

General Microbiology

**Tishk International University-
Nursing**

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Lec. 1-3

2024-2025

Reference:

Microbiology (Principle and Exploration)

Jacquelyn G.Black- 5th edition

2- Microbiology Experiments (fourth edition)

A health Science perspective John Kleyn- Mary Bicknell

3- Microbiology (A human perspective)

Fourth edition Nester, Anderson , PEARSALL.

4- text book of microbiology

P.C. Trivedi Sonali, Pandey Seema , Bhadauria

5- Antimicrobials

Mohammed Almarjani

Weekly course outline

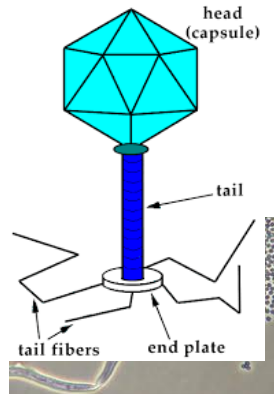
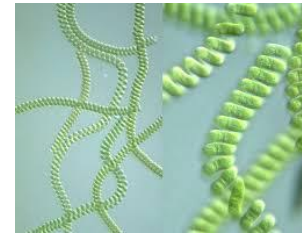
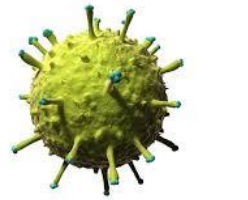
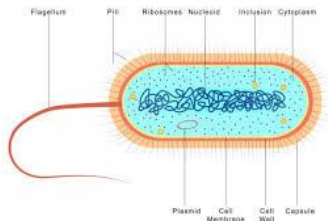
No	Subject Title
1-2	Introduction to microbiology , new concept in microbiology, virus
3	Microbial cell structure and functions –fungi, algae protozoa

4-5	Microbial growth and population, principle of gram stain and microbial metabolism
6-8	Antimicrobial activity ,Antibiotic, Classification of antibiotic , Antifungal
9	Food microbiology
10-11	Medical microbiology
12-13	fungal and protozoan diseases

What is Microbiology?

Microbiology: - Is the science which study the living microorganism of microscopic size, which include the following: bacteria, fungi, viruses, algae and protozoa.

Microbiology in Nursing refers to the study and application of microbiology principles in the nursing field. It involves understanding the role of microorganisms—such as bacteria, viruses, fungi, and parasites—in health and disease, and how this knowledge impacts patient care.



History of Microbiology

- A. Anton van Leeuwenhoek (1632–1723): was the first microbiologist and the first person to observe bacteria using a single-lens microscope of his own design.
- B. Louis Pasteur (1822–1895): Pasteur developed a process (today known as pasteurization) to kill microbes. pasteurization is accomplished by heating liquids to 63 to 65 C for 30 minutes or to 73 to 75 C for 15 seconds.
- C. Robert Koch (1843–1910): was a pioneer in medical microbiology and worked in cholera, anthrax and tuberculosis. He was awarded a Nobel prize in 1905 (Koch's postulates) he set out criteria to test.
- D. Alexander Fleming (1929): Discovered penicillin.

- **Microbes and microorganisms**

Both terms include all organisms that are too small to be seen without a microscope.

- Most of us think microorganisms are harmful, but it is not true. Most of the microorganisms are harmless.

Harmful Effects of microorganisms

1. Diseases to animal and plant
2. Spoilage of food
3. Food poisoning



Beneficial of microorganisms

Microorganisms are used in the production of beneficial material such as antibiotics, dairy products (yoghurt), ethanol, vitamins, and proteins.



- **Microbiology has many applied area:-**

- 1. Bacteriology-** The study of bacteria.
- 2. Virology:** The study of viruses.
- 3. Mycology:** The study of fungi.
- 4. Parasitology:** The study of parasites.
- 5. Immunology:** The study of the immune system.
- 6. Environmental Microbiology:** The study of microorganisms in the environment.
- 7. Industrial Microbiology:** The use of microorganisms in industrial processes.
- 8. Medical Microbiology:** The study of microorganisms that cause diseases in humans.
- 9. Food Microbiology:** The study of microorganisms in food.
- 10. Agricultural Microbiology:** The study of microorganisms in agriculture.
- 11. Microbial Genetics:** The study of the genetics of microorganisms.
- 12. Pharmaceutical Microbiology:** The study of microorganisms in the development of pharmaceuticals.

The study of microbiology includes:-

1. The distribution of microorganism in nature.
2. The relationship to each other and other living organisms.
3. The effect of microorganisms on animal, plant, and human being.
4. The ability of microorganism to make **physical and chemical** effects in their environment.
5. The reaction of microorganism **to chemical and physical agents.**

Microbiota or Normal flora:

Microbiota: refers to the community of microorganisms—such as bacteria, viruses, fungi, and archaea—that live on and within the specific area of humans, animals body, as well as in various environments like soil, water, and air

- Probiotics:** Live beneficial bacteria that are consumed through supplements or fermented foods, intended to enhance the microbiota's balance.

- Prebiotics:** Non-digestible food components (like fiber) that stimulate the growth and activity of beneficial microorganisms in the gut

The human microbiota consists of thousands of different species of bacteria, viruses, fungi, and archaea. The gut microbiota alone is composed of around 1,000 to 1,200 different bacterial species.

Distribution in the Body

- **Gut Microbiota:** The majority of the microbiota resides in the gastrointestinal tract, particularly in the colon. The gut contains about 100 trillion bacteria, which is the largest concentration of microbes in the body.
- **Skin Microbiota:** The skin is another major habitat, with about 1 million bacteria per square centimeter of skin. The total number of microbes on the skin is estimated to be around 1 trillion.
- **Oral Microbiota:** The mouth hosts a diverse community of microorganisms, with billions of bacteria residing on the teeth, gums, and tongue. There are around 700 different species in the oral cavity.
- **Respiratory and Urogenital Tract:** These areas also contain significant microbial populations, although the numbers are lower compared to the gut and skin.

Normal Flora

The normal flora is present :

- skin, upper respiratory tract, oral cavity, intestine, especially large intestine, vaginal tract.
- Very little normal flora in eyes and stomach.

The normal flora is absent in:

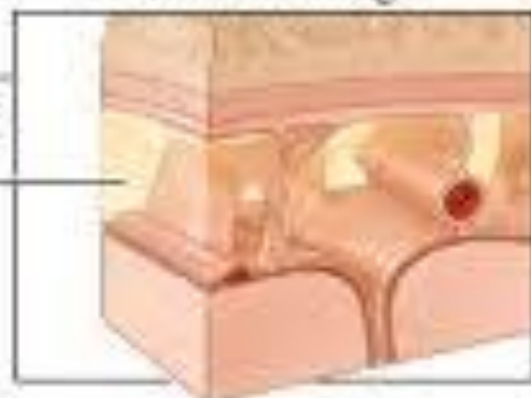
- Sterile tissue in a healthy human, the internal tissues such as blood, brain, muscle, cerebrospinal fluid, meninges and lower respiratory tract are normally free of microorganisms.

A human body contains around 10^{13} cells. The human body is home to around 10^{14} bacteria.

One fourth of fecal weight is made of bacteria.

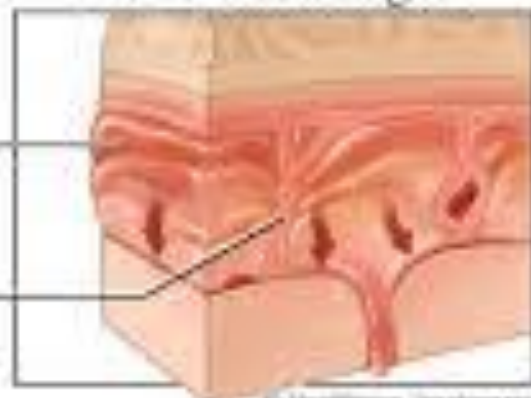


Normal meninges



Cerebral
spinal
fluid

Infected meninges



Infected
cerebral
spinal
fluid

Swollen
tissue

Beneficial effects of normal flora:

- 1- Competing with invaders for space and nutrients.
- 2- Producing compounds (bacteriocins) which kill other bacteria.
- 3- lowering the pH, so that other bacteria can not grow.
- 4-In addition; normal flora help us in other ways eg
Producing vitamins we are not able to produce such as vitamin **k**
produced by *E. coli*
- 5-Help digest food
- 6-Help the development of the immune system.

Note: Antibiotic treatment of bacterial infection also killed beneficial bacteria

Dysbiosis:

- Dysbiosis refers to an imbalance or disruption in the microbiota, where harmful microbes outnumber beneficial ones.

Methods use to determine the microbiota in the body:

Culture-Based Methods,

Quantitative PCR (qPCR),

16S rRNA Gene Sequencing , Metagenomic Sequencing ,

Flow Cytometry,

Fluorescence In Situ Hybridization (FISH),

Mass Spectrometry (e.g., MALDI-TOF),

Fecal Microbiota Transplantation (FMT) as a Diagnostic Tool

,Next-Generation Sequencing (NGS)

Infection

- **Infection:** the invasion and multiplication of microorganisms such as bacteria, viruses and parasites, that are not normally present within the body. An infection may cause no symptoms and it may be cause symptoms.
- Infection is caused by microorganism.
- The microorganisms may be a bacteria, a virus, a para fungus.
- Microorganisms that live naturally in the body are not considered infection.



Contamination

- Presence of an organism in a culture that was not in the sample when taken.
- E.g. a culture of blood contaminated with an organism from the skin.
- Sample contaminated in the lab.





Relationship among microorganisms

There are many different types of relationship that the body can have with the microorganisms:

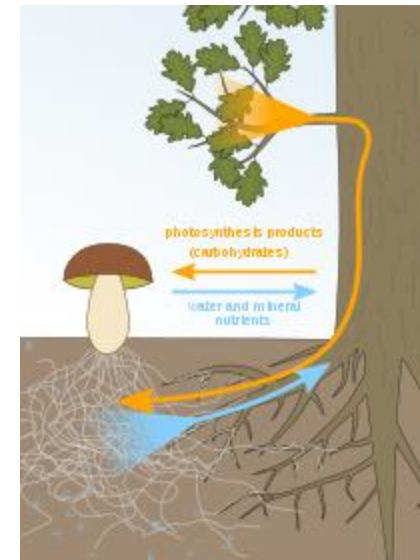
- 1- **Mutualism:** A symbiotic relationship in which both species benefits.
- 2- **Commensalism:** A symbiotic relationship in which one species benefits and the other species is neither helped nor harmed.
- 3- **Parasitism:** A symbiotic relationship in which one species benefits and the other species is harmed.

Example of microbial community

Mycorrhiza- Fungal symbiotic association with plants which helps plants to absorb phosphorus from soil.

Examples of commensalism are where the waste products of one organism is utilized by another.

Example of parasitism: all microorganism that cause disease.



Key Aspects of Microbiology in Nursing:

1. Understanding Infectious Diseases:

Nurses need to understand how different microorganisms cause diseases, their modes of transmission, and the symptoms they produce. This helps in recognizing early signs of infection and taking appropriate actions.

2. Infection Control:

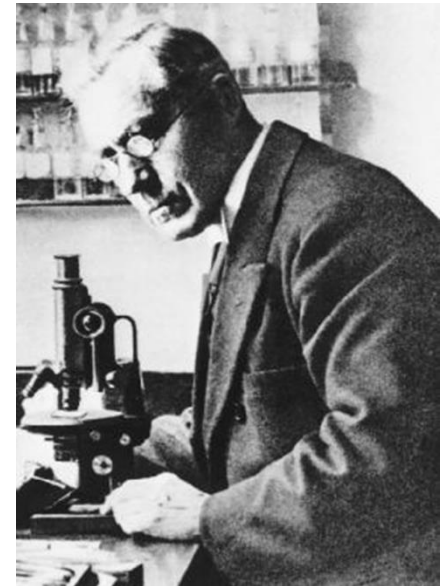
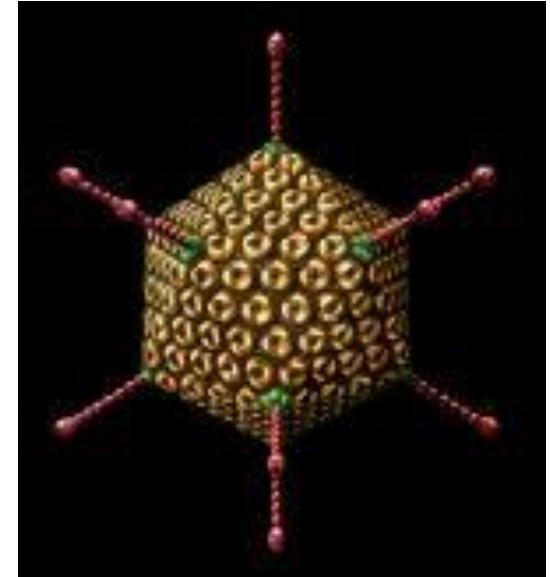
1. Microbiology knowledge is crucial for implementing effective infection control practices. This includes understanding how infections spread in healthcare settings and the importance of hand hygiene, sterilization, disinfection, and the use of personal protective equipment (PPE).

3. Patient Care and Safety:

Nurses use microbiology to protect patients, especially those who are vulnerable, such as the immunocompromised, newborns, and the elderly. Understanding how to prevent and manage infections in these populations is a critical aspect of nursing.

Member of Microorganisms- A-Virus

- A virus is a non-cellular particle made up of genetic material and protein that can invade living cells.
- Beijerinck (1897) coined the Latin name “virus” meaning poison
- He studied filtered plant juices & found they caused healthy plants to become sick



Characteristics

1. Small size:

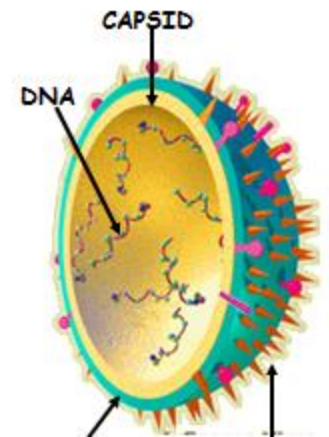
- o The smallest infectious agents (20-300 nm in diameter)
- o Bacteria (300-1000nm); RBC (7500nm)

2. Genome:

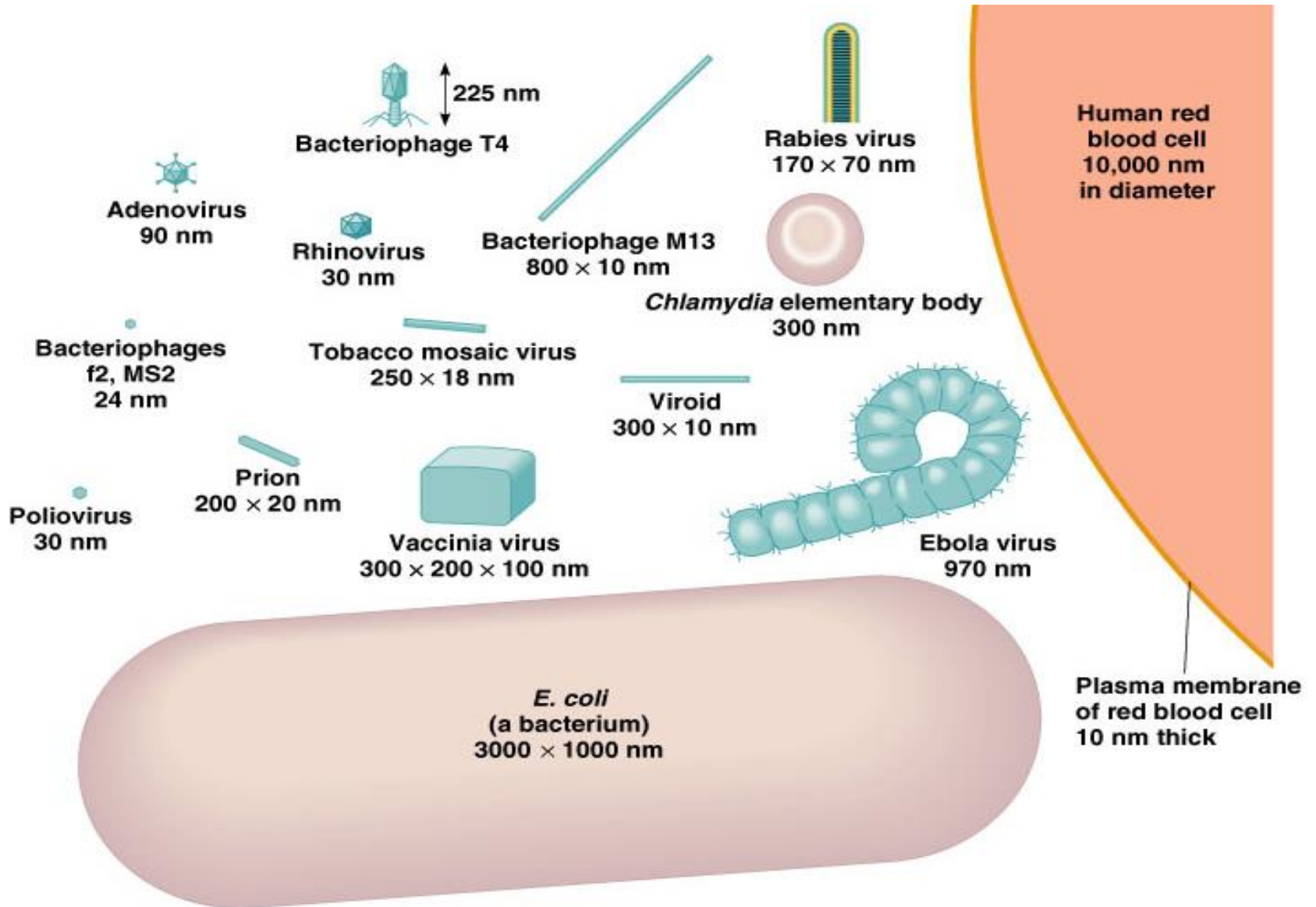
- o Either DNA or RNA

3. Metabolically inert:

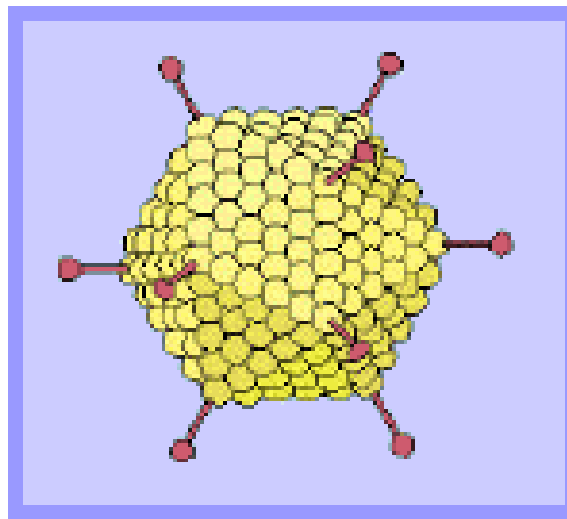
- o Do not possess active protein synthesizing apparatus
- o Do not have a nucleus, cytoplasm, mitochondria or ribosomes
- o No metabolic activity outside host: obligate intracellular parasites
- o Can replicate only inside living cells; NOT on inanimate media



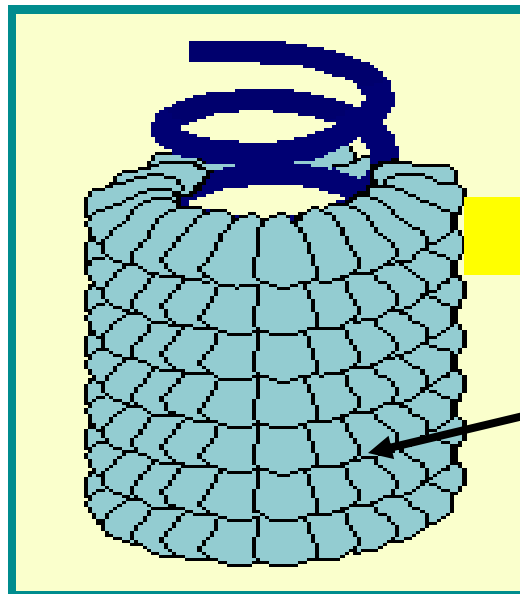
Size of Viruses



- **Capsid:** protein coat surrounding the genome
 - Provides structural symmetry
 - Participates in attachment to susceptible host
 - Facilitates transfer of viral nucleic acid in to host cell
 - Protects the viral genome from nucleases in blood stream



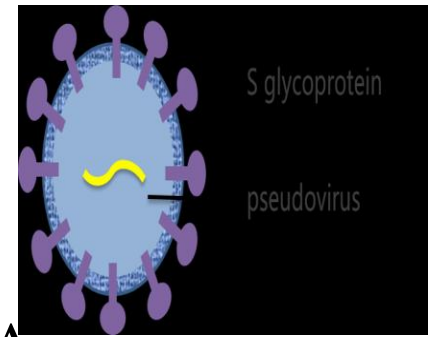
- **Capsomeres:** the structural units making up capsid: consist of one or several proteins



CAPSOMERES

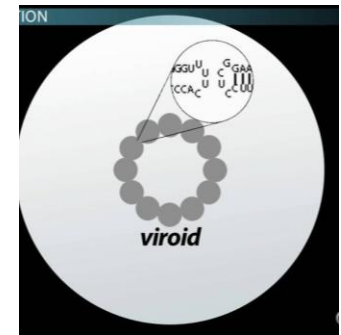
Pseudovirions

- Contain host cell DNA instead of viral DNA within the capsid
- Can infect cells but do not replicate.



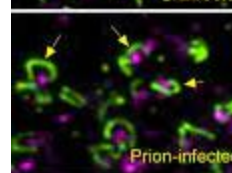
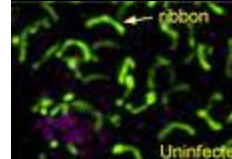
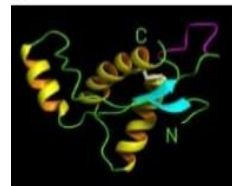
Viroids

- Are infectious agents that consist only of naked RNA without any protective layer such as a protein coat.
- Cause several plant diseases but are not implicated in human diseases (Potato spindle tuber viroid)

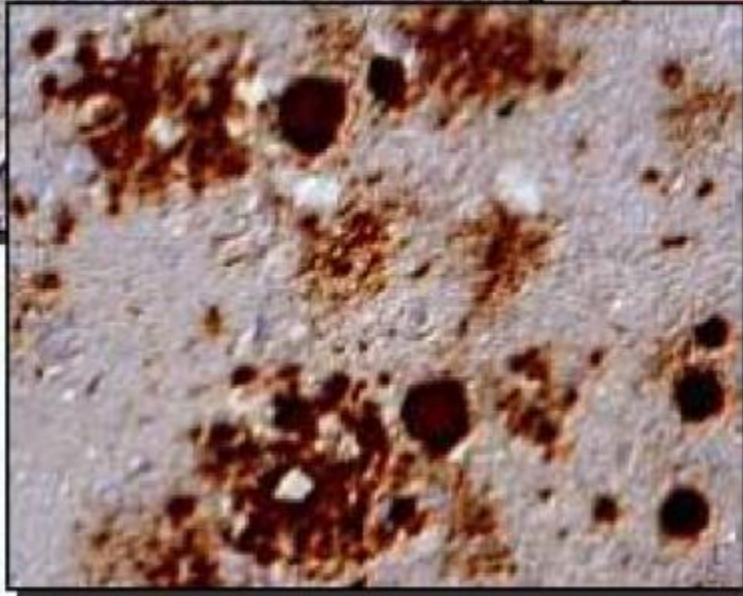


Prions

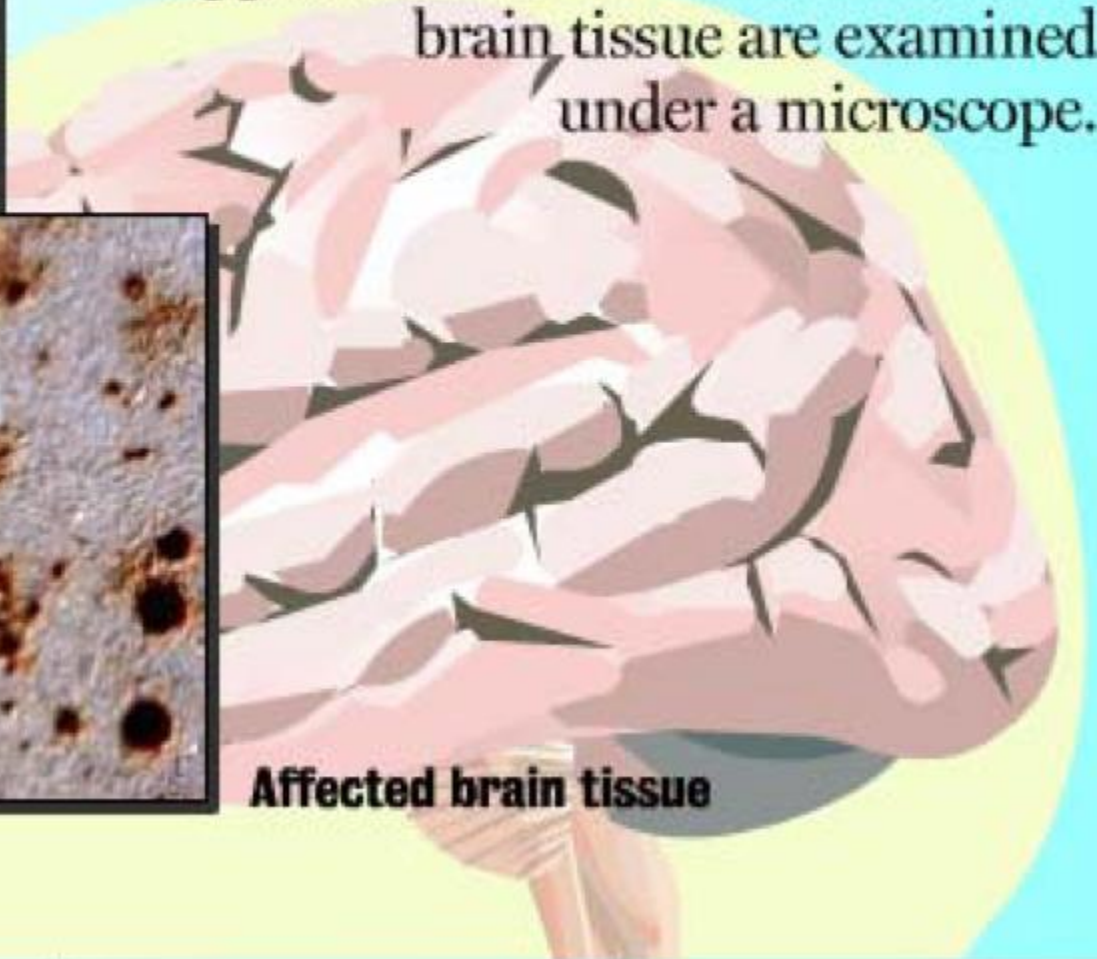
- A prion is a type of protein that can trigger normal proteins in the brain to fold abnormally. Prion diseases can affect both humans and animals and are sometimes spread to humans by infected meat products.
- The most common form of prion disease that affects humans is Creutzfeldt-Jakob disease (CJD).



Normal brain tissue



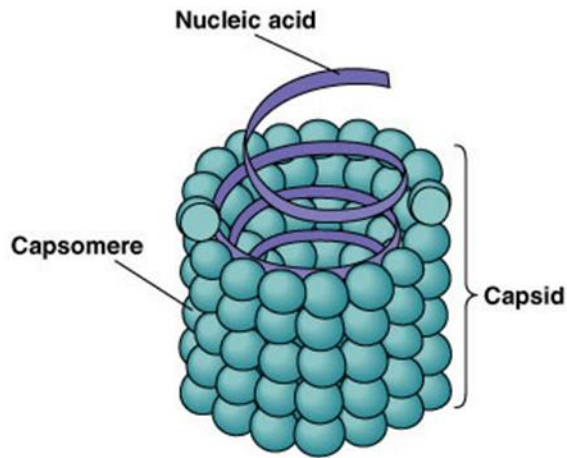
Prions on cell surfaces allow too much fluid to enter cells, producing a spongy appearance when cross-sections of brain tissue are examined under a microscope.



Affected brain tissue

Viral Shapes

- Viruses come in a variety of shapes
- Some may be helical shape like the Ebola virus

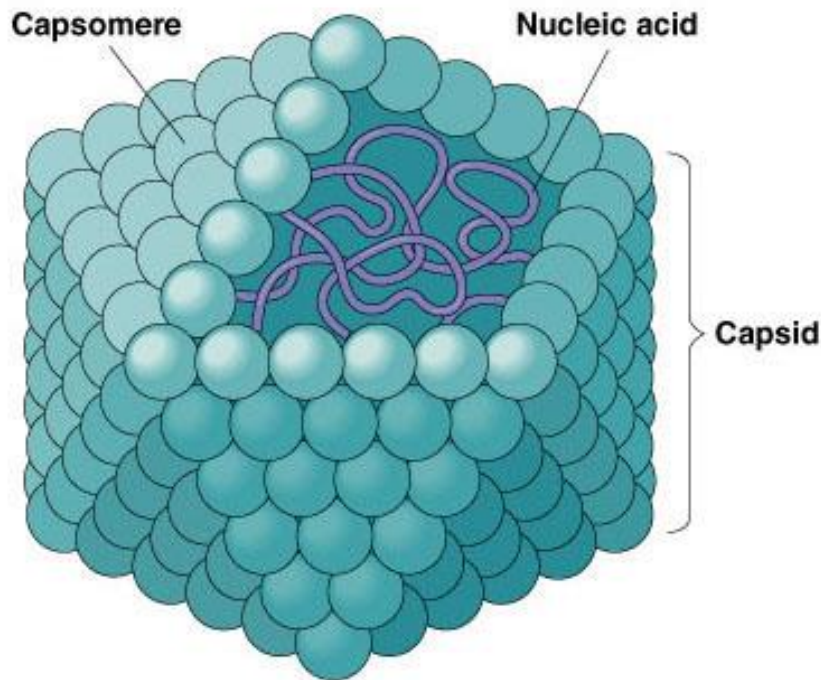


(a) A helical virus

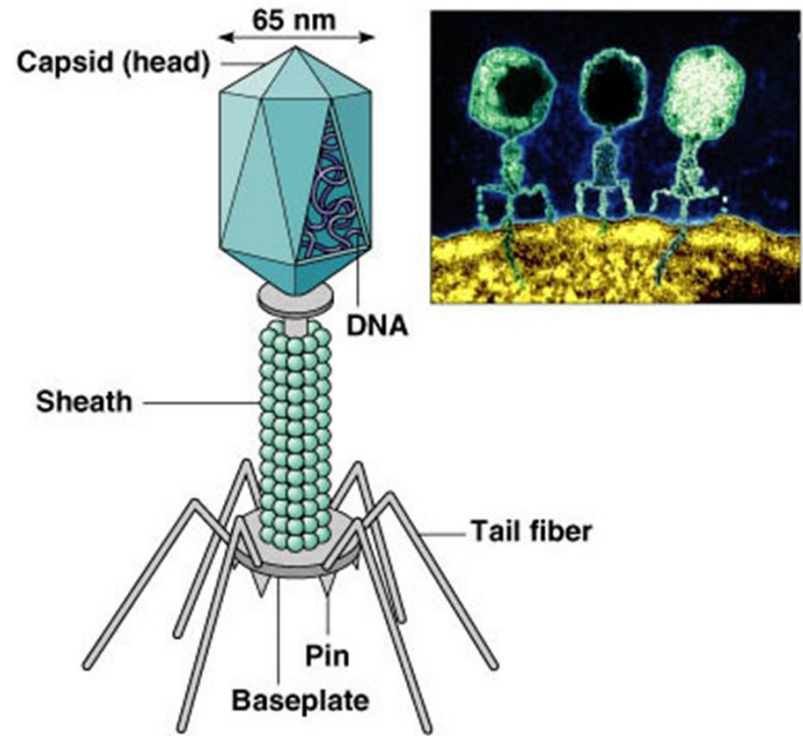


(b) Ebola virus

- Some may be polyhedral shapes like the influenza virus
- Others have more complex shapes like bacteriophages



(a) A polyhedral virus



(a) A T-even bacteriophage

Cultivation of viruses:

need living cells, living hosts, Tissue cultures, embryonated eggs,



Some question and Answers about Viruses:

Q/ Are viruses cellular organisms?

A/ Viruses are considered living organisms but they do not have a cellular structure.

Q/ What is the basic structure of a virus?

A/ Viruses are made up of genetic material (DNA or RNA) covered by a protein capsule also known as a capsid. Some viruses, like HIV, also have an external envelope produced from the plasma membrane of the host cell from which it came.

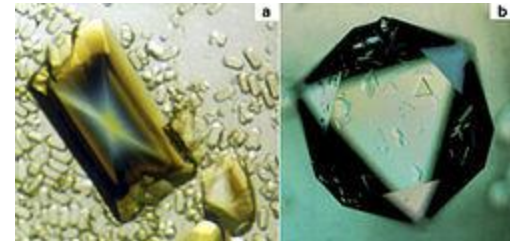
Q/ Are there non-parasitic viruses?

A/ All viruses are obligate intracellular parasites, meaning that they depend on a host cell to complete their life cycle. A virus does not have its own metabolism.

Q/ What is the crystallization of a virus? What is the importance of this process?

A/ Crystallization is the process of the transformation of viral components into organized solid particles.

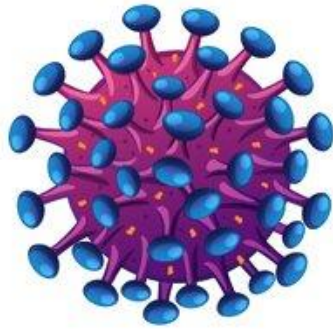
The crystallization of biological macromolecules, including viral components, is used to study structural characteristics, through X-rays or laser beams.



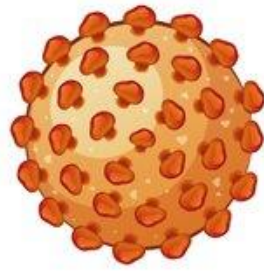
Q/What are the main human diseases caused by viruses?

A/ Among diseases caused by viruses are the common cold, the flu, mumps, smallpox (considered eradicated nowadays), rubella, measles, AIDS, viral hepatitis, papillomatosis (HPV infection), rabies, dengue fever, yellow fever, poliomyelitis (a disease almost eradicated in developed countries), hemorrhagic fever from the Ebola virus and SARS (severe acute respiratory syndrome). Covid 19

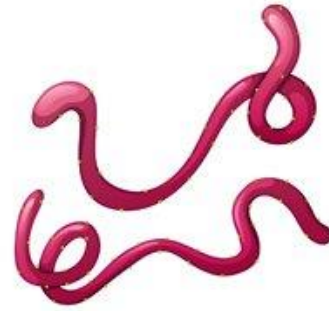
Viruses also cause many other diseases in animals and plants.



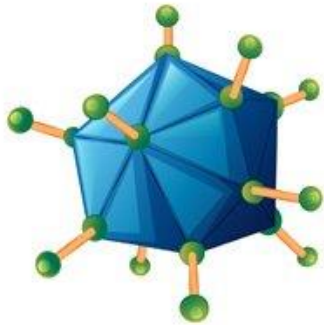
HIV



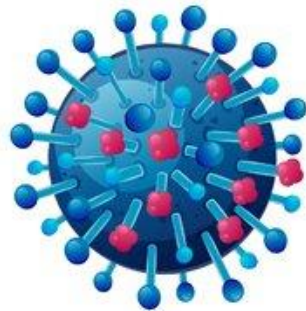
Hepatitis B



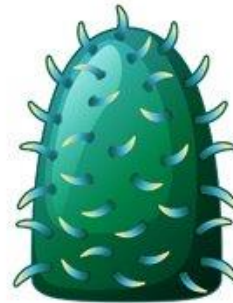
Ebola Virus



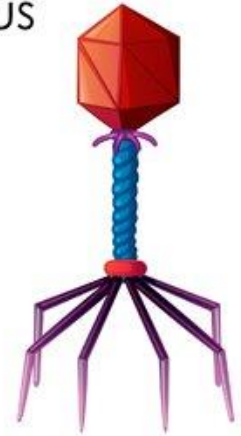
Adenovirus



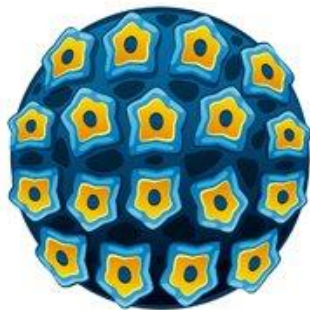
Influenza



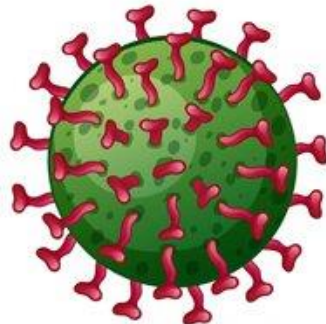
Rabies Virus



Bacteriophage



Papillomavirus



Rotavirus



Herpes Virus

Virus

Living Cell

	Virus	Living Cell
<i>Structure</i>	RNA or DNA core (center), protein coat (capsid)	Cell membrane, cytoplasm, genetic material, organelles
<i>Reproduction</i>	Copies itself only inside host cell--REPLICATION	Asexual or Sexual
<i>Genetic Material</i>	DNA <u>or</u> RNA	DNA <u>and</u> RNA
<i>Growth and Development</i>	-	YES—Multicellular Organisms
<i>Obtain and Use Energy</i>	-	YES
<i>Response to Environment</i>	-	YES

Prokaryotic cell structure

- Prokaryotic cells are about 10 times smaller than eukaryotic cells.
- Prokaryotes are very simple cells when compare with eukaryotic cells and yet they are able to perform the necessary processes of life.
- Reproduction of prokaryotic cells is by **binary fission** (the simple division of one cell into two cells, after DNA replication and the formation of separating membrane and cell wall)
- Prokaryotic cells: **bacteria** and **archae**
- Do **not have true nucleus** or other **membrane-bound organelles** (Mitochondria, Golgi apparatus ...)

Bacteria

Important characteristics:

- Prokaryotic
- Unicellular
- Simple internal structure
- Grow on artificial laboratory media
- Reproduction by binary fission

Practical significance:

- Some cause diseases
- Some perform role in natural cycling of elements and increase soil fertility.
- Manufacture of valuable compounds in industry.

Structures common to all bacterial cells

- Cell membrane
- Cytoplasm
- Ribosomes
- One (or a few) chromosomes

Structures found in most bacterial cells

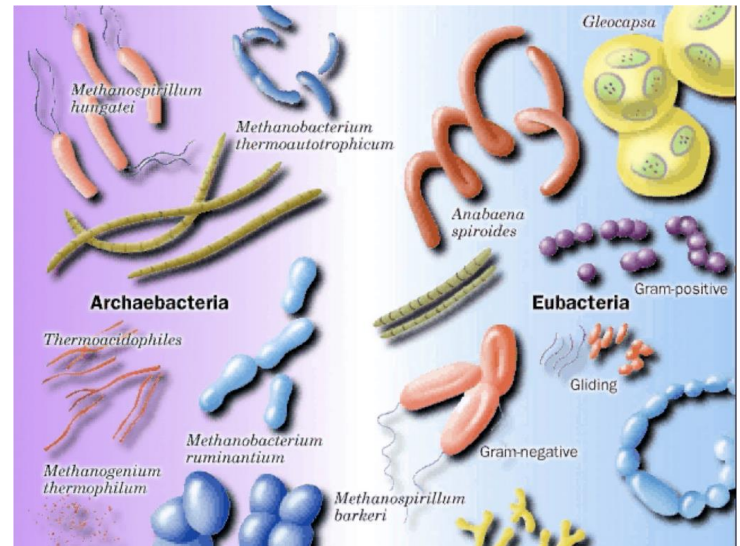
- Cell wall
- Surface coating or glycocalyx

Structures found in some bacterial cells

- Flagella
- Pili
- Fimbriae
- Capsules
- Slime layers
- Inclusions
- Actin cytoskeleton
- Endospores

Archaeobacteria

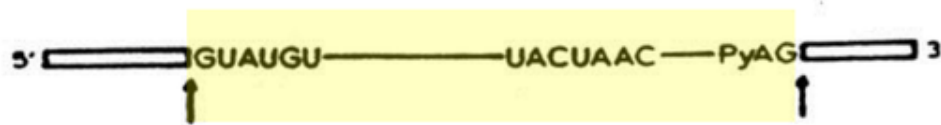
- These can easily survive under very harsh conditions such as, The cell membranes of the Archaeobacteria are composed of lipids.
- **Unicellular**
- Autotrophic and heterotrophic
- Prokaryotes
- Live in harsh environments



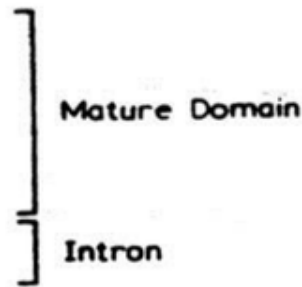
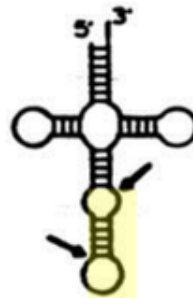
Bacteria	Archaea
Cell wall structure contains peptidoglycan	Cell wall structures do not contain peptidoglycan. They have : Polysaccharide Protein, or no cell wall
Introns absent	Introns present
Ribosomal protein (58)	Ribosomal protein (64)
Can be parasitic and cause infectious disease	None are parasitic

Five Classes of Introns

■ Nuclear mRNA

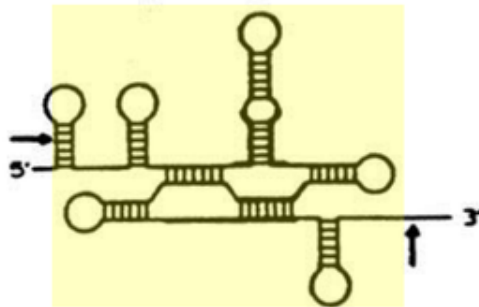


■ tRNA

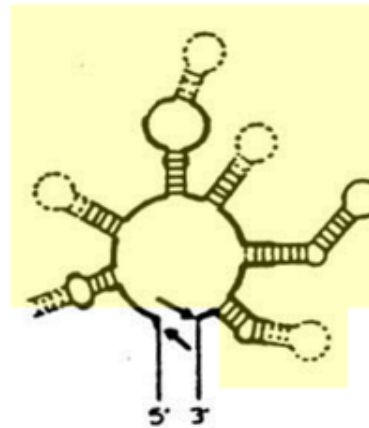


Archaeal introns
(tRNAs and rRNAs)

■ Self-Splicing



Group I



Group II

Fungi:

- The study of fungi is called **mycology**
- Fungi are diverse and widespread
- They are essential for well-being of most terrestrial ecosystems because the **break down organic material and recycle vital nutrients**

Fungi include:

Yeast, mold, mushroom and toadstools, puffballs, etc.

Micro fungi include **Yeast and mold**



Characteristics of fungi:

1- Fungi are eukaryotic microorganisms, heterotrophic, they do not have chlorophyll.

2- Most are multicellular except unicellular yeast.

3- They are surrounded by a true **cell wall** except for slime mold.

Cell walls are made of **chitin**.

5- The fungal colony may be a mass of yeast cells or it may be a filamentous mold.

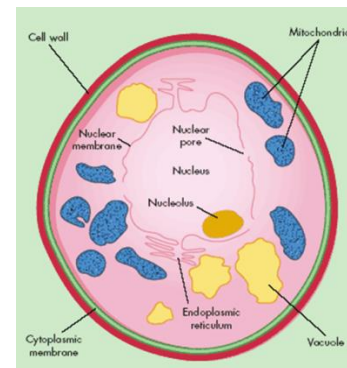
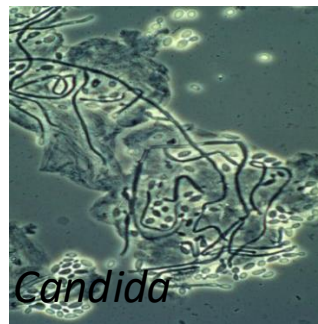
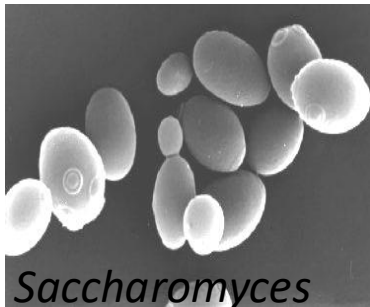
6- Reproduce sexually and asexually

Asexually by spores, Sexually by mating of hyphae filaments



Yeast:

- Yeast are unicellular organisms about 5 to 10 times larger than bacteria.
- The shape is commonly egg shaped, but some are elongated and some are spherical.
- The yeast cell have no flagellum or other organelles of locomotion.
- Most yeast reproduce asexually by a process called budding.
- Some yeasts may also undergo sexual reproduction



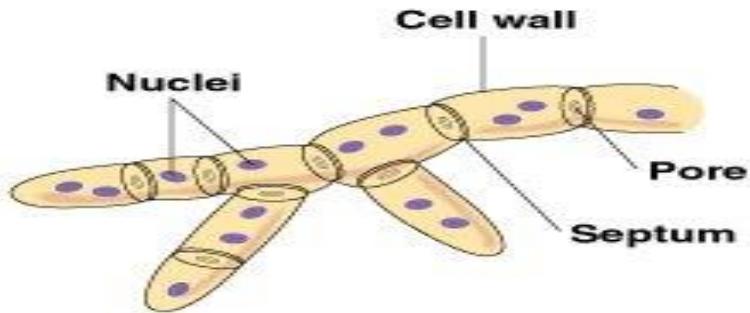
Mold:

- Molds are the major fungal organisms that can be seen by the naked eye.
- Thallus (body) of a mold or fleshy fungus consist of long filaments of cells joined together, these filaments are called **hyphae**
- Many hyphae together form a thick mass called a mycelium

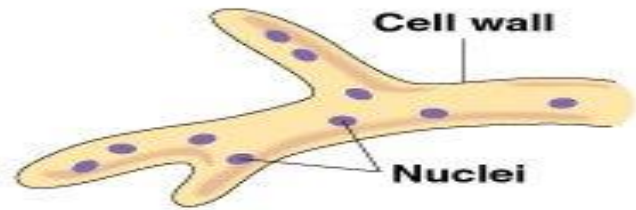
Fungal hyphae may be septate or aseptate

- Hyphae of septate fungi are divided into cells by cross walls called **septa**
- Hyphae of **aseptate** fungi lack cross walls (**coenocytic**)
- Parasitic fungi have modified hyphae called **haustoria**, which penetrate the host tissue but remain outside cell membrane

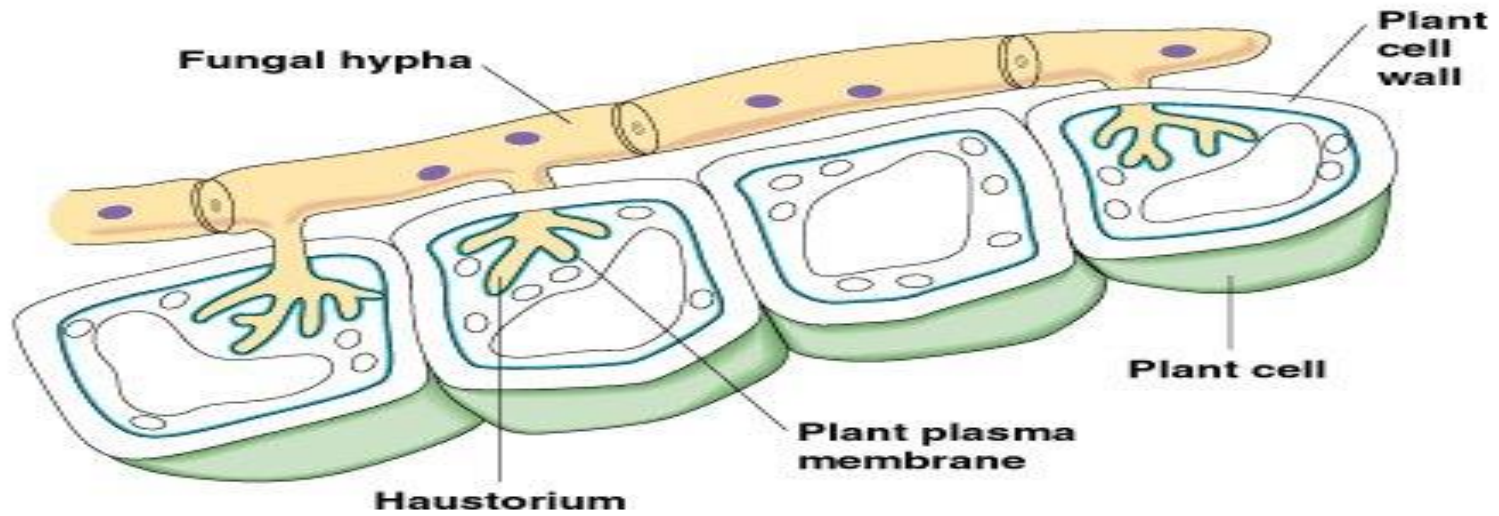
Fungal hyphae may be septate or aseptate



(a) Septate hypha



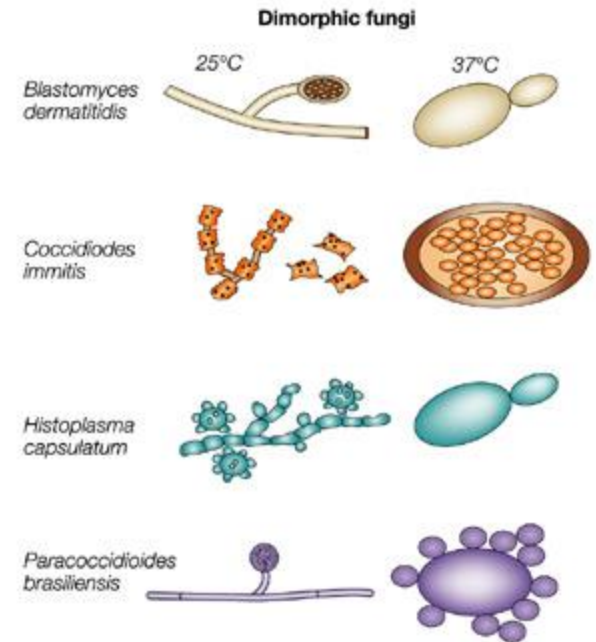
(b) Coenocytic hypha



(c) Haustoria

Morphological classification

1. Yeasts
2. Yeast-like fungi
3. Filamentous fungi (molds)
4. Dimorphic fungi



Systematic classification

Based on sexual spores formation: 4 classes

1. Zygomycetes
2. Ascomycetes
3. Basidiomycetes
4. Deuteromycetes



Deuteromycetes



Encarta Encyclopedia, Andrew
McClenaghan/Science Source/Photo
Researchers, Inc.

Fungi Nutrition

- Heterotrophs depend on other organisms for food
- Unlike animals, fungi do not ingest their food
Instead they digest food outside their bodies and then absorb it
- Many feed by absorbing nutrients from decaying matter in the soil (decomposers)
- Others live as parasites, absorbing nutrients from their hosts

Beneficial Effects of Fungi

- * Decomposition - nutrient and carbon recycling.
- * Biosynthetic factories. Can be used to produce drugs, antibiotics, alcohol, acids, food (e.g., fermented products, mushrooms).
- * Model organisms for biochemical and genetic studies.

Harmful Effects of Fungi

- * Destruction of food, lumber, paper, and cloth.
- * Animal and human diseases, including allergies.
- * Toxins produced by poisonous mushrooms and within food (e.g., grain, cheese, etc.).
- * Plant diseases.

-Algae

- ❖ Algae are autotrophic, diverse group of eukaryotic organisms, ranging from unicellular to multicellular forms. except Cyanobacteria(Blue green algae) are Prokaryotic
- ❖ Aquatic (fresh water and marine) and terrestrial environment.
- ❖ They also occur in moist stones, soils, wood, on snow and on ice.



Marine Algae



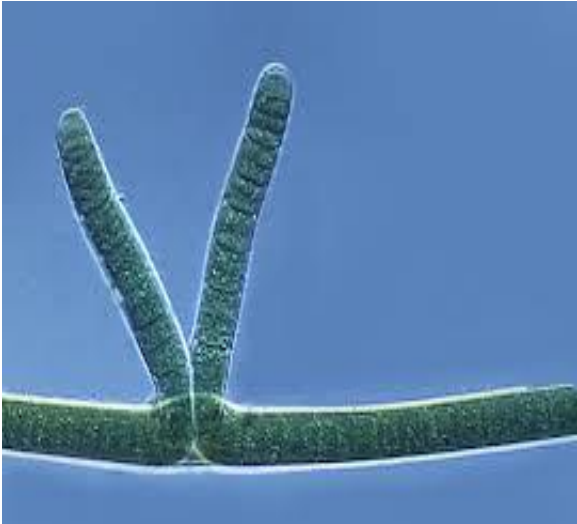
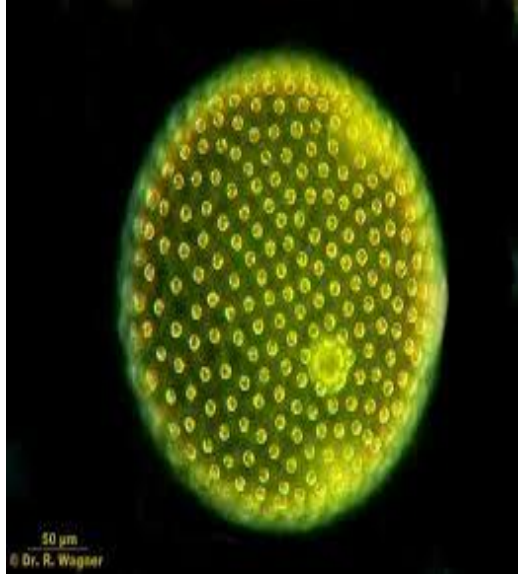
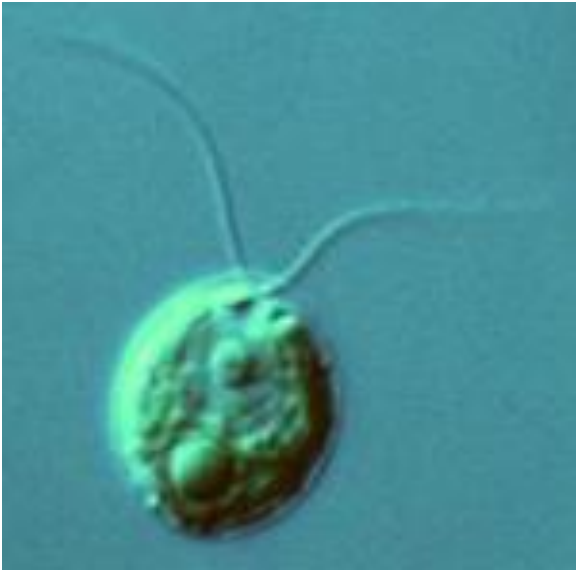
Algae on wood

The Form of Algae

Algae exhibit great diversity in organization of plant body.

- Unicellular
 - Motile e.g. *Chlamydomonas*
 - Non-motile e.g. *Chlorella*
- Colonial e.g. *Volvox*
- Filamentous
 - Simple or un branched e.g. *Ulothrix*
 - Branched e.g. *Sytonema*
- Dendroid means tree like. e.g. *Prasinocladus*

Shapes of Algae



Reproduction in Algae

1. Vegetative reproduction is by fragmentation.
2. Asexual reproduction is by the production of different types of spores, the most common being the **zoospores**.
3. Sexual reproduction takes place through fusion of two gametes. Gametes may be isogamy or anisogamy or oogamy.

Classification of Algae based on

- Color
- Type of chlorophyll
- Food storage substance
- Cell wall composition

Advantages of Algae

- Source of food
- Used as biofertilizer
- Sewage treatment
- Alternative to chemical dyes and colouring agents
- Commercial uses Agar

- **Protozoa**
- **Characteristics of Protozoan Phyla**

- 1.They are unicellular with some colonial and multicellular stages.
- 2.Most are microscopic.
- 3.All symmetries are present within members of the group.
- 4.No germ layers are present.
- 5.No organs or tissues are formed, but specialized organelles serve many of these functions.

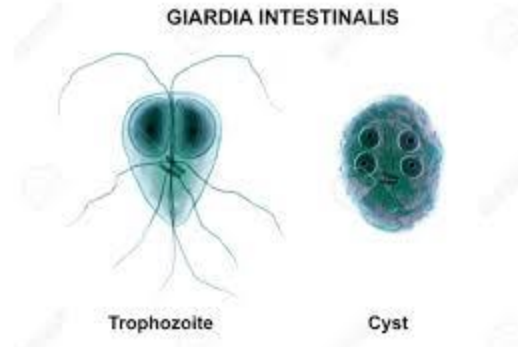
- 6.They include free-living, mutualistic, commensal and parasitic forms.
 - 7.They move by pseudopodia, flagella, cilia and they can direct cell movements.
 - 8.Most are naked, but some have a simple endoskeleton or exoskeleton.
- All types of nutrition are present: autotrophic, heterotrophic and saprozoic.
10. They can be aquatic or terrestrial.
 11. Reproduction is asexual by fission, budding or cysts; or sexual by conjugation or syngamy of gametes.

- **Parasite** - one animal(organism) deriving its sustenance(substances) from another without making compensation. The uncompensated animal is the host.
- **Parasitology** - the science or study of host-parasite relationships.
- **Medical parasitology** - study of parasites which infect humans.
- **Host** - the partner providing food and/or protection. Some parasites require more than one host to complete their life cycle; Or may not require a host during some stage(s).

- **Definitive host** - the host in which sexual maturity and reproduction takes place.
- **Intermediate host** - the host in which the parasite undergoes essential development.
- **Reservoir (carrier) host** - the host harboring a parasite in nature, serving as a source of infection for other susceptible hosts. Reservoir hosts show no sign or symptom of disease.
- **Vector** - “carrier” of a parasite from one host to another. Often an insect.

The Protozoa

- **Trophozoite** - the motile vegetative stage; multiplies via binary fission; colonizes host.
- **Cyst** - the inactive, non-motile, infective stage; survives the environment or is a dormant stage of a protozoan that helps to survive in unfavorable environmental conditions.
- due to the presence of a cyst wall. Cysts do not multiply, however, some organisms divide within the cyst wall.



Transmission:

- **mostly person-to-person,**
- **fecal-oral route; fecally contaminated food or water; other means include sexual transmission, insect bites or insect feces.**