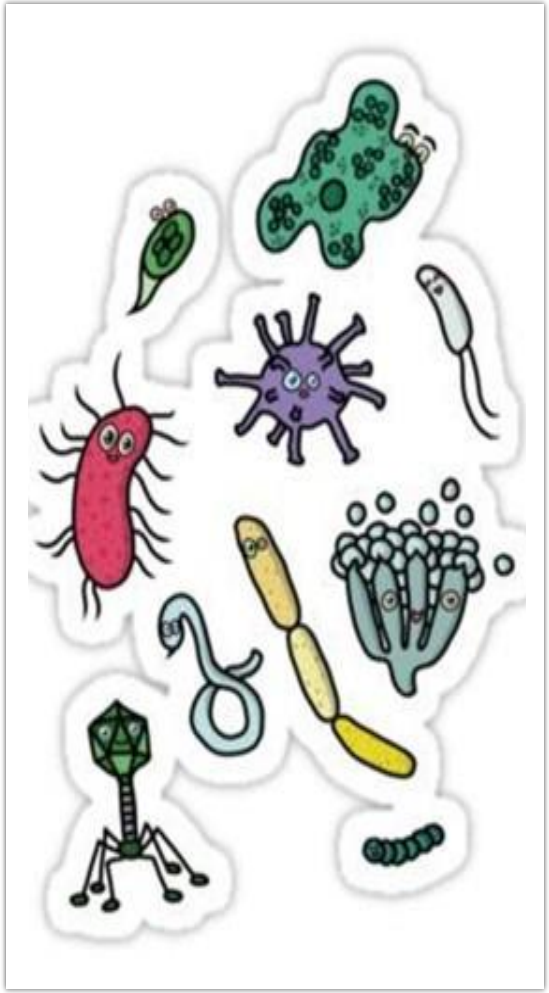
General Microbiology Book

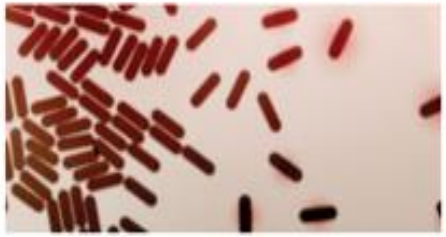
(2nd Biotechnology 2023)



WHAT IS MICROBIOLOGY?

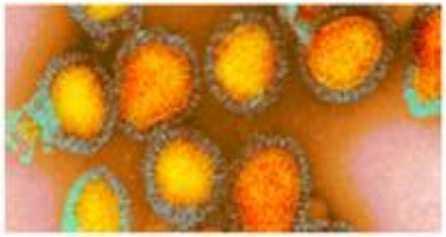
- Micro-organisms and their activities are vitally important to all processes on Earth.
- Micro-organisms matter because they affect every aspect of our lives – they are in us, on us and around us.
- Microbiology is the study of all living organisms that are too small to be visible with the naked eye.
- This includes bacteria, archaea, viruses, fungi, prions, protozoa and algae, collectively known as 'microbes'.
- These microbes play key roles in nutrient cycling, biodegradation, climate change, food spoilage, the cause and control of disease, and biotechnology.
- Microbes can be put to work in many ways: making life-saving drugs, the manufacture of biofuels, cleaning up pollution, and producing/processing food and drink.

Introducing microbes



Bacteria

More than just pathogens - can be friend or foe.

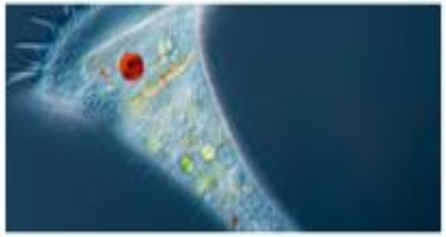


Viruses

Smallest of all the microbes, but are they alive?

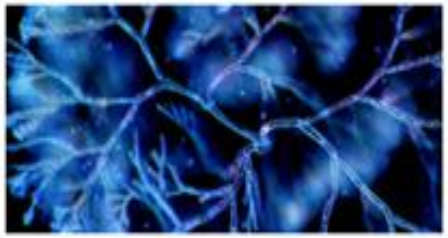
Fungi

More than just mushrooms.



Protozoa

Microbes with a taste for poo and so much more.



Algae

Microbial powerhouses essential for life.

Archaea

First found existing on the edge of life.

Microbes in the world

Microbes and the human body

Ever wondered why when we are surrounded by microbes we are not ill all the time?

Microbes and food

Food for thought – bread, chocolate, yoghurt, blue cheese and tofu are all made using microbes.

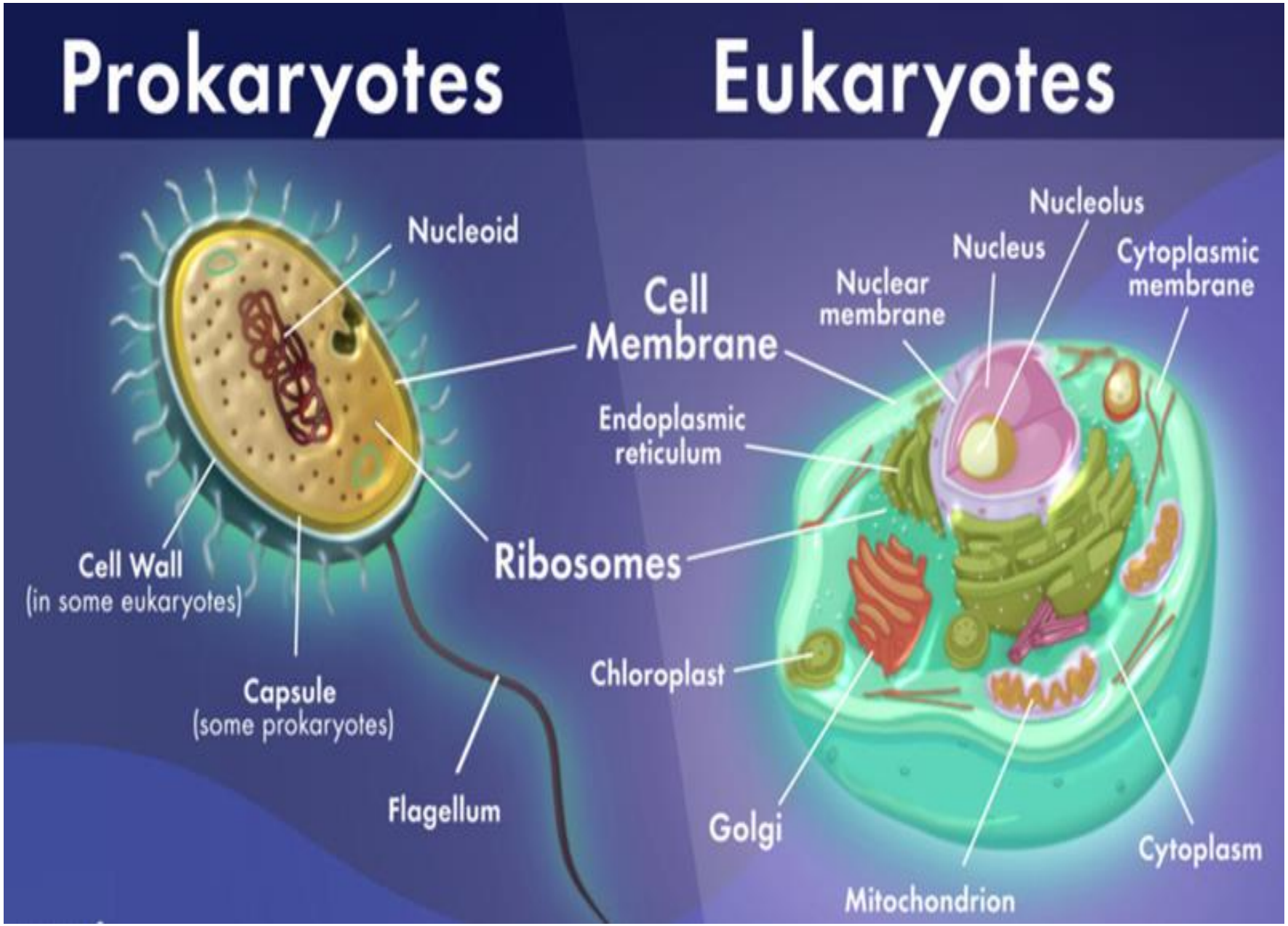
Microbes and the outdoors

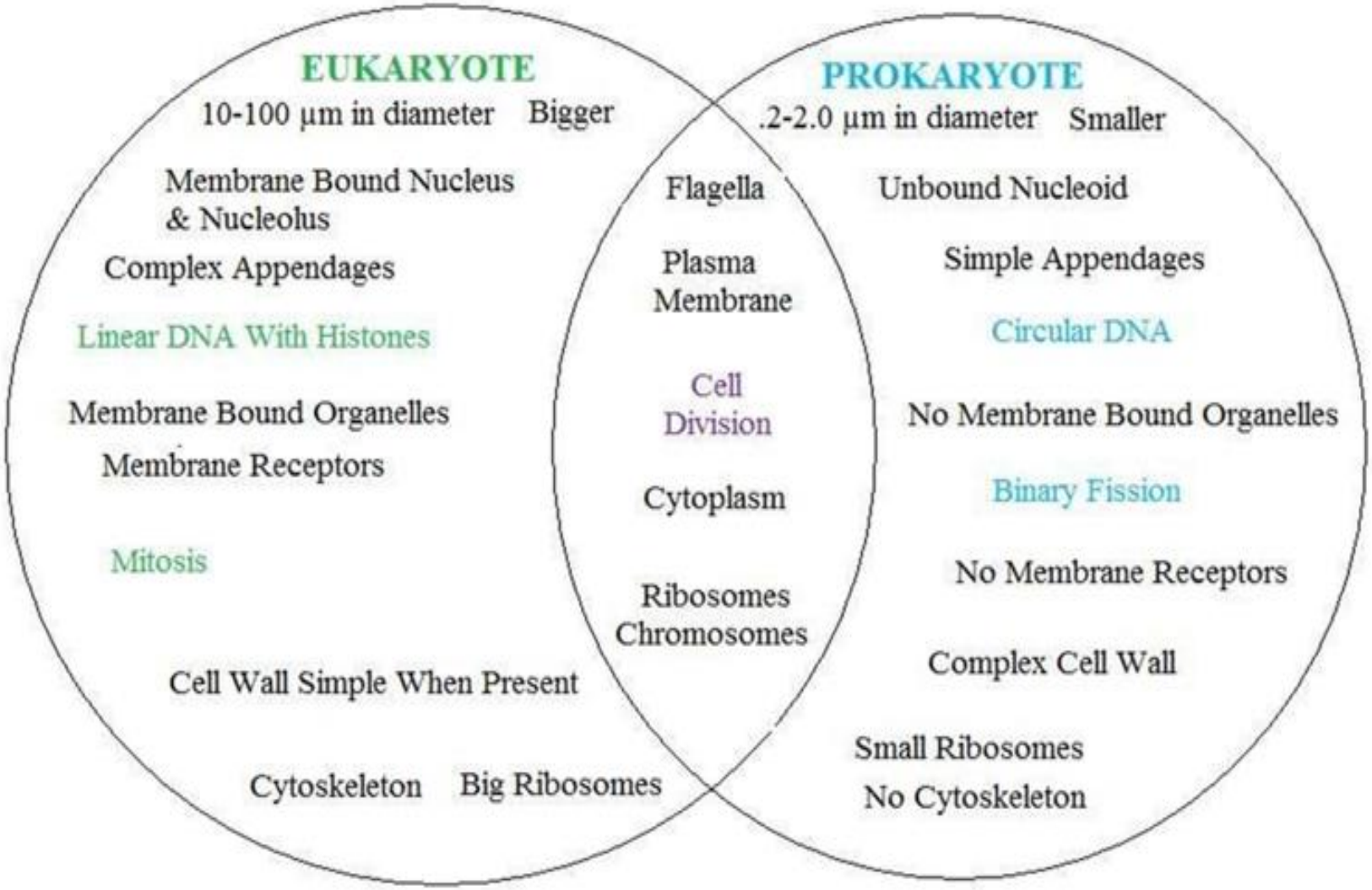
The function of microbes as tiny chemical processors is to keep the life cycles of the planet turning.

Microbes and climate change

How are microbes contributing to climate change?

- Microbiology (from Greek mīkros, "small", bios, "life"; and - logia) is the scientific study of microorganisms.
- Those being unicellular (single cell), multicellular (cell colony), or acellular (lacking cells).
- Microbiology including virology, bacteriology, protistology, mycology, immunology and parasitology.


Prokaryotes
Eukaryotes
Nucleoid
Cell Membrane
Cell Wall
(in some eukaryotes)
Ribosomes
Capsule
(some prokaryotes)
Flagellum
Nucleolus
Nucleus
Nuclear membrane
Cytoplasmic membrane
Endoplasmic reticulum
Chloroplast
Golgi
Mitochondrion
Cytoplasm


EUKARYOTE
10-100 µm in diameter Bigger
Membrane Bound Nucleus & Nucleolus
Complex Appendages
Linear DNA With Histones
Membrane Bound Organelles
Membrane Receptors
Mitosis
Cell Wall Simple When Present
Cytoskeleton
Big Ribosomes
Flagella
Plasma Membrane
Cell Division
Cytoplasm
Ribosomes
Chromosomes
PROKARYOTE
.2-2.0 µm in diameter Smaller
Unbound Nucleoid
Simple Appendages
Circular DNA
No Membrane Bound Organelles
Binary Fission
No Membrane Receptors
Complex Cell Wall
Small Ribosomes
No Cytoskeleton

- Historical background

- Microbiology essentially began with the development of the microscope.
- Although others may have seen microbes before him, it was Antonie van Leeuwenhoek, who was the first to provide proper documentation of his observations.
- His findings in a series of letters to the British Royal Society during the mid-1670s.
- Although his observations stimulated much interest, no one made a serious attempt either to repeat or to extend them.
- It was only later, during the 18th-century about whether life could develop.

◦ Microbes and disease

- an Italian scholar, advanced an infection that passes from one thing to another.
- A description is passed along eluded discovery until the late 1800s, when the work of many scientists, Pasteur foremost among them, determined the role of bacteria in fermentation and disease.
- Robert Koch, a German scholar, defined that a specific organism causes a specific disease.
- The period from about 1880 to 1900. Students of Pasteur, discovered a host of bacteria capable of causing specific diseases (pathogens).

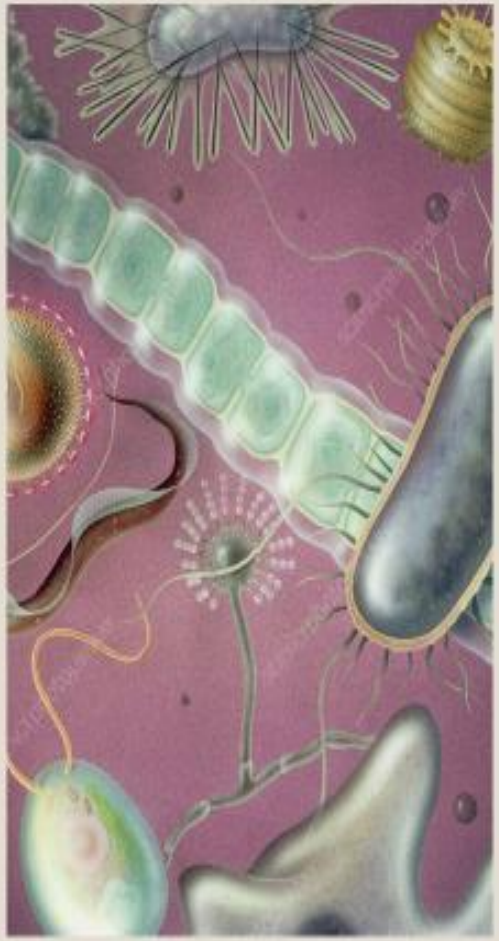
All of these developments occurred in Europe. Not until the early 1900s did microbiology become established in America.

Many microbiologists who worked in America at this time had studied microbiology or at the Pasteur Institute in Paris.

Once established in America, microbiology especially with regard to such related as biochemistry and genetics.

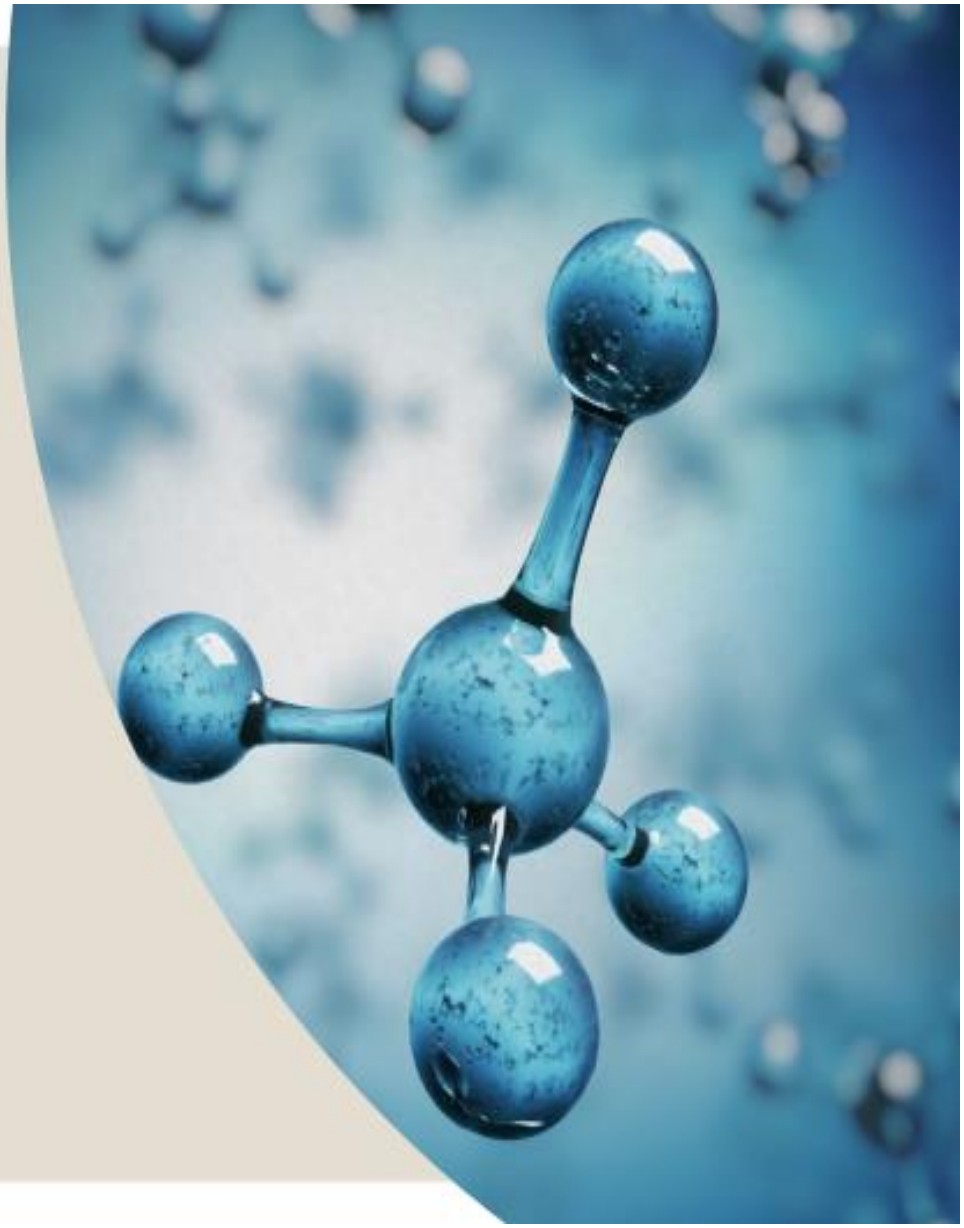
In 1923 American bacteriologist David Bergey established that science's primary reference, updated editions of which continue to be used today.

- The study of microorganisms has also advanced the knowledge of all living things.
- Microbes are easy to work with and provide a simple studying the complex processes of life; as such they have become a powerful tool for studies in genetics and metabolism at the molecular level.
- Knowledge of the basic metabolism and nutritional requirements of a pathogen, for example, often leads to a means of controlling disease or infection.



- **The six main physical factors affecting the growth of microorganisms. The factors are:**
  - 1. Water acidity
  - 2. Temperature
  - 3. pH
  - 4. Oxygen requirements
  - 5. Pressure
  - 6. Radiation.

- **Control of microorganisms is essential in order to:**
  - Prevent the transmission of diseases and infection.
  - Stop decomposition and spoilage and prevent unwanted microbial contamination.



Microorganisms are controlled by means of physical agents and chemical agents.

- Control by physical agents include:
  - high or low temperature.
  - Desiccation.
  - Osmotic pressure.
  - Radiation.
  - Filtration.
- Control by chemical agents refers to the use of:
  - Disinfectants.
  - Antiseptics.
  - Antibiotics.
  - Chemotherapeutic antimicrobial chemicals.

Basic terms used in discussing the control of microorganisms include:

1. **Sterilization:**
   - Sterilization is the process of destroying all living organisms and viruses. A sterile object is one free of all life forms, including bacterial endospores, as well as viruses.
2. **Disinfection:**
   - Disinfection is the elimination of microorganisms, but not necessarily endospores, from inanimate objects or surfaces.
3. **Decontamination:**
   - Decontamination is the treatment of an object or inanimate surface to make it safe to handle.
4. **Disinfectant:**
   - A disinfectant is an agent used to disinfect inanimate objects but generally too toxic to use on human tissues.

5. **Antiseptic:**

An antiseptic is an agent that kills or inhibits growth of microbes but is safe to use on human tissue.

6. **Sanitizer:**

A sanitizer is an agent that reduces microbial numbers to a safe level.

7. **Antibiotic:**

An antibiotic is a metabolic product produced by one microorganism that inhibits or kills other microorganisms.

8. **Chemotherapeutic synthetic drugs:**

Synthetic chemicals that can be used therapeutically.

9. **Cidal:**

An agent that is cidal in action will kill microorganisms and viruses.

10. **Static:**

An agent that is static in action will inhibit the growth of microorganisms.

- **Sterilization processes:**

1. Heat:

A. Dry heat:

- **(hot air oven):**

  Basically, the cooking oven. but dry heat is not as effective as moist heat (i.e., higher temperatures are needed for longer periods of time). For example, 160°C /2hours or 170°C /1hour is necessary for sterilization. The dry heat oven is used for glassware, metal, and objects that will not melt.

- **Incineration:**

  Burns organisms and physically destroys them. Used for needles, inoculating wires, glassware, etc. and objects not destroyed in the incineration process.

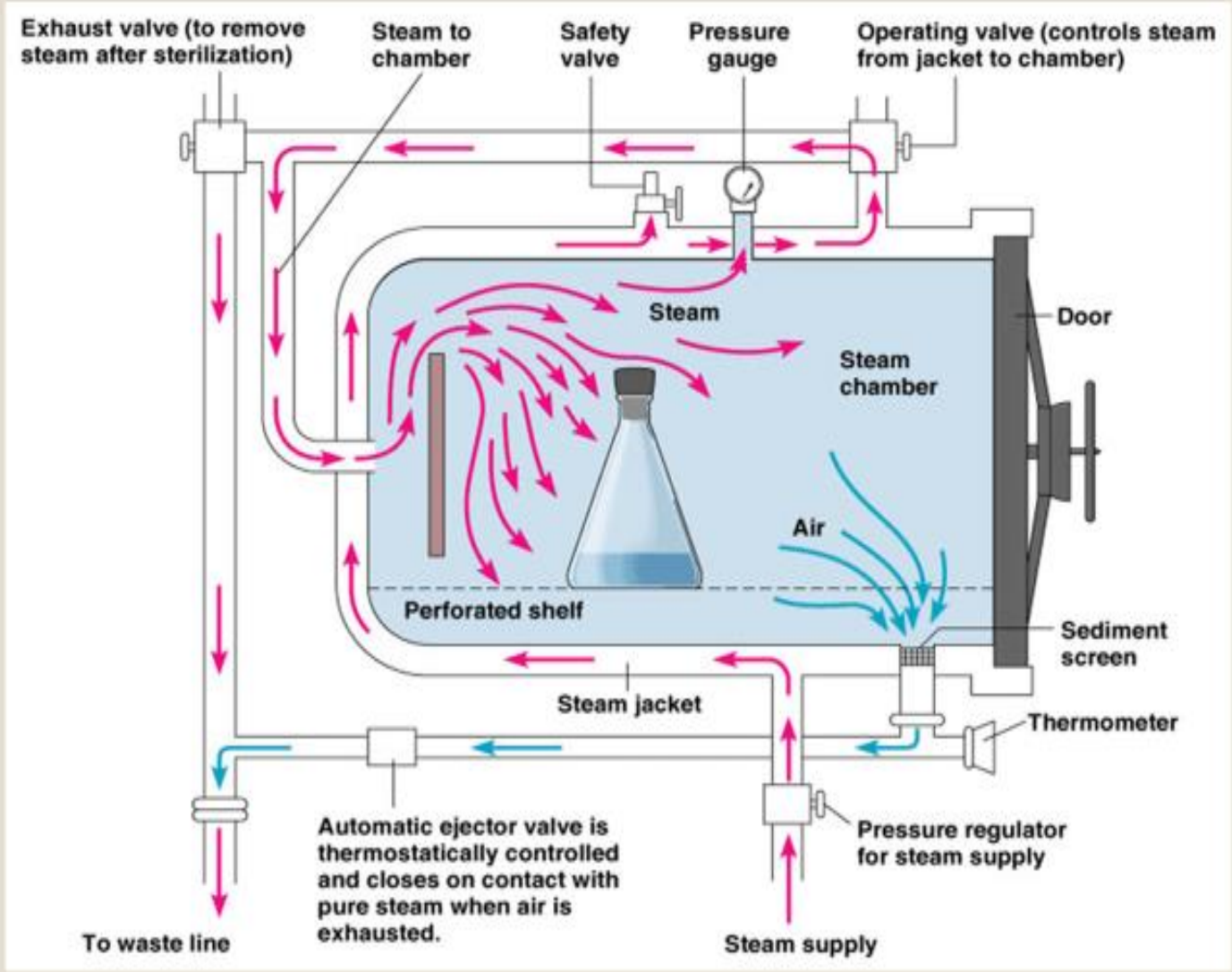
B. Wet heat:

- **Boiling:**

  100°C for 30 minutes. Kills everything except some endospores. To kill endospores, and therefore sterilize a solution, very long (>6 hours) boiling, or intermittent boiling is required.

- **Autoclaving (steam under pressure or pressure cooker):**

  Autoclaving is the most effective and most efficient means of sterilization. The usual standard temperature/pressure employed is 121°C /15 psi for 15 minutes. Autoclaving is ideal for sterilizing biohazardous waste, surgical dressings, glassware, many types of microbiologic media, liquids, and many other things.


Exhaust valve (to remove steam after sterilization)
Steam to chamber
Safety valve
Pressure gauge
Operating valve (controls steam from jacket to chamber)
Steam
Door
Steam chamber
Air
Perforated shelf
Sediment screen
Steam jacket
Thermometer
Automatic ejector valve is thermostatically controlled and closes on contact with pure steam when air is exhausted.
Pressure regulator for steam supply
To waste line
Steam supply

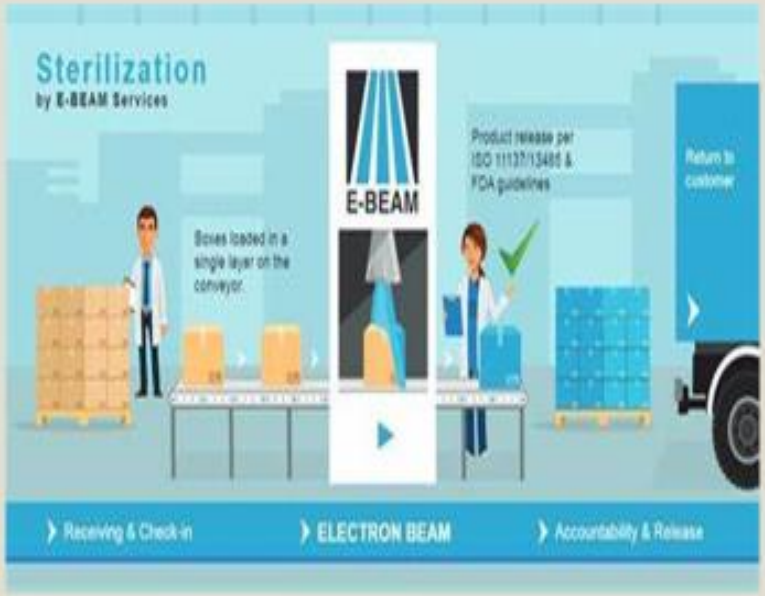
2. **Ionizing radiation:**

A: Gamma radiation:

Are forms of ionizing radiation used primarily in the health care industry, are similar in many ways to microwaves and x-rays. Gamma rays are highly effective in killing microorganisms and do not leave residues.

B: Electron beam radiation:

E-beam irradiation is like gamma radiation in that it alters various chemical and molecular bonds on contact.



3. Filtration:

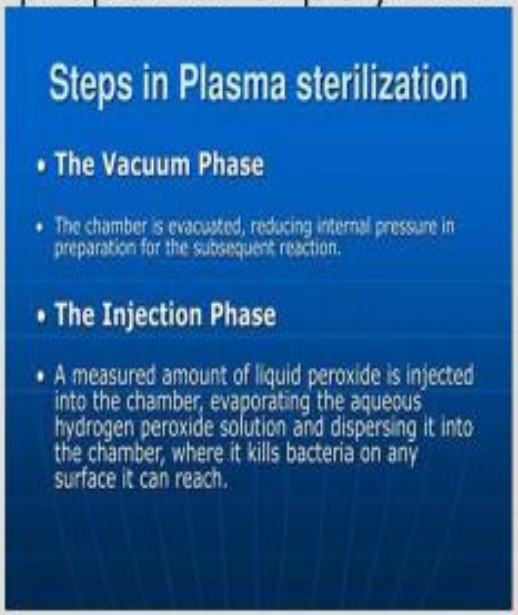
Involves the physical removal (exclusion) of all cells in a liquid or gas. It is especially important for sterilization of solutions which would be denatured by heat (e.g. antibiotics, injectable drugs, amino acids, vitamins, etc.).

Essentially, solutions or gases are passed through a filter of sufficient pore diameter (generally 0.22 micron) to remove the smallest known bacterial cells.

4. Chemical and gas sterilization:

A. Low temperature gas plasma (LTGP):

Gas plasmas are generated in an enclosed chamber under deep vacuum using RF or microwave energy to excite the gas molecules and produce charged particles, many of which are in the form of free radicals. Plasma treatment has been used to alter the surface properties of polymers without affecting their bulk properties.

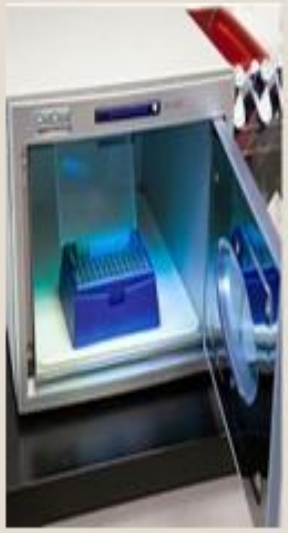


B: Ethylene oxide (ETO):

Is the most used form of chemical sterilization. Due to its low boiling point of 10.4◦C at atmospheric pressure, EtO behaves as a gas at room temperature. EtO chemically reacts with amino acids, proteins, and DNA to prevent microbial reproduction.

C: UV ozone sterilization:

Has been recently approved for use in the U.S. It uses oxygen that is subjected to an intense electrical field that separates oxygen molecules into atomic oxygen, which then combines with other oxygen molecules to form ozone.



D: Common antiseptics and disinfectants:

Chemical	Uses
Ethanol (50-70%)	Antiseptic used on skin
Isopropanol (50-70%)	Antiseptic used on skin
Formaldehyde (8%)	Disinfectant, kills endospores
Tincture of Iodine (2% I2 in 70% alcohol)	Antiseptic used on skin Disinfection of drinking water
Chlorine (Cl_2) gas	Disinfect drinking water; general disinfectant
Silver nitrate ($AgNO_3$)	General antiseptic and used in the eyes of newborns
Mercuric chloride	Disinfectant, although occasionally used as an antiseptic on skin
Detergents (e.g. quaternary ammonium compounds)	Skin antiseptics and disinfectants
Phenolic compounds (e.g. carbolic acid, lysol, hexylresorcinol, hexachlorophene)	Antiseptics at low concentrations; disinfectants at high concentrations

CULTURE MEDIA

CULTURE MEDIA

- Culture media contains nutrients and physical growth parameters necessary for microbial growth. All microorganisms cannot grow in a single culture medium.

1 Classification of bacterial culture media on the basis of consistency:

1.0.1 Solid medium

1.0.2 Semisolid medium

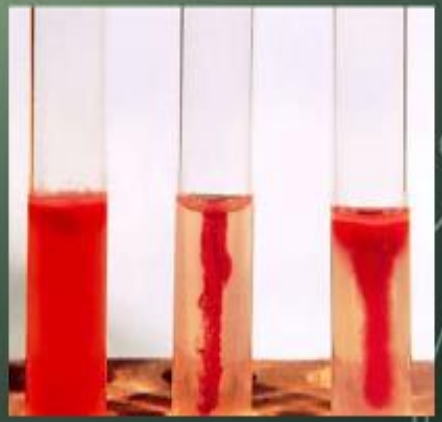
1.0.3 Liquid (Broth) medium

1.0.1 Solid medium:

Solid medium contains agar at a concentration of 1.5-2.0%. Solid medium has physical structure and allows bacteria to grow in physically informative or useful ways (e.g. as colonies or in streaks). Solid medium is useful for isolating bacteria or for determining the colony characteristics of the isolate.

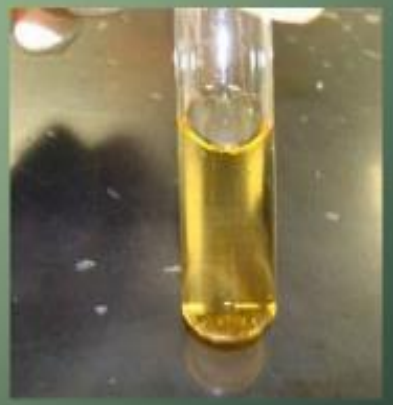
1.0.2 Semisolid medium

Semisolid medium is prepared with agar at concentrations of 0.5% or less. Semisolid medium has a soft custard-like consistency and is useful for the cultivation of microaerophilic bacteria or for the determination of bacterial motility.



1.0.3 Liquid (Broth) medium

These media contain specific amounts of nutrients but don't have a trace of gelling agents such as gelatine or agar. Broth medium serves various purposes such as propagation of a large number of organisms, fermentation studies, and various other tests. e.g. sugar fermentation tests, MR-VR broth.

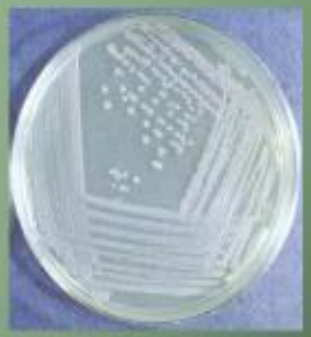


2 Classification of Bacterial Culture media on the basis of purpose/ functional use/ application:

- 2.1 General-purpose media/ Basic media
- 2.2 Enriched medium (Added growth factors)
- 2.3 Selective and enrichment media
  - 2.3.1 Selective medium
  - 2.3.2 Enrichment culture medium
- 2.4 Differential/ indicator medium: differential appearance
- 2.5 Transport media
- 2.6 Anaerobic media
- 2.7 Assay media

2.1 General-purpose media/ Basic media:

Peptone-water, nutrient broth, and nutrient agar (NA) are considered as basal medium. These media are generally used for the primary isolation of microorganisms.



2.2 Enriched medium (Added growth factors):

Addition of extra nutrients in the form of blood, serum, egg yolk, etc, to basal medium makes enriched media.

2.3 Selective and enrichment media:

These media are designed to inhibit unwanted commensal or contaminating bacteria and help to recover pathogens from a mixture of bacteria.

2.3.1 Selective medium:

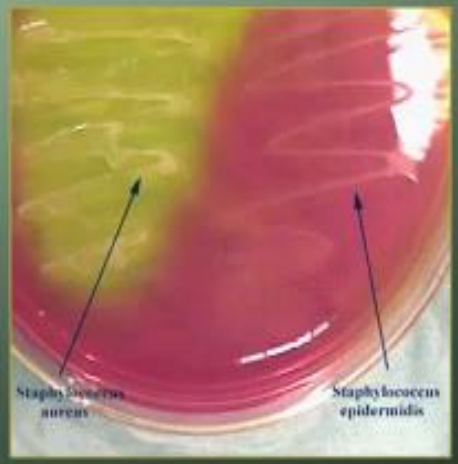
Selective medium is designed to suppress the growth of some microorganisms while allowing the growth of others. Selective medium is agar-based (solid) medium so that individual colonies may be isolated.

2.3.2 Enrichment culture medium:

Enrichment medium is used to increase the relative concentration of certain microorganisms in the culture prior to plating on solid selective medium. Unlike selective media, enrichment culture is typically used as a broth medium.

2.4 Differential/ indicator medium: differential appearance:

Certain media are designed in such a way that different bacteria can be recognized on the basis of their colony color.



2.5 Transport media:

Clinical specimens must be transported to the laboratory immediately after collection to prevent overgrowth of contaminating organisms or commensals. This can be achieved by using transport media. Such media prevent drying (desiccation) of a specimen, maintain the pathogen to commensal ratio, and inhibit the overgrowth of unwanted bacteria.

2.6 Anaerobic media:

Anaerobic bacteria need special media for growth because they need low oxygen content, reduced oxidation-reduction potential and extra nutrients.

2.7 Assay media:

These media are used for the assay of vitamins, amino acids, and antibiotics. E.g. antibiotic assay media are used for determining antibiotic potency by the microbiological assay technique.

VIRUSES

VIRUS HISTORY:

- Chamberland experiments (1884):

Filter pores (0.1-1micron).

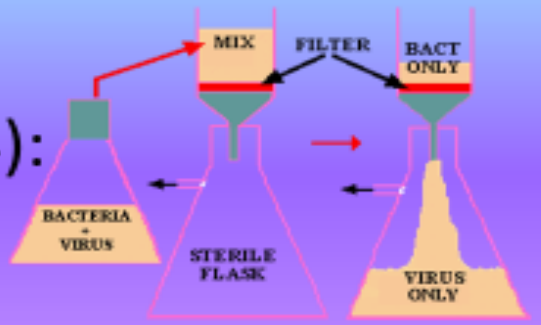


Figure. 1. Filtration of a mixture of bacteria and viruses.

- In 1892 D. IWANOWSKI applied this test to a filtrate of plants suffering from **TOBACCO MOSAIC DISEASE**

❖ new pathogenic life-form "**FILTERABLE VIRUS**".

Size

- To put viral size into perspective, a medium sized virion next to a flea is roughly equivalent to a human next to a mountain twice the size of Mount Everest.
- Viruses have a **capsid** diameter between **10 and 300 nanometers**.
- While most viruses are unable to be seen with a light microscope, both scanning and transmission electron microscopes are used to visualize virus particles.

Principles of Virus Architecture

- In its infective form, outside the cell, a virus particle is called a **virion**.
- **Viroids** (meaning "viruslike") are disease-causing organisms that contain only nucleic acid and have no structural proteins.
- Other viruslike particles called **prions** are composed primarily of a protein tightly integrated with a small nucleic acid molecule.

- Viruses are generally classified by the organisms they infect, **animals**, **plants**, or **bacteria**.

- Since viruses cannot penetrate plant cell walls, all plant viruses are transmitted by **insects** or **other organisms that feed on plants**.

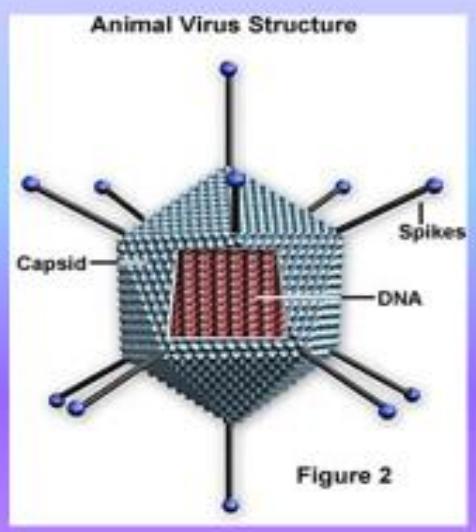
- **Viruses are classified into families and genera based on three structural considerations:**

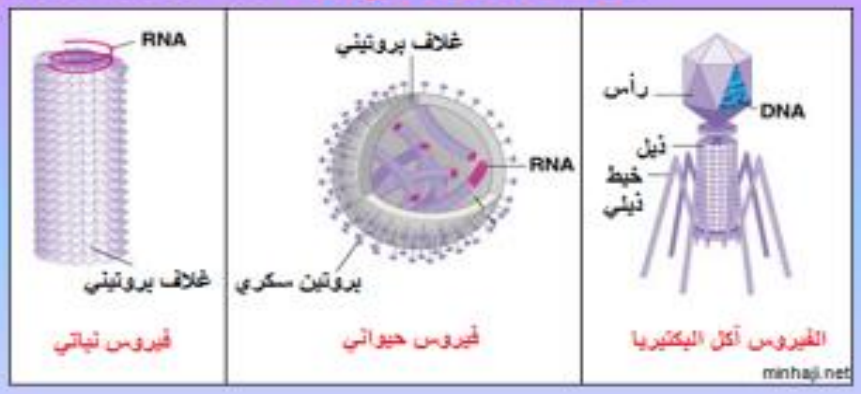
1) The type and size of their **nucleic acid**,

2) The size and shape of the **capsid**,

3) Whether they have a **lipid envelope** surrounding the nucleocapsid (the capsid enclosed nucleic acid).

- **Capsid** - The capsid is the protein shell that encloses the nucleic acid; with its enclosed nucleic acid, it is called the **nucleocapsid**.
- This shell is composed of protein organized in subunits known as **capsomers**.





➢ The capsid has three functions:

1) It **protects** the nucleic acid from digestion by enzymes,
2) Contains special sites on its surface that allow the virion to **attach** to a host cell,
3) Provides proteins that enable the virion to **penetrate** the host cell membrane and, in some cases, to **inject** the infectious nucleic acid into the cell's cytoplasm.

➢ Envelope

- Many types of virus have a **Lipoprotein envelope** surrounding the nucleocapsid.
- The envelope is composed of two lipid layers interspersed with protein molecules (**lipoprotein bilayer**)

➢ Nucleic Acid:

- DNA or RNA (never both)

General Features of Viruses

1. small size: cannot be viewed with a light microscope, pass through filters that retain bacteria, range of size = 0.1-0.3 micrometers

2. characteristic shapes: spherical, helical, rod or polyhedral, sometimes with **tails** or **envelopes**.

General Features of Viruses

3. obligate intracellular parasites: Viruses do not contain within their coats the machinery for replication. For this they depend upon a host cell

4. no built-in metabolic machinery: Viruses have no metabolic enzymes and cannot generate their own energy.

5. no ribosomes : Viruses cannot synthesize their own proteins. For this they utilize host cell ribosomes during replication.

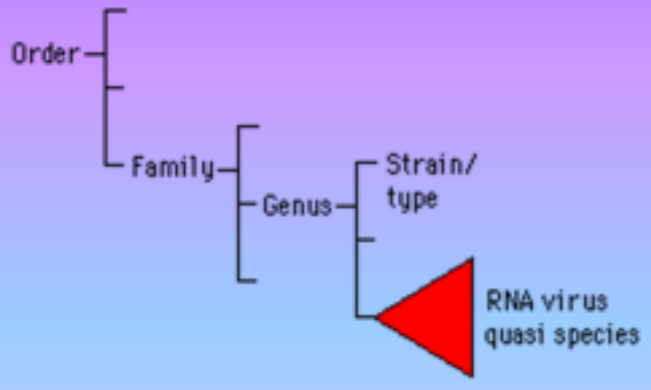
General Features of Viruses

6. only one type of nucleic acid: Viruses contain either DNA or RNA (never both) as their genetic material.

7. do not grow in size: Unlike cells, viruses do not grow in size.

Viral Classification

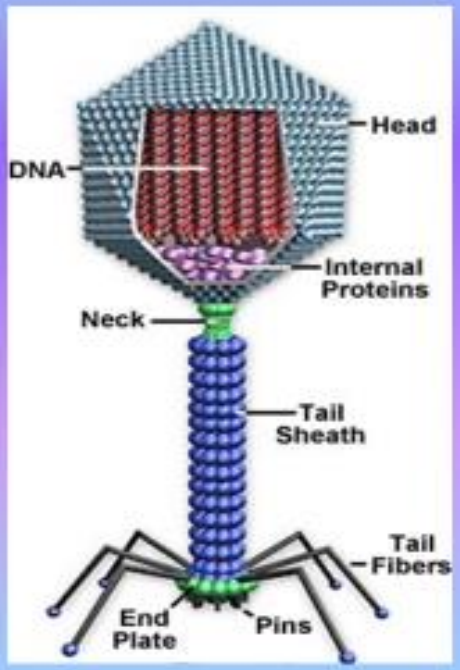
- Hierarchical virus classification:
- **Order - family - subfamily - genus - species - strain/type**



All families have the suffix **viridae** e.g.

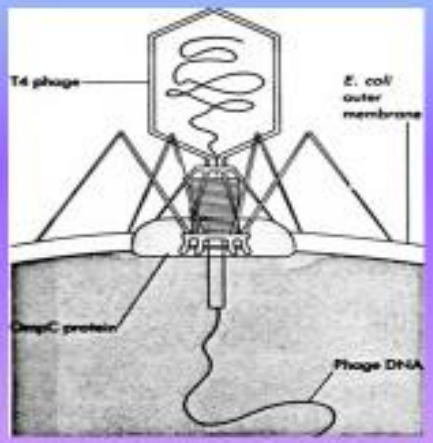
- Poxviridae
- Herpesviridae
- Parvoviridae
- Retroviridae

The Bacteriophages

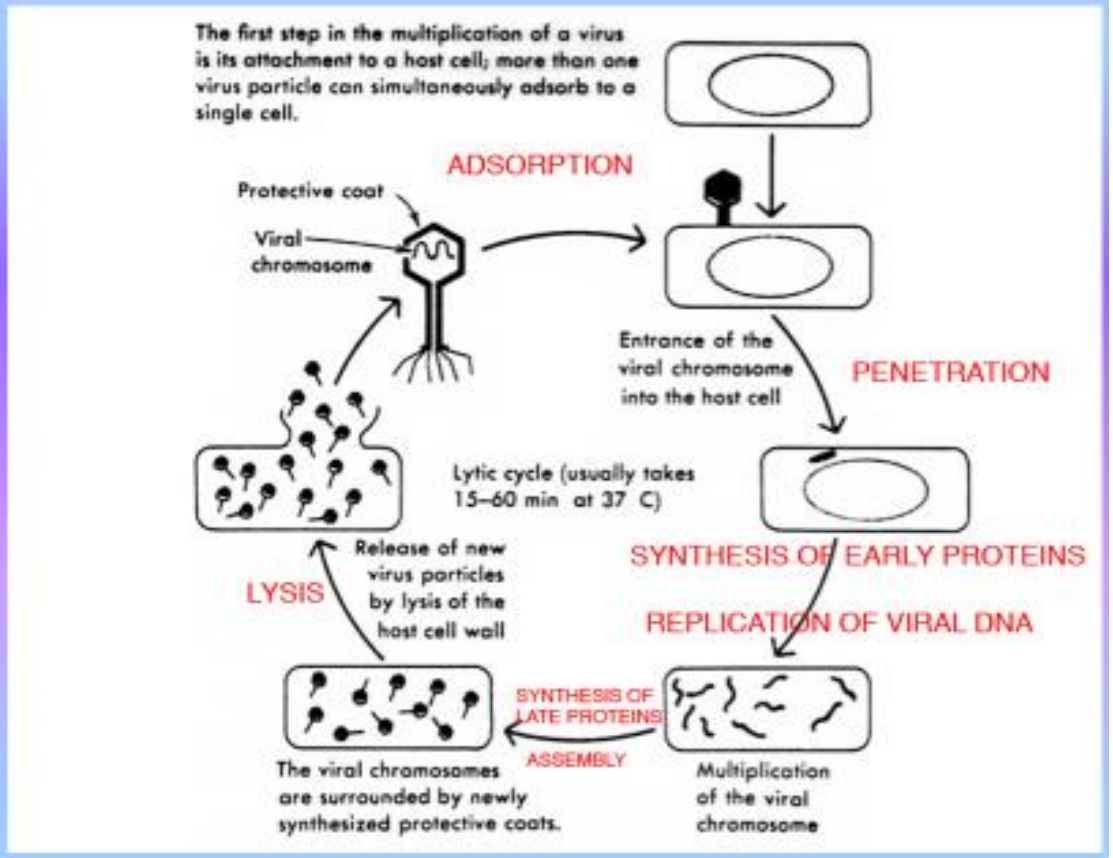


Bacteriophage structure

Lytic Infections

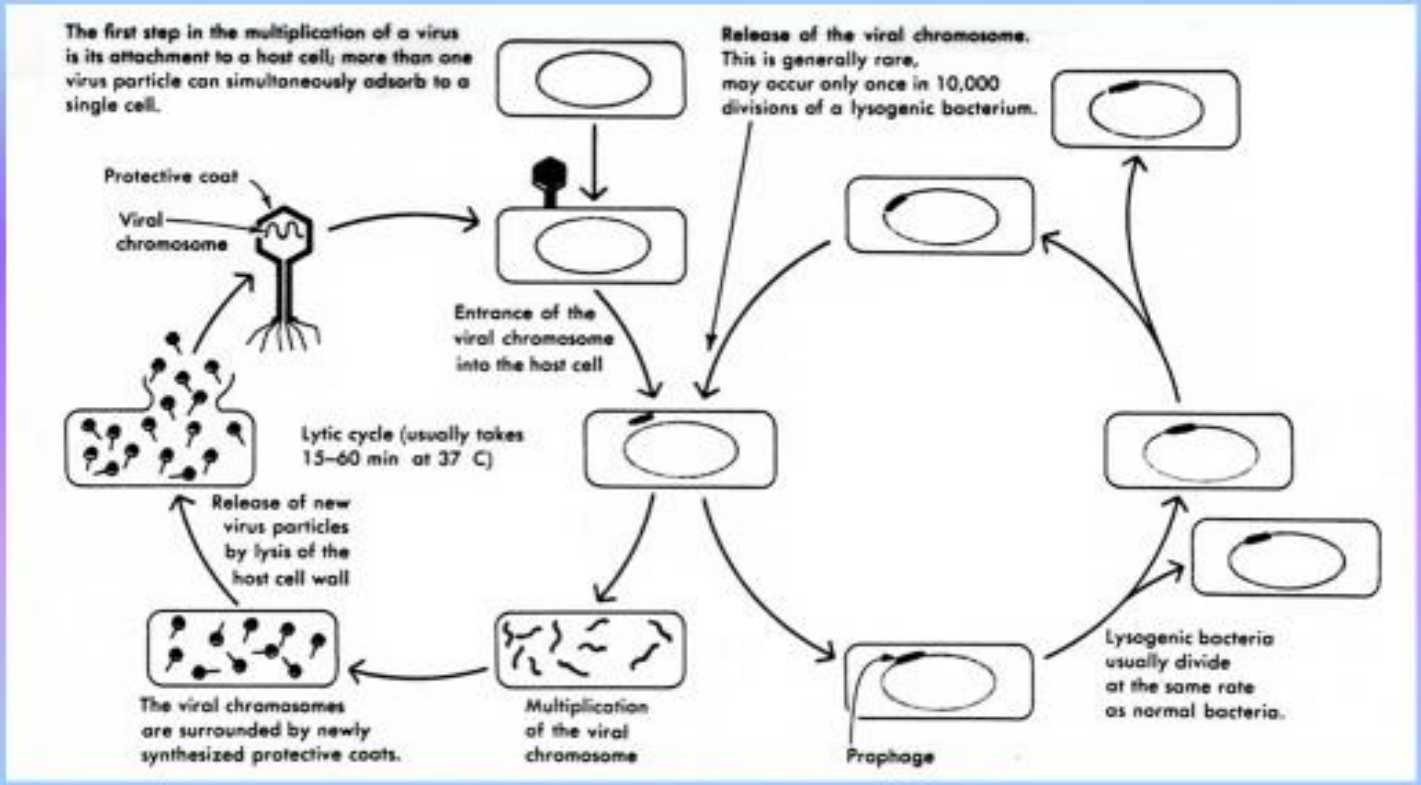


Adsorption, penetration and injection of bacteriophage T4 DNA into an *E. coli* cell.



The lytic cycle of a bacterial virus

Lysogenic Infections

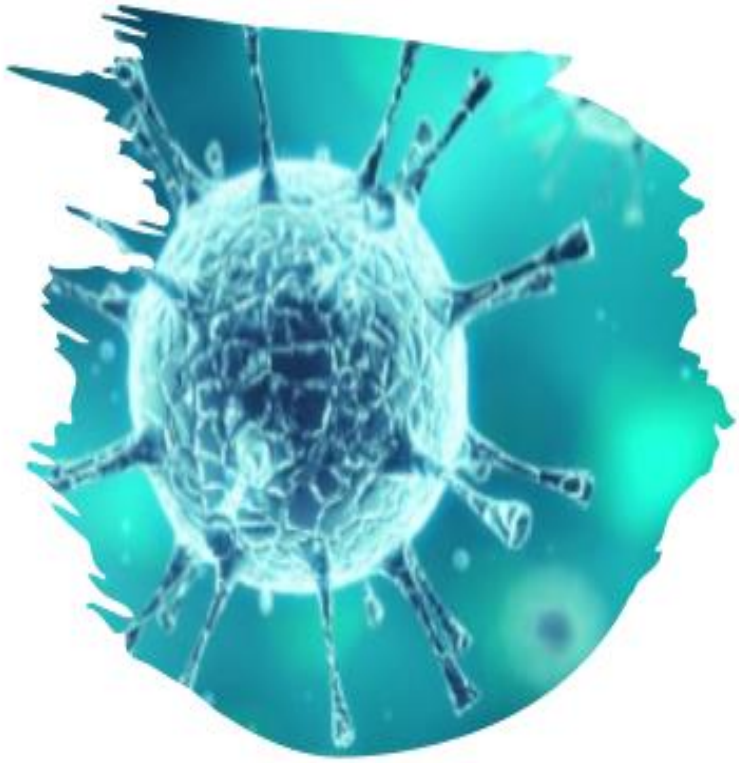


The lysogenic cycle of a bacterial virus

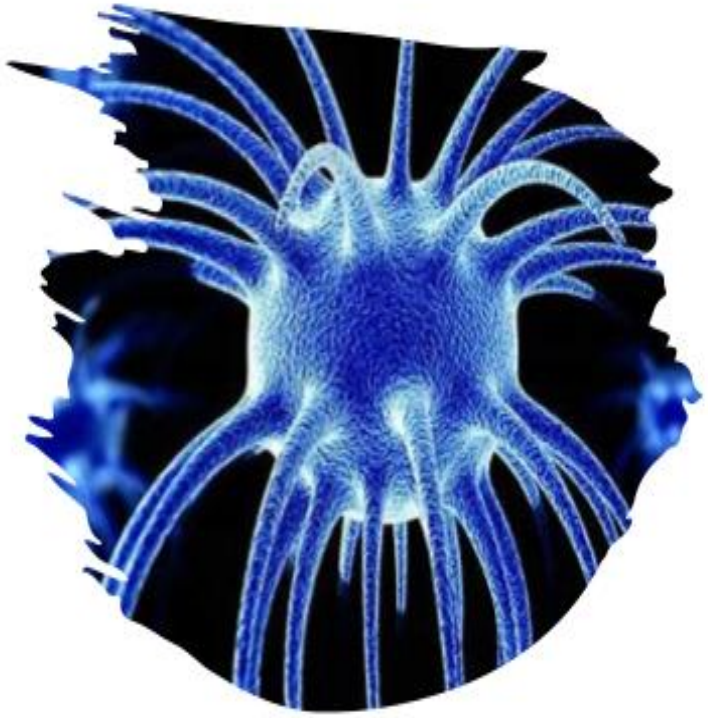
BASIC OF VIROLOGY

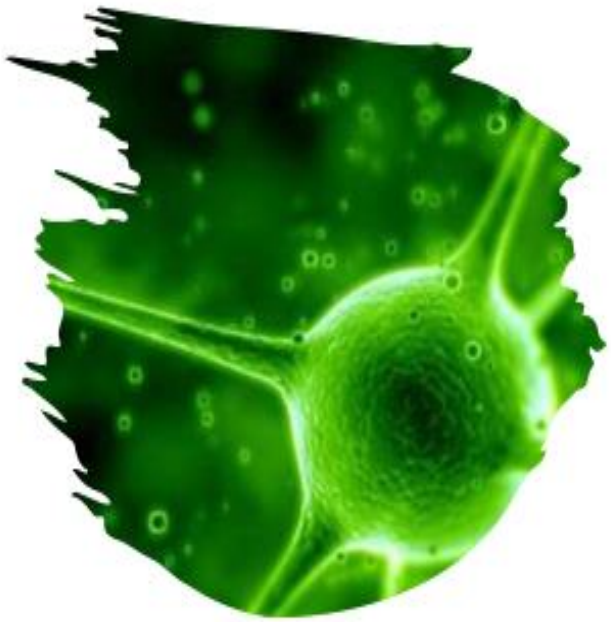
VIROLOGY

- Virology is a branch of natural science that deals with the biology of viruses and viral diseases, along with the biochemistry, occurrence, pathogenesis, life cycle, ecology, and evolution of viruses and virus-like particles.

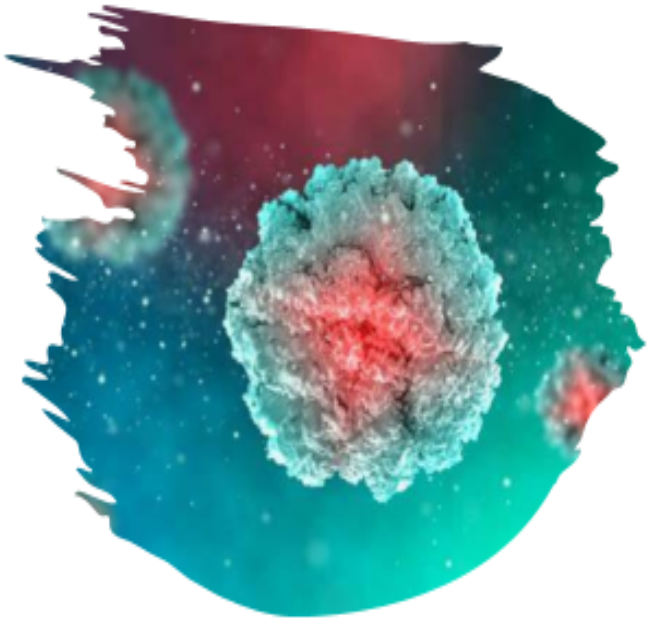


- Viruses and viral diseases have been at the focus of science, agriculture, and medicine for a long time, and some of the greatest challenges in science have involved virology.
- Virology is an important clinical science that deals with diseases of new emerging viruses and viral diseases.
- The importance of virology has been observed throughout time in the form of viral outbreaks, epidemics, and pandemics.



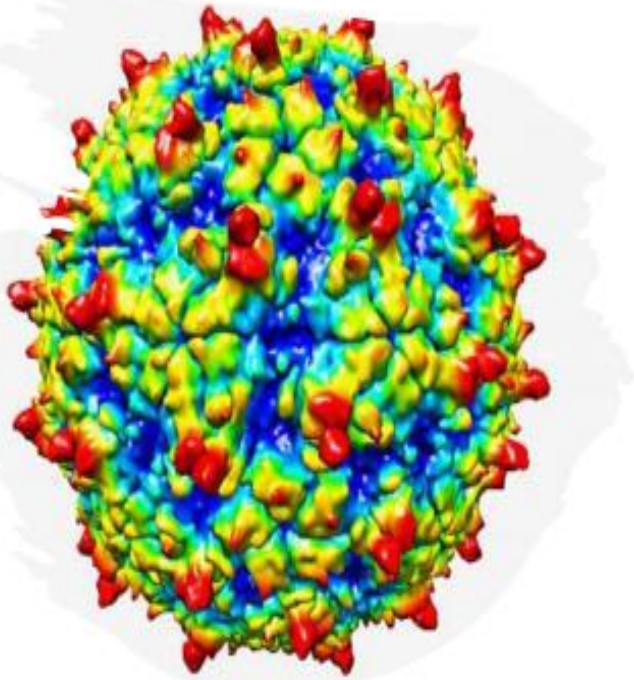


- Virology is a reasonably difficult science due to the complex nature of viruses. Viruses are obligatory parasites that require living cells for growth which makes it difficult to culture them in laboratories.
- Besides, these are minute particles that cannot be seen through a compound microscope. These are also comparatively more pathogenic, resulting in deadly diseases.
- All of these difficulties has made extensive research on viruses and viral diseases quite challenging.



- However, modern science has made significant advancements in microscopy and other techniques that have made the observation and culture of viruses on artificial surfaces possible.
- Much of the initial attention of virologists were focused on viruses as disease-causing agents, and great progress continues to be made in this area.
- Many acute viral infections are prevented or controlled in much of the world through vaccination and other public health measures.

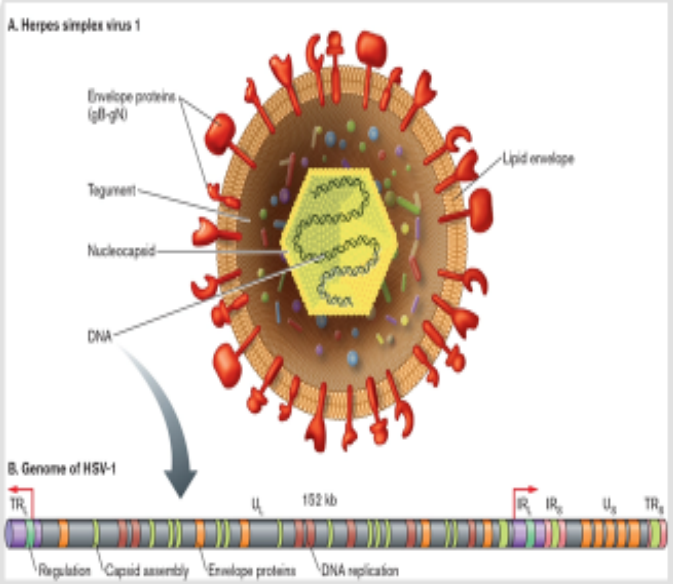
- It has also been recognized that viral infections cause a substantial fraction of the world's cancer burden, most commonly hepatitis B virus and other virus infections, both of which can be prevented by vaccination.
- Viruses also cause severe diseases in plants and livestock, which include viruses like TMV.
- Beyond their medical and agricultural importance, numerous studies done on viral replication have provided important information on the mechanism of viral diseases.
- Virology continues to focus on clinical science in order to discover the nature of viral gene products, their application as vaccines, and as antimicrobial agents.



Herpes simplex virus I (HSV-I)- An Overview

- **Structure of Herpes simplex virus 1 (HSV-1):**

1. Herpesviruses are large (150-200 nm size), spherical in shape with symmetry shape.
2. The protein capsid with average diameter 100 nm consists of 162 hollow hexagonal and pentagonal capsomeres containing the double stranded DNA genome with 125-240 kbp (the size of the gene) nucleotides, together forming the nucleocapsid.
3. The nucleocapsid is surrounded by an envelope which is lipoprotein in nature.
4. Lipid part is derived from the nuclear membrane of the infected host cell.



Epidemiology of Herpes simplex virus I (HSV-I)

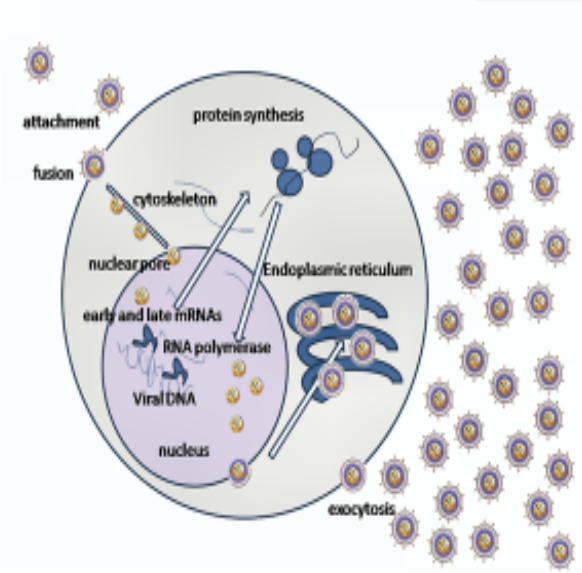
HSV lesions on a child's face.
(Credit: R.E. Sumpter, CDC, PHIL)

- Herpes simplex viruses are worldwide in distribution, equally between the sexes, and without seasonal variation.
- HSV-1 infection is more common than HSV-2 infection with 65% of persons in the United States having antibodies to HSV-1.
- The epidemiology in Europe is similar, with at least half of the population seropositive for HSV-1.
- In the developing world, HSV-1 is almost universal, and usually acquired from intimate contact with family in early childhood.

Transmission of Herpes simplex virus I (HSV-I)

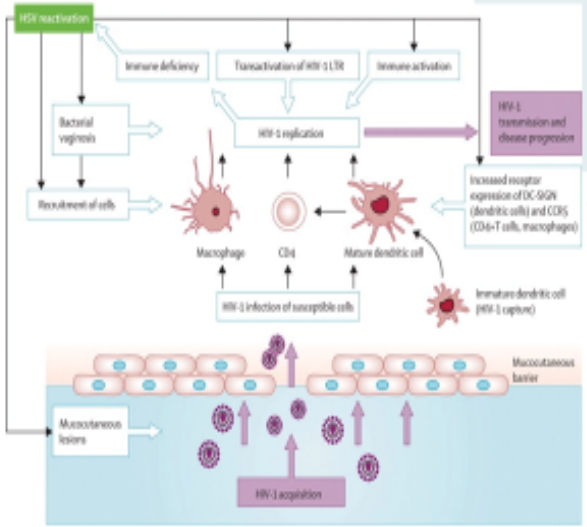
- HSV-1 infection is transmitted orally through saliva.
- It is usually transmitted by oral contact, such as by kissing or by sharing of the toothbrushes or other saliva-contaminated items.
- The HSV infection can also occur following mouth-to-skin contact, with the virus entering through minor abrasions in the skin.
- Autoinoculation may also cause infection of the eye.

Replication of Herpes simplex virus I (HSV-I)



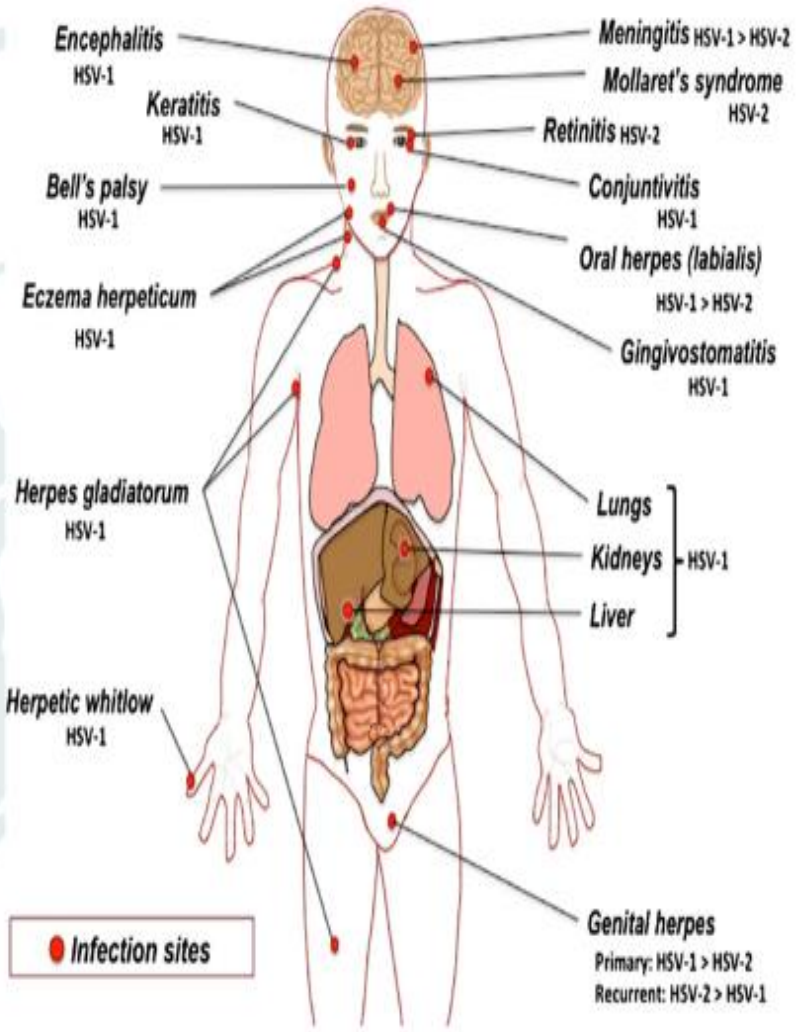
- Invasion of cells by HSV1 requires binding of the envelope gC (glyco-protein-C) and/or gB to Heparan sulfate receptors, fusion of the viral envelope with the cell plasma membrane and delivery of the viral capsid into the cell cytoplasm.
- Along with the capsid viral proteins VHS and VP16 are also released in the cytoplasm.
- Replication, which takes place upon replicated genomes in virus replication compartments formed in the infected cell nucleus.
- Viral DNA synthesis begins shortly after the appearance of the Beta proteins and the temporal program of viral gene expression ends with the appearance of the Gamma or late proteins.
- Viral transcription and DNA replication occurs in the nucleus; the particle exits from epithelial cells in the skin causing a primary infection.
- The virion acquires its envelope by budding through the nuclear membrane.

Pathogenesis of Herpes simplex virus I (HSV-I)



- HSV-1 is spread by kissing or exchanging saliva.
- Virions interact with specific cell-surface receptors through glycoproteins.
- This happens rapidly on mucous membranes and non-keratinizing epithelia; on the skin.
- Natural killer (NK) cells play a significant role in early defenses by recognizing and destroying HSV-infected cells.
- After the infection at the local site of incoluation virus then invades the local nerve ending.
- Primary HSV infections are usually mild; in fact most are asymptomatic.
- HSV does not replicate in latent stage except for a small RNA.
- Reactivation processes are still not clearly understood.

Clinical manifestations of Herpes simplex virus I (HSV-I)



Algae

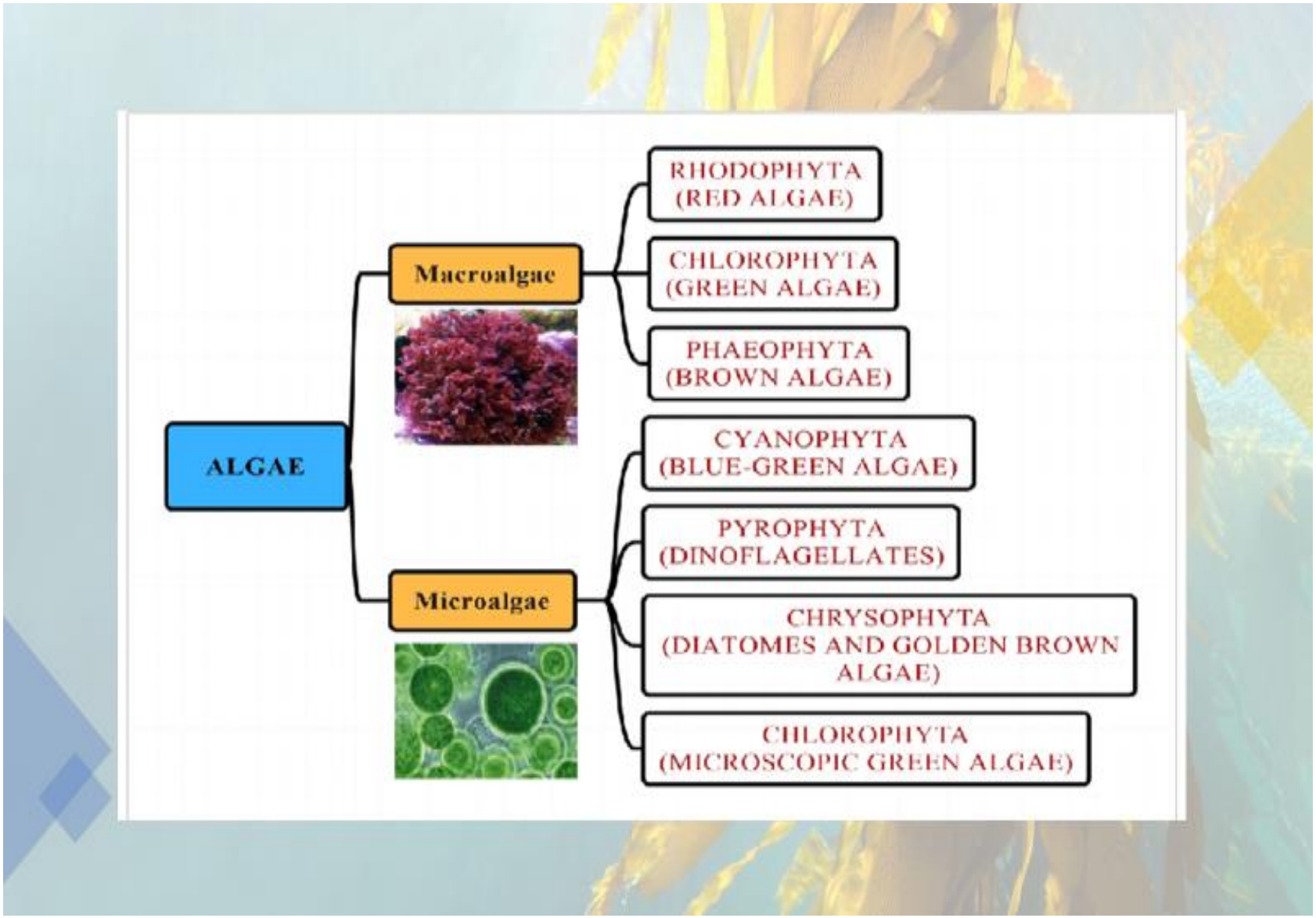
What is Algae?

- Algae is a group of organisms that are aquatic, nucleus-bearing, and photosynthetic. Unlike plants, algae do not have stems, leaves, roots, or reproductive structures like plants. Algae consist of cells that are not found among any plants or animals. even the photosynthesis pigments are a lot different than that of plants.
- The smallest Algae can range in size anywhere between 0.2 to 2 micrometers and at the same time, the bigger one can be as big as 60 meters.
- Algae cells can possess one single nucleus or even multiple nuclei. Algaes are eukaryotic organisms with three varied types of double membrane-bound organelles. It has a nucleus, mitochondria, and chloroplast.

- There are few species of Algae that produce toxins and are harmful to fish, finfish, and shellfish, and hence these fishes are harmful if consumed. The dinoflagellates that release toxins in water are harmful to aquatic life and are also responsible for red tides. The toxins released in the air by dinoflagellates can also cause health issues for any organisms that breath air.
- Algae play quite a few important roles in Earth's atmosphere. Algae is responsible for producing about half the oxygen and storing carbon dioxide to ensure it is out of the Earth's atmosphere.

Algae - Classification, Life Cycle and Uses

- The word algae address a large diversity of eukaryotic organisms ranging from unicellular microalgae to multicellular organisms.
- In general, algae are plant-like organisms that are subdivided into two parts: photosynthetic and aquatic. Although it is a plant-like organism, it still does not have true roots, stems, leaves, and vascular tissue but possesses simple reproductive structures.
- Algae or their spores can be found in a variety of environments such as freshwater, marine water, air, soil, or other organisms. The majority of the variety of algae found are microscopic, yet some variety is found to be very large, such as marine seaweeds which can grow up to 50m in length.
- They are subdivided into two parts: Microalgae and the other is Macroalgae.


ALGAE
Macroalgae
RHODOPHYTA
(RED ALGAE)
CHLOROPHYTA
(GREEN ALGAE)
PHAEOPHYTA
(BROWN ALGAE)
Microalgae
CYANOPHYTA
(BLUE-GREEN ALGAE)
PYROPHYTA
(DINOFLAGELLATES)
CHRYSOPHYTA
(DIATOMES AND GOLDEN BROWN
ALGAE)
CHLOROPHYTA
(MICROSCOPIC GREEN ALGAE)

1.Microalgae: It is the unicellular form of algae.

2.Macroalgae: It is the multicellular form of algae.

Microalgae are photosynthetic, heterotrophic organisms that have an extraordinary potential for cultivation as energy crops.
Algae has its nature that it can grow or can be cultivated under any difficult climatic conditions.
Algae produce various commercial by-products such as fats, oils, sugars, and other useful bioactive compounds. The term also includes some members of the red, brown, and green algae.

They are photosynthetic in nature and "simple" because they don't possess the bunch of complicated organs as found in land plants. Hence they are excluded from being considered as plants.

- The algae possess chlorophyll in their structure which is responsible for the manufacturing of their own food by the photosynthesis process within the membrane-bound structure called the chloroplasts.
- Almost all the algae are eukaryotes except the Cyanobacteria (which is a bacterial organism traditionally included as algae), which possess a prokaryotic cell structure. Algae are extremely important species.
- They produce the highest amount of oxygen as compared to all the living land plants in the world as well as being an important food source for many animals such as little shrimps and huge whales.
- Thus, they are at the bottom of the food chain because many living organisms are dependent on them.

Recent research has proved that the algae can be used for producing Biodiesel, which possesses certain advantages like biofuel of algae, is non-toxic, contains no sulfur, and is highly biodegradable.

Moreover, they are high-yielding as compared to other energy crops. The estimates suggest that microalgae are capable of producing up to 15,000 gallons of oil per hectare a year. This oil can be converted into fuels and chemicals and more.

They can provide much higher yields of biomass and fuel, 10-100 times higher than comparable any energy crops. Also, they have the potential to grow under any conditions which may be unsuitable for conventional crop production.

Micro-algae have the capacity to reduce atmospheric CO_2 levels, thus fixing the increasing percentage of CO_2 in the atmosphere, responsible for the global pollution problem.

Classification of Algae

Taxonomic classification of algae is based upon the same rules that are used for the classification of land plants.

Microscopic research has shown differences in the features of algae which contributes to another method of their classification.

Various features that differentiate various types of algae are: organelle structure, flagellar apparatus, and cell division process. Division-level classification (kingdom-level classification) is negligible for algae.

Some scientists place classes like Xanthophyceae, Bacillariophyceae, in division Chromophyta, whereas some scientists place each class in the division: xanthophyll, Bacillariophyceae.

In general and widely accepted terms, the classification of algae is done based on the following six types:

1.Nuclear Organization – prokaryotic or eukaryotic

2.Nature of Cell Wall – cellulosic or non-cellulosic (protein, acid, polysaccharide)

3.Pigmentation and Photosynthetic Apparatus – 3 pigments (chlorophylls, carotenoids, and lipoproteins)

4.Nature of Reserve Food – Starch, oil, mannitol, leucosis, etc. is the various types of reserve food in various classes.

5.Flagellation – Type, number, and position of flagella determine the class.

6.Type of Life Cycle – complete absence or presence and the complexity of cycle.

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Properties of Algae

Different algae have different requirements. Hence, several essential factors such as water, carbon dioxide, minerals, and light play important roles in the cultivation of algae.

- **Size and Structure**

  For single-celled algae, the thallus is the body of the vegetative form of algae and for multi-celled algae; the thallus consists of the entire, continuous organism. The thallus is an example of complex algae, which appears to be a macroscopic, and multicellular organism but is one giant, unicellular structure only.

  The aquatic habitat is a relatively benign and uniform place, which helped the organisms to get into shape. Because water supports the algal plant body, they easily flow with the water currents and waves. Since water surrounds the plant on all sides, individual algal cells absorb moisture (water), minerals, and sunlight directly from the surrounding.

  Mostly they are photosynthetic in nature, possess four different kinds of chlorophyll pigments (include blue, red, brown, golden) may be microscopic and float in the surface waters (phytoplankton) or macroscopic and live attached to rocky coasts (seaweeds). Size ranges from the size of bacteria (0.5 μm) to over 50 m long.

- **Temperature**

  The temperature of the water must be in a range that will support the growth of specific algal species. Temperature plays a major role in the growth of any algal species. The optimal temperature for phytoplankton cultures is between 20-30 °C. If the temperature is <16 °C it slows down the growth and a temperature >35 °C is lethal for a number of species.

- **Light**

  A light that is very strong or very low hinders the algae growth. In most algal-cultivation systems, light only penetrates the top 3 - 4 inches of the water. As the algae grow and multiply vigorously and become dense, they block light penetration into ponds, tanks, etc. the light required by algae is only 1/10th of sunlight received by other plants. Direct and strong sunlight is harmful and destroys the growth of algae.

Where do Algae Grow?

The habitat of algae can be anywhere and everywhere. Algae are the most robust organism in terms of habitat, as they can grow in a wide range of conditions. Algae can be found in both environments: terrestrial and aquatic. Moreover, it's more common to find algae in moist regions than dry ones, as algae do not have vascular tissues and other adaptations for living on land. Yet algae can be found in any and every part of the world. The examples include snails, turtles, worms, rotifers, worms, alligators, three-toed sloths, aquatic ferns, freshwater sponge, aquatic plants, on and inside water plants.

The Chemical Composition of Algae

Algae are Composed of Two Types of Cells:

eukaryotic or prokaryotic cells. These are cells with nuclei and organelles. The functional systems of algae are plastids, which are bodies with chlorophyll and carry out photosynthesis. Some have only Chlorophyll A, some A, and B, A and C, etc. the primary composition of algae is made up of proteins, carbohydrates, fats, nucleic acids, in varying proportions. All types of algae found completely comprise of the following, in varying proportions: Proteins, Carbohydrates, Fats and Nucleic Acids. While the percentages vary with the type of algae, types of algae are there, some of them comprising up to 40% of their overall mass by fatty acids. This fatty acid from the algae can be extracted and converted into biodiesel. Algal oil is very high in unsaturated fatty (UFA) acids which include Arachidonic acid (AA), Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA), Gamma-linolenic acid (GLA), Linoleic acid (LA), etc.

Lifecycle of Algae

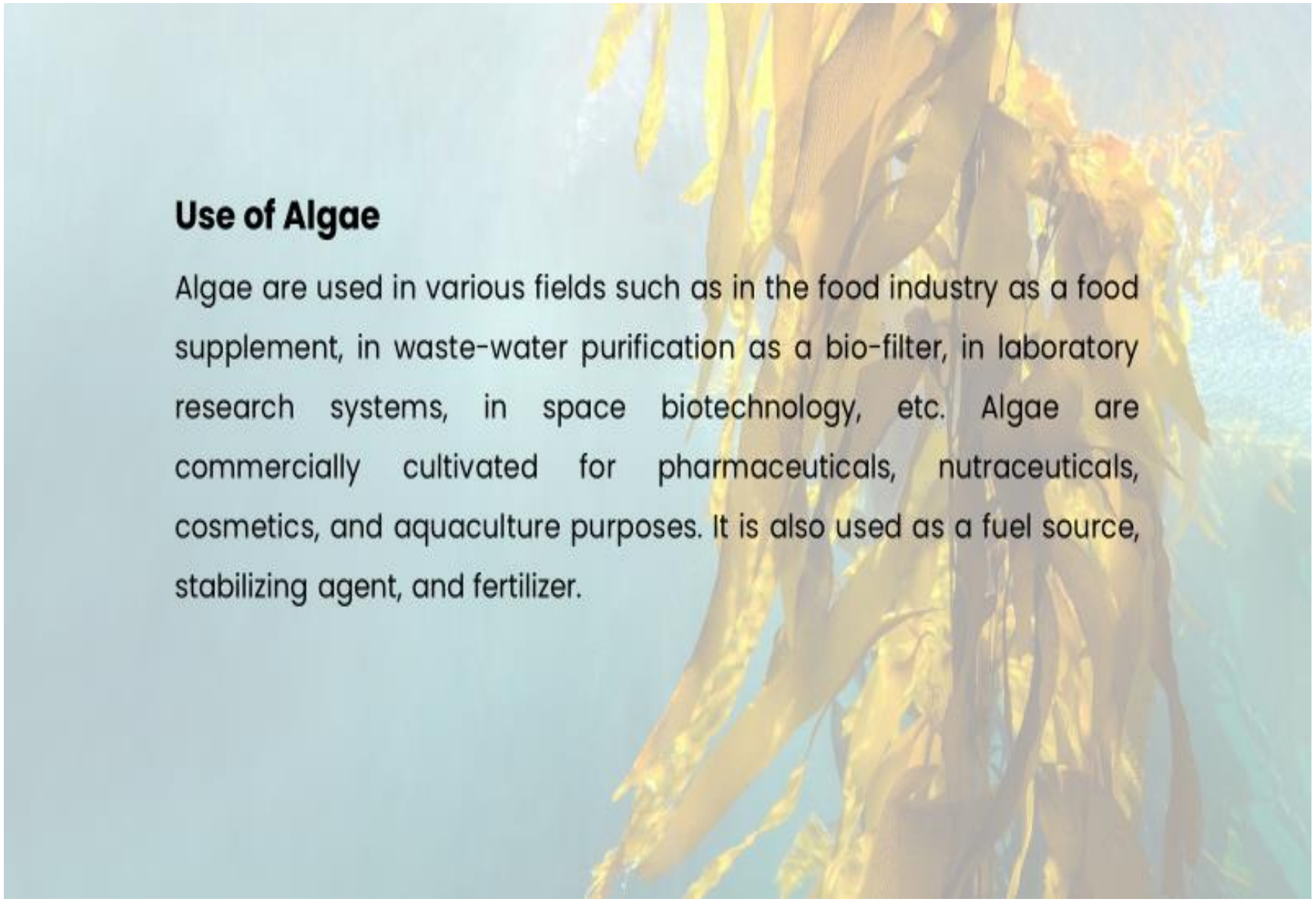
Four main patterns of lifecycle in the algae are:

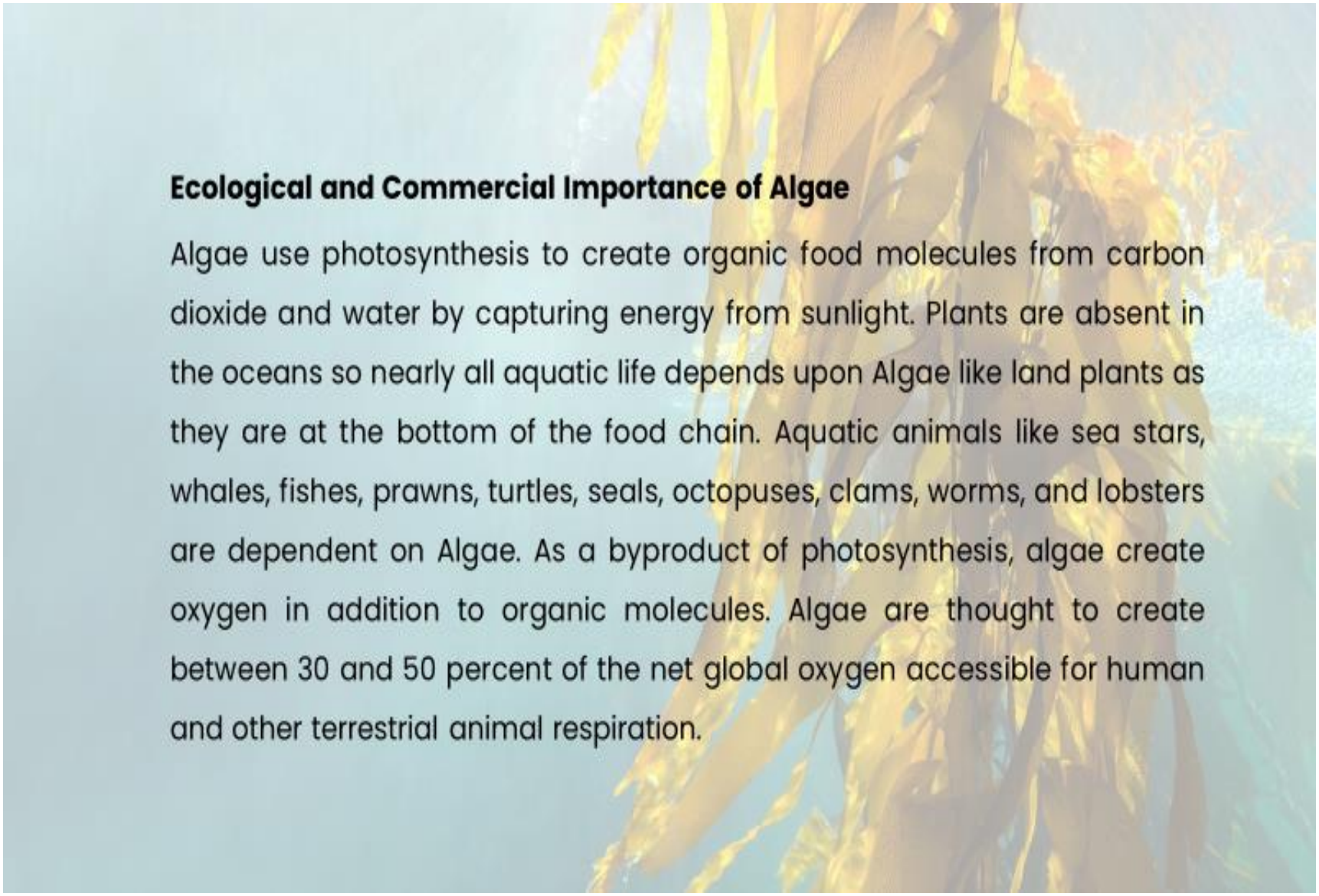
1. Hypotonic Life Cycle –The plant body is a gametophyte. The gametophytic plant produces haploid gametes. The gametes fuse to form a zygote, which is diploid. Thus, diploid represents the sporophytic phase (diploid phase) of their lifecycle. This lifecycle is also known as the monogenic lifecycle and is found to be active in a majority of classes.

2. Diplontic Life Cycle – The plant body is a sporophyte. The sex organs produce gamete by meiosis, and they represent the gametophytic stage. The gametes soon unite and fertilize to form a zygote. The zygote does not undergo any meiosis. The zygote is only responsible for giving rise to new sporophytic plant bodies.

3. Diplohaplontic Life Cycle – In this type, both the diploid and haploid phases are equally present and prominent, expressed by two distinct vegetative individuals. There is a difference in both only in terms of chromosome numbers and functions. The diploid (sporophytic stage) reproduces by the asexual process, while the haploid (gametophytic stage) reproduces by the sexual method. This kind of life cycle has two types: isomorphic (homologous) and heteromorphic (heterologous).

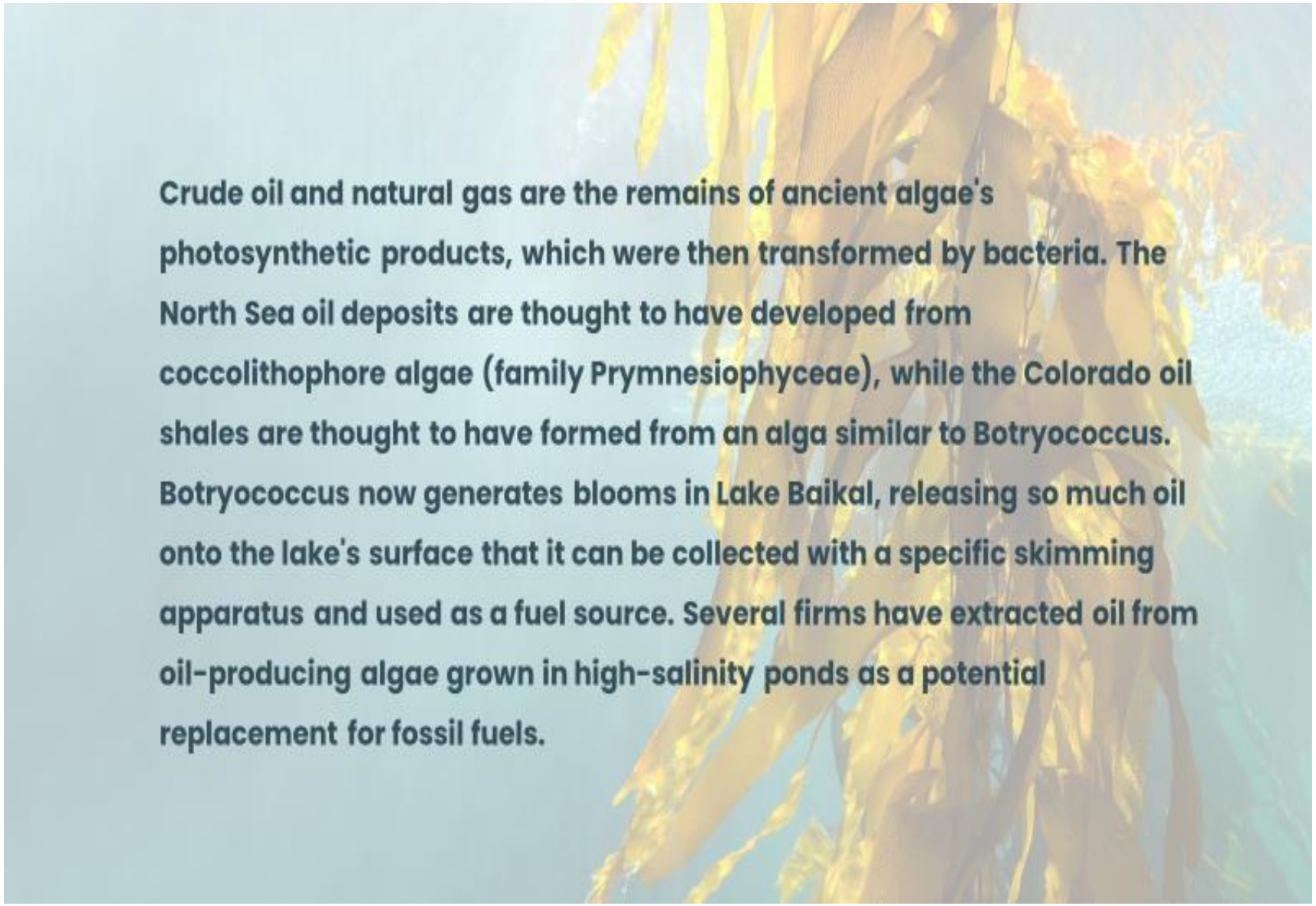
4. Triphasic Life Cycle – In this type, there is a succession of three distinct generations. This type of lifecycle has two types: Haplobiontic and diplobiotonic type.


Use of Algae
Algae are used in various fields such as in the food industry as a food supplement, in waste-water purification as a bio-filter, in laboratory research systems, in space biotechnology, etc. Algae are commercially cultivated for pharmaceuticals, nutraceuticals, cosmetics, and aquaculture purposes. It is also used as a fuel source, stabilizing agent, and fertilizer.



Ecological and Commercial Importance of Algae

Algae use photosynthesis to create organic food molecules from carbon dioxide and water by capturing energy from sunlight. Plants are absent in the oceans so nearly all aquatic life depends upon Algae like land plants as they are at the bottom of the food chain. Aquatic animals like sea stars, whales, fishes, prawns, turtles, seals, octopuses, clams, worms, and lobsters are dependent on Algae. As a byproduct of photosynthesis, algae create oxygen in addition to organic molecules. Algae are thought to create between 30 and 50 percent of the net global oxygen accessible for human and other terrestrial animal respiration.


Crude oil and natural gas are the remains of ancient algae's photosynthetic products, which were then transformed by bacteria. The North Sea oil deposits are thought to have developed from coccolithophore algae (family Prymnesiophyceae), while the Colorado oil shales are thought to have formed from an alga similar to Botryococcus. Botryococcus now generates blooms in Lake Baikal, releasing so much oil onto the lake's surface that it can be collected with a specific skimming apparatus and used as a fuel source. Several firms have extracted oil from oil-producing algae grown in high-salinity ponds as a potential replacement for fossil fuels.

BASIC BIOLOGY OF FUNGI

- Fungi are a kingdom of mostly microscopic organisms that are closely related to animals. They include spore producing organisms such as mushrooms, yeast and molds.

Fungi are almost always invisible to the naked eye. At certain times, some fungi will produce large 'fruiting bodies' called mushrooms that produce huge numbers of spores for reproduction.

- Fungi are different from all other living things by the type of cell wall they have surrounding each of their cells. As opposed to plants, bacteria and some protists which have cell walls made from other compounds (e.g. cellulose), the cell walls of fungi are made from a compound called 'chitin'.

More than100,000 species of fungi have been identified by biologists. It is estimated that more than 1.5 million species currently exist on Earth. Two groups of multicellular fungi contain over 95% of all species. One of these two groups is called 'basidiomycetes' which includes the mushroom producing fungi.

Types of fungi

- Fungi are subdivided on the basis of their life cycles, the presence or structure of their fruiting body and the arrangement of and type of spores (reproductive or distributional cells) they produce.
- The three major groups of fungi are:

1. Multicellular filamentous moulds.
2. Macroscopic filamentous fungi that form large fruiting bodies. Sometimes the group is referred to as 'mushrooms', but the mushroom is just the part of the fungus we see above ground which is also known as the fruiting body.
3. Single celled microscopic yeasts.

- ***Multicellular filamentous moulds***
- Moulds are made up of very fine threads (hyphae). Hyphae grow at the tip and divide repeatedly along their length creating long and branching chains. The hyphae keep growing and intertwining until they form a network of threads called a mycelium. Digestive enzymes are secreted from the hyphal tip. These enzymes break down the organic matter found in the soil into smaller molecules which are used by the fungus as food.

- Some of the hyphal branches grow into the air and spores form on these aerial branches. Spores are specialised structures with a protective coat that shields them from harsh environmental conditions such as drying out and high temperatures. They are so small that between 500 – 1000 could fit on a pin head.

- Spores are similar to seeds as they enable the fungus to reproduce. Wind, rain or insects spread spores. They eventually land in new habitats and if conditions are right, they start to grow and produce new hyphae. As fungi can't move they use spores to find a new environment where there are fewer competing organisms.

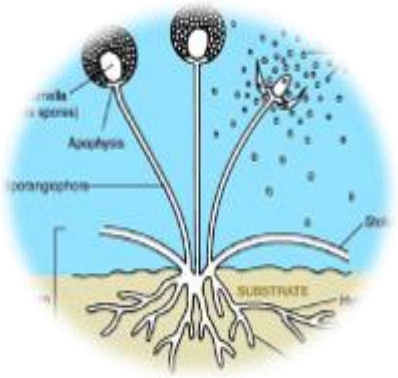
IMPORTANCE OF FUNGI

- Fungi are very important for a number of reasons worldwide. Mushrooms and yeast have a significant place in the food and alcohol industries as sources of food and in the process of fermentation. They are also used in the production of antibiotics.

- Fungi are one of the most important decomposers of dead plant material and the recycling of nutrients back into ecosystems. On the flip side, all around the world fungi can be problematic for farmers because they can infect and decompose crops.

- Many fungi, known as mycorrhizae, live in close association with the roots of plants and actually help them to absorb more nutrients. The vast majority of plants depend on help from fungi to successfully compete with neighbouring plants for nutrients.

STRUCTURE OF FUNGI



Fungi live as either single-celled organisms or multicellular organisms. Single-celled fungi are referred to as yeasts. The vast majority of fungi are multicellular.

Most of the body of a fungi is made from a network of long, thin filaments called 'hyphae'. Hyphae filaments are made from tubular cells that connect end on end. Each cell is surrounded by a cell wall composed of a compound called 'chitin'. The chitin cell wall is a defining feature of the fungi kingdom.

When the hyphae of a multicellular fungi creates a complex network of filaments it is called a 'mycelium'. Because the hyphae of fungi are so thin, they have an incredibly high surface area to volume ratio. The large surface area makes fungi extremely well adapted to absorbing nutrients from soil and other substrates.

MUSHROOMS

Mushrooms, or toadstools, are the fruiting body common to many species of fungi and are used to store and release spores into the environment. A mushroom is made from a collection of fungal cells called 'hyphae'. Hyphae are woven together to produce a spore bearing mushroom.

Many species of fungi would be almost completely invisible were it not for their large mushrooms. The rest of their tissue is hidden within the soil or the dead plant that they are feeding on. Mushrooms can be found in most land-based environments but they are particularly common in damp areas where they are most efficient at decomposing.

- The important of mushrooms is to bear spores and release them into the environment. Any given mushroom may house and release as many as a billion spores. The spores are then carried by the wind or water and germinate if they land in a nice moist environment with a good food source. This method of dispersal has allowed for single species of fungi to be found all around the globe.

- Mushrooms are of huge economic importance especially in Asia and Europe where most of the world's mushrooms are grown and eaten. They have been harvested and cultivated for years for their nutritional value and taste.

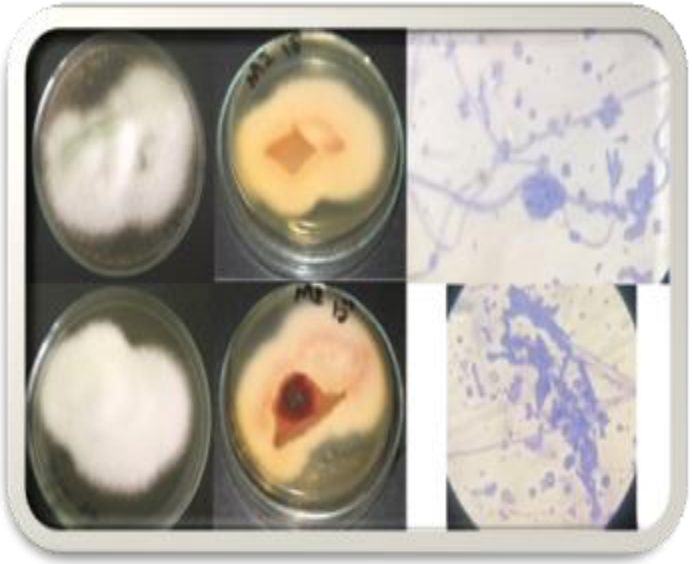
- The most common market sold mushroom is the common white mushroom, which is considered safe to eat (by mushroom standards) but does in fact have toxins which are destroyed during cooking. Many mushrooms can be fatally poisonous and eating wild mushrooms should be avoided unless you have a good knowledge of which mushrooms are safe to eat.

- ***Macroscopic filamentous fungi***

- Macroscopic filamentous fungi also grow by producing a mycelium below ground. They differ from moulds because they produce visible fruiting bodies that hold the spores.

The fruiting body is made up of tightly packed hyphae which divide to produce the different parts of the fungal structure, for example the cap and the stem.

The cap are covered with spores and a 10 cm diameter cap can produce up to 100 million spores per hour.



MOLDS

- Molds belong to a group of fungi called zygomycetes. Around 1,000 different zygomycetes species have currently been identified.

Molds are a group of fast growing fungi that are responsible for the spoiling of many foods such as bread, fruits, vegetables and dairy products. The hyphae of molds spread across a food source and penetrate into the food. Once the hyphae have penetrated into the food they are able to absorb it nutrients.

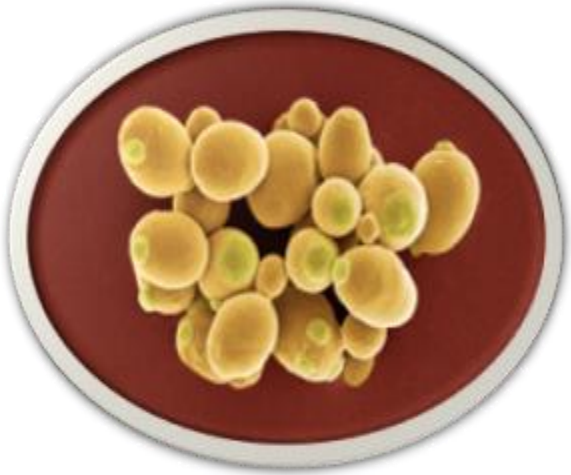
YEASTS

- Single-celled fungi are known as yeasts. Around 1,500 species of fungi are recognised as yeasts. Some fungi have the ability to shift between living as yeasts or in a multicellular form with hyphae.

- Yeasts are found in a variety of places– in both aquatic environments and on land. They are also found living in and on plants and animals.

- For thousands of years yeasts have been used to create certain foods. Yeasts are able to metabolize carbohydrates into alcohol and carbon dioxide.

- Humans have utilised the fermentation of carbohydrates by yeasts to create fermented foods and drinks such as bread, beer and wine.



LICHENS

- A lichen forms when a fungi and photosynthetic organisms, such as a green algae or cyanobacteria, form a symbiotic relationship. A symbiotic relationship is any relationship between different individuals from different species. In the case of lichens, it is a relationship between a fungi and many single-celled, photosynthetic organisms.
- In lichens, photosynthetic cells are caught in a dense network of fungal hyphae. The fungi provides the photosynthetic cells with a suitable habitat. The fungi receives the benefit of excess sugars and nutrients produced by the green algae or cyanobacterium.
- Over 16,000 different lichen species have so far been identified.



MYCORRHIZAE

- Mycorrhizae are fungi that live in close association with plant roots and help plants to absorb more nutrients. Mycorrhizal fungi do not come from one particular group of fungi but include species from different and distantly related groups.

- The hyphae of mycorrhizal fungi grow into the roots of plants and branch into an extremely thin network of hyphae. These hyphae are far thinner thinner than the thinnest roots of plants and so they are able to absorb more nutrients for their volume.

- Over 90% of all plant species have mycorrhizal relationships with a fungal species. If soils are lacking in fungal populations then many plants will struggle to survive in the absence of mycorrhizal fungi.

FUNGAL DISEASES

- Fungal diseases can affect anyone. Learning about them can help you and your doctor recognize the symptoms of a fungal disease early and may help prevent serious complications.

- Mild fungal skin diseases can look like a rash and are very common. Fungal diseases in the lungs are often similar to other illnesses such as bacterial or viral pneumonia. Some fungal diseases like fungal bloodstream infections are less common than skin and lung infections but can be deadly.

Types of Fungal Diseases

- **Most common fungal diseases:**
  - **Fungal Nail Infections**

Fungal nail infections, also known as "onychomycosis," are very common. They may affect up to14% of the general population. Fungal toenail infections are more common than fungal fingernail infections.

  - **Ringworm**

Ringworm is a common skin infection that is caused by a fungus. It's called "ringworm" because it can cause a circular rash (shaped like a ring) that is usually red and itchy. Anyone can get ringworm. The fungi that cause this infection can live on skin, surfaces, and on household items such as clothing, towels, and bedding.

- **Vaginal Candidiasis:**
- Candidiasis is an infection caused by a yeast (a type of fungus) called Candida. Candida normally lives on skin and inside the body such as in the mouth, throat, gut, and vagina, without causing any problems. Candida can cause an infection if conditions change inside the vagina to encourage its growth. Things like hormones, medicines, or changes in the immune system can make infection more likely. The common term for candidiasis in the vagina is a vaginal yeast infection.

- **Candida infections of the mouth and throat:**
- Candidiasis is an infection caused by a yeast (a type of fungus) called Candida.
- Sometimes, Candida can multiply and cause an infection if the environment inside the mouth, throat, or changes in a way that encourages fungal growth.

Who Gets Fungal Infections?

Anyone can get a fungal infection, even people who are otherwise healthy. Fungi are common in the environment, and people breathe in or come in contact with fungal spores every day without getting sick. However, in people with weakened immune systems, these fungi are more likely to cause an infection.

People with weakened immune systems

- **Infections that happen because a person 's immune system is weakened. These illnesses can be caused by bacteria, viruses, or fungi.**
- **Some infections can be more serious. Lung infections like Valley fever or histoplasmosis can happen in people who live in or visit certain areas.**

What weakens an immune system?

- Some people are born with a weakened immune system. Others may have an illness that attacks the immune system such as HIV. Some medicines, like corticosteroids or cancer chemotherapy, can also lower the body's ability to fight infections.

- If you have a weakened immune system, you should be aware that fungal infections can happen. Learning about fungal infections can help you and your doctor recognize them early. This may help prevent serious complications.

Outbreaks and Investigations

- Fungal disease outbreaks are rare. An outbreak occurs when two or more people get sick from contact with the same source, sometimes in the same time or place. This can happen outdoors or in a health care setting, such as a hospital.

- Detecting fungal outbreaks early is important so that the people affected can get the right treatment and so that health officials can prevent others from getting sick.

Solving Fungal Outbreaks with Partnerships and Data

- When fungal disease outbreaks occur, CDC's Mycotic Diseases Branch works closely with federal, state, and local public health agencies and other partners. Together, they collect different types of data to find the source of the outbreak:

- **Epidemiologic data to answer questions such as "Who got sick?" "When?" and "Where?"**
- **Patient samples such as blood or tissue are tested in a laboratory to find out which fungus is causing the illnesses.**
- **Environmental samples can help health officials determine if fungi in the environment match the patient samples, providing clues about where they might have gotten infected.**

Antimicrobial-Resistant Fungi

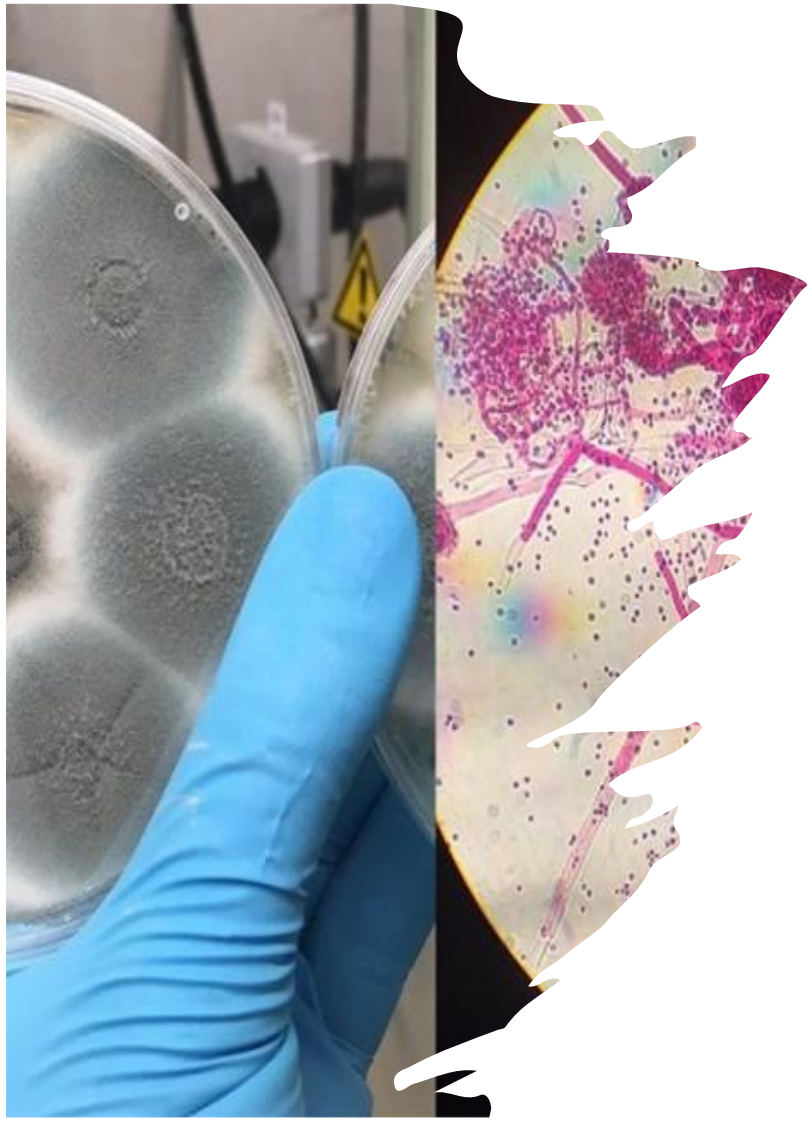
- Antifungal drugs treat fungal infections by killing or stopping the growth of dangerous fungi in the body. Fungi can develop resistance to antifungal drugs the same way bacteria can develop resistance to antibiotics. Resistance happens when germs develop the ability to defeat the drugs designed to kill them. That means the germs are not killed and continue to grow.

- Currently, only a small number of antifungal drug types exist, so resistance can severely limit treatment options.
- Some types of fungi, like *Candida auris*, can become resistant to all the antifungal drugs normally used to treat these infections. Resistance is especially concerning for patients with invasive fungal infections—severe infections that affect the blood, heart, brain, eyes, or other parts of the body.

What causes antimicrobial-resistant fungi

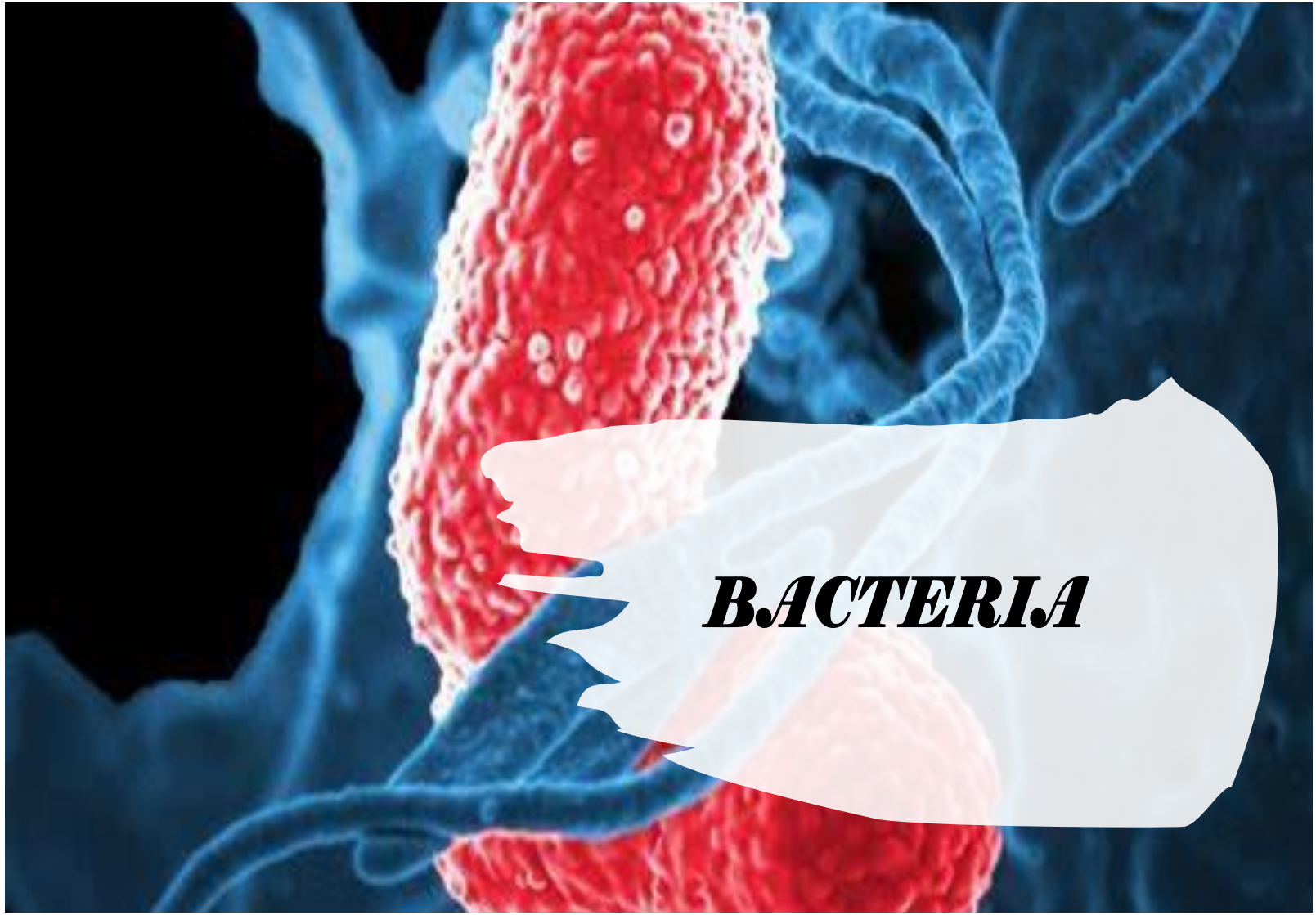
- Some species of fungi are naturally resistant to certain types of antifungal drugs. For example, the drug fluconazole does not work against infections caused by the fungus *Aspergillus*, a type of mold found throughout the environment.
- Resistance can also develop over time when fungi are exposed to antifungal drugs. This resistance can occur when antifungal drugs are used to treat sick people, especially if the drugs are used improperly (for example, when dosages are too low or when treatment courses are not long enough).

- Use of fungicides in agriculture to prevent and treat fungal diseases in crops can also contribute to resistant disease in people.
- For example, when *Aspergillus* found in the environment is exposed to fungicides, which are similar to medical antifungal drugs, the *Aspergillus* can become resistant to the drugs used to treat infections in people.
- People can then breathe in those resistant *Aspergillus* spores from the environment and become sick.



Fungal Diseases and COVID-19

- COVID-19-associated fungal infections can lead to severe illness and death.
- Symptoms of certain fungal diseases can be similar to those of COVID -19, including fever, cough, and shortness of breath.
- Some patients can have COVID-19 and a fungal infection at the same time. Laboratory testing is necessary to determine if a person has a fungal infection, COVID-19, or both.


BACTERIA

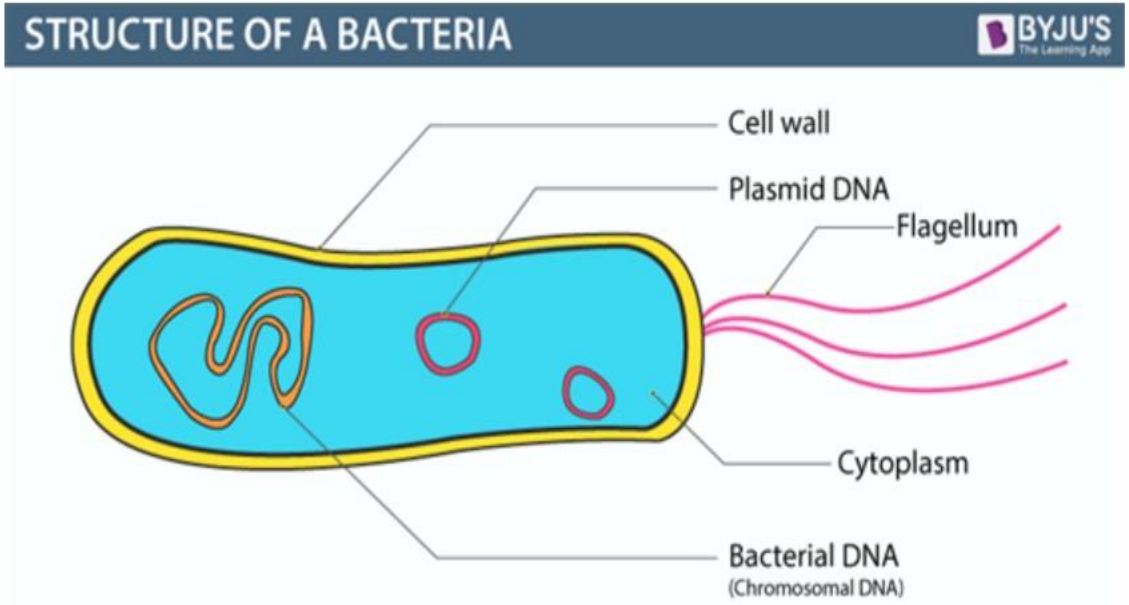
One of the very first organisms to evolve on earth was probably a unicellular organism, similar to modern bacteria. Ever since then, life has evolved into a life forms over many decades.

- Today, bacteria are considered as one of the oldest forms of life on earth. Even though most bacteria make us ill, they have a long-term, mutual relationship with humans and are very much important for our survival. But before we elaborate on its uses, let us know the structure of bacteria, its classification, and the bacteria diagram in detail.

Bacteria Definition "Bacteria are unicellular organisms belonging to the prokaryotic group where the organisms lack a few organelles and a true \nucleus".

Bacteria Diagram

The bacteria diagram given below represents the structure of a typical bacterial cell with its different parts. The cell wall, plasmid, cytoplasm and flagella are clearly marked in the diagram.



Bacteria Diagram representing the Structure of Bacteria

Ultrastructure of a Bacteria Cell

The structure of bacteria is known for its simple body design. Bacteria are single-celled microorganisms with the absence of the nucleus and other **cell organelles**; hence, they are classified as prokaryotic organisms.

They are also very versatile organisms, surviving in extremely inhospitable conditions. Such organisms are called extremophiles. Extremophiles are further categorized into various types based on the types of environments they inhabit:

1. Thermophiles
2. Acidophiles
3. Alkaliphiles
4. Osmophiles
5. Barophiles
6. Cryophiles

Another fascinating feature of bacteria is their protective **cell wall**, which is made up of a special protein called peptidoglycan. The components of bacterial cell wall forms an important basis upon which the bacteria can be divided. This particular protein isn't found anywhere else in nature except in the cell walls of bacteria.

But few of them are devoid of this cell wall, and others have a third protection layer called capsule. On the outer layer, one or more flagella or pili is attached, and it functions as a locomotory organ. Pili can also help certain bacteria to attach themselves to the host's cells. They do not contain any cell organelle as in animal or plant cell except for ribosomes.

Ribosomes are the sites of protein synthesis. In addition to this DNA, they have an extra circular DNA called plasmid. These plasmids make some strains of bacteria resistant to antibiotics.

Classification of bacteria based on Shape

Type of Classification	Examples
Bacillus (Rod-shaped)	Escherichia coli (E. coli)
Spirilla or spirochete (Spiral)	Spirillum volutans
Coccus (Sphere)	Streptococcus pneumoniae
Vibrio (Comma-shaped)	Vibrio cholerae

Classification of Bacteria

Bacteria can be classified into various categories based on their features and characteristics. The classification of bacteria is mainly based on the following:

- Shape
- Composition of the cell wall
- Mode of respiration
- Mode of nutrition

Classification of bacteria based on the Composition of the Cell Wall

Type of Classification	Examples
Peptidoglycan cell wall	Gram-positive bacteria
Lipopolysaccharide cell wall	Gram-negative bacteria

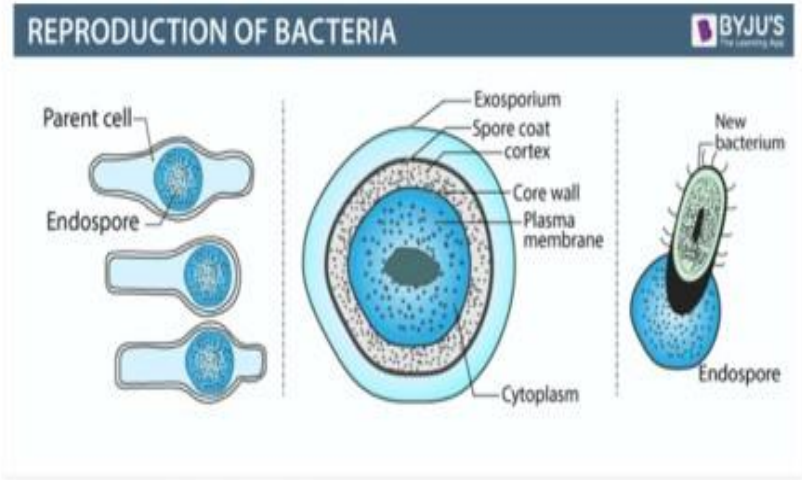
Classification of bacteria based on the Mode of Nutrition

Type of Classification	Examples
Autotrophic Bacteria	Cyanobacteria
Heterotrophic Bacteria	All disease-causing bacteria

Classification of bacteria based on the Mode of Respiration

Type of Classification	Examples
Anaerobic Bacteria	Actinomyces
Aerobic Bacteria	Mycobacterium

Reproduction in Bacteria



Bacteria follow an asexual **mode of reproduction**, called binary fission. A single bacterium divides into two daughter cells. These are identical to the parent cell as well as to each other. Replication of DNA within the parent bacterium marks the beginning of the fission. Eventually, cell elongates to form two daughter cells.

The rate and timing of reproduction depend upon the conditions like temperature and availability of nutrients. When there is a favourable condition, E.coli or Escherichia coli produces about 2 million bacteria every 7 hours.

Bacterial reproduction is strictly asexual, but it can undergo sexual reproduction in very rare cases.

Genetic recombination in bacteria has the potential to occur through conjugation, transformation, or transduction. In such cases, the bacteria may become resistant to antibiotics since there is variation in the genetic material (as opposed to asexual reproduction where the same genetic material is present in generations)

Binary fission

Most prokaryotes reproduce by a process of binary fission, in which the cell grows in volume until it divides in half to yield two identical daughter cells. Each daughter cell can continue to grow at the same rate as its parent. For this process to occur, the cell must grow over its entire surface until the time of cell division, when a new hemispherical pole forms at the division septum in the middle of the cell. In gram-positive bacteria the septum grows inward from the plasma membrane along the midpoint of the cell; in gram-negative bacteria the walls are more flexible, and the division septum forms as the side walls pinch inward, dividing the cell in two. In order for the cell to divide in half, the peptidoglycan structure must be different in the hemispherical cap than in the straight portion of the cell wall, and different wall-cross-linking enzymes must be active at the septum than elsewhere.

A group of environmental bacteria reproduces by budding. In this process a small bud forms at one end of the mother cell or on filaments called prosthecae. As growth proceeds, the size of the mother cell remains about constant, but the bud enlarges. When the bud is about the same size as the mother cell, it separates. This type of reproduction is analogous to that in budding fungi, such as brewer's yeast (*Saccharomyces cerevisiae*). One difference between fission and budding is that, in the latter, the mother cell often has different properties from the offspring. In some *Pasteuria* strains, the daughter buds have a flagellum and are motile, whereas the mother cells lack flagella but have long pili and holdfast appendages at the end opposite the bud. The related *Planctomyces*, found in plankton, have long fibrillar stalks at the end opposite the bud. In *Hyphomicrobium* a hyphal filament (prostheca) grows out of one end of the cell, and the bud grows out of the tip of the prostheca, separated by a relatively long distance from the mother cell.

Budding

Useful Bacteria

Not all bacteria are harmful to humans. There are some bacteria which are beneficial in different ways. Listed below are few benefits of bacteria:

1. Convert milk into curd – Lactobacillus or lactic acid bacteria
2. Ferment food products – Streptococcus and Bacillus
3. Help in digestion and improving the body's immunity system – Actinobacteria, Bacteroidetes, Firmicutes, Proteobacteria
4. Production of antibiotics, which is used in the treatment and prevention of bacterial infections – Soil bacteria

Also Refer: Antibiotics

Harmful Bacteria

There are bacteria that can cause a multitude of illnesses. They are responsible for many of the **infectious diseases** like pneumonia, tuberculosis, diphtheria, syphilis, tooth decay. Their effects can be rectified by taking antibiotics and prescribed medication.

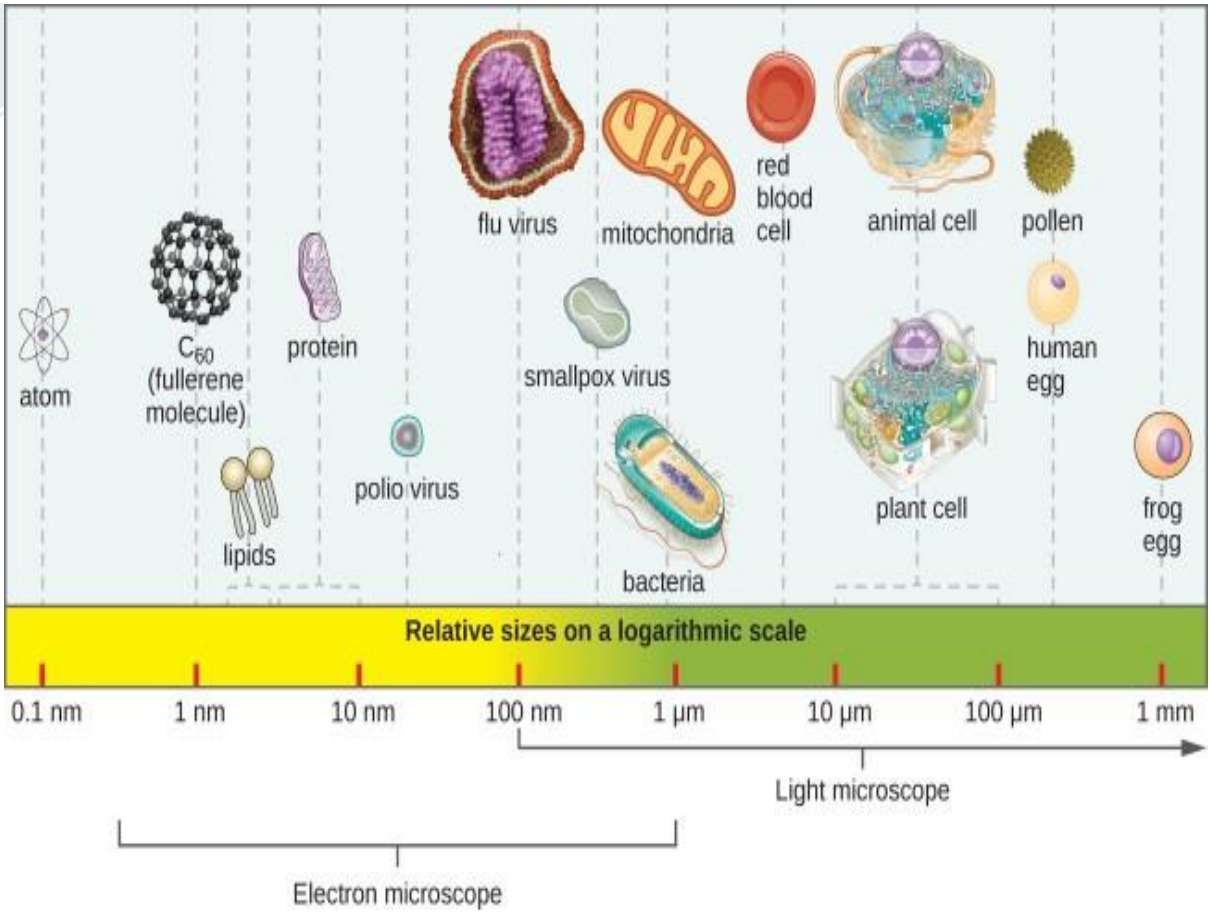
However, precaution is much more effective. Most of these disease-causing bacteria can be eliminated by sterilizing or disinfecting exposed surfaces, instruments, tools and other utilities. These methods include- application of heat, disinfectants, UV radiations, pasteurization, boiling, etc.

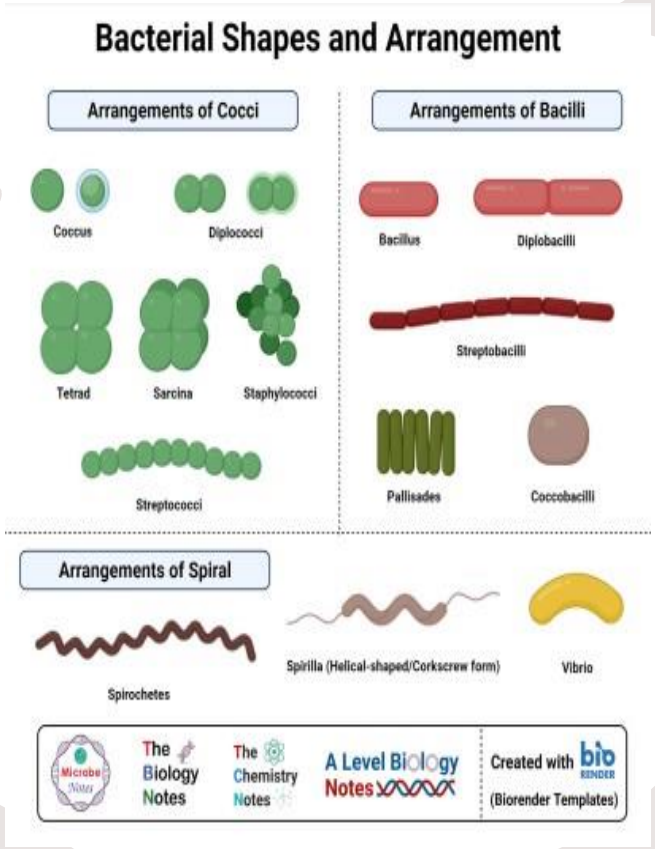
To know more about bacteria, its definition, the structure of bacteria, bacteria diagram, classification of bacteria, and reproduction in bacteria keep visiting BYJU'S website or download BYJU'S app for further reference.

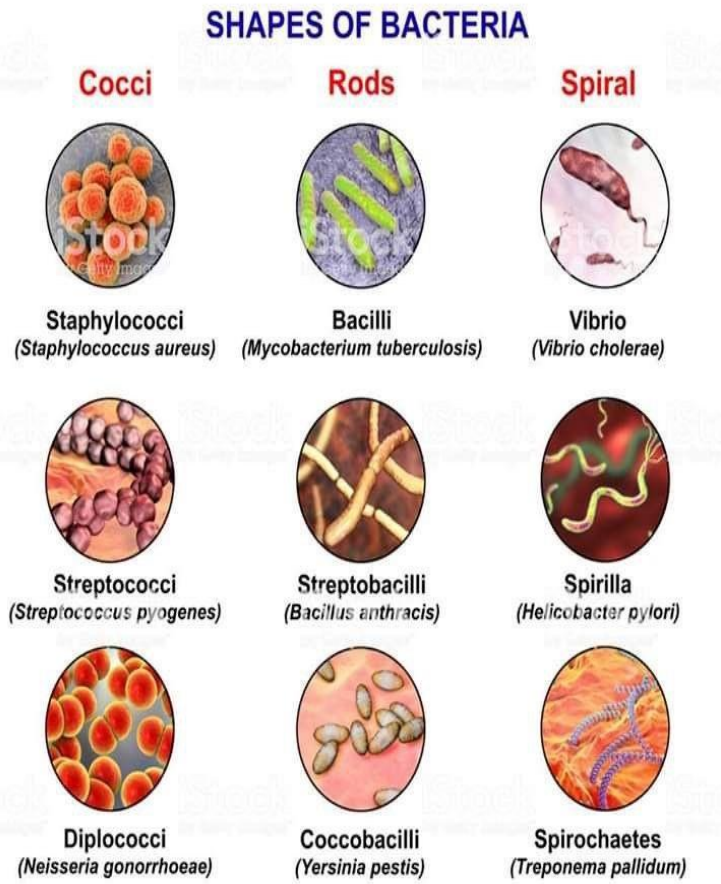
Diversity of structure of bacteria

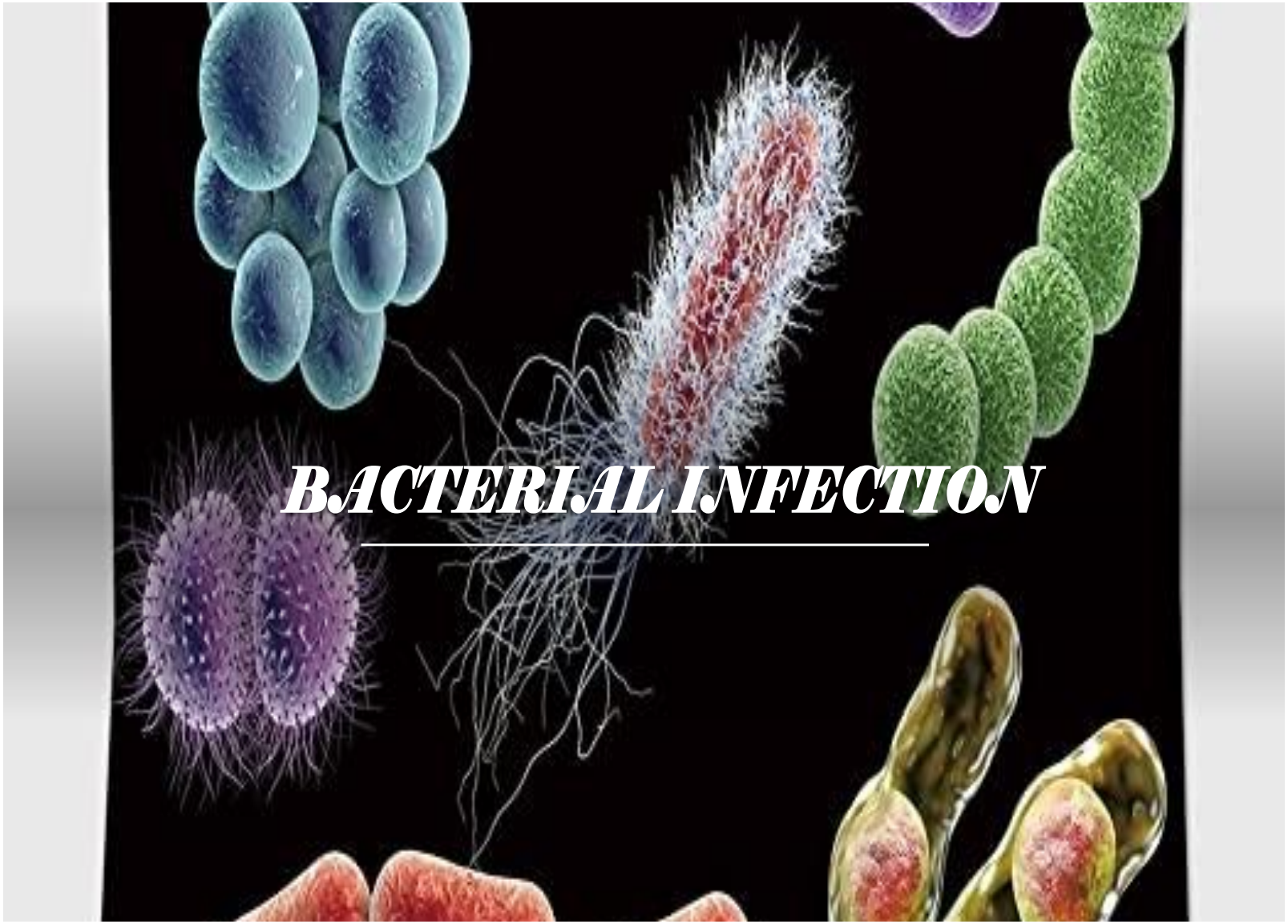
- Although bacterial cells are much smaller and simpler in structure than eukaryotic cells, the bacteria are an exceedingly diverse group of organisms that differ in size, shape, habitat, and metabolism. Much of the knowledge about bacteria has come from studies of disease causing bacteria, which are more readily isolated in pure culture and more easily investigated than are many of the free-living species of bacteria. It must be noted that many free-living bacteria are quite different from the bacteria that are adapted to live as animal parasites or symbionts. Thus, there are no absolute rules about bacterial composition or structure, and there are many exceptions to any general statement.

- Bacteria are the smallest living entities. An average-size bacterium—such as the rod-shaped *Escherichia coli*, a normal inhabitant of the intestinal tract of humans and animals—is about 2 micrometres (μm; millionths of a metre) long and 0.5 μm in diameter, and the spherical cells of *Staphylococcus aureus* are up to 1 μm in diameter.
- A few bacterial types are even smaller, such as *Mycoplasma pneumoniae*, which is one of the smallest bacteria, ranging from about 0.1 to 0.25 μm in width and roughly 1 to 1.5 μm in length; the rod-shaped *Bordetella pertussis*, which is the causative agent of whooping cough, ranging from 0.2 to 0.5 μm in diameter and 0.5 to 1 μm in length; and the corkscrew-shaped *Treponema pallidum*, which is the causative agent of syphilis, averaging only 0.1 to 0.2 μm in diameter but 6 to 15 μm in length. The cyanobacterium *Synechococcus* averages about 0.5 to 1.6 μm in diameter.


flu virus
mitochondria
red blood cell
animal cell
pollen
atom
C_{60} (fullerene molecule)
protein
smallpox virus
human egg
lipids
polio virus
bacteria
plant cell
frog egg
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
Light microscope
Electron microscope


Bacterial Shapes and Arrangement
Arrangements of Cocci
Coccus
Diplococci
Tetrad
Sarcina
Staphylococci
Streptococci
Arrangements of Bacilli
Bacillus
Diplobacilli
Streptobacilli
Palisades
Coccobacilli
Arrangements of Spiral
Spirochetes
Spirilla (Helical-shaped/Corkscrew form)
Vibrio
Microbe Notes
The Biology Notes
The Chemistry Notes
A Level Biology Notes
Created with bio RENDER
(Biorender Templates)


SHAPES OF BACTERIA
Cocci
Rods
Spiral
Staphylococci
(Staphylococcus aureus)
Bacilli
(Mycobacterium tuberculosis)
Vibrio
(Vibrio cholerae)
Streptococci
(Streptococcus pyogenes)
Streptobacilli
(Bacillus anthracis)
Spirilla
(Helicobacter pylori)
Diplococci
(Neisseria gonorrhoeae)
Coccobacilli
(Yersinia pestis)
Spirochaetes
(Treponema pallidum)

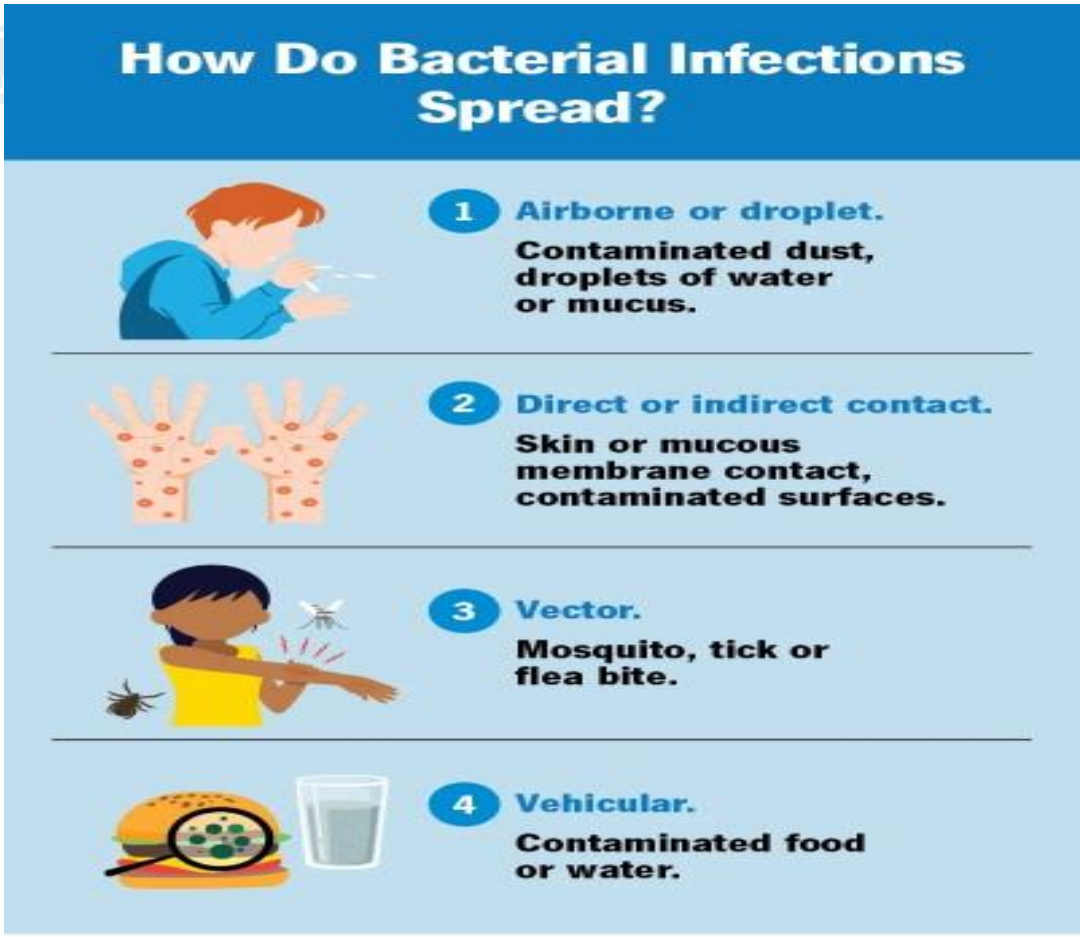

BACTERIAL INFECTION

- Bacterial infections are diseases that can affect your skin, lungs, brain, blood and other parts of your body.
- You get them from single-celled organisms multiplying or releasing toxins in your body.
- Common bacterial diseases include UTIs(urinary tract infections), food poisoning, STIs(sexually transmitted infections) and some skin, sinus and ear infections. They're often treated with antibiotics.

What is a bacterial infection?

- Bacterial infections are any illness or condition caused by bacterial growth or poisons (toxins). You can get sick from getting harmful bacteria in your skin, gut (GI tract), lungs, heart, brain, blood or anywhere else in your body.

- Harmful bacteria from the environment, an infected person or animal, a bug bite or something contaminated (like food, water or surfaces) can cause infections. Bacteria that's not normally harmful but that gets into a place in your body where it shouldn't be can also cause infections.


How Do Bacterial Infections Spread?
1
Airborne or droplet.
Contaminated dust, droplets of water or mucus.
2
Direct or indirect contact.
Skin or mucous membrane contact, contaminated surfaces.
3
Vector.
Mosquito, tick or flea bite.
4
Vehicular.
Contaminated food or water.
Cleveland Clinic

What is bacteria?

- Bacteria are living things with only a single cell that can reproduce quickly. There are millions of bacteria that live all around us— in soil or water and on surfaces in our homes and workplaces. There are even millions of bacteria that live on your skin and inside of your body.
- Most bacteria aren't harmful, and many are even helpful. They can help you digest food and kill off other harmful forms of bacteria that try to invade your body. But even the helpful ones can hurt you if they grow where they're not supposed to.

What's the difference between a bacterial infection and viral infection?

- Living, single-celled organisms that can reproduce on their own cause bacterial infections. Only a few types of bacteria cause illness in people.
- An organism that's not made up of cells causes viral infections. Viruses always need to infect humans or other living things to create more copies of itself.
- Antibiotics can treat most bacterial infections, but only a few viral infections have medications that treat them.

What are the types of bacterial infections?

- Bacteria can cause many types of infections, depending on how you're exposed and what part of your body it infects. Some common types of bacterial infections include:
- Food poisoning (gastroenteritis).
- Some skin, ear or sinus infections.
- Some sexually transmitted infections (STIs).
- Bacterial pneumonia.
- Most urinary tract infections (UTIs).

What are some examples of bacterial infections?

- Common bacterial infections include:
- *Campylobacter* and *Salmonella* infections, common types of food poisoning.
- Cellulitis, boils and impetigo, skin infections.
- Pneumococcal disease, including ear and sinus infections and some types of pneumonia.
- Lyme disease, a disease spread by ticks.
- Bacterial vaginosis, an overgrowth of bacteria in your vagina.
- Chlamydia and gonorrhea, sexually transmitted infections.
- Strep throat, a bacterial infection common in children that causes a sore throat.
- *C. diff*, an infection in your intestines.
- *E. coli*, a common cause of urinary tract infection (UTI).

Is a bacterial infection serious?

- There are many bacterial infections that aren't usually serious or can be treated easily with antibiotics. Impetigo and boils are examples. However, any bacterial infection that gets deep into your body, like in your blood, heart, lungs or brain, can be life-threatening.

How do bacterial infections spread?

- Bacterial infections can spread through droplets or dust in the air, direct or indirect contact, a vector (like a tick or mosquito) or contaminated food or water (vehicular).

- **Airborne or droplet**
- You can get bacterial infections through the air from contaminated dust or droplets of water or mucus (like phlegm or snot). Legionnaires' disease, pertussis (whooping cough), tuberculosis, meningococcal disease and strep throat spread this way.
- **Contact**
- You can get bacterial infections from direct contact with infected skin or mucous membranes, or from indirect contact with contaminated surfaces. Bacterial diseases you get by contact include skin infections and some sexually transmitted infections (STIs) like gonorrhea and chlamydia.

- **Vector**
- Infections you get from bugs (like mosquitos, ticks or fleas) are called vector-borne. You can get Rocky Mountain spotted fever, Lyme disease and shigellosis through vectors.
- **Vehicular**
- While it sounds like something you get from your car, “vehicular” usually means you get sick from water or food (the “vehicle” of transmission). You can get gut (gastrointestinal) infections from *E. coli*, _Campylobacter _and _Salmonella_ bacteria in contaminated food or water.

Who do bacterial diseases affect?

- Anyone can get a bacterial disease, and most of us will at some point in our lives. You're at higher risk for getting an infection if you have:
- Diabetes.
- A weakened immune system (due to HIV/AIDS, cancer, cancer treatments or immunosuppressive medications).
- An open wound.
- Had surgery recently.

How does a bacterial infection affect my body?

- Bacteria can hurt your body either when they reproduce or by releasing poisons (toxins) that damage your cells.
- Infections that only affect the surface of your skin or mucous membranes (like your throat or intestines) aren't usually serious, but sometimes, bacteria can spread in your body and cause life-threatening illnesses.
- If bacteria gets into your blood, it can cause a reaction to the infection that causes organ damage, which is sometimes fatal.

What are common symptoms of a bacterial infection?

- Symptoms of bacterial infections vary depending on where in your body is infected. The main symptom is often fever, except skin infections, which usually cause redness or pain on your skin. Common symptoms of bacterial infections include:
- Fever.
- Chills.
- (tiredness).
- Headache.

Additional symptoms can include:

Location	Symptoms
Skin.	Redness, blisters, ulcers, swollen or painful skin.
GI tract.	Diarrhea, stomach pain, nausea, vomiting.
Lungs.	Cough, shortness of breath, chest pain, phlegm (sputum).
Lining around your brain (meningitis).	Neck stiffness, nausea or vomiting, sensitivity to light, confusion.
In your bloodstream and spreading (septicemia).	High fever, weakness, sweating, low blood pressure.
Heart (endocarditis).	High fever, chest pain, night sweats, shortness of breath, cough, muscle, joint pain.
Urinary tract or genitals.	Burning or pain when you pee, discharge from your penis or vagina, increased need to pee, painful intercourse.

How do you get a bacterial infection?

Common ways you can get bacterial infections include:

- Eating or drinking contaminated food or water.
- Eating or drinking unpasteurized dairy products.
- Antibiotic use, which can kill the good bacteria that usually fight off bad bacteria.
- From contaminated surfaces.
- From other people (through coughing or close contact).
- From getting contaminated water into your lungs (aspirating).
- Through oral, anal or vaginal sex.
- Through contaminated dirt (soil).
- From a bite from an infected tick, mosquito or flea.
- From a surgery or intubation (tube in your throat).

How are bacterial infections diagnosed?

- A healthcare provider diagnoses a bacterial infection by listening to your symptoms, doing an examination (listening to your heart and lungs, feeling your abdomen, looking at your skin) and taking samples to test for bacteria.
- If they think you have bacteria in your lungs, brain or other internal organ, they might get X-rays, ultrasound, MRI or CT imaging to look for signs of infection.

Tests for bacterial infections

- Your provider might send body fluid or tissue samples to a lab to look for signs of an infection (antibodies or antigens). A lab technician might also try to grow bacteria from your samples. Types of samples they might take include:
- Skin or other affected tissue.
- Blood.
- Phlegm (sputum).
- Fluid around your brain and spinal cord (CNS fluid).
- Pee (urine).
- Fluid from your eye (secretions).
- Poop (stool).

How are bacterial infections treated?

- Not all bacterial infections need to be treated — some go away on their own. When you do need treatment, healthcare providers use antibiotics. Depending on where your infection is and how serious it is, antibiotics can be prescribed as:
- Oral medication (pills).
- IV medication, given to you at a doctor's office or hospital directly into a vein.
- Ointment or cream.
- Eye drops.

How can I prevent bacterial infections?

Ways to reduce your risk of various types of bacterial infections include:

- **Get vaccinated.** There are vaccines for many bacterial diseases, including tetanus, whooping cough, diphtheria and bacteria that cause certain forms of meningitis (*Neisseria meningitides*), pneumonia (*Streptococcus pneumoniae*, *Haemophilus influenzae* type b) and bloodstream infections.
- **Practice good hygiene.** This includes maintaining good hand-washing habits, wearing clean and dry clothes and not sharing personal items with other people.
- **Keep wounds clean.** Breaks in your skin allow bacteria to get in. Clean and cover cuts or wounds in your skin.
- **Practice safe food habits.** This includes storing food properly, heating meat and poultry to a temperature that kills bacteria and washing or peeling fruits and vegetables before eating.
- **Use a condom or dental dam during any kind of sex.**
- **Protect yourself from bug bites.** Wear protective clothing, use bug spray and check yourself and your pets for ticks after being outdoors.

END