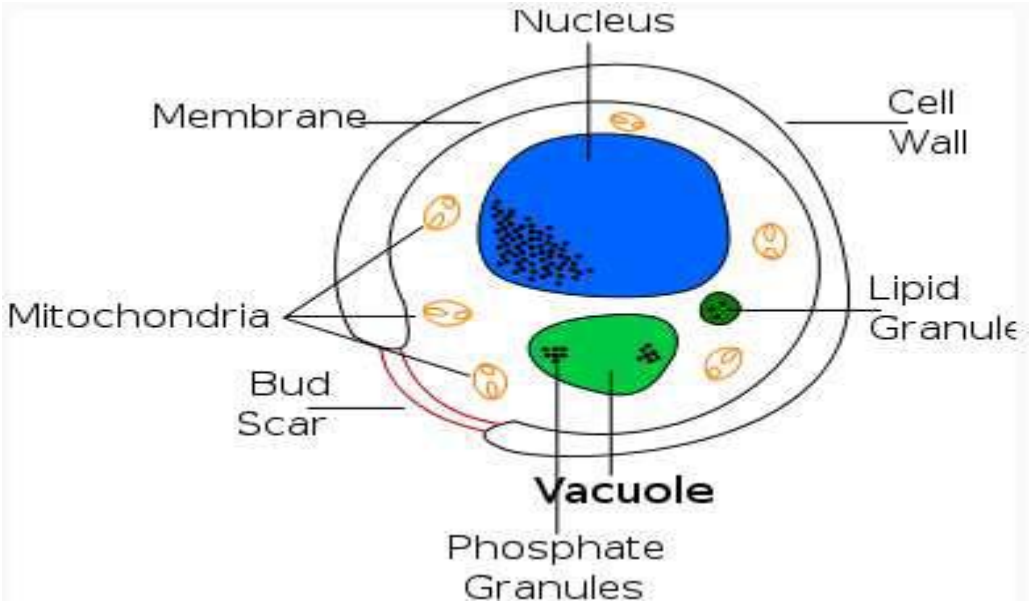

Fig 1: A Diagram of a Yeast Cell
Source: Wikimedia Commons by Frankie Robertson using Inkscape (2009)

Molds
The thallus of a mold consists of long branched threadlike filaments of cells called hyphae. These hyphae form a mycelium which is a tangled mass or tissue like aggregation of hyphae.

Hyphae
- Each hypha is about 5 to 10µm wide. Hyphae are composed of an outer tube like wall surrounding a cavity the Lumen which is filled or lined by protoplasm. Between the protoplasm and the wall is the plasmalemma, a double layer membrane which surrounds the protoplasm.
- The hyphal wall consists of microfibrils composed of hemicelluloses or chitin. True cellulose occurs only in the walls of lower fungi.
- Wall matrix material in which the microfibrils are embedded consists of proteins, lipids and other substances. Growth of a hypha is distal near the tip.

The Mycelium
The mycelium is a complex of several filaments called hyphae (singular, hypha). New hyphae generally arise from a germinated spore. The germinated spore puts out a germ tube or tubes which elongate to form hyphae.

These hyphae form a tangled mass or tissue like aggregation.

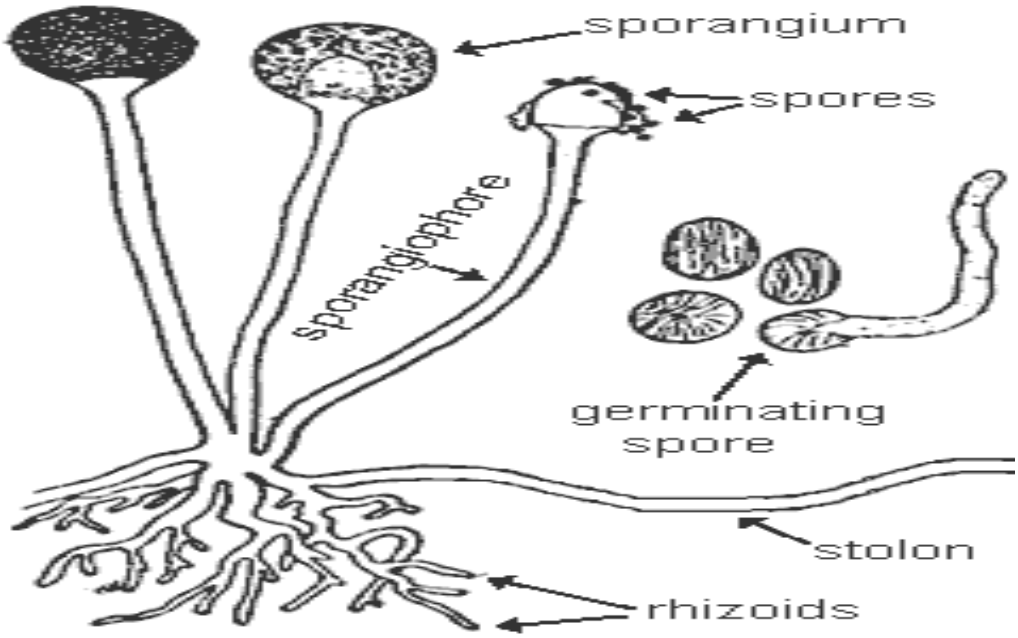

Fig. 2: Rhizopus Stolonifer
Source: Retrieved From The Backyard Nature Website At File://G:\Bread Mold Fungus, Rhizopus Stolonifer.Htm.

In some fungi, protoplasm streams through hyphae uninterrupted by cross walls, these hyphae are called coenocytic or aseptate.

The hyphae of others have cross walls called septa (*s. septum*) with either single pore or multiple pores that enables cytoplasmic streaming.

These hyphae are termed septate.

Summarily, hyphae can be said to occur in three forms:

- Nonseptate or coenocytic; such hyphae have no septa.
- Septate with uninucleate cells.
- Septate with multinucleate cells. Each cell has more than one nucleus in each compartment.

3.3 Nutrition and Metabolism

Most fungi are saprobes, securing their nutrients from dead organic matters. They release hydrolytic exo-enzymes that digest external substrates and absorb the soluble products.

They are also chemoorganoheterotrophs, i.e. they use organic compounds as a source of carbon, electrons and energy. Fungi are usually aerobic; however, some yeasts are facultatively anaerobic and can obtain their energy by fermentation. Obligately anaerobic fungi are found in the rumen of cattle.

3.4 Reproduction

Reproduction in fungi can either be asexual or sexual.

Asexual Reproduction
Asexual reproduction is a type of reproduction involving only one parent that produces genetically identical offspring by budding or by the division of a single cell or the entire organism into two or more parts. Asexual reproduction, also called somatic or vegetative reproduction is accomplished in several ways and does not involve the fusion/union of nuclei, sex cells or sex organs. It may be accomplished by:

- fission of somatic cells yielding two similar daughter cells
- budding each bud a small outgrowth of the parent cell develops into a new individual
- fragmentation or disjointing of the hyphal cells each fragment becoming a new organism spore formation.

There are several types of asexual spores each with a name.

Sporangiospores: These are single-celled spores formed within sacs called sporangia (singular: sporangium) at the end of special hyphae called sporangiospores).

There are two types of sporangiospores: Aplanospores which are non-motile and zoospores which are motile. Motility is due to the presence of flagella.

Condiospores or conidia (singular, conidium). These are formed at the tip or side of a hypha. Single celled conidia are called microconidia while large multicelled conidia are called macroconidia.

Oidia (singular oidium) or arthrosopores: These are singlecelled spores formed by disjointing of hyphal cells.

Chlamydospores: These are thick walled single celled spores which are highly resistant to adverse conditions. They are found from cells of the vegetative hypha.

Blastospores: These are spores formed by budding.

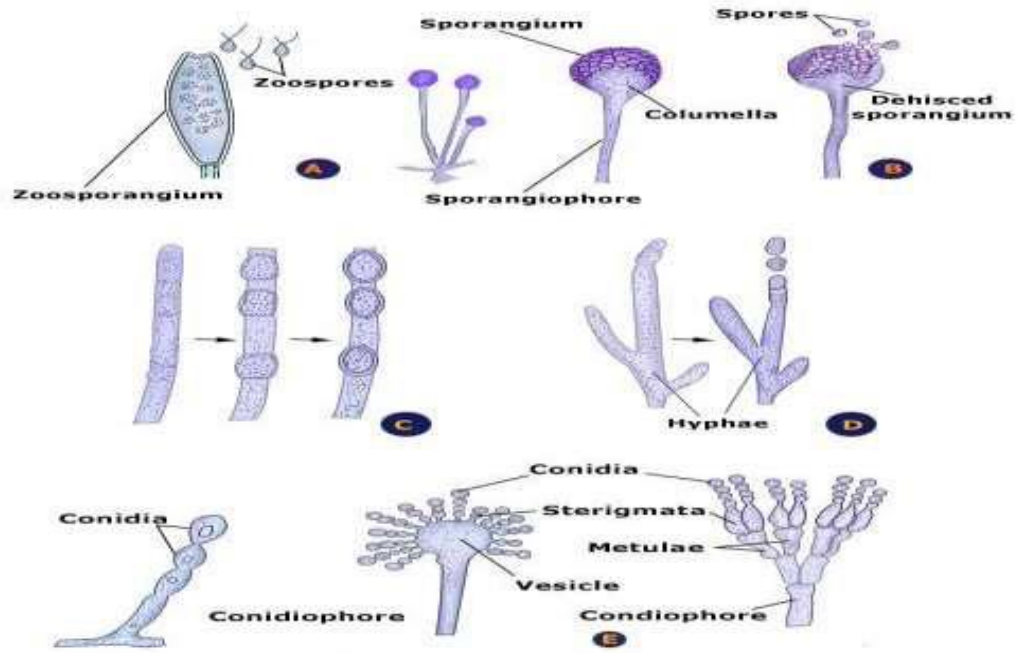

Fig. 3: Different types of Asexual Spores
Source: (http://mb0804mycology.wordpress.com/2008/07/29/reproduction-of-fungi/)

Sexual Reproduction
Sexual reproduction is a type of reproduction in which two parents give rise to offspring that have unique combinations of genes inherited from the gametes of the two parents.

It is carried out by fusion of the compatible nuclei of two parent cells. The process of sexual reproduction begins with the joining of two cells and fusion of their protoplast (plasmogamy) thus enabling the two haploid nuclei of two mating types to fuse together (karyogamy) to form a diploid nucleus. This is followed by meiosis, which again reduces the number of chromosomes to the haploid number.

The sex organelles of fungi if present are called gametangia. They may form differentiated sex cells called gametes or may contain instead one or more gamete nuclei. If the male and female gametangia are morphologically different, the male gametangium is called the antheridium (plural antheridia) and the female gamentangium is called the Oogonium (Oogonia).

Methods of sexual reproduction include:
Gametic copulation: This is the fusion of naked gametes, one or both of which are motile.

Gamete-gametangial copulation: Two gametangia came into contact but do not fuse; the male nucleus migrate through a pore or fertilisation to be into the female gamentangium.

Gametangial copulation: Two gamentangia or their protoplast fuse and give rise to a zygote that develops into a resting spore.

Somatic copulation: Fusion of somatic or vegetative cells.

Spermatisation: Union of a special male structure called a spermatium (plural spermatia) with a female receptive structure.

The spermatum empties its content into the female during plasmogamy.

Sexual spores are produced by the fusion of two nuclei. Examples are:
Ascospores: These are single-celled spores produced in a sac called an ascus. There are usually eight ascospores in each ascus.

Basidiospore: These are single celled spores borne on a club shaped structure called a basidium.

Zygospores: These are large thick walled spores formed when the tips of two sexually compatible hyphae or gametagia fuse together.

Oospores: These are formed with a special female structure, the oogonium. Fertilisation of the eggs or oospheres by the male gametes formed in an antheridium give rise to oospores.

3.5 Physiology

- Fungi are better able to withstand certain extreme environments than other microorganisms. They can tolerate more acidic conditions than other microbes. Some types of yeasts are facultative; they can grow under both aerobic and anaerobic conditions. Molds and many types of yeast are usually aerobic microorganisms.
- Fungi grow over a wide range of temperature. The optimum temperature for most saprobic species is 22 to 300C, while pathogenic fungi have a higher temperature optimum of 30 to 370C.
- Some fungi will grow at or near 00C and thus can cause spoilage of meat and/or vegetables in cold storage.

3.6 Importance of Fungi

- About 90,000 fungal species have been described according to literature. However, some estimates suggest that 1.5 million species may exist. Fungi are important to humans in both beneficial and harmful ways.
- Beneficially, fungi act as decomposers. They degrade complex organic materials in the environment and release simple organic and inorganic molecules like carbon, nitrogen, phosphorus needed by other living organisms.
- Moulds and yeasts are used in many industrial processes involving fermentation to produce beer, wine and bread, cheese, soy-sauce, organic acids and many antibiotics.
- They are important research tools in the study of fundamental processes such as cytology, genetics, biochemistry and microbiology.
- On the other hand, fungi cause many diseases of plants, animals and humans. About 20 new human fungal pathogens are documented each year.

4.0 Conclusion

In this unit, we have discussed about general characteristics of fungi and there nature as beign eukaryotic spore bearing organisms that lack chlorophyll and reproduce both asexually and sexually. Also discussed was its grouping into molds or yeasts based on the development of the thallus.

5.0 Summary

In this unit, you have learnt about the following:

- Distinguishing Characteristics of Fungi
- Structure and Forms of Fungi
- Nutrition and Metabolism
- Reproduction
- Physiology
- Importance of Fungi.

6.0 Tutor- Marked Assignment

Activity: Give five examples of infection caused by fungi

1. Describe the structure of a mold. LO4
2. Describe each of the following types of asexual fungal spores:
   i. Sporangiospore
   ii. Conidiospore and
   iii. Blastospore. (LO6)
3. Describe the structure of yeast? (LO3)
4. Describe the structure of mold (LO4)
5. Enumerate general characteristics of fungi (LO2)
6. Describe sexual reproduction as it occurs in fungi (LO6)
7. Describe the mode of nutrition in fungi (LO5)

7.0 References/ Further Reading

Atlas, R.M. (1995). *Microorganisms in Our World*. Mosby Year Book.Inc.

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Unit 3 General Characteristics Of Viruses

1.0 Introduction

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. This unit examines the general characteristics of viruses, their structures, genomes, symmetry, replication in hosts and purification.

2.0 Objectives

At the end of this unit, you should be able to:

- define the term virus
- state the general characteristics of virus
- describe the structure of a typical virus particle
- explain virus genome
- explain the process of viral replication in susceptible host
- sate various methods of cutting viruses
- state the various methods of virus purification.

3.0 Main Content

Definition
Viruses are simple acellular entities that can only reproduce within living cells.

3.1 General Characteristics of Viruses

- They are the smallest microorganisms. They range in size from 10 to 400□m in diameter and can only be viewed under an electronmicroscope.
- They are acellular, i.e. not cellular and non living.
- They only reproduce when present within living cells.
- They are infectious agents.
- A complex virus particle or virion consists of one or more molecules of DNA or RNA enclosed in a coat of protein.
- 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 synthesise virion components which are later released.

Viruses differ from living cells in three ways:

- They have simple acellular organisation.
- The presence of either DNA or RNA but not both in almost all virions.
- They do not have the ability to reproduce independent of cells and carry out cell division as procaryotes and eukaryotes do.

3.2 Virion Size

Virions range in size from about 10 to 400μm in diameter. The smallest viruses are a little larger than ribosomes whereas the pox viruses which include vaccinia are about the same size as the smallest bacteria and can be seen in the light microscope. Most viruses however, are too small to be visible in the light microscope and must be viewed with scanning and transmission electron microscope.

3.3 The 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) 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.

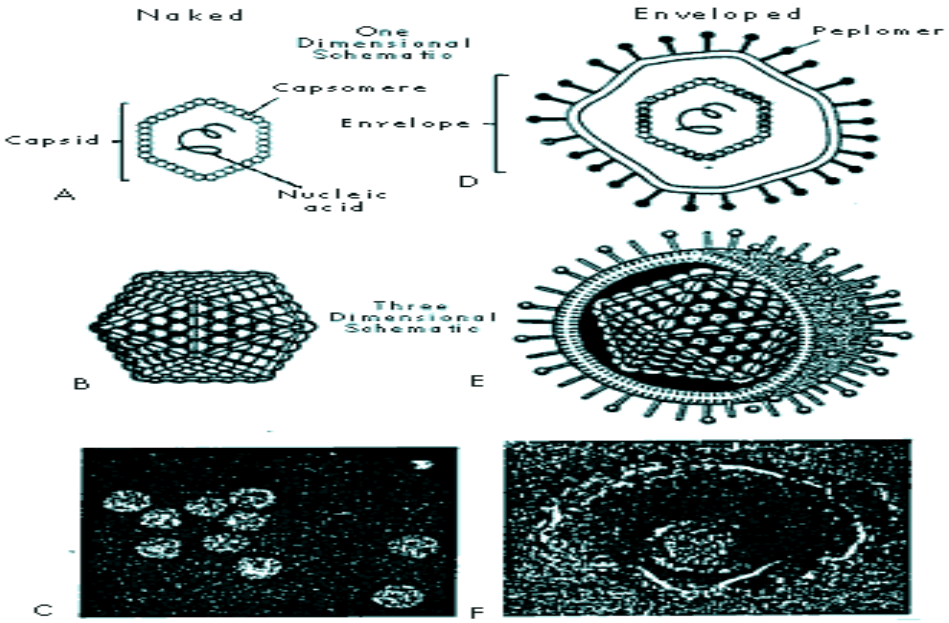

Fig. 1: Generalised Structures of Viruses (Source: triroc.com)

3.4 Viral Genomes

All cells contain double stranded DNA genomes. By contrast, viruses have either DNA or RNA genomes (one group of viruses does use both DNA and RNA as their genetic material but at different stages of the replication cycle). Hence, we have RNA viruses or DNA viruses.

Virus genomes can be classified based on whether the nucleic acid in the virion is DNA or RNA and further subdivided to whether the nucleic acid is single or double stranded. Linear or circular, some viral genomes are circular but most are linear. We can have single stranded DNA, double stranded DNA, single stranded RNA and double stranded RNA. All four types are found in animal viruses. Most plant viruses have single stranded RNA genomes and most bacteria viruses contain double stranded RNA.

3.5 Virus Reproduction

Viruses need a host cell in which to reproduce; hence the first step in the life cycle of a virus is attached to a 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.

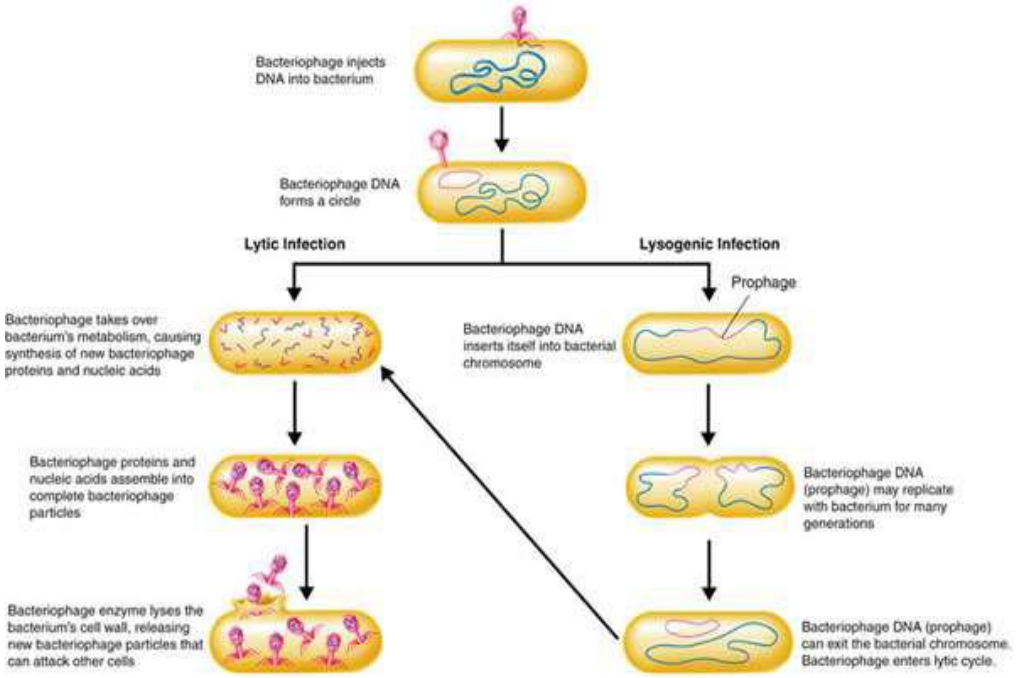

Fig.2: Generalised Illustration of Virus Reproduction (Source: goldiesroom.org**)**

Once free in the 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.

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.

3.6 The Cultivation of Viruses

Because viruses are unable to reproduce independent of living cells, they cannot be cultured in the same way as prokaryotic and eukaryotic microorganisms. Animal viruses are cultivated by inoculating suitable host animals or embryonated egg – fertilised chicken eggs

incubated about 6 to 8 days after lying. More recently, animal viruses have been grown in tissue (cell) culture on monolayers of animal cells.

3.7 Virus Purification and Assay

Viral purification and Assays are necessary so as to accurately study virus structure, reproduction and other aspects of their biology.

Virus Purification
This involves getting or isolating the viral particle in its pure state, purification makes use of several virus properties. Four of the most widely used methods to isolate and purify viruses are:

- Differential and density gradient centrifugation. This is often used in the initial Purification steps to separate virus particles from host cells.
- Precipitation of viruses' particles.
- Denaturation of contaminants.
- Enzymatic digestion of host cells constituents.

Virus Assays
The quantity of viruses in a sample can be determined either directly by counting particle numbers using the electron microscope or indirectly by measurement of an observable effect of the virus using techniques such as the hemaglutination assay.

4.0 Conclusion

In this unit, we have discussed the general characteristics of viruses and established the fact that Viruses are simple acellular entities that can only reproduce within living cells. A virus is made up of a central genetic nucleic acid molecule which could be DNA or RNA surrounded by a protein called capsid.

5.0 Summary

In this unit, you have learnt about the following:

- General Characteristics of Viruses
- Virion Size
- The Structure of Viruses
- Viral Genomes
- Virus Reproduction
- The Cultivation of Viruses
- Virus Purification and Assay.

6.0 Self-Assessment Exercise

Activity: Discuss three diseases common in your hospital that are caused by virus

Answer the following questions:

1. Mention three ways viruses differ from living cells (LO2)
2. Enumerate the characteristics of virus (LO2)
3. Write briefly on virus genome (LO4)
4. Describe the structure of a typical virus particle (LO3)
5. Explain how viruses are cultivated in different hosts (LO6)
6. Explain four major approaches by which viruses may be purified (LO7).
7. Define the following terms:
    - virus (LO1)
    - nucleocapsid (LO2)
8. Explain the processes involved in viral replication or virus reproduction (LO5)

7.0 References/Further Reading

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