**MICROBIOLOGY**

**Introduction**

Microbiology is the study of all living organisms that are too small to be visible with the naked eye. This includes bacteria, Achaea, viruses, fungi, prions, protozoa and algae, collectively known as 'microbes'. These microbes play key roles in nutrient cycling, biodegradation / bio deterioration, climate change, food spoilage, the cause and control of disease, and biotechnology. Thanks to their versatility, 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.

Microbiologists study microbes, and some of the most important discoveries that have underpinned modern society have resulted from the research of famous microbiologists, such as Jenner and his vaccine against smallpox, Fleming and the discovery of penicillin, Marshall and the identification of the link between *Helicobacter pylori* infection and stomach ulcers, and zur Hausen, who identified the link between papilloma virus and cervical cancer.

Microorganisms are said to be **ubiquitous** meaning they are virtually everywhere.

Most scientists do not consider viruses to be living organisms, they are often referred to as infectious agents or infectious particles rather than microorganisms.

Pathogens: A pathogen is a microorganism that causes disease. Viruses and [bacteria](https://www.webmd.com/digestive-disorders/video/truth-about-bacteria) can be pathogens, but there are also other types of pathogens. Every single living thing, even bacteria themselves, can get infected with a pathogen.

Non-pathogens: Nonpathogenic microorganisms are those that do not cause disease, harm or death to another organism.

**Importance of Microorganisms**

**Production of Antibiotics:**

Antibiotics are metabolic products of several harmless microorganisms. They are used to kill various pathogenic microorganisms, so helpful in treating many diseases.

Besides their use in the treatment of human diseases, certain antibiotics are used as food preservatives. Some antibiotics are found use in the control of plant pathogens. For example, Griseofulvin, which is not suitable to man is used in the control of bean rust.

**Production of Dairy Products:**

Microorganisms are useful in the production of cheese, butter milk and other dairy products. Cheese production from milk and is dependent upon the activity of microorganisms like *Streptococcus lactis*, *S. cremoris*, *Leuconostoc citrivorum* etc.

**Production of Alcoholic Beverages:**

Alcoholic beverages are produced by the fermentation of sugars by yeast *Saccharomyces cerevisae*. They include vinegar, beer, wine, yum.

**4. Production of Bread making:**

Selected strains of *S. cerevisae* are mixed in the dough. Fermentation results in the production of carbon dioxide which causes the dough to rise (leavening) and brings about a desired change in the texture and flavor. The quality of the bread depends upon the strain of yeast, selection of raw materials and incubation conditions.

**Production of Food Yeast:**

Yeast is used as a very nourishing material and is often taken as a food supplement *Torulopsis utilis* is a food yeast cultured and marketed commercially. Yeast is a good source of Vitamin B complex and also rich in proteins. Yeast is a byproduct of brewing industry, and is also cultured in a medium containing molasses, cane sugar, potatoes of other fermentable carbohydrates.

**Production of Organic Acids:**

**Some of the common organic acids are produced commercially by microorganisms:**

**(a) Acetic acid:**

It is the vinegar obtained by the fermentation of fruits and sugar containing syrups by *Acetobacter spp.*

**(b) Citric acid:**

It is an important industrial product obtained through *Aspergillus niger*. Citric acid is used in medicine flavoring extracts, food and candies, manufacture of ink, dyeing etc.

**(c) Fumeric acid:**

This is produced through *Rhizopus nigricans*.

**(d) Gluconic acid:**

It is obtained by growing *Aspergillus niger* or *Pencillium purpurogenum* in a medium containing corn sugar with ammonium phosphate, magnesium sulphate and calcium carbonate. It is used to produce calcium gluconate, a source of calcium in feeding infants and pregnant women.

**(e) Lactic acid:**

It is produced by Lactobacillus delbruck L. bulgaricus and Streptococcus lactis from corn starch or potatoes. Lactic acid is used in confectionery extracts, fruit juices, essences pickles, canned vegetables, fish products etc.

**Production of Vitamins**

Microorganisms are useful to mankind as they produce many vitamins. Yeasts manufacture vitamin B. complex. For commercial production of B12, *Cobalamin*, bacteria and *actinomycetes* like *Streptomyces olivaceus* and *Bacillus megatherium* are used. Riboflavin (B2) is produced by a number of microorganisms like *Ashbya gossypii*, *Eremothecium ashbyii* and *Closteridium bytyricum*. L-Sorbose, a precursor of vitamin C, ascorbic acid, is produced by different species of *Acetobacter* from D-Sorbitol by biological dehydrogenation.

**Production of Enzymes:**

Many enzymes are synthesized by microorganisms. They are commercially not important as their separation and purification involved high cost.

**Some of the microbial enzymes useful to man are:**

**(i) Amylases:**

Produced from *Bacillus subtilis*, *Aspergillus niger* and *Rhizopus oryzae*.

**(ii) Dextran sucrase:**

Produced from *Leuconostoc meseniteroides*.

**(iii) Lactase:**

Produced by *Saccharomyces cerevisae*.

**(iv) Lipase:**

Obtained from *Candida lipolytica*.

**(v) Pectinase:**

Manufactured from *Byssochlamys fulvo*.

**(vi) Proteases and peptidases:**

Obtained from *Bacillus subtilis* and *Mortierella renispora*.

**(vii) Invertase:**

Obtained from *S. cerevisiae*.

**(viii) Penicillinase:**

Produced from *Actinomyces candidus*.

**Production of Steroids:**

Microbes like *Actinomycetes, Aspergillus*, *Streptomyces* and *Gliocladium* are used to produce different steroids from progesterone by microbial transformations. Steroids manufactured by combination of chemical and microbial methods are finding wide use in family planning and in treatment of diseases.

**Production of Dextrans:**

They are polymers of D-glucose and also are polyglucosans. Fermentation process with the help of *Leuconostoc meseniteroides* is used in their production. Dextrans with different molecular weights have clinical use.

**Soil Microbiology:**

Microorganisms are beneficial in increasing the fertility of soil. Nitrogen fixing bacterium *Rhizobium* helps in fixing atmospheric nitrogen in the root nodules of leguminous plants. Different soil bacteria convert organic substances into inorganic compounds, releasing nutrients to growing plants. They also decompose dead plants and animals.

**Coal and Petroleum Microbiology:**

Microbes play an important role in the formation of coal and petroleum. Bacteria oxidizes the organic matter to compounds similar to petroleum. Some important bacteria associated with petroleum formation are *Clostridium perfringers*, *Vibrio desulphuricans* and *Beggiatoa alba*.

**Sewage Microbiology:**

Many microorganisms are useful to purify domestic wastes. They are responsible for digestion and oxidation of organic materials. They destroy the pathogenic types.

**Bioassay**

Microorganisms are employed in biological studies. They can be experimented to study the effect of different drugs. In few cases, they are utilized to test organisms to detect the presence of unknown chemical substances. For instance, the presence of traces of copper can be detected by growing *Aspergillus niger*.

**Biological Pest Control:**

Bacteria and viruses can cause epidemics among different insect pests without destroying beneficial insects.

**Biological Warfare:**

Microbes or their toxic products can be used in biological warfare. Their release through air or water may spread different diseases and cause damage to man, domestic animals and plants.

**Importance of studying Microbiology**

Microbes are vitally important to all life on Earth. As versatile organisms, they play a major role in various biochemical processes such as biodegradation, bio deterioration, climate change, food spoilage, epidemiology and biotechnology.

By applying microbes in a range of controlled settings, microbiologists can harness their power for beneficial use in areas as diverse as healthcare, food production and agriculture.

In medicine alone, microbiologists have contributed to some of history's most important scientific breakthroughs. Edward Jenner invented the world’s first smallpox vaccine. Robert Koch identified the causes of cholera, tuberculosis and anthrax. Alexander Fleming discovered penicillin. And, more recently, Barry Marshall identified the link between Helicobacter pylori infection and stomach ulcers. Microbiologists are pushing the envelope of science and helping to save lives in the process.

The [Microbiology Society](https://microbiologysociety.org/why-microbiology-matters/what-is-microbiology.html) sum up the importance of the field:

*“Microbiology research has been and continues to be, central to meeting many of the current global aspirations and challenges, such as maintaining food, water and energy security for a healthy population on a habitable earth. Microbiology research will also help to answer big questions such as 'how diverse is life on Earth?', and 'does life exist elsewhere in the Universe'?”*

The essential ongoing work of microbiologists includes making agriculture more sustainable, cleaning up pollution, manufacturing biofuels, and processing food and drink.
With the threat of antibiotic-resistant bacteria and global pandemics on the rise, microbiologists are also helping to produce the vital life-saving drugs that many people around the world rely on for survival.

**History and Development of Microbiology**

* Bacteria and protozoa were the first microorganisms to be observed by humans. It then took about 200 years before a connection was established between microorganisms and infectious disease. Among the most significant events in the history of microbiology were:
* development of microscopes
* bacterial staining procedures
* culture techniques
* isolation of microorganisms

Historians are unsure who made the first observations of microorganisms, but the microscope was available during the mid‐1600s, and an English scientist named **Robert Hooke** made key observations. He is reputed to have observed strands of fungi among the specimens of cells he viewed.

**Anton van Leeuwenhoek (1632-1723)**

He was the first person to bacteria and protozoa thus he is referred to as the father of microbiology. (Father of bacteriology, protozoology).

He was not a trained scientist. He was a fabric merchant, a surveyor, a wine assayer, and a minor city official in Delft, Holland.

As a hobby, he ground tiny glass lenses, which he mounted in small metal frames, thus creating what today is known as Single lens microscopes or simple microscope.

During his lifetime he made more than 500 such microscopes. His fine art of grinding lenses that would magnify an object 200-300 times its size was lost at his death because he did not teach anyone his skill.

He had a curiosity of examining things as he used his microscope and he could examine almost anything he could get his hands. He examined scrapings from his teeth, water from the ditches and ponds, water which he had soaked peppercorns, blood, sperm, and his own diarrhea stools. In many of these specimens he observed a variety of tiny living creatures which he called animalcules. He recorded his observations in letters which finally convinced scientists of the late 17th century of the existence of microorganisms.

**Louis Pasteur (1822-1895)**

Louis Pasteur is a French chemist who made numerous contributions to microbiology and those contributions are considered by many people to be the foundation of the science of microbiology and a cornerstone of modern medicine. Some of these contributions are:

While attempting to discover why wine becomes contaminated with undesirable substances, Pasteur discovered what occurs during alcohol fermentation. He discovered different types of microorganisms that produce different fermentation products .e.g yeast convert glucose in grapes into ethyl alcohol (ethanol) by fermentation, *acetobacter* convert glucose to acetic acid (vinegar) by fermentation.

Pasteur discovered forms of life that could exist in the absence of oxygen. He introduced the term aerobes (organisms that require oxygen to live) and anaerobes (organisms that do not require oxygen for life).

The developed the process of pasteurization (a process to kill microorganisms). Microorganisms were subjected to higher temperatures of 55 degree and the temperature for several minutes.

Pasteur made significant contribution to the germ theory of disease, the theory that specific microorganisms cause specific infectious disease.

Pasteur championed changes in hospital practices to minimize spread of disease by pathogens. e.g aseptic technique and sterilization.

Pasteur developed vaccines to prevent chicken pox, anthrax, and swine erysipelas (a skin disease).

**Robert Koch (1843-1910)**

* Robert Koch a German physician, made numerous contributions to the science of microbiology.
* -he made significant contributions to the germ theory of disease. e.g he proved that anthrax bacillus (*Bacillus anthracis*) was truly the cause of anthrax by injecting pure cultures of the bacilli into mice and showing that the bacilli invariably caused anthrax.
* -Koch also discovered that *Bacillus anthracis* produced spores capable of resisting adverse conditions.
* He developed method of fixing, staining, and photographing bacteria as well as methods of cultivating bacteria on a solid media (petri dish).
* Koch discovered the bacterium (mycobacterium tuberculosis) that causes tuberculosis and the bacterium (*vibrio cholerae*) that causes cholera.
* Koch’s work on tuberculin (a protein derived from (*M. tuberculosis*) ultimately led to the development

Despite the advances in microbiology, it was rarely possible to render life‐saving therapy to an infected patient. Then, after World War II, the **antibiotics** were introduced to medicine. The incidence of pneumonia, tuberculosis, meningitis, syphilis, and many other diseases declined with the use of antibiotics.

Work with viruses could not be effectively performed until instruments were developed to help scientists see these disease agents. In the 1940s, the **electron microscope** was developed and perfected. In that decade, cultivation methods for viruses were also introduced, and the knowledge of viruses developed rapidly. With the development of vaccines in the 1950s and 1960s, such viral diseases as polio, measles, mumps, and rubella came under control.

**Modern microbiology:** Modern microbiology reaches into many fields of human endeavor, including the development of pharmaceutical products, the use of quality‐control methods in food and dairy product production, the control of disease‐causing microorganisms in consumable waters, and the industrial applications of microorganisms. Microorganisms are used to produce vitamins, amino acids, enzymes, and growth supplements. They manufacture many foods, including fermented dairy products (sour cream, yogurt, and buttermilk), as well as other fermented foods such as pickles, sauerkraut, breads, and alcoholic beverages.

**Microorganisms and Infection**

Few of the micro-organisms are disease producing in nature thus pathogenic to man.

Most of the micro-organisms live in soil, water or in air and are unable to invade the living body

Some obtain their energy from day light while others live and feed on their host known as **parasites**

Others constitute the normal flora/indigenous micro-flora/commensals of the body; (they live and obtain nourishment from the areas they live in). Such areas include: - the skin, mucous membranes of respiratory tract, intestines, and vagina.

However under special circumstances they may cause **opportunistic infections**

True pathogens: are **infectious agents that causes diseases in virtually any susceptible host**.

Their growth or production of toxins (harmful/poisonous substances) damages the tissues and causes disease.

Opportunistic pathogens are potentially infectious agents that rarely cause disease in individuals with healthy immune systems.

**Infection**

**Infection is the invasion and growth of germs in the body**. The germs may be bacteria, viruses, yeast, fungi, or other microorganisms. The severity can range from mild to fatal.

**Incubation Period**: Time interval between initial contact with an infectious agent and appearance of the first sign or symptom of disease in question.

**Host**: - living organism in which a parasite grows and multiplies at hosts (its) cost.

The host usually provides shelter or nourishment to the other organism, which may use the host to partially or completely develop.

**Forms of Infection**

**Primary infection**: - **the first time you are exposed to and infected by a pathogen**. During a primary infection, your body has no innate defenses against the organism, such as antibodies

**Secondary infection**: - **an infection that occurs during or after treatment for another infection**. It may be caused by the first treatment or by changes in the immune system. Two examples of a secondary infection are: A vaginal yeast infection after taking antibiotics to treat an infection caused by bacteria.

**Mixed infection**: - when more than one organism simultaneously infect a host

**Focal infection: - a localized or general infection caused by the dissemination of microorganisms or toxic products from a focus of infection**.

**Endogenous infection**: - infection caused by the normal microbial flora due to lowering of host immunity

**Exogenous infection**: - infection caused by pathogenic organism from outside the host

**Reservoir**: - a host which harbors a parasite and acts as a sources of infection

**Vector:** - a **living organism that transmits an infectious agent from an infected animal to a human or another animal**. Vectors are frequently arthropods, such as mosquitoes, ticks, flies, fleas and lice.

**Sources of Microorganisms**

1. **Animals**: - especially them that act as reservoirs
2. **Insects/ arthropods** that act as vectors -like mosquitoes-malaria
	1. fleas-plague,
3. **Soil: - eg.** Ingestion of spores of *Bacillus anthracis*
4. **Air**:-expelled in spitting, blowing, sneezing or coughing
5. **Food:** - contaminated by food handlers, during preparation, hands.
6. **Water: -** contaminated poor environmental hygiene e.g. water washed -scabies, water borne-cholera, water related-malaria

**Modes of Transmission of Infections**

1. **Contact**
* Direct skin-to-skin contact e.g common cold virus is frequently transmitted from the hand of someone who has just blown his nose to another person by hand shaking. Within the hospital this mode of transmission is common and that why it is important to wash hands after every patient contact.
* Direct mucous membrane –to mucous membrane contact by kissing or sexual intercourse. Most STDs are transmitted that way i.e syphilis, gonorrhea, and infections caused by Chlamydia, herpes and HIV.

Indirectly via formites that become contaminated by respiratory secretions, blood, feces, vomitus, or exudates from hospitalized patients

1. **Inhalation** (**breathing**)
	* Indirectly via airborne droplets of respiratory secretions usually produced as a result of sneezing or coughing e.g improperly cleaned inhalation therapy equipment can easily transfer these pathogens from one patient to another. Diseases such as mumps, colds, influenza, measles, chicken pox, and pneumonia spread this way.
2. **Ingestion (swallowing)**
	* Indirectly via contamination of food and water by fecal material
3. **Mother to child -** before, During and after birth
4. **Self-infection**
	* from normal flora
5. **Medical or surgical procedures**
	* Indirectly via transfusion of contaminated blood or blood products from an ill person or by parenteral injection.
	* Invasive procedures

**Classification of Microorganisms**

Micro-organism of medical importance is divided into **five** classes

* + Bacteria
	+ Rickettsiae and Chlamydia
	+ Viruses
	+ Fungi
	+ protozoa

**Bacteria**

* Unicellular
* Reproduce by binary fission
* Has a permeable cell wall which controls internal osmotic pressure
* Divided into gram- positive and gram-negative
* Within the cell there is cytoplasm surrounded by cytoplasmic membrane
* Within the cytoplasm there is ribosome's (containing cell`s ribonucleic acid (RNA) and chromosome or nuclear body consisting of double-stranded deoxy-ribonucleic acid (DNA)
* Some bacteria forms capsules outside their cell walls
* Some have whip-like organelle of locomotion (flagella) protruding from their surfaces
* Others have Pilli (hair-like protrusions) enabling them to attach to surfaces
* A few forms spores helps in reducing metabolic activities and increase resistance to adverse conditions
* Bacteria often attach to surfaces and form dense aggregations called [biofilms](https://www.wikidoc.org/index.php/Biofilm) or [bacterial mats](https://www.wikidoc.org/index.php/Bacterial_mat).
* Complex morphological changes are sometimes possible. For example, when starved of amino acids, [Myxobacteria](https://www.wikidoc.org/index.php/Myxobacteria%22%20%5Co%20%22Myxobacteria) detect surrounding cells in a process known as [quorum sensing](https://www.wikidoc.org/index.php/Quorum_sensing), migrate towards each other, and aggregate to form fruiting bodies.

**Types of Bacteria**

Bacteria varies greatly in size usually ranging from spheres, long spiral-shaped bacteria, to even longer filamentaous bacteria.

There are three basic shapes of bacteria

* Round or spherical shaped- bacteria-the cocci
* Rectangular or rod shaped- bacteria-the bacilli
* Curved or spiral shaped-bacteria-the sprilla

Bacteria can also be other shapes such as **filamentous (long and thin), square, star-shaped, and stalked.**

The **cocci:-**

* May be seen in singly or in pairs
* May be seen in chains (streptococci)
* May be seen in clusters (staphylococci)
* May be in packets of four (tetrads)
* May be in packets of eight (octads)
* Examples of cocci include: - *enterococcus spp*, *Neisseria spp*, *Staphylococcus spp*, *Streptococcus spp*.

**The Bacilli**

* May be short or longer (cocobacilli) e.g *Listeria monocytogenes* (common cause of neonatal meningitis)
* thick or thin
* May be pointed or with curve or blunt ends
* May be singly or pairs (diplobacilli)
* May be in chains (streptobacilli)
* May have long filaments or branched
* May be stuck up next to each other
* May be side by side in a palisade arrangement e.g *Corynebacterium diphtheriae*

**Examples of bacilli:-**

Members of *Enterobacterial* family - *enterobacter*, *Escherichia*, *Klebsiela*, *Proteus*, *Salmonella*, and *Shigella spp*., *Haemophilus influenza*, *Pseudomonas aeruginosa*, *bacillus spp* and *clostridium spp*.

**Curved and spiral shaped bacteria**:- e.g *Vibrio spp.* (*Vibrio cholerae* - cholera), *Vibrio Parahaemolyticus* -(common cause of diarrhea)

Are curved (comma shaped) bacilli:-

-a pair of curved bacilli resembles a bird and is described as having a gull-wing morphology e.g campylobacter spp (common cause of diarrhea)

**Spiral shaped** bacteria (spirochetes);

* + Are cork-crew like spirals
	+ They may be singly or in form of pairs.

**Staining Procedures**

Staining is crucial in bacteriology because bacteria are colorless and transparent hence

There are two basic types of preparation used to view specimens with a light microscope: wet mounts and fixed specimens.

The simplest type of preparation is the **wet mount**, in which the specimen is placed on the slide in a drop of liquid. Some specimens, such as a drop of urine, are already in a liquid form and can be deposited on the slide using a dropper. Solid specimens, such as a skin scraping, can be placed on the slide before adding a drop of liquid to prepare the wet mount. Sometimes the liquid used is simply water, but often stains are added to enhance contrast. Once the liquid has been added to the slide, a coverslip is placed on top and the specimen is ready for examination under the microscope.

The second method of preparing specimens for light microscopy is **fixation**. The “fixing” of a sample refers to the process of attaching cells to a slide. Fixation is often achieved either by heating (**heat fixing**) or chemically treating the specimen. In addition to attaching the specimen to the slide, fixation also kills microorganisms in the specimen, stopping their movement and metabolism while preserving the integrity of their cellular components for observation.

To heat-fix a sample, a thin layer of the specimen is spread on the slide (called a **smear**), and the slide is then briefly heated over a heat source (Figure 1b). **Chemical fixatives** are often preferable to heat for tissue specimens. Chemical agents such as acetic acid, ethanol, methanol, formaldehyde (formalin), and glutaraldehyde can denature proteins, stop biochemical reactions, and stabilize cell structures in tissue samples.

Bacteria are colorless, transparent, and difficult to see hence different staining methods have been devised in examining bacteria.

Dyes used in staining can be acidic or basic. **A positive stain** is a dye that will be absorbed by the cells or organisms being observed, adding color to objects of interest to make them stand out against the background.  A **negative stain** is absorbed by the background but not by the cells or organisms in the specimen. Negative staining produces an outline or silhouette of the organisms against a colorful background.

The most commonly used basic dyes include **basic fuchsin**, **crystal violet**, **malachite green**, **methylene blue**, and **safranin** which serve as positive stains. Commonly used acidic dyes include **acid fuchsin**, **eosin**, and **rose bengal**.

**Reading Assignment: Gram staining Procedure**

**Rickettsiae**

* Are very short rods
* Have a cell wall(resembles that of gram-negative rods)
* They are bacteria as they contain RNA and DNA
* They are **obligately intracellular Gram-negative bacteria**
* Divide by binary fission within the host cell
* Some Rickettsiae are Cocci or bacilli
* Have a common feature of being spread by arthropod vectors – tick, louse, fleas
* Example: *Coxiella burnetiid*, *typhus*

**Chlamydia**

* Chlamydia are obligate intracellular bacteria i.e they can grow only within cells.
* They have a rigid cell wall but lack a typical peptidoglycan layer.
* Their cell wall resemble those of gram-negative bacteria but lack muramic acid.
* Chlamydia are spherical and have intracellular developmental cycle where infective forms are phagocytosed by host cell and develop inside the cell to reticulate bodies
* In 40hrs become elementary bodies and rupture within 48-72hrs to infect other cells

**Viruses**

* Very small unclear whether they are living or not hence referred to as **active** and **inactive**
* **Virion –**is a virus particle
* Viruses are particles composed of an internal core containing either RNA or DNA (but not both) covered by a protective coat.
* Viruses do not have a nucleus, cytoplasm, mitochondria, or ribosomes.
* The nucleic acid core is packed within **protein coat (capsid)** which protects it during transmission between host cells. Multiply by replication in host cell (are obligate intracellular parasites)
* Classified according to nucleic acid, presence of envelop, size and symmetry of the capsid

Viruses of medical importance can be classified as DNA or RNA viruses:

DNA Viruses:

* Parvovirus
* Polyomaviruses
* Papllomaviruses
* Adenoviruses
* Hepadnaviruses
* Herpesviruses
* Poxviruses

RNA Viruses

* Picornaviruses
* Caliciviruses
* Reoviruses
* Flaviviruses
* Togaviruses
* Retroviruses
* Orthomyxoviruses
* Paramyxoviruses
* Rhabdoviruses
* Filoviruses
* Coronaviruses
* Arenaviruses

**Pathogenesis:**

* The ability of virus to cause disease can be viewed in two levels:-

1. Changes that occur within individual cell

2. Process that takes place in infected patient

Effects of viral infection on the cell

* Death, fusion of cells to form multinucleated cells, malignant transformation, and no apparent morphologic or functional change.

**Reading Assignment: Make short notes on various types of viruses.**

**Fungi**

* The study of fungi is called mycology
* Fungi are a diverse group of eukaryotic organisms that include yeasts, molds, and mushrooms
* Fungi have no chlorophyll
* Fungal spores are very resistant structures that are carried great distances by wind-resist heat, cold, acids bases, and other chemicals. Many people are allergic to fungal spores.
* Are found almost everywhere on earth
* Some are (saprophytic) living on organic matter in water and soil.
* Others are parasitic living on and within animals and plants
* Some are harmful and others beneficial
* Beneficial fungi are important in production of cheese, beer, wine, and other foods as well as certain drugs.
* Have thick cell wall which contains cytoplasmic membrane target for antifungal drugs
* Their cell wall do not contain cellulose
* Fungal cell wall contain chitin (polysaccharide)
* Although many fungi are unicellular(e.g yeast) others grow filaments called hyphae
* Reproduce by budding, hyphal extension or formation of asexual spores (conidia)
* Many fungi pathogenic for men are dimorphic (affects skin)

**Classes of Fungi**

* They are divided into five classes based in their mode of sexual production
* **Zygomycotina (zygomycetes)** - include the common bread molds and other fungi that cause food spoilage.
* **Chytridiomycotina (chytrdiomycetes)** - live in water (water molds) and soil.
* **Ascomycotina (ascomycetes)** - include certain yeasts and some fungi which cause plant disease. E.g dutch Elm disease
* **Basidiomycotina (basidiomycetes)** - include some yeasts and some fungi which cause plant disease and the fleshy fungi that live in the woods. e.g mushrooms, toadstools bracket fungi
* **Deutromycotina (deutromycetes) -** contains fungi having no mode of sexual reproduction e.g *aspergillus* and *penicillium*

**N.B**

* Yeasts are microscopic ,eukaryotic, single celled organisms that lack mycelia, usually they reproduce by budding

**Fungal diseases**

Yeast: - e.g *candida albicans* - causes thrush, *Creptococcus neoformans* - causes creptococcosis (lung infection, meningitis etc)

Molds: - e.g *Aspergillus spp* - causes aspergillosis (lung infection, systemic infection, tinea (ring worm) infections.

**Protozoa**

The study of protozoa is called protozoology

Protozoa are unicellular, eukaryotic, heterotrophic organisms. They are either free-living or parasites. They lack a cell wall.

There are many protozoa that cause various diseases in animals and humans, e.g. *Plasmodium* (malarial parasite), *Trypanosoma* (sleeping sickness), *Trichomonas* (trichomoniasis), etc.

The protozoa have many stages in their life cycle. Some of the stages of the life cycle are infectious.

The cyst stage is dormant and resistant to environmental stress, the trophozoite stage is reproductive and causes disease.

**General Characteristics of Protozoa**

**Habitat -**Protozoa are found in the aquatic environment. They live in freshwater or oceans. Some are free-living and some are parasitic in plants and animals. Mostly they are aerobic but some are anaerobic and present in the rumen or human intestine.

Some of the species are found in extreme environments like hot springs. Some of them form resting cyst to overcome dry environments.

**Size and Shape -**The size and shape of Protozoa vary greatly, from microbial (1µm) to large enough and can be seen by the naked eye. The shell of unicellular foraminifera can have a diameter of 20 cm.

They lack a rigid cell wall, so they are flexible and found in various shapes. Cells are enclosed in a thin plasma membrane. Some of the species have a hard shell on the outer surface. In some of the protozoans especially in ciliates, the cell is supported by **Pellicle,**which may be flexible or rigid and give organisms the definite shape and help in locomotion.

**Cellular Structure -**They are unicellular having a eukaryotic cell. The metabolic functions are performed by some specialized internal structures.

* They mostly have one membrane-bound nucleus in the cell
* The nucleus has diffused appearance due to scattered chromatin, the vesicular nucleus contains a central body called endosome or nucleoli. Nucleoli of apicomplexans have DNA, whereas amoeboids lack DNA in their endosome
* Ciliates have micronucleus and macronucleus
* The plasma membrane encloses the cytoplasm and other locomotory projections like flagella, pseudopodia and cilia
* Some of the genera have a membranous envelope called pellicle, which gives a definite shape to the cell. In some of the protozoans, epibiotic bacteria attach to the pellicle by their fimbriae
* The cytoplasm is differentiated into outer ectoplasm and inner endoplasm, ectoplasm is transparent and endoplasm contains cell organelles
* Some of the protozoa have cytostome for ingesting food. Food vacuoles are present, where ingested food comes. Ciliates have a gullet, a body cavity which opens outside
* The central vacuole is present for osmoregulation, that removes excess water
* Membrane-bound cell organelles, like mitochondria, Golgi bodies, lysosomes and other specialised structures are present

**Nutrition-**Protozoa are heterotrophic and have holozoic nutrition. They ingest their food by phagocytosis. Some of the protozoan groups have a specialised structure called **cytostome**for phagocytosis.

The pseudopodia of amoeboids help in catching the prey. Thousands of cilia present in ciliates drive the food-laden water into the gullet.

The ingested food comes to the [food vacuole](https://byjus.com/neet/food-vacuole/) and gets acted on by lysosomal enzymes. The digested food gets distributed throughout the cell.

**Locomotion-**Most of the protozoa species have flagella, cilia or pseudopodia. Sporozoa, which don’t have any locomotory structure, have subpellicular microtubules, which help in the slow movement.

**Life Cycle-**The life cycle of most of the protozoa alternates between dormant cyst stage and proliferating vegetative stage, e.g. trophozoites.

The cyst stage can survive harsh conditions without water and nutrients. It can remain outside the host for a longer duration and get transmitted.

The trophozoite stage is infectious, and they feed and multiply during this stage.

**Reproduction-**Mostly they reproduce by asexual means. They multiply by binary fission, longitudinal fission, transverse fission or budding.

In some of the species, sexual reproduction is present. The sexual reproduction is by conjugation, syngamy or by gametocytes formation.

Classification of Protozoa

* **Sarcodina**. e.g ameba-move by means of cytoplasimic extensions called pseudopodia
* **Mastigophora (flagellates) .**e.g move by whip like flagella. e.g *Trypanosoma cruzi*, *Trypanosoma brucei*, *Trichomonas vaginalis*, *Giardia lambia*
* **Ciliates (ciliophora**) - move about by means of a large number of hair-like cilia on their surfaces e.g *Balantidium spp.* (causes dysentry)
* **Sporozoa e.g Plasmodium**

**Parasitology**

* Parasitology is the study of parasites.
* Parasites occur in two distinct forms:-
	+ - * Single-celled **protozoa**
			* Multicellular metozoa **helminths**

**Metozoa** are divided into:-

* Platyhelminthes (flatworms)
* Nemathelminthes

Platyhelminthes contains two medically important classes:-

* Cestoda (tapeworms)
* Trematoda (flukes)

A good example of blood and tissue protozoa is plasmodium which is a malaria - causing parasite. The types include:

* *Plasmodium vivax*
* *Plasmodium ovale*
* *Plasmodium malariae*
* *Plasmodium falciparum*

*P. vivax* and *P. falciparum* are more common causes of malaria than are *P. ovale* and *P. malariae*.

The vector and definitive host for plasmodia is the female anopheles mosquito (only the female takes a blood meal).

**Assignment: Read and make short notes on the life cycle of *plasmodium* both inside the vector (anopheles mosquito) and in human being.**

**Metozoa**

Helminths cause much disease and are the largest of human parasites.

Helminths of medical importance are divided into three zoological classes namely;

* Nematodes
* Cestodes
* Trematodes

**Cestodes (Tapeworms)**

* Tapeworm consist of two main parts
	+ - A rounded head called a **scolex**
		- Flat body of multiple segments called proglottids
* The scolex has specialized means of attaching to the intestinal wall-suckers, hooks, or sucking grooves
* The worm grows by adding new proglottids from its germinal centre next to the scolex.
* The oldest proglottids at the distal end are gravid and produce many eggs, which are excreted in the feces and transmitted to various intermediate hosts such as cattle, fish, and pigs.
* Humans acquire the infection when undercooked flesh containing the larvae is ingested.
* Two important diseases caused by **cestodes** (tapeworms)
	+ - **Hydatid disease**
		- **Cystercosis**
* **There are four medically important cestodes**
* ***Taenia solium*** - causes cystercosis (human)
* ***Taenia saginata*** - cause cystercosis (in other animals not human)
* ***Diphyllobothrium latum*** (lives in fish) - causes diphyllobothriasis
* ***Echinococcus granulosus*** (dogs definitive host, sheep intermediate host) - causes echinococcosis (hydatid cyst).
* Trematoda (flukes) and cestoda (tapeworm) are the two large classes of parasites in the phylum platyhelminthes.
* The most important trematodes are:-
* **Schistosoma species**-blood flukes (schistosomiasis) e.g *Schistosoma mansoni*, *Schistosoma japonicum* (gastrol interstinal tract), *Schistosoma haematobium* - urinary tract.
* **Clonorchis sinensis** - liver fluke (cause clonorchiasis)
* **Paragonimus westerman** - lung fluke (cause paragonimiasis)
* Schistosomiasis have the greatest impact in terms of the number of people infected, morbidity, and mortality.
* The lifecycle of the medically important trematodes involves sexual cycle in humans (definitive host) and asexual reproduction in fresh water snails (intermediate host).
* Transmission to humans takes place either through penetration of the skin by the free-swimming cercariae of the schistosomes or through ingestion of undercooked (raw) fish or crabs in clonorchis and paragonimus infection,respectively.

**NEMATODES (NEMATHELMINTHES)**

Nematodes are round worms with a cylindrical body and complete digestive tract including the mouth and an anus.

The body is covered with a non-cellular, highly resistant coating called a cuticle.

Nematodes have separate sexes;-female usually larger than male. The male has typically has a coiled tail.

Medically important nematodes are divided into two categories according to their primary location in the body of the host:

* + - **Intestinal nematodes**
		- **Tissue nematodes**

**Intestinal Nematodes**

They spend the majority of their lifecycle in the bowel lumen and are classified as intestinal nematodes. Most of them are transmitted through contact with soil.

They include:

*Ascaris lumbricoides*, *Trichuris trichiura* (whipworm), *Ancylostoma duodenale* and *Necator americanus* (the two human hookworms), *Enterobius vermicularis* (pinworm), and *Strongyloides stercoralis*.

* ***Enterobius vermicularis* (pinworm) -** causes enterobiasis (human)
* ***Trichuris trichiura* (whipworm) -** causes trichuriasis (human); may cause diarrhea and rectal prolapse in children.
* ***Ascaris lumbricoides* (giant round worm) -** causes ascariasis (human)
* ***Necator americanus***
* ***Ancylostoma duodenale* (the two hookworm)**
* ***Strongyloides stercoralis* (small roundworm) -** causes strongyloidiasis

Tissue Nematodes

* The important tissue nematodes include:-
* ***Wuchereria bancrofti*** - causes lymphatic filariasis (elephantiasis); - transmitted by female a mosquito anopheles and culex.
* ***Onchocera volvulus*** - causes onchoceriasis; - transmitted by black fly
* ***Loa loa*** - causes loasis; - transmitted by deer fly (mango fly)
* The three are called filarial worms because they produce motile embryos called microfilariae in blood and tissue fluids.
* A fourth species is the guinea worm - ***Drucunculus medinensis*** whose larvae inhabit tiny crustaceans (copepods) and are ingested in drinking water.
* Nematodes cause disease as a result of presence of adult worms within the body.
* ***Trichinella spirallis*** causes Trichinellosis