ARULMIGU PALANIANDAVAR ARTS COLLEGE FOR WOMEN
(AUTONOMOUS)

PG DEPARTMENT OF ZOOLOGY

LEARNING RESOURCES

MICROBIOLOGY

INTRODUCTION TO MICROBIOLOGY

Although it may seem niche, microbiology is one of the most significant branches of biology. Microbiologists play an important role in disease prevention, the development of agrochemicals, and even the preservation of the environment by closely analysing microorganisms. Here, the discipline is utilised to learn about every part of the organisms in order not only to understand how they exist in their environments but also how they affect their individual surroundings and, in turn, other organisms nearby (human beings, animals, etc.). Microbiology has consistently proved to be one of the most significant fields in biology, making it possible to define how some microorganisms cause diseases, discover treatments for such diseases and even use a few microbes for industrial applications etc. The majority of the natural elements on the earth contain microorganisms. All living things, including humans, plants, and animals, are intimately connected to the microbes that consistently recycle important nutrients like carbon and nitrogen, break down organic matter, and influence our daily lives.

Microbiology is the study of microscopic organisms, or living things, that are too small to be seen with the naked eye. These living organisms can only be observed under a microscope, and they are referred to as microbes or microorganisms. Bacteria, viruses, archaea, protozoa, microscopic yeasts and fungi, and microscopic algae are all examples of microorganisms. Characteristics of these microorganisms, including their evolution, behaviour, biochemistry, ecology, and physiology, as well as the pathophysiology of the diseases they cause, are addressed by microbiology research. These microbes are essential for the biotechnological process as well as for the cycling of nutrients, biodegradation, food spoilage, climate change, and the cause and treatment of various diseases. Scientists estimate that 2 to 3 billion species coexist with humans on the earth, and they make up more than 60% of its living matter. Some microbes also break down organic matter and recycle nutrients like carbon and nitrogen, which are essential for life. They can be used in various processes, including the production of biofuels, removal of pollution, and manufacture or processing of food and beverages. The following paragraphs will discuss several areas wherein microbiology is extremely significant.

Useful Microorganisms and Harmful Microorganisms

In an environment, bacteria and fungi serve as essential decomposers. They release inorganic molecules as they decompose trash or dead organic matter. Green plants absorb these nutrients, which are then consumed by animals, and the byproducts of these plants and animals are then broken down by decomposers. A single-celled fungus called yeast naturally inhabits the fruit's surface. It is commercially significant in the production of bread, beer, yoghurt etc. Microorganisms are multicellular and lack differentiated tissues; thus, they are generally unicellular. Microorganisms cause disease and decay because neither of these alterations is an inherent characteristic of organic objects. Numerous microorganisms are known to enter human bodies and cause a variety of diseases in cattle, crops, and other animals. Examples of well-known human diseases include: Bacteria: Bacterial Dysentery, Pneumonia, Diphtheria, Typhoid, Cholera, Meningitis, Salmonella, Meningococcal, Bubonic Plague. Virus: Chickenpox, German Measles, Measles, Mumps, Warts, Cold Sores, Influenza.Protozoa: Amoebic Dysentery, Malaria.Fungi: Athlete's Foot and Ringworm

Importance of Microbiology

There are several ways in which microorganisms benefit the earth. Apart from those that threaten us, there are those who play a vital role in maintaining the health of our ecosystem. Here are some of these important benefits explained. Importance of Microbiology in the Pharmaceutical Industry-One of the most significant contributions of microbiology to the pharmaceutical industry is the discovery of antibiotics. Microorganisms produce antibiotics as a metabolic byproduct. Another significant microbiological discovery is the vaccine, which prevents viral infection. For instance, the polio vaccine helps in the eradication of polio worldwide. Another pharmaceutical item produced by microbes is steroids. Other significant advancements in the field of microbiology include the prevention of microbial contamination of medications, injectables, eye drops, nasal sprays, and inhalation products.

Importance of Microbiology in Medicine and Science-Cells in both humans and animals can profit from and be harmed by microorganisms. Viruses, bacteria, fungi, and parasites are some of these microbes. Microbiology in medicine is significant for a number of reasons. Microbiologists are able to recognise, isolate, diagnose, and prevent harmful bacteria due to

their expertise in medical microbiology. They can also create antibacterial medications by genetically engineering advantageous microbes. A good example of medical microbiology that assists in the prompt detection of pathogens in tissue specimens is fluorescent fusion.

Importance of Microbiology in the Field of Biotechnology-There are many applications for microorganisms in biotechnology. Microbes are used in fermentation to break down complicated organic materials to produce organic acids, ethanol, vinegar, and fermented meals. In molecular biology and recombinant DNA technology, microbes, such as viruses, are utilised as a source of molecular vectors like plasmids, phagemids, and cosmids. In bioremediation, organic wastes are broken down by microbes to eliminate hydrocarbons and organic compounds from sewage water. Bioleaching and biomining are two processes that microbiologists use to extract metals or heavy metals from their ore. Enzymes, organic acids, vitamins, amino acids, antibiotics, and polysaccharides are additional metabolic products produced by microorganisms for commercial purposes.

Importance of Microbiology in the Food Industry-Bacteria, yeasts, and moulds are a few of the microbes that are involved in food microbiology. Bacteria primarily cause food poisoning and food deterioration, which leads to various disorders affecting the human gastrointestinal tract. A variety of foods and dairy products are produced using different bacterial strains. These bacterial strains include *Lactobacillus Bulgaricus*, *Bifidobacterium sp.* and *Streptococcus Thermophiles*.A few microorganisms, such as bacteria and viruses, are used to control pests that damage agricultural crops. Consequently, they are known as natural pesticides. They are so particular to pests or insects and do not affect humans, animals, plants, or other living things.Nisin, an antibacterial substance used in cheese, meats, and beverages to prolong shelf life by inhibiting the growth of undesirable bacteria, is an example of microbiology employed in the food sector.

Importance of Microbiology in the Environment-Environmental microbiology is the study of the composition and biology of microbial communities in natural environments. It is applied to the degradation of oil. Although it is difficult to address oil spills in coastal areas and the open sea, a significant amount of the oil can be removed by the hydrocarbon-degrading activities of microbial populations, particularly the Hydrocarbon clastic bacteria (HCB). These species can contribute to the ecological restoration of maritime environments that have been affected by oil contamination. It is also used to degrade aromatic compounds. Isolated environmental *Acinetobacter* strains are capable of degrading a variety of aromatic

compounds. Importance of Microbiology in Chemical Substances-Microorganisms are used to manufacture a wide range of industrial chemical products. Acetaldehyde, acetoacetic acid, acetic acid, ethanol, butanol, galactose, fructose, glycerol, mannitol, lactic acid, mannose, sorbose, succinic acid, and pyruvic acid are some of these products. These compounds are produced by various microorganisms, including *Aerobacter aerogenes*, lactic acid bacteria, acetic acid bacteria, butyric acid bacteria, propionic acid bacteria, and *E. coli*.

Importance of Microbiology in Biofuel-Biomethane can be produced by anaerobic digestion of microalgae biomass, and ethanol can be produced by fermenting carbohydrates. Biofuel can also be produced from extracted microalgae oil. A significant source of oil content for the manufacturing of biodiesel is microalgae. Additionally, they have higher levels of lipids, which are used as an initial point for the synthesis of biodiesel. Large amounts of cellulose, starch, mannitol, agar, and laminarin found in microalgae are fermented to alcohol (ethanol and butanol). *Chlorella*, *Dunaliella*, *Chlamydomonas*, *Spirulina*, and *Scenedesmus* are among the microalga in this group.

Importance of Microbiology in Everyday Life -In our daily lives, microbiology is used and has a significant impact. Microbiology is used in many aspects of daily life, including food production, biodegradation, the manufacture of commercial goods and genetic engineering. They are required in a variety of dishes. Microorganisms, for instance, are required for the production of curd and cheese.The lactose sugar in milk is converted to lactic acid by a bacterium known as *Lactobacillus*, turning milk into curd. Yeast can also be used to make bread, while bacteria are necessary when manufacturing yoghurt. Additionally, only the microorganisms in the human body can manufacture vitamin K.

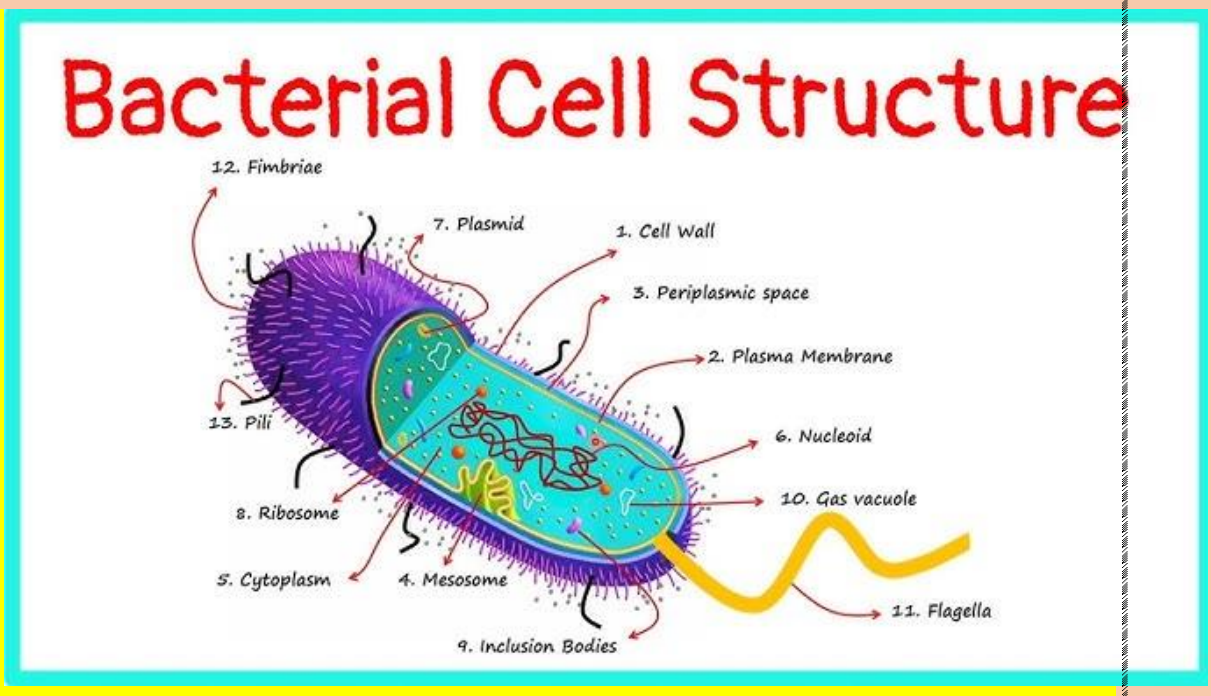
In order to improve and broaden our fundamental understanding of microorganisms, the science of microbiology investigates their morphology, physiology, metabolism, reproduction, and genetics. This is how microbiology contributes significantly to several industries. In the coming years, we will witness a wide range of further applications of microbiology that will be extremely advantageous for us in every way.

BACTERIA

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

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 Thermophiles, Acidophiles, Alkaliphiles, Osmophiles, Barophiles, 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.

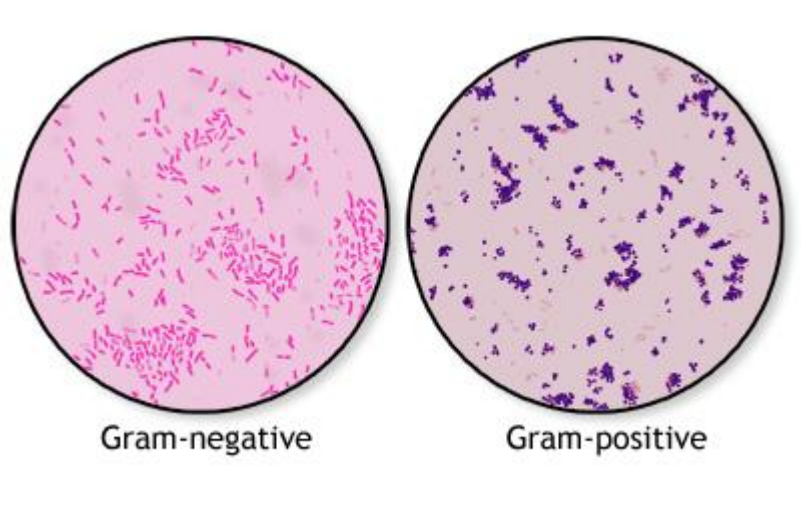
Ribosomes are the sites of protein synthesis. In addition to this DNA, they have an extra circular DNA called plasmid. These plasmids make some strains of bacteria resistant to antibiotics. Gram negative bacteria are the genus of bacteria family and a member of the phylum Firmicutes. They are the group of aerobic bacteria which does not retain the crystal violet dye during the procedure of Gram staining and appear pink in colour when examined under the microscope. There are several gram-negative bacteria with medical significance. The most important of these are members of the family Enterobacteriaceae. Further genera of Gram-negative bacteria include *Vibrio*, *Campylobacter*, *Pseudomonas*, and other bacteria which are normally found in the gastrointestinal tract. General Characteristics of Gram-Negative Bacteria

The gram-negative bacteria have the following characteristics: The cell wall is thin without an outer layer. A high percentage of lipids can be found. It contains all types of amino acids. The muramic acid content is less. It is sensitive to streptomycin. It is devoid of magnesium ribonucleate and teichoic acid. It contains lipopolysaccharides, sialic acid, and flagella. The cell wall of Gram-negative bacteria is thin and is composed of peptidoglycan. The cell envelope has 3 layers including, a unique outer membrane, a thin peptidoglycan layer, and the cytoplasmic membrane. An outer membrane of the cell wall is a bilayer structure consisting of phospholipids molecules, lipopolysaccharides (LPS), lipoproteins and surface proteins. Endotoxin is toxins released by the cell during infections and function as receptors and blocking immune response. The porin proteins are present in the upper layer of a cell which functions by regulating the entry and exit of the molecules within the cell.

Gram Negative and Gram Positive Bacteria

The diseases caused by gram negative bacteria are diarrhoea, inflammatory disease of the large intestine, infantile diarrhoea, kidney damage, typhoid fever, bubonic plague, cholera etc. Gram-positive bacteria are the genus of the bacteria family and a member of the phylum Firmicutes. These bacteria retain the colour of the crystal violet stain which is used during gram staining. These bacteria give a positive result in the Gram stain test by appearing purple coloured when examined under a microscope, hence named, gram-positive bacteria. Actinomyces, *Clostridium*, *Mycobacterium*, Streptococci, Staphylococci, and *Nocardia* are a

few examples of Gram-positive bacteria. Characteristics of Gram-Positive Bacteria. They have a thick peptidoglycan layer and cytoplasmic lipid membrane. These bacteria lack an outer membrane. Have a lower lipid content and more teichoic acids. They move around with the help of locomotion organs such as cilia and flagella. The walls of *Staphylococcus aureus* and *Streptococcus faecalis* contain teichoic acid.



The composition of a gram-positive bacteria cell wall includes:

Peptidoglycan

It is a permeable, cross-linked organic polymer and rigid structure which plays an important role in providing shape and strength to the cell wall. It makes up about 90% of the cell wall enclosing the plasma membrane and protects the cell from the environment. Peptidoglycan is composed of three main components including Glycan backbone, Peptide, and Tetra-peptide.

Lipid

The lipid element found in the gram-positive bacteria cell wall supports its anchoring to the membrane. The total percentage of lipid content in a gram-positive bacterium cell wall is 2 – 5 per cent.

Teichoic acid

It is water-soluble and a polymer of glycerol. Teichoic acid is the major surface antigen of gram-positive bacteria and it makes up about fifty per cent of the total dry weight of the cell wall.

Benefits of Gram-Positive Bacteria- These species of bacteria are non-pathogenic and reside within our body including the mouth, skin, intestine, and upper respiratory tract. They are an essential ingredient in producing Emmentaler or Swiss cheese. The species of Corynebacterium are used in the industrial production of enzymes, amino acids, nucleotides, etc. Various Bacillus species are used in the secretion of large quantities of enzymes. A few species of gram-positive bacteria are also involved in cheese ageing, bioconversion of steroids, degradation of hydrocarbons, etc. *Bacillus amyloliquefaciens* of gram-positive bacteria are a good source of a natural antibiotic protein – Barnase. The substantial increase in skin and mucous infections in all humans are caused by staphylococcal species. These organisms are mainly transmitted through skin contact, fomite contact, inhaling infected aerosolized particles, by pets, etc. Other risk factors include food poisoning, Respiratory Diseases, tooth cavities, Diphtheria, Mycobacterium tuberculosis, etc.

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. 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)

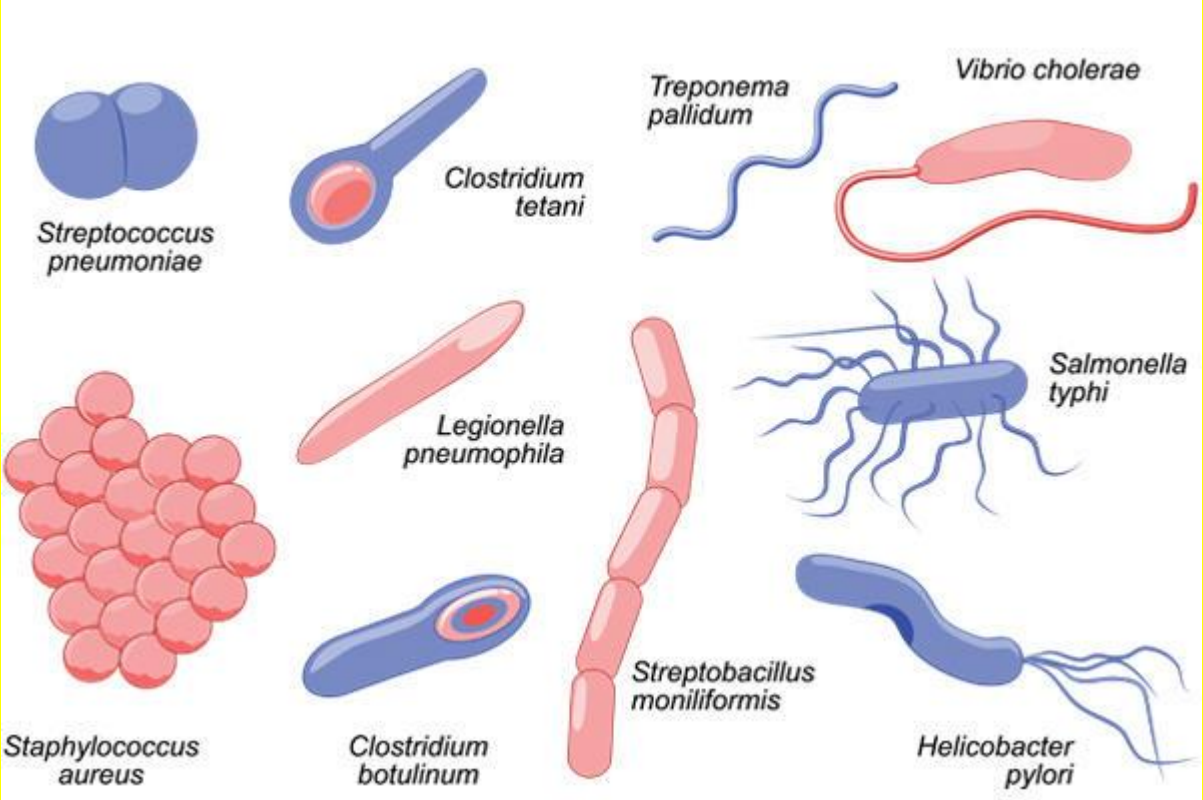
Not all bacteria are harmful to humans. There are some bacteria which are beneficial in different ways. Listed below are few benefits of bacteria: Convert milk into curd – Lactobacillus or lactic acid bacteria.Ferment food products – Streptococcus and Bacillus .Help in digestion and improving the body's immunity system – Actinobacteria, Bacteroidetes, Firmicutes, Proteobacteria. Production of antibiotics, which is used in the treatment and prevention of bacterial infections – Soil bacteria.

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, disinfect. Bacteria can be divided into several types based on several characteristics such as shape, cell wall composition, mode of respiration, and mode of nutrition. Bacteria are prokaryotic unicellular organisms. They have a relatively simple cell structure compared to eukaryotic cells. They also do not possess any membrane-bound organelles such as a nucleus. However, do they possess genetic material (DNA or RNA) in the intracellular space called the nucleoid. Bacteria reproduce through a process called binary fission. In this process, a single bacterium divides into two daughter cells. These daughter cells are identical to the parent cell as well as to each other.

Bacteria are microbes with a cell structure simpler than that of many other organisms. Their control centre, containing the genetic information, is contained in a single loop of DNA. Some bacteria have an extra circle of genetic material called a plasmid rather than a nucleus. The plasmid often contains genes that give the bacterium some advantage over other bacteria. For example it may contain a gene that makes the bacterium resistant to a certain antibiotic.

Bacteria are classified into five groups according to their basic shapes: spherical (cocci), rod (bacilli), spiral (spirilla), comma (vibrios) or corkscrew (spirochaetes). They can exist as single cells, in pairs, chains or clusters.

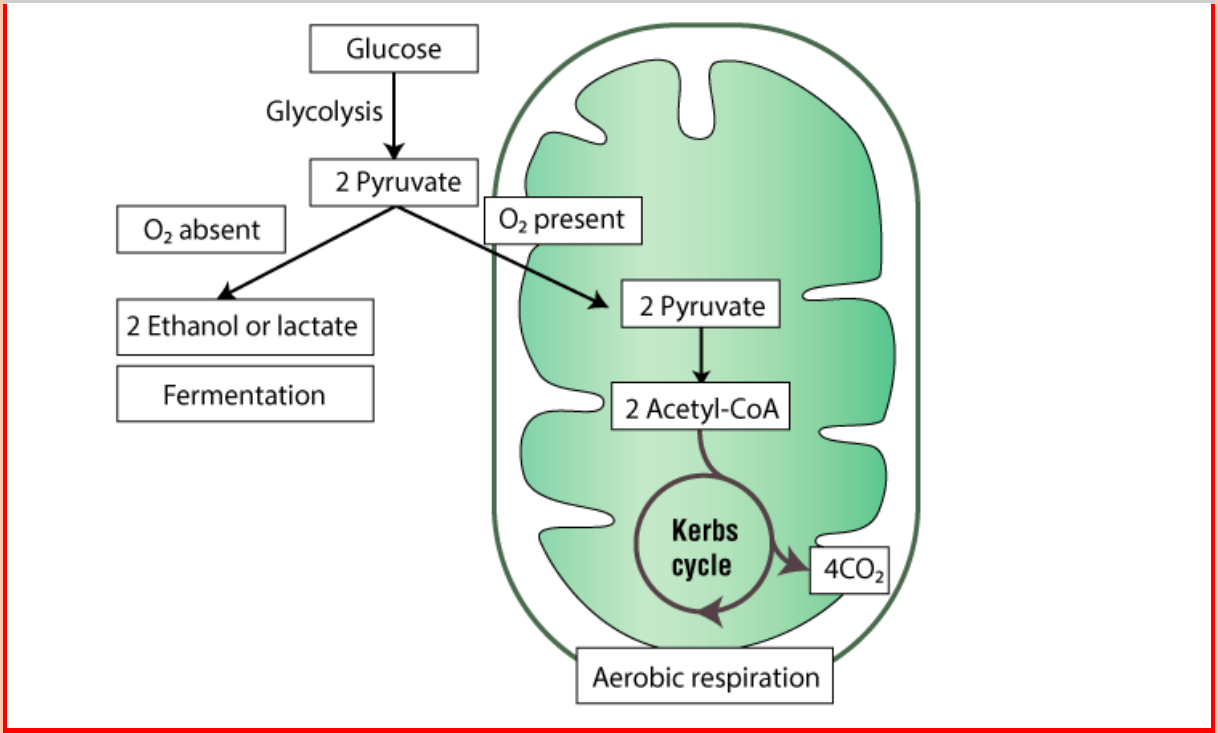


Bacteria are found in every habitat on Earth: soil, rock, oceans and even arctic snow. Some live in or on other organisms including plants and animals including humans. There are approximately 10 times as many bacterial cells as human cells in the human body. A lot of these bacterial cells are found lining the digestive system. Some bacteria live in the soil or on dead plant matter where they play an important role in the cycling of nutrients. Some types cause food spoilage and crop damage but others are incredibly useful in the production of fermented foods such as yoghurt and soy sauce. Relatively few bacteria are parasites or pathogens that cause disease in animals and plants. Most bacteria reproduce by binary fission. In this process the bacterium, which is a single cell, divides into two identical daughter cells. Binary fission begins when the DNA of the bacterium divides into two (replicates). The bacterial cell then elongates and splits into two daughter cells each with identical DNA to the parent cell. Each daughter cell is a clone of the parent cell.

When conditions are favourable such as the right temperature and nutrients are available, some bacteria like *Escherichia coli* can divide every 20 minutes. This means that in just seven hours one bacterium can generate 2,097,152 bacteria. After one more hour the number of bacteria will have risen to a colossal 16,777,216. That's why we can quickly become ill when pathogenic microbes invade our bodies. Some bacteria can form endospores. These are dormant structures, which are extremely resistant to hostile physical and chemical conditions such as heat, UV radiation and disinfectants. This makes destroying them very difficult. Many endospore-producing bacteria are nasty pathogens, for example *Bacillus anthracis*, the cause of anthrax.

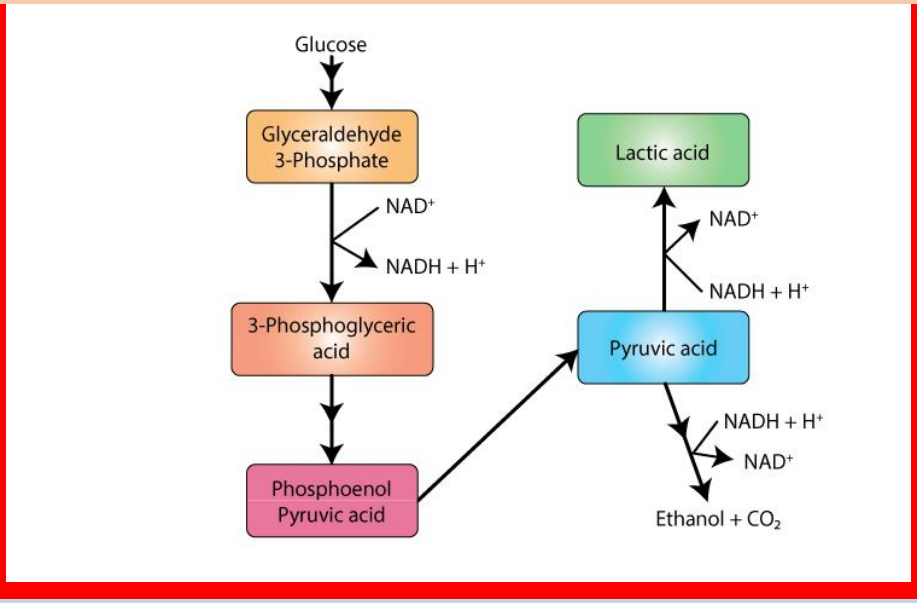
FERMENTATION

All living organisms get the energy required to perform cellular functions by respiration. In most of the animals, respiration occurs in the presence of oxygen (aerobically). Some organisms like bacteria, yeast, etc. can produce energy in the absence of oxygen (anaerobically). Fermentation is an enzyme catalysed, metabolic process whereby organisms convert starch or sugar to alcohol or an acid anaerobically releasing energy. The science of fermentation is called “zymology”.



Process of Fermentation

Fermentation is an anaerobic biochemical process. In fermentation, the first process is the same as cellular respiration, which is the formation of pyruvic acid by glycolysis where net 2 ATP molecules are synthesised. In the next step, pyruvate is reduced to lactic acid, ethanol or other products. Here NAD+ is formed which is re-utilized back in the glycolysis process.



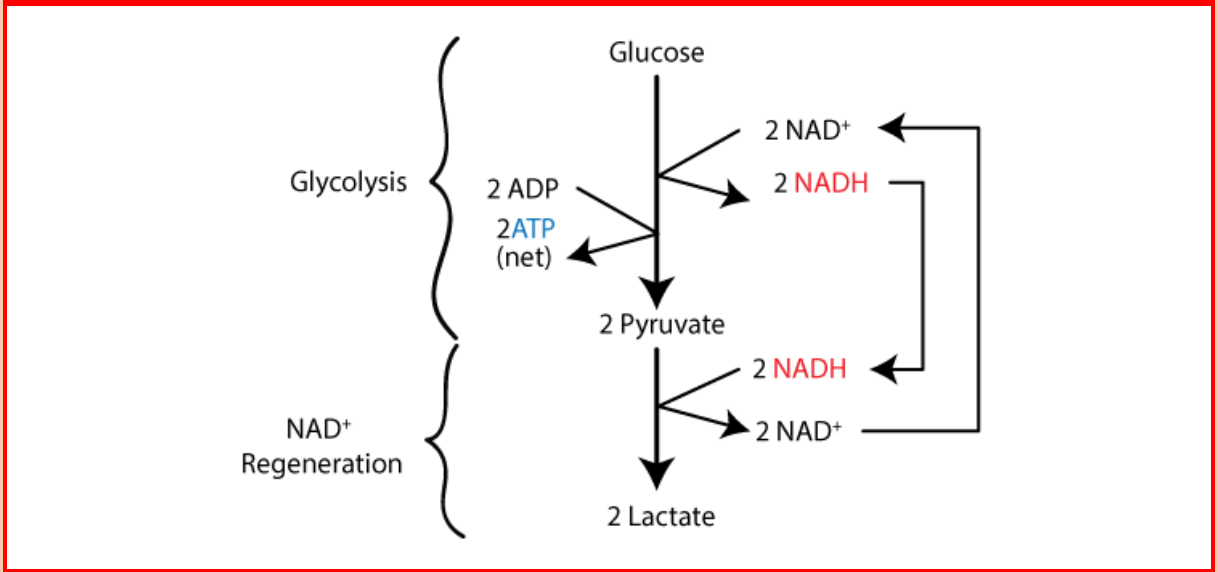
Types of Fermentation -Homo fermentation: only one type of product formation, Hetero fermentation: more than one product formed

On the basis of the end product formed, fermentation can be categorized as follows:

1. Lactic Acid Fermentation

Lactic acid is formed from pyruvate produced in glycolysis. NAD+ is generated from NADH. Enzyme lactate dehydrogenase catalyses this reaction. Lactobacillus bacteria prepare curd from milk via this type of fermentation. During intense exercise when oxygen supply is inadequate, muscles derive energy by producing lactic acid, which gets accumulated in the cells causing fatigue.

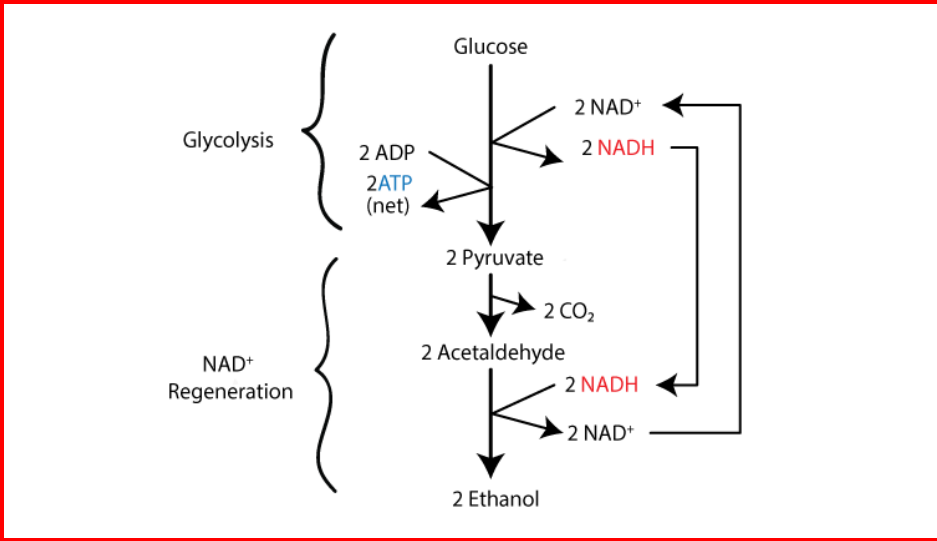
$$C_6H_{12}O_6(Glucose) \xrightarrow[Lactate\ dehydrogenase]{Lactobacillus} 2CH_3CHOHCOOH(Lactic\ Acid)$$



2. Alcohol Fermentation

This is used in the industrial production of wine, beer, biofuel, etc. The end product is alcohol and CO_2. Pyruvic acid breaks down into acetaldehyde and CO_2 is released. In the next step, ethanol is formed from acetaldehyde. NAD+ is also formed from NADH, utilized in glycolysis. Yeast and some bacteria carry out this type of fermentation. Enzyme pyruvic acid decarboxylase and alcohol dehydrogenase catalyse these reactions.

$$C_6H_{12}O_6(Glucose) \xrightarrow[Decarboxylase]{Dehydrogenase} 2CH_3CHO(Acetaldehyde) + 2CO_2 \rightarrow 2C_2H_5OH(Ethanol)$$



3. Acetic acid Fermentation

Vinegar is produced by this process. This is a two-step process.

The first step is the formation of ethyl alcohol from sugar anaerobically using yeast.

In the second step, ethyl alcohol is further oxidized to form acetic acid using acetobacter bacteria. Microbial oxidation of alcohol to acid is an aerobic process.

$$C_2H_5OH(ethanol) + O_2 \xrightarrow{acetobacter} CH_3COOH(acetic\ acid) + H_2O$$

4. Butyric acid Fermentation

This type of fermentation is characteristic of obligate anaerobic bacteria of genus clostridium. This occurs in retting of jute fibre, rancid butter, tobacco processing and tanning of leather. Butyric acid is produced in the human colon as a product of dietary fibre fermentation. It is an important source of energy for colorectal epithelium. Sugar is first oxidized to pyruvate by the process of glycolysis and then pyruvate is further oxidized to form acetyl-CoA by the oxidoreductase enzyme system with the production of H_2 and CO_2. Acetyl-CoA is further reduced to form butyric acid. This type of fermentation leads to a relatively higher yield of energy. 3 molecules of ATP are formed.

$$C_6H_{12}O_2 \xrightarrow[butyricum]{clostridium} C_4H_8O_2 + 2CO_2 + 2H_2$$

Fermentation is suitable for all kinds of environments. It is one of the oldest metabolic processes which is common to prokaryotes and eukaryotes. Fermentation is widely used in various industries.

Using suitable microorganisms and specified conditions different kinds of fermentation products are formed namely: -Wine, Beer, Biofuels, Yoghurt, Pickles, Bread, Sour foods containing lactic acid, Certain antibiotics and vitamins.

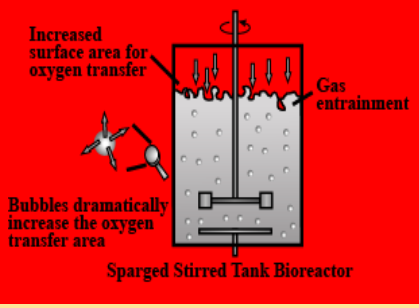
Fermentation can make food nutritious, digestible, and flavoured. There are many benefits of consuming fermented food. It improves digestion and helps to maintain intestinal bacteria. It has an anti-cancer effect. Improves immune system. Reduces lactose intolerance. Other than the food industry, there are many other areas where the fermentation process is used. Methane is produced by fermentation in sewage treatment plants and freshwater sediments.

Fermentors, also known as bioreactors, are sterilised and enclosed vessels that are used for the growth of microorganisms under optimal conditions. The microorganisms can be grown in large quantities to produce metabolites for commercial uses. Fermentors are equipped with special components for heating, mixing, and aeration. Its volume can be as big as 500,000 litres for an industrial scale, or as small as 1 litre for laboratory uses.

Different Types of Fermentors

Continuous Stirred-Tank Fermentor-The continuous

stirred-tankreactor (CSTR) is composed of a vessel with pipes, pumps, valves, agitator, motor, shaft, and impeller(s).



The shaft is situated at the

bottom of the tank, and the number of impellers

depends on the

size of the bioreactor. In this type of fermentor, a structure

called sparger is found that keeps adding air to the culture

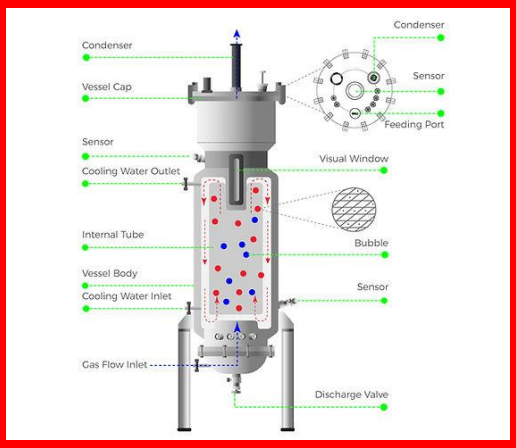
medium. It is a ring-like structure with many holes.

The sparger, along with the impellers, distribute gas in

the entire vessel. The impellers break the bubbles into smaller ones that are homogeneously distributed in the bioreactor.

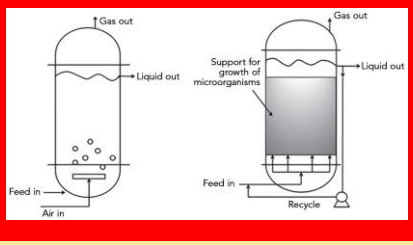
Airlift Fermentor - The airlift bioreactors contain a baffle or a draft tube in the middle through which air is pumped into the vessel. There are two types of airlift fermentors: Internal loop airlift bioreactor: It has a single central draft tube that provides inner circulation channels. External loop airlift bioreactor: It contains external loops that separate the liquids flowing into independent channels.

Airlift Fermentor



Packed Bed Fermentor- In a packed bed fermentor, a hollow tube or pipe is packed with a biocatalyst. The bed is immobile in nature. The culture medium flows through the biocatalyst, which produces the metabolites continuously in the broth. These bioreactors are easy to operate but are often blocked due to poor oxygen circulation.

Packed Bed Fermentor

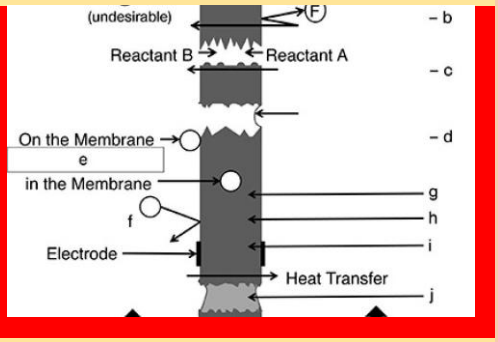


Fluidised Bed Fermentor - In this type of reactor, a solid granular bed that is usually made up of a biocatalyst is present. The fluid, that is, liquid or gas, is passed through the solid bed at high speeds, such that the suspended solid behaves like a fluid. This type of fermentor is used for microbial flocs, immobilised cells, and enzymes.

Membrane Fermentor - Membrane bioreactors work in conjugation with ultrafiltration and microfiltration. This type of fermentor is used for the biological treatment of wastewater. There are two types of membrane bioreactors: Submerged membrane bioreactor: In this type

of fermentor, the membrane is found inside the vessel submerged in the wastewater. Side-stream membrane bioreactor: In this type of fermentor, the membrane is found outside the reactor and filtration by the membrane is an additional step in the whole process.

Bubble Column Fermentor- A bubble column fermentor is equipped with a cylindrical column that is filled with liquid, and gas is inserted into it from the bottom. It is vertically arranged, such that the introduction of gas from the bottom creates a turbulent stream and allows optimum gas exchange. The sparger mixes the contents of the vessel. The liquid flows either in a parallel direction or in a counter-current direction.



The metabolic process that induces chemical changes in organic substrates by the action of enzymes is known as fermentation. It uses microorganisms such as bacteria, algae and fungi. The use of this process on a large scale to produce pharmaceuticals, enzymes and proteins is known as industrial fermentation.

Media Requirements

To obtain a good product from fermentation, the medium in which the microorganisms are grown must be supplied with enough energy sources and nutrients. Several factors must be kept in mind before designing or choosing the growth medium for fermentation. To obtain primary metabolites such as citric acid and ethanol, the media should be rich in components that support good growth. Similarly, for secondary metabolites such as alkaloids and antibiotics, the substrate requirement for product formation must be kept in mind.

While doing fermentation on a small scale, such as in laboratories, pure graded chemicals are used that are expensive. However, in large scale industrial fermentation, cheaper and unrefined chemicals are used. Therefore, the choice of media for fermentation is a crucial step that requires a lot of thought processes.

The fermentation media can either be liquid, known as broth, or it can be a solid-state fermentation. The media should satisfy all the nutritional requirements of the microorganism and should also obtain the target molecule. A typical media requires a carbon source, a nitrogen source, salts, water and micronutrients.

Carbon Source

Typically sugars and carbohydrates are used as carbon sources, but alcohols may also be used in making products such as vinegar. For laboratory uses, refined and pure carbon sources such as glucose, sucrose and glycerol are used that give a uniform product. However, in the case of industrial fermentation, inexpensive sources such as whey, malt extract, molasses, corn steep liquor or sugar cane juice are used.

Nitrogen Source

The nitrogen source for microorganisms may be used in the form of organic or inorganic compounds. Inorganic sources include ammonium salts or the free form of ammonia. Inexpensive nitrogen sources are used for bulk production, such as tryptone, peptone, soy meal, corn steep liquor and yeast extract.

Growth Factors

Trace salts and growth factors are important components in the fermentation media. Yeast extract is a good source of vitamins and macronutrients. Trace elements such as copper, zinc, iron, cobalt, molybdenum, manganese are all usually found in the unrefined nitrogen sources but may need to be added when using pure sources.

Miscellaneous

The process of fermentation sometimes produces a large amount of gas that forms a layer of foam and hinders the process. To get rid of this problem, antifoaming agents are also added to the fermentation medium. To stabilise pH of the media, mineral buffering salts such as phosphates and carbonates are also added. The addition of chelating agents may also be required when high concentrations of metals are present in the media.

Optimisation of the Fermentation Medium

Optimisation is the process of developing a fermentation medium that gives the best quality and quantity of the target product. One of the most common methods to optimise a media is to optimise one factor at a time (OFAT). In this method, only one component of the media is changed while others are kept constant, and the results are observed. Similar observations can be done for all the components in a group of experiments, and the best optimised media can be prepared by analysing the results.

The metabolic process by which the skeletal muscles of humans, bacteria, and yeast produce energy (ATP) in the absence of oxygen. Fermentation is divided into ethanol fermentation and lactic acid fermentation. In ethanol fermentation (yeasts and some bacteria) the end

product of glycolysis is converted into ethanol and carbon dioxide. In lactic acid fermentation (skeletal muscles) the end product of glycolysis is converted to lactic acid.

Principle of fermentation:

Fermentation is based on the principle of Anaerobic respiration for deriving energy from the breakdown of carbohydrates such as glucose.

In this process, glucose is first broken to pyruvate by glycolysis.

The pyruvate is then converted to alcohol or lactic acid along with the regeneration of NAD^+

This process of anaerobic respiration produces only 5% of the energy obtained by aerobic respiration.

MICROBES AND DISEASES

Microbes are better known as microorganisms that are very tiny to be seen through naked eyes. Microbes that are harmful and capable of producing microorganism diseases are also termed pathogens. But not all microbes are harmful, and they do not cause microbial infection. Rather some are useful as well and serve in our everyday life. Hazardous microbes are responsible for creating human bacterial disease and microbial diseases through various means and unhealthy practices. Microbes are unicellular organisms and can be located anywhere on this earth be it any place or in our bodies themselves. Typically, there are four major types of microorganisms that cause infection. They are bacteria, protozoa, fungi, and viruses. The pathogenesis of microorganisms is efficient in causing infections upon the hosts themselves. Pathogens are capable of causing many harsh diseases. Few disease examples of bacteria are rabies, malaria, cholera, and many more. Upon the invasion of these microorganisms, the cellular activities are very likely to get disturbed. Thus, we can say microorganisms and diseases are directly proportional to each other.

here are many diseases caused by microorganisms most of which can have adverse effects on an individual. Even recent studies reveal that these tiny organisms can be indirectly responsible for creating non-infectious diseases as well that are mostly chronic such as cancer. The human bacterial disease is largely responsible for creating irritating health problems. Now, we shall discuss in detail some of the major problems that they can initiate and the way behind that, and the list of bacterial diseases.After reaching the targeted portion of the body they start to multiply very quickly. The microbes handle a counterattack from the immune system very efficiently and continue to affect the portion. Further, they pull out nutrients from the recipient's body as well. Microbes and diseases stay interconnected, and one needs to have much concern to prevent them. Microbes or microorganisms are minute, unicellular organisms that cannot be seen by naked eyes. Some microbes are useful in our day-to-day life while others are harmful to our health. The harmful microorganisms are called pathogens.

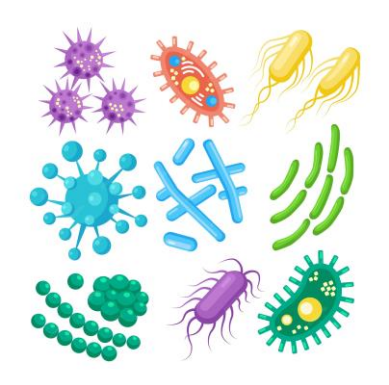
The diseases causing microorganisms include bacteria, viruses, protozoa, fungi and a few variations of worms. Once they invade the host cell, they disrupt or damage the normal cellular activities. This leads to diseases on a larger scale. There are several diseases caused by microorganisms. Let us have a look at a few of them. Viral diseases are caused by viruses. These include both acute and infectious diseases like the common cold, to chronic disease like AIDS. Apart from these acute diseases, viruses are also responsible for mumps, polio,

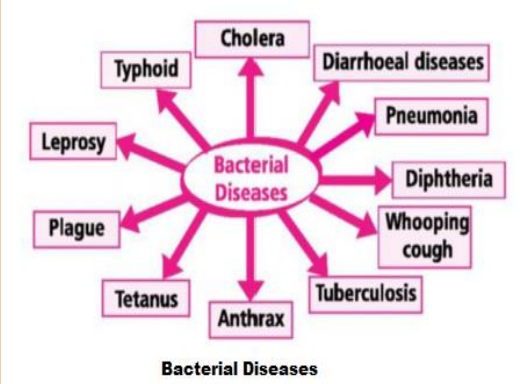
rabies etc. Diseases caused by bacteria include diphtheria, typhoid, cholera etc. Malaria and sleeping sickness are diseases caused by protozoa. Worms like roundworms, tapeworms could cause diseases like Ascariasis and Taeniasis respectively. The microorganisms cause diseases in the following ways: They reach their target site in the body. Multiply rapidly. Attach to the target site to be infected. Avoid and survive an attack by the immune system of the host. Obtain nutrients from the host.

Diseases caused by microorganisms transmitted through different sources are ample in number. One needs to have the right idea about them to take the needful precautions right on time. Studies say the list of bacteria diseases is on a rise and needs to have the right precautions taken. Here we will see those diseases caused by them, learn about parasitic microorganisms definition, and the treatments that can be adapted to prevent them.

Viruses are tiny organisms and are called parasites. A virus is known as a viral organism and hence the diseases transmitted through them are called viral diseases. They are capable of causing many infectious diseases putting serious effects on one's health. There are times when these microorganisms further have a release from the cell resulting in the death of the same. This closely establishes the relation between microorganisms and diseases. Viruses can be seen only through an electron microscope. They are inactive outside a living cell. Once they are inside the host body, they take over the entire cellular activities of the organism. They cannot be destroyed by antibiotics. Common cold, measles, mumps, smallpox are some of the diseases caused by viruses.

Bacteria- Not all bacteria cause diseases. The bacteria that infects an organism produces toxins that can cause diseases. Cholera, tuberculosis, anthrax are caused by bacteria. These can be killed by antibiotics.





Fungi -Fungi can grow in damp, moist areas on the body and lead to infections such as athlete's foot, ringworm, etc.

Protozoa -Protozoans such as amoeba cause diseases such as amoebic dysentery. Malaria and sleeping sickness is also caused by protozoans.

Following is the list of microorganisms and infectious diseases caused by them:

Diseases	Microorganisms
Cold	*Rhinovirus*
German Measles	*Rubella*
Chickenpox	*Varicella zoster*
Whooping cough	*Bardotella pertussis*
Bubonic plague	*Yersinia pestis*
Ringworm	*Trichophyton rubrum*
Tuberculosis	*Mycobacterium tuberculosis*
Malaria	*Plasmodium falciparum*
Athlete's foot	*Trichophyton mentagrophytes*

The sources and means of transfer of these infections are quite different. The sources through which the bacteria spread diseases is different from that of viruses. The main source of bacterial infection is contaminated food and water while viral diseases spread mainly through the air. Hence, bacterial and viral diseases are usually communicable. Other means of transfer of pathogens include direct physical contact i.e. blood transfusion, breastfeeding, sexual contact etc.Microbes enter our body through different sites: Respiratory tract, Urogenital tract, Gastrointestinal tract, Skin surface.Certain pathogenic diseases are organ or tissue-specific. For example, tuberculosis affects the lungs of the individuals while jaundice causing viruses target the liver.

There is the quote, 'prevention is better than cure'. Drugs like antibiotics or antibacterials are used to destroy or slow down the growth of bacteria. These antibiotics, however, are not effective for viral infections. The depth or severity of infection depends on the amount and

rate at which microbes spread. Microbes are tiny, microscopic organisms that live all around us and inside our bodies. Examples of microbes are bacteria, fungi, and protists. The “hygiene hypothesis” is a theory that suggests that our immune system needs to be exposed to certain microbes during childhood for the development of the immune system. some microbes can be harmful to humans, and some microbes can be beneficial. There are many different types of harmful microbes that can be transmitted through a variety of mediums. Some of the most harmful microbes known to man are Streptococcus Pyogenes, Escherichia Coli (E.Coli), Pseudomonas Aeruginosa. Microbes are tiny living beings that can be classified as bacteria, protists, or fungi. In the human body, they exist in large numbers and play a number of vital functions. However, some microbes are also known to be pathogenic and cause diseases in humans.

Diseases Caused by Microorganisms -Common types of flu-like influenza, Cough and cold, Rabies, Measles, Polio, Chickenpox, Rubella, HIV, HSV, HPV. In this regard, the diseases caused by microorganisms can be faced with the help of immunity systems as it is beneficial in clearing the infections. There are antiviral drugs available to fight infections like hepatitis C, HIV. There is evidence that some viruses can dwell lifelong in one's body and can rejuvenate further such as HSV. There are past examples as well as microbial infection being dismissed through treatments.

The bacterium or pathogenic bacteria, in particular, is responsible for the cause of human bacterial disease. The commonly noted or known ones among people are Diphtheria, cholera, etc, these are a few human diseases caused by bacteria. Billions of bacteria reside in the human body or intensities, and many are also denoted as "healthy bacteria" as they turn out to be positive for physical health. But there are harmful bacteria as well as capable of causing diseases. Even they are efficient to pour toxins that can readily work as a factor to damage the body. There are a number of harmful diseases caused by bacteria. Studies say there are at least 10 diseases caused by bacteria. Coliform Bacteria are mostly the cause of Urinary Tract Infections. Food poisoning due to bacterial pathogens. Cholera, Tetanus, Botulism, Anthrax, Lyme, Tuberculosis, Cough, Vaginosis due to bacterial attacks. Some examples of pathogenic bacteria are cryptosporidium, Salmonella, etc. These pathogenic bacteria examples can be really harmful to human health. The list of bacteria diseases is indeed long and in most cases, antibiotics are applied to get rid of it. Antibiotics can steadily disrupt the multiplication of bacteria and are capable of diminishing them completely. The type of bacteria pouncing upon your health is understood by the physician and they prescribe you as

per the need. There are instances of the misuse of these antibiotics resulting in adverse health issues.

Fungal Infections

The list of diseases caused by microorganisms and the carriers are innumerable in number existing on this planet. Fungi are among the types of microorganisms that cause infection lying all over the environment. They are basically yeasts and molds mostly found in patchy areas, soils, any moist places even in our washrooms. Normally molds can be detected but there are times when these microbes are extremely small and are impossible to be pointed out through naked eyes. All fungi aren't capable of harming you but there are some that can cause several diseases.

They are: Aspergillosis, Histoplasmosis, Yeast infections, Infections like meningitis, Thrush, Ringworm. Similar to the list of bacteria disease the fungal disease can be battled with antifungal medicines. The treatment depends on the type of fungi the human body is carrying. There are antifungal creams available in the market as well.