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Textbook of Microbiology for GNM Students

As per the INC Syllabus

2nd Edition

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Contents

1. Introduction to Microbiology 1
1.1 Understanding Microorganisms 3

2. Classification, Structure, Growth and Pathogenesis 23
2.1 Classification of Microorganisms 25
2.2 Structure of Microorganisms 38
2.3 Viruses: Structure and Life Cycle 51
2.4 Growth and Nutrition of Microorganisms 62
2.5 Microbial Reproduction 72
2.6 Bacterial Culture and Isolation Techniques 83
2.7 The Normal Flora of Human Body 98
2.8 Pathogenic Microorganisms 102
2.9 Diseases Caused by Microorganisms 111
2.10 Coronavirus Disease 2019 146

3. Infection and its Transmission 157
3.1 Infection and Transmission of Pathogenic Microorganisms 159
3.2 Nosocomial Infection 173
3.3 Collection of Specimen by Nurses 179

4. Immunity 193
4.1 Fundamentals of Immunity 195
4.2 Hypersensitivity and Autoimmunity 213
4.3 Immunoprophylaxis of Infectious Diseases and Immunization Schedule 232
4.4 Principles and Uses of Serological Tests 249

5. Control and Destruction of Microbes.....261
5.1 Fundamentals of Control and Destruction of Microorganisms 263
5.2 Biosafety and Waste Management 300

6. Practical Microbiology 317
6.1 Introduction to Laboratory Techniques 319

Model Questions and Answers.....351
Glossary 357
Suggested Reading.....410
Index 411

CHAPTER

2.1 Classification of Microorganisms

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WHAT IS THE CLASSIFICATION OF MICROORGANISMS?

Biological Classification, or Taxonomy is a method of classifying and categorizing living organisms into groups which share similar characteristic features. There are different types of microorganisms, each differing in its characteristic features. In order to have a systematic study they can be classified under various groups.

WHY WE NEED TO CLASSIFY MICROORGANISMS?

More than five million species of microorganisms have already been reported. Thousands more are added to the list every year. It would be difficult to describe and name each one individually. If any microorganism is picked up randomly it would not be possible to describe its basic properties and features so easily. But if their groups are made based on similarities of characteristics then it would be easy to identify them and understand their basic characteristic features.

BASIS OF CLASSIFICATION

We classify microorganisms on the following basis:

- Cell type: Eukaryotic or prokaryotic
- Cellular or acellular
- Biochemical properties

MAJOR GROUPS OF MICROORGANISMS

Eukaryotic Microorganisms

Basic Features of Eukaryotic Cells

- Contain nucleus bounded by nuclear membrane
- Contain complex phospholipids, sphingolipids, histones and sterols

- Have multiple diploid linear (straight) chromosomes and nucleosomes
- Have 80s ribosomes
- Have membrane bound cell organelles, such as vacuoles, mitochondria, etc.

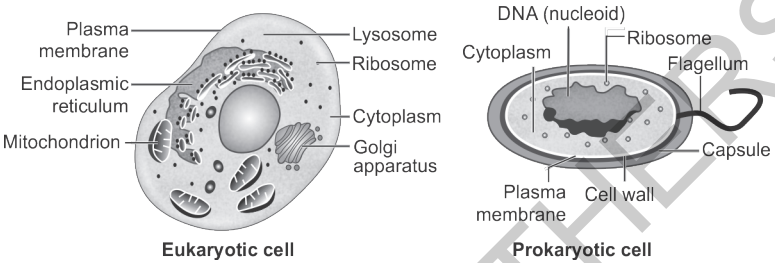

Figure 2.1.1: Eukaryotic and prokaryotic cells.

The following are the types of eukaryotic microorganisms:

Protozoa

- Protozoa are eukaryotic microorganisms.
- Protozoa lack the capability for photosynthesis, although the genus Euglena is renowned for motility as well as carrying out photosynthesis and is, therefore, considered both as alga and protozoan.
- Although most protozoa reproduce by asexual methods, sexual reproduction has been observed in several species.
- Most protozoa species are aerobic but some anaerobic species have been found in the human intestine and animal lumen.
- Protozoa are located in most moist habitats. Free-living species inhabit freshwater and marine environments and terrestrial species inhabit decaying organic matter. Some species are parasites of plants and animals.
- Protozoa play an important role as **zooplankton,** the free-floating aquatic organisms of the oceans.
- Their cells have no cell walls and therefore can assume an infinite variety of shapes.
- Most protozoa have a single nucleus but some have both macronucleus and one or more micronuclei. Contractile vacuoles may be present in protozoa to remove excess water and food vacuoles are often observed.
- Protozoa are **heterotrophic** microorganisms and most species obtain large food particles by **phagocytosis.**

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- Many protozoa species move independently by one of three types of locomotor organelles: flagella, cilia and pseudopodia.
- *Example: Entamoeba histolytica* causes amoebiasis in human beings.

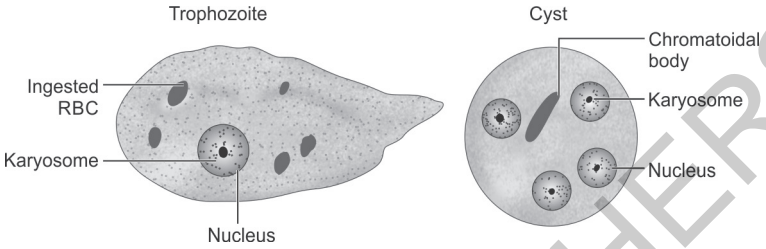

Figure 2.1.2: *Entamoeba histolytica*, the causal agent of amoebiasis in human beings.

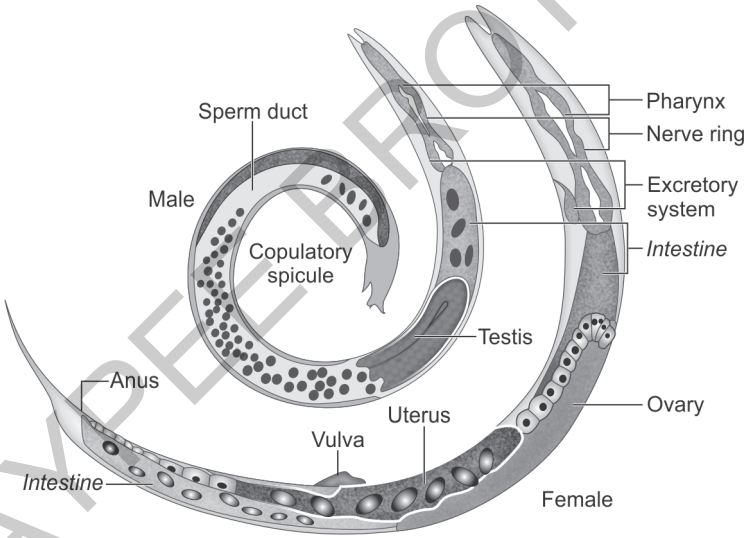

Figure 2.1.3: *Ascaris lumbricoides* (roundworm), the causal agent of ascariasis in humans.

Helminths

- Helminths are parasitic, multicellular eukaryotic animals.
- The majority of these animals belong to phyla Platyhelminthes and Nematoda.

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- Many parasitic helminths do not have a digestive system and instead absorb nutrients from the food that is consumed by their host organisms, the host's body fluids and tissues.
- Parasitic helminths have very simple nervous system because they have to respond to very few changes in their host's environment.
- They lack or have reduced means of locomotion because they are transferred from one host to another.
- Parasitic helminths have complex reproductive system that produces fertilized eggs (zygotes) which infect the host organism.
- Examples:
  - *Taenia solium* (Pork tapeworm) causes Taeniasis
  - *Ascaris lumbricoides* (roundworm) causes Ascariasis

Fungi

- Fungi are **eukaryotic** and have membrane-bound cellular organelles and nuclei.
- They have no plastids of any kind (and no chlorophyll). The hyphae of fungi are of two general kinds: Some are **septate** and are divided by **septa** (walls) that separate cylindrical hyphae into cells; in **nonseptate** fungi, the hypha is one long tube.
- Mitosis occurs in nonseptate hyphae, but there is no accompanying **cytokinesis** (division of the cytoplasm) so the hyphae are **multinucleate** (with many nuclei).

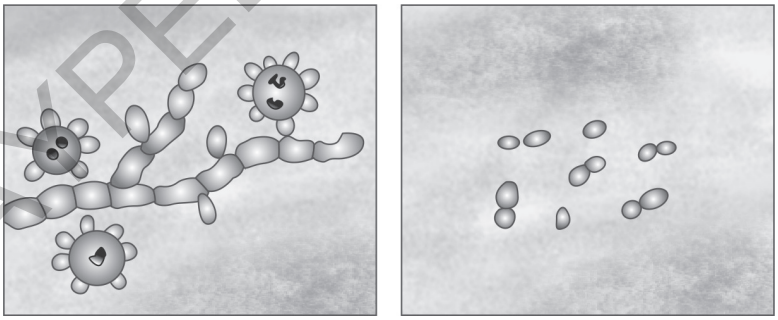

Figure 2.1.4: *Histoplasma capsulatum*, the causal agent of histoplasmosis in human beings.

- An organism or part of an organism with many nuclei not separated by walls or membranes—is termed as **coenocytic** and the organism is a coenocyte.

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- Fungi are **heterotrophic** but unlike animals and many other heterotrophs can ingest their nutrients as bits or bites of food, the fungi secrete digestive enzymes into their surroundings and in effect digesting their food outside of their bodies.
- They can absorb smaller particles and incorporate nutrients into their own cells. Some are **parasites** obtaining nutrients from living organisms but more are **saprobes (saprotrophs)** that digest and recycle materials from dead organisms.
- *Example: Histoplasma capsulatum* causes histoplasmosis in human beings.

Algae

- **Algae** are eukaryotic organisms that have no roots, stems, or leaves but do have chlorophyll and other pigments for carrying out photosynthesis.
- Algae may be unicellular or multicellular.
- **Unicellular algae** occur most frequently in water especially in plankton.
- **Phytoplankton** is the population of free floating microorganisms composed primarily of unicellular algae.
- Algae establish symbiosis with fungi to form lichen.
- Reproduction in algae occurs in both asexual and sexual forms. Asexual reproduction occurs through fragmentation of colonial and filamentous algae or by spore formation (as in fungi). Spore formation takes place by mitosis. Binary fission also occurs (as in bacteria).
- *Example: Prototheca cutis* causes skin infection in human beings.

Prokaryotic Microorganisms

Basic Features of Prokaryotic Cells

- Lack nuclei.
- Have single circular chromosome. Some also contain plasmids.
- Have 70s ribosomes.
- Lack membrane bound cell organelles, such as vacuoles, mitochondrias, etc.
- Bacteria
  - Bacteria are prokaryotic organisms.
  - They are microscopic, unicellular, may occur singly or in aggregations to form colonies.

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- They possess rigid cell walls. **Cell wall** is made up of **peptidoglycan (Mureins) and Lipopolysaccharides**.
- **Ribosomes** are scattered in cytoplasmic matrix and are of **70s type.**
- Most of the bacteria are heterotrophic. Some bacteria are autotrophic, possess **bacteriochlorophyll** which is not in plastids and instead it is found to be scattered.
- Motile bacteria possess one or more **flagella.**
- The common method of multiplication is **binary fission.**
- True sexual reproduction is lacking but **genetic recombination** occurs by conjugation, transformation and transduction.
- *Examples:*
  - *Vibrio cholerae* causes Cholera
  - *Salmonella typhi* causes Typhoid
  - *Mycobacterium tuberculosis* causes Tuberculosis

Some special categories of bacteria are as follows:

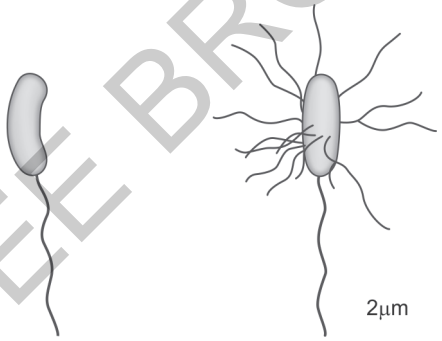

Figure 2.1.5: *Vibrio cholerae*, the causal agent of cholera in human beings.

Chlamydia

- *Chlamydia* are Gram-negative bacteria.
- They are obligate intracellular parasites. They can survive only by establishing "residence" inside the infected cells.
- They need their host's ATP as energy source for their own cellular activity.
- They are coccoid in shape and non-motile.
- They can be transmitted from person-to-person contact or by airborne respiration.

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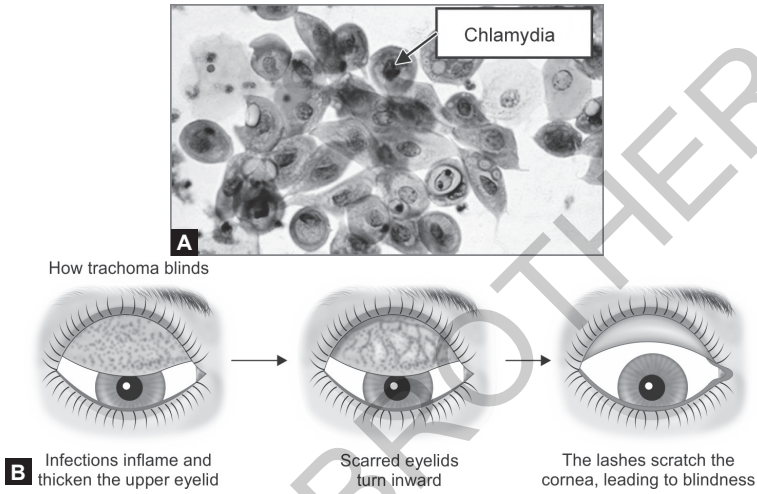
- *Examples:*
  - *Chlamydia trachomatis* causes trachoma
  - *C. pneumoniae* causes mild form of pneumonia in adolescence
  - *C. psittaci* causes psittacosis



Figures 2.1.6 A and B: *Chlamydia trachomatis*, the causal agent of trachoma in human beings.

Mycoplasma

- The *Mycoplasma* are tiny free-living organisms capable of self-replication.
- They are smaller than some of larger viruses.
- They lack cell walls.
- Are only prokaryotes that contain sterols.
- They are facultatively anaerobic bacteria.
- Take on many shapes (pleomorphic).
- Mycoplasmas can also resemble fungi because some Mycoplasmas produce filaments that are commonly seen in fungi. It is these filaments that led scientists to name it Mycoplasma. Myco means "fungus."
- Mycoplasma are unable to move by themselves because they do not have flagella but some are able to glide on a wet surface.

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- *Examples*:
  - *Mycoplasma pneumonia* is the cause of atypical pneumonia commonly referred to as walking pneumonia.
  - *Ureaplasma urealyticum* is a bacterium that is found in urine and one that can cause urinary tract infection.

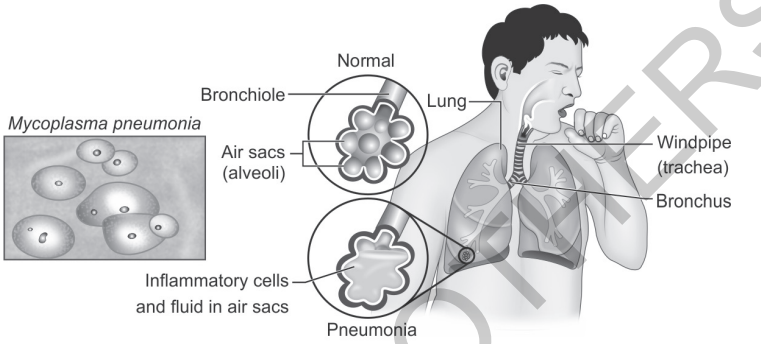

Figure 2.1.7: *Mycoplasma pneumonia*, the causal agent of atypical pneumonia in human beings.

Rickettsia

- Rickettsias are small rod-shaped or spherical bacteria that live in the cells of ticks, lice, fleas, mites (arthropods) and can be transmitted to humans when bitten by arthropods.
- They are small, Gram-negative, non-motile, rod to coccoid-shaped bacteria.
- Rickettsias reproduce by binary fission.
- It is similar to Chlamydia in that they both are of the size of large viruses.

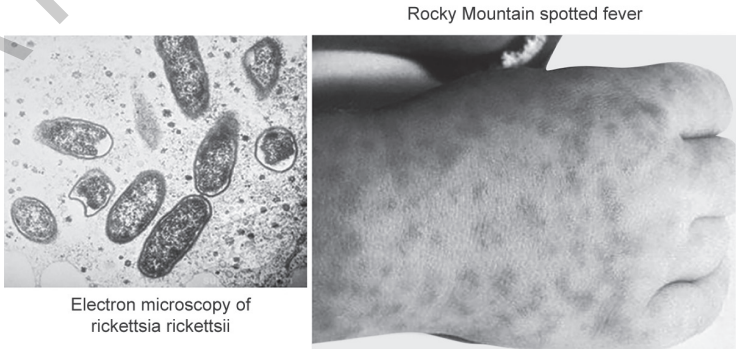

Figure 2.1.8: *R. rickettsii*, the causal agent of Rocky Mountain spotted fever in human beings.

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- Like Chlamydia they are obligate intracellular parasites who can't produce ATP and depend for the same on attacked host cell.
- *Examples:*
  - *Rickettsia prowazekii* is transmitted by lice and causes endemic typhus.
  - *R. rickettsii* is transmitted by ticks and causes Rocky Mountain spotted fever.

Siprochaetes

- Spirochaetes are tiny Gram-negative organisms that look like corkscrews.
- They move in a unique spinning motion via 6 thin endoflagella called axial filaments.
- These organisms replicate by transverse fission.
- They cannot be cultured in ordinary media.
- They are too small to be seen using light microscope. Special procedures are required to view these organisms, including darkfield microscopy, immunofluorescence and silver stains.
- *Examples:*
  - *Treponema pallidum* causes syphilis
  - *Borrelia burgdorferi* causes Lyme disease

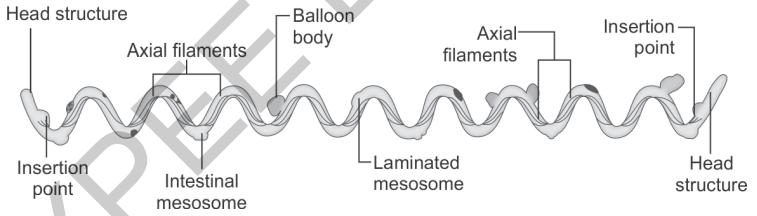

Figure 2.1.9: *Treponema pallidum,* the causal agent of syphilis.

Archaebacteria

- Cell wall is not made up of peptidoglycan.
- Cell membrane contains long-chain branched alcohols (phytanols) bound to glycerol by ethereal linkages.
- They are extremophiles as they can grow in extreme habitats such as at high temperature, under high pressure.
- The major categories of archaebacteria comprise essentially of:
  - *Methanogenic bacteria:* example, *Methanococcus*
  - *Extreme halophiles:* example, *Halobacterium*
  - *Thermophiles:* example, *Thermoplasma*
  - *Acidophiles:* example, *Sulfolobus*

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Acellular Microorganisms

Basic Features of Acellular Microbes

- These are neither prokaryotic nor eukaryotic.
- Do not contain cell wall, cell membrane of any cell organelles.
- Do not behave as living organisms outside the host cells.
- They are made-up of nucleic acid and protein (e.g. virus), only nucleic acid (e.g. viroids) or only protein (e.g. prions).

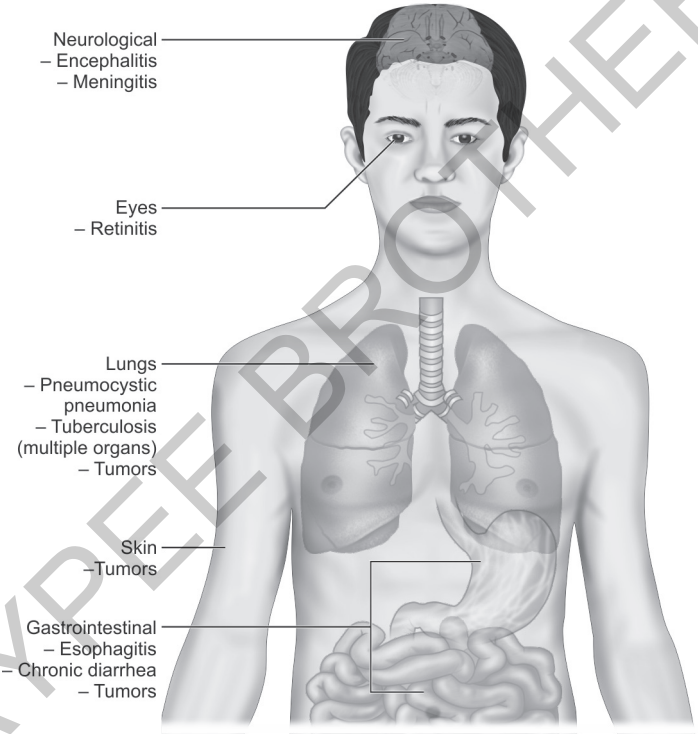

Figure 2.1.10: Symptoms of AIDS.

Viruses

- Are acellular and are not visible with light microscope.
- Are obligate intracellular parasites.
- Contain no organelles or biosynthetic machinery except for few enzymes.
- Contain either RNA or DNA as genetic material.

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- Are called as bacteriophages (or phages) if they have bacterial host.
- *Examples:*
  - Poxviridae causes pox (pus-filled lesions) diseases such as smallpox
  - Poliovirus causes poliomyelitis
  - Human immunodeficiency virus (HIV) causes acquired immunodeficiency syndrome (AIDS)

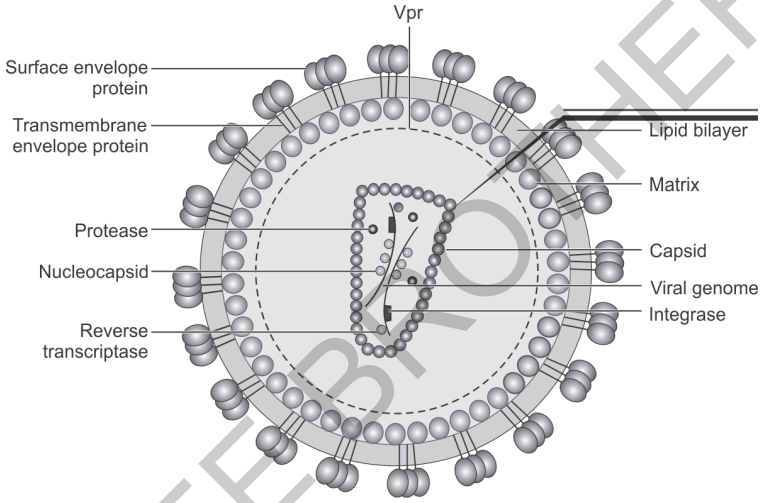

Figure 2.1.11: HIV, causal agent of AIDS.

Prions

- Are infectious particles associated with diseases of the central nervous system.
- Are made of proteins only.
- Diseases caused by prions are:
  - Scrapie disease in sheep and goats
  - Bovine spongiform encephalopathy ('mad cow disease') in cows
  - Kuru disease in humans (cannibals)
  - Creutzfeldt-Jakob disease in humans.

Viroids

- Are not cells and not visible with light microscope.
- Are obligate intracellular parasites.

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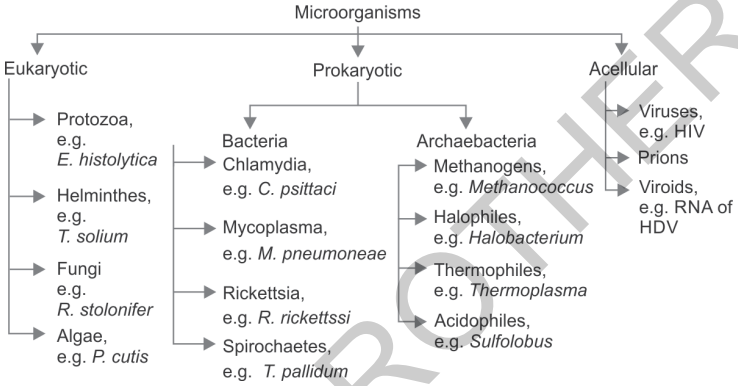
- Are single-stranded, covalently closed, circular RNA molecules that exist as base-paired, rod like structures.
- Cause plant diseases but have not been proven to cause human disease, although the RNA of Hepatitis D virus (HDV) is viroid-like.

Flowchart 2.1.1: Classification of microorganisms.



POSSIBLE QUESTIONS

1. What is taxonomy? Give an account of classification of microorganisms.
2. Write Short Notes:
   a. Parasites
   b. Tapeworm
   c. Protozoa
   d. Viruses
   e. Prions
   f. Extremophiles
   g. Lichens
   h. Viroids
   i. Rocky Mountain spotted fever
   j. Mycoplasma
   k. Spirochaete
   l. Rickettsia
   m. Saprophytes

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MULTIPLE CHOICE QUESTIONS

1. Eukaryotic microorganisms have ribosome_____.
   a. 80s b. 60s
   c. 40s d. 50s
2. Free-floating protozoa of oceans are called as_____.
   a. Phytoplankton b. Zooplankton
   c. Phagocytes d. None of the above
3. Amoebiasis is caused by _____.
   a. *Entamoeba histolytica* b. *Ascaris lubrieoides*
   c. *Histoplasma capsulatum* d. *Prototheca cutis*
4. The wall that separates cylindrical hyphae into cells in fungi are called as _____.
   a. Septa b. Fragments
   c. Lipopolysaccharides d. Flagella
5. Histoplasmosis in humans is caused by _____.
   a. *H. capsulatum* b. *P. cutis*
   c. *V. cholerae* d. *R. prowazekii*
6. Chlamydia is _____ bacteria.
   a. Gram (+) b. Gram (-)
   c. Flagellated d. Both b and c
7. The word pleomorphic mean _____.
   a. Occurs in various form b. Occurs only in one form
   c. Omnipresent d. Multicellular
8. Prokaryotic cell wall is made up of _____.
   a. Peptidoglycan b. Lipopolysaccharides
   c. Both a and b d. Cellulose
9. Trachoma is caused by _____.
   a. *C. pneumoniae* b. *C. psittaci*
   c. *C. trachomatis* d. Both a and b
10. Siprochaetes reproduce through_____.
    a. Binary fission b. Budding
    c. Transverse fission d. Fragmentation

Answers

1. a	2. b	3. a	4. a	5. a
6. d	7. a	8. a	9. c	10. c

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Textbook of Microbiology for GNM Students

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- Well-illustrated with relevant diagrams, images, and tables
- MCQs, short notes, and long questions in each chapters.

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