CELL BIOLOGY

UNIT I: CELL AS A BASIC UNIT OF LIVING SYSTEMS AND CELLULAR ORGANELLS

Introduction: -Biotechnology is defined as the 'application of scientific and engineering principles to the processing of material by biological agents to provide goods and services. A technique that used living organisms to make or modify a product, to improve plants or animals or to develop microorganisms for specific uses.

Biotechnology is the applied science and has made advances in two major areas, viz., molecular biology and production of industrially important bio-chemical. The scientists are now diverting themselves toward biotechnological companies; this has caused the development of many biotechnological industries.

In USA alone more than 225 companies have been established and successfully working, like Biogen, Cetus, Genentech, Hygrotech, etc. In world, USA, Japan, and many countries of Europe are leaders in biotechnological researchers encouraged by industrialists.

The advances in recombinant DNA technology have occurred in parallel with the development of genetic processes and biological variations. The development of new technologies have resulted into production of large amount of biochemically-defined proteins of medical significance and created an enormous potential for pharmaceutical industries.

Biotechnology in itself is a vast subject and its scope is extended to various branches of biology. This includes plant tissue culture, production of transgenic in animal and plants, applications in medicine as tools and therapeutics, creation of new enzymes and their immobilization for industrial use, development of monoclonal antibodies and control of pollutions, et

Scope of Biotechnology: -

1. **Genomics:** The molecular characterization of all genes in a species.
2. **Bioinformatics:** The assembly of data from genomic analysis into accessible forms, involving the application of information technology to analyze and manage large data sets resulting from gene sequencing or related techniques.
3. **Transformation:**

   The introduction of one or more genes conferring potentially useful traits into plants, livestock, fish and tree species.

   (iv) Genetically improved organism.

   (v) Genetically modified organism (GMO).

   (vi) Living modified organism (LMO)
4. **Molecular breeding:** Identification and evaluation of useful traits in breeding programs by the use of marker-assisted selection (MAS);
5. **Diagnostics:** The use of molecular characterization to provide more accurate and quicker identification of pathogens

6. **Vaccine technology:** -The use of modem immunology to develop recombinant deoxyribonucleic acid (rDNA) vaccines for improved control of livestock and fish diseases. Biotechnology consists of a gradient of technologies, ranging from the long-established and widely used techniques of traditional biotechnology to novel and continuously evolving modem biotechnology techniques

7.Drug Delivery: - These drug delivery systems are mainly used for drugs whose physical and chemical characteristics make them insufficiently stable in reaching their site of action intact

8.Livestock Breeding: Modern biotechnology is being employed commercially to introduce novel performance features in productive livestock. The transgenic specimens then display for example different wool characteristics for sheep, or improved milk characteristics in cattle.

9.**Green Biotechnology**:-Green biotechnology is the application of biotechnology processes in agriculture and food production. The main dominant forces in green biotechnology today are agro giants with a world-wide area of operation such as BASF, Bayer Crop-Science.

History of Biotechnology: -

Biotechnology in B.C. :- The Chinese use mouldy curds as an antibiotic to treat boils 250 BC: The Greeks practice crop rotation to increase soil fertility in 100 BC: Chinese use powdered as an insecticide

Pre-20th Century Biotechnology :-Robert Hook discovered in 1663, Robert Hooke discovers cells in 1675, Leeuwenhoek discovers bacteria and protozoa. Edward Jenner 1797inoculates a child with a viral vaccine to protect him from smallpox.

Pre-20th Century Biotechnology:-In 1830 Proteins, the building blocks of cells. The nucleus of the cell is discovered in1855: The E. coli bacterium is discovered in 1855: Pasteur works with yeast, eventually proving they are living organisms. 1863: Mendel discovers genes while working with peas. He lays the groundwork for genetics.

Pre-20th Century Biotechnology:- In1879: Flemming discovers chromatins.1883: The rabies vaccine is developed.1888: Waldner discovers the chromosome

Biotechnology In The First Part Of The 20th Century:- In1902: The term "immunology" first used 1906: The term "genetics" is used. 1915: Bacterial viruses, called phages, are discovered 1919: The word "biotechnology" is first used in 1927: Muller discovers that X-rays cause mutation • 1928: Fleming discovers penicillin 1938: The term "molecular biology" is used 1941: The term "genetic engineering" is first used

Biotechnology In the First Part Of The 20th Century :- In 1942: The electron microscope is used and characterizes viruses that infect bacteria, called bacteriophages In 1944: DNA is shown to be the building block of the gene. In1949: Pauling proves that sickle cell anemia is a "molecular disease" caused by a mutation

Biotechnology in the1950s and 1960s: In Watson and Crick understand the structure of DNA 1954: Cell-culturing techniques are first used. 1955: An enzyme involved in the production of a nucleic acid

is isolated .1956: The fermentation process is perfected1960: Messenger RNA is discovered 1961: The genetic code is understood

Biotechnology in the 1970s:- The DNA composition of humans is shown to be 99% similar to that of chimps and gorillasm.1977: Genetically-engineered bacteria are used to make human growth protein. 1978: North Carolina scientists, Hutchinson and Edgell, prove it is possible to introduce specific mutations at specific sites in a DNA molecule. In 1979: The first monoclonal antibodies are synthesized.

Biotechnology in the 1980s:- The U.S. Supreme Court approves the patenting of genetically-engineered life forms 1980: The U.S. patent for gene cloning is awarded to Boyer and Cohen. 1981: The North Carolina Biotechnology Centre is created—the 1st state-sponsored research centre for biotechnology. In 1981: The first genetically-engineered plant is reported • 1981: 1st mice to be successfully cloned. In 1982: Humulin, human insulin drug, produced by genetically-engineered bacteria (first biotech drug approved by the FDA)

Biotechnology in the 1990s :- 1990: The first federally-approved gene therapy treatment is performed successfully.1992: The structure of HIV RT is elucidated: The FDA declares that genetically engineered foods are "not inherently dangerous" 1994: The first breast cancer gene is discovered 1996: Scientists clone identical lambs from early embryonic sheep

Biotechnology in the 1990s:- 1998: Scientists clone three generations of mice from nuclei of adult ovarian cells .1998: Embryonic stem cells are used to regenerate tissue and create disorders that mimic diseases. 1998: The Biotechnology Institute is founded by BIO as an independent, national, 501(c)(3) education organization .1999: The genetic code of the human chromosome is deciphered

Biotechnology 2000 and Beyond :-2000: A rough draft of the human genome is completed 2000: Pigs are the next animal cloned by researchers to help produce organs for human transplant 2001: The sequence of the human genome is published in Science and Nature 2002: Scientists complete the sequence of the pathogen of rice, a fungus that ruins enough rice to feed 60 million people annually • 2003: Dolly, the cloned sheep from 1997.

CYTOLOGY: Cytology is a branch of biology that studies the structure and function of the cell which is the basic unit of life. Cell biology is concerned with the physiological properties metabolic processes, signalling pathways, life cycle, chemical composition and interactions of the cell with their environment. Cell biology is the study of the structure and functions of the cells. It is also called Cytology. It is a young branch of Biology. It started as an independent branch in 1893, when Hertwig made a clear distinction between cytology and histology. **Schwann is generally called the Father of Cell Biology** because he described the Morphology and Physiology of the cell for the first time.

HISTORY OF CELL THEORY: -The cell was first discovered and named by **Robert Hooke** in 1665.He observed plant cells (cork) in microscope and named it as **CELLS (Small rooms).** Robert Hooke in 1665 described the individual units of the honeycomb-like structure in cork under compound microscope. Landmarks in Cell Study

- Discovery of Cell: Cell was discovered by an English scientist Robert Hook in the year 1665. He published this information in his book **'Micrographia'**. He observed that dead cells in a thin cork slice in a self-made microscope. And this was the beginning of cell study and discovery.
- **Anton Von Leeuwenhoek** designed an improved microscope and observed first **free-living cells** (Bacteria) in the year.
- **Robert Brown** A Scottish Botanist discovered **nucleus** in the year 1831.
- A French Zoologist **Dujardin** discovered the semifluid living material inside a cell and named it **Sarcode**.
- Purkinje in the year 1840 renamed it as **'Protoplasm – The First Substance'**.

Schleiden in 1838 and **Schwann** 1839 formulated cell theory and summarized his observations as such:

Cell theory is a concept proposed by **Schleiden (1838) and Schwann** (1839) to explain the nature of cells. It states that

The three postulates of cell theory are the following:

- All living things are made of cells.
- The cell is the structural and functional unit of cell
- All cells come from pre-existing cells.

<u>Scope of Cell Biology:</u>

1.Studies of the cell structure, a very integral part of Cell Biology, is essential in Biotechnology research as the latter involves knowledge of cell structure of living cells in order to carry out cell therapeutics and related genetic studies

2.Cell and tissue culturing, an essential unit of cell biology inculcates knowledge and practice of the fundamental techniques involved in the growth of the cell type of interest. This is applied in biotechnology to nature cells of interest in preparation for Genetic studies.

3.Cell division in Cell Biology, is crucial in Biotechnological studies, when monitoring growth of Cancer cells for therapeutic purposes.

4. Cell physiology, studied in Cell Biology, helps Biotechnologists to understand the concept of Cell transport which they apply in Mutation studies to confirm how wild strains and mutants behave physiologically.

5.Biotechnologists apply the concept of Cell Death (a unit in Cell Biology) to study the effects of external and internal forces influencing the cell's life-maintaining signals, this therefore helps them know and appreciate the concept of cell apoptosis (programmed cell death).

CELL: Cell is a structural and functional unit of life. The term cell is derived from the Latin 'cella' means storeroom or chamber. Cells are the building blocks of organisms. Loewry and Siekevitz defined cell as a unit of a organism enclosed by plasma membrane and capable of self reproduction. The cell was first discovered and named by **Robert Hooke** in 1665.The cell is a living unit and cell residues in it.The cell possess a basic characters of life such as nutrition,locomotion,reproduction,irritability. **Antione van Leeuwenhoek** in 1674 described the algae spirogyra.

Functions of cells: -

- Cells make the body of a plant as animals.
- Life exists inside the cells.
- In unicellular organisms, a single cell does all the functions of the organism
- Cells eat, digest, respire, secrete and do all other functions.

Prokaryotes: -Prokaryotic cells fall into a size range of about 1–5µm and hence can be observed clearly by microscopes. However, some prokaryotic cells may be larger than this. Prokaryotes are single-celled organisms belonging to the domains Bacteria and Archaea. Prokaryotic cells are much smaller than eukaryotic cells, have no nucleus, and lack organelles. All prokaryotic cells are encased by a cell wall. Many also have a capsule or slime layer made of polysaccharide.

Prokaryotes often have appendages (protrusions) on their surface. Flagella and some pili are used for locomotion, fimbriae help the cell stick to a surface, and sex pili are used for DNA exchange. Most prokaryotic cells have a single circular chromosome. They may also have smaller pieces of circular DNA called plasmids.

Flagella:-Flagella are whip like structures made of protein and provide motility to the cell. Monotrichous – Cells that have one flagellum..Lophotrichus – Cells that have a clump of flagella known a tuft, at one end of the cell.Amphitrichous – Cells that have flagella at two ends of the cell. Peritrichous – Cells that have flagella covering the entire cell on the surface.

Fimbriae and pili:- Fimbriae are proteinaceous, sticky, projected structure used by cells to attach to each other and to objects around them, while pili are tubules that are used to transfer DNA from one cell to another cell.

Capsule:- Depending on the type of bacterium, there may be an exterior surrounding layer.such as a capsule or slime layer, made of glycocalyx

Cell wall :-The prokaryotic cell's cell wall is present outside the plasma membrane. It provides rigidity to the cell shape and structure and protects the cell from its environment. Bacterial cell wall is primarily composed of peptidoglycan and on the basis of cell wall composition the bacteria classified into gram-positive and gram-negative organisms.

Cytoplasmic Membrane:-The cytoplasmic membrane is a membrane that provides a selective barrier between the environment and the cell's internal structures.

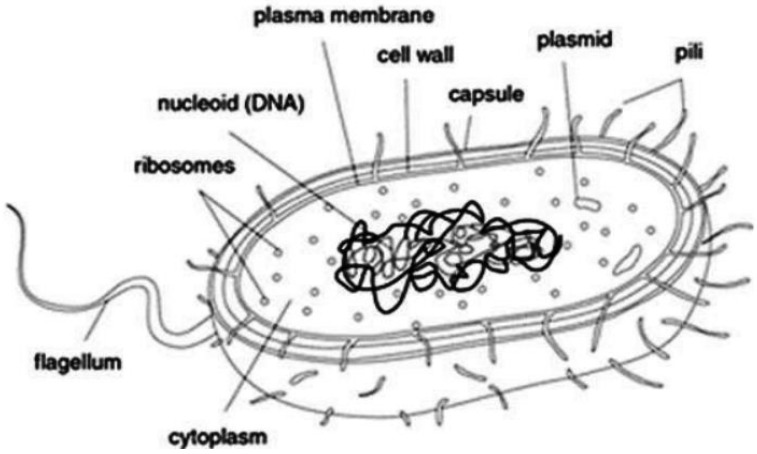
Cytoplasm: -Cytoplasm is thick.aqueous, semitransparent, and elasticsmifluid present inside the prokaryotic cell. It is about 80% water and contains primarily proteins (enzymes), carbohydrates, lipids, inorganic ions, and many low- molecular-weight compounds. Inorganic ions are present in much higher concentrations in cytoplasm than in most media.

Nucleoid/Genetic material:-The cytoplasm also contains a region called the nucleoid, which is where the DNA of the cell is located. The prokaryotic cell consists of a chromosome that isn't contained within a nuclear membrane or envelope. The nucleoid or bacterial chromosome comprises a closed circle of double stranded DNA, many times the length of the cell and is highly folded and compacted.

Ribosomes:-Ribosomes are the principle structure in a prokaryotic cell after the nucleoid. They are composed of a complex of protein and RNA, and are the site of protein synthesis in the cell. The prokaryotic ribosomes are 70S, comprised of sub units 50S and 30S (S stands for the sydberg coefficient which is a function of their size and shape, and determined by their rate of sedimentation in a centrifuge)

Inclusion bodies:-Many granular structures known as inclusion bodies are found in the cytoplasm of certain bacteria. These contain organic compounds such as starch, glycogen or lipid and act as food reserves. Some sulphur and polyphosphate containing bodies are also found and are known as volutin or metachromatic granules.

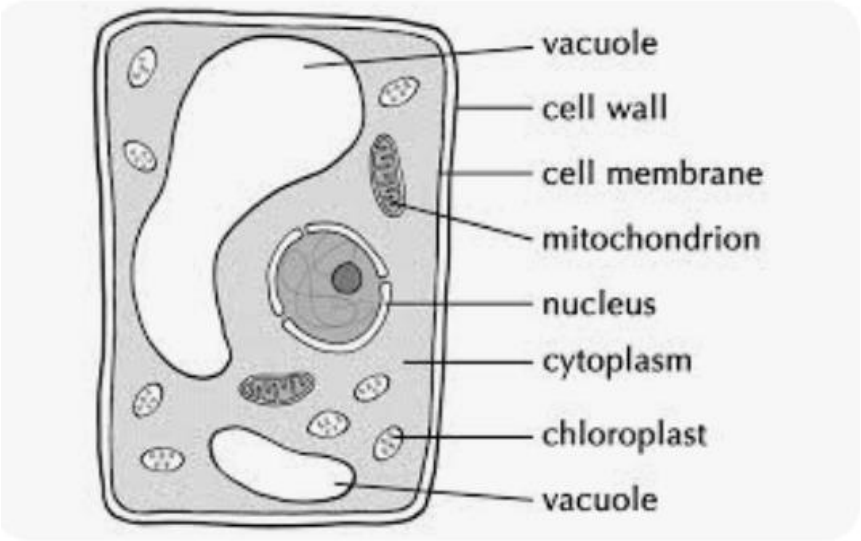
Endospore:- A number of gram-positive bacteria can form a special resistant, dormant structure called an endospore. Endospores develop within vegetative bacterial cells and are extraordinarily resistant to environmental stresses such as heat, ultraviolet radiation, gamma radiation, chemical disinfectants, and desiccation.



STRUCTURE OF PROKARYOTIC CELL

Structure of Eukaryotic cell (both plant cell and animal cell)

Ultra-structure of plant cell: All plant cells have the same basic eukaryotic organization. The major difference between plant cell and animal cell is the present of cell-wall. Plant cells are eukaryotic cells that vary in several fundamental factors from other eukaryotic organisms. Both plant and animal cells contain nucleus along with similar organelles. **One of the distinctive aspects of a plant cell is the presence of a cell wall outside the cell membrane.**



Structure of plant cell

Cell Wall: It is a rigid layer which is composed of cellulose, glycoproteins, lignin, pectin, and hemicellulose. It is located outside the cell membrane. It comprises proteins, polysaccharides, and cellulose.

Cell membrane:- It is the semi-permeable membrane that is present within the cell wall. It is composed of a thin layer of protein and fat. The cell membrane plays an important role in regulating the entry and exit of specific substances within the cell.

Nucleus:- The nucleus is a membrane-bound structure that is present only in eukaryotic cells. The vital function of a nucleus is to store DNA or hereditary information required for cell division, metabolism, and growth

Plastids:- They are membrane-bound organelles that have their own DNA. They are necessary to store starch, to carry out the process of photosynthesis. It is also used in the synthesis of many molecules which form the building blocks of the cell

ChloroplastsIt is an elongated organelle enclosed by phospholipid membrane. The chloroplast is shaped like a disc and the stroma is the fluid within the chloroplast that comprises a circular DNA. Each chloroplast contains a green coloured pigment called chlorophyll required for the process of photosynthesis

Central Vacuole: It occupies around 30% of the cell's volume in a mature plant cell. Tonoplast is a membrane that surrounds central vacuole.

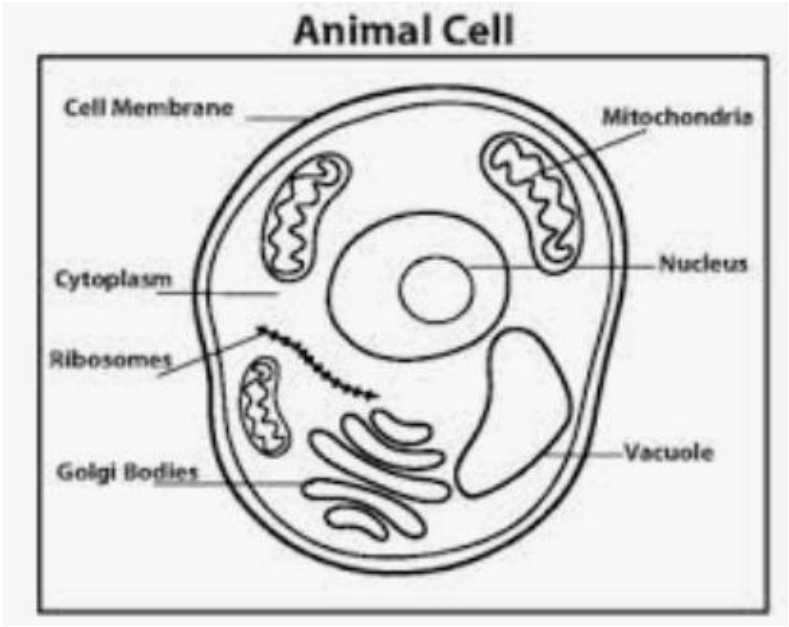
Golgi Apparatus They are found in all eukaryotic cells which are involved in distributing synthesized macromolecules to various parts of the cell.

RibosomesThey are the smallest membrane-bound organelles which comprise RNA and protein. They are the sites for protein synthesis,

MitochondriaThey are the double-membraned organelles found in the cytoplasm of all eukaryotic cells. They provide energy by breaking down carbohydrate and sugar molecules.

Lysosome: Lysosomes are called as suicidal bags as they hold digestive enzymes in an enclosed membrane. They perform the function of cellular waste disposal by digesting worn-out organelles, food particles and foreign bodies in the cell

Structure of animal cell:-Animal cells are typical of the eukaryotic cell, enclosed by a plasma membrane and containing a membrane-bound nucleus and organelles. The microscope has been a fundamental tool in the field of cell biology and is often used to observe living cells in culture.



Structure of Animal cell

- **Centrioles** - Centrioles are self-replicating organelles made up of nine bundles of microtubules and are found only in animal cells. They appear to help in organizing cell division, but aren't essential to the process.
- **Cilia and Flagella** - For single-celled eukaryotes, cilia and flagella are essential for the locomotion of individual organisms. In multicellular organisms, cilia function to move fluid or materials past an immobile cell as well as moving a cell or group of cells.
- **Endoplasmic Reticulum** - The endoplasmic reticulum is a network of sacs that manufactures, processes, and transports chemical compounds for use inside and outside of the cell. It is connected to the double-layered nuclear envelope, providing a pipeline between the nucleus and the cytoplasm.
- **Endosomes and Endocytosis** - Endosomes are membrane-bound vesicles, formed via a complex family of processes collectively known as **endocytosis**, and found in the cytoplasm of virtually every animal cell. The basic mechanism of endocytosis is the reverse of what occurs during exocytosis or cellular secretion. It involves the invagination (folding inward) of a cell's plasma membrane to surround macromolecules or other matter diffusing through the extracellular fluid.
- **Golgi Apparatus** - The Golgi apparatus is the distribution and shipping department for the cell's chemical products. It modifies proteins and fats built in the endoplasmic reticulum and prepares them for export to the outside of the cell.
- **Intermediate Filaments** - Intermediate filaments are a very broad class of fibrous proteins that play an important role as both structural and functional elements of the cytoskeleton. Ranging in size from

8 to 12 nanometers, intermediate filaments function as tension-bearing elements to help maintain cell shape and rigidity.

- **Lysosomes** - The main function of these microbodies is digestion. Lysosomes break down cellular waste products and debris from outside the cell into simple compounds, which are transferred to the cytoplasm as new cell-building materials.
- **Microfilaments** - Microfilaments are solid rods made of globular proteins called actin. These filaments are primarily structural in function and are an important component of the cytoskeleton.
- **Microtubules** - These straight, hollow cylinders are found throughout the cytoplasm of all eukaryotic cells (prokaryotes don't have them) and carry out a variety of functions, ranging from transport to structural support.
- **Mitochondria** - Mitochondria are oblong shaped organelles that are found in the cytoplasm of every eukaryotic cell. In the animal cell, they are the main power generators, converting oxygen and nutrients into energy.
- **Nucleus** - The nucleus is a highly specialized organelle that serves as the information processing and administrative center of the cell. This organelle has two major functions: it stores the cell's hereditary material, or DNA, and it coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division).
- **Peroxisomes** - Microbodies are a diverse group of organelles that are found in the cytoplasm, roughly spherical and bound by a single membrane. There are several types of microbodies but peroxisomes are the most common.
- **Plasma Membrane** - All living cells have a plasma membrane that encloses their contents. In prokaryotes, the membrane is the inner layer of protection surrounded by a rigid cell wall. Eukaryotic animal cells have only the membrane to contain and protect their contents. These membranes also regulate the passage of molecules in and out of the cells.
- **Ribosomes** - All living cells contain ribosomes, tiny organelles composed of approximately 60 percent RNA and 40 percent protein. In eukaryotes, ribosomes are made of four strands of RNA. In prokaryotes, they consist of three strands of RNA.

SURFACE ARCHITECTURE

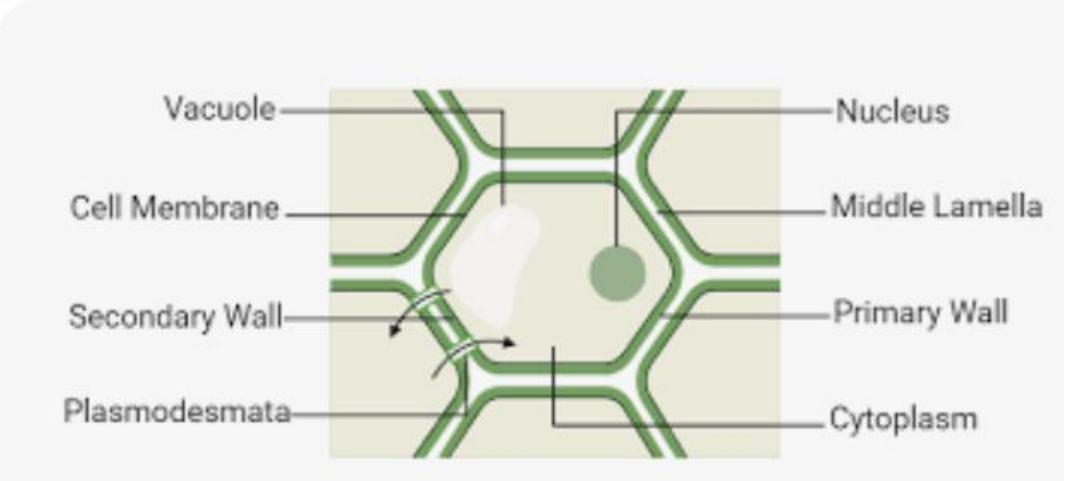
Cell wall of plants

Cell Wall: - covers the outermost layer of the cell-protecting it from the outer environment. The composition of the cell wall varies based on the organism. It has a permeable nature, separating the interior content of the cell from exterior components. The cell wall is responsible for providing support, protection, and shape to the cell. It is present only in fungi, eukaryotic plants, and very few prokaryotes. A fundamental difference between plant and animal cells is that the plant cell is surrounded by a rigid cell wall,made of polysaccharides (cellulose, hemicellulose, pectin) and lignin. Plants cell wall is divided into primary cell wall, secondary cell wall and middle lamella.

Primary cell walls are thin and characteristic of young, growing cells. This is the first cell wall which is situated closest to the inside of the cell. This cell wall is formed of cellulose which allows the wall the stretch and grows easily. Most of the primary cells contain structural proteins and pectic polysaccharides. The primary cell wall is thinner than most other layers and is comparatively permeable than others.

Secondary cell walls are thicker and stronger, and they are deposited when most cell enlargement has ended and Secondary cell walls have their strength and toughness due to lignin; a glue-like material. After the cell grows completely, this wall is formed in the inner part of the primary cell wall. Certain cells are formed of lignin and cellulose, providing additional rigidity and waterproofing to the cells. Further, the rectangular shape of the cell is also provided by this layer. This layer provides permeability, and it's also the thickest layer.

Middle lamella is a intracellular structure separating the walls of two adjacent cell wall Middle lamella is composed of is made up of pectin. It is the outermost layer of the cell wall. It is like an interface between the neighbouring cells, gluing them together. The middle lamella is mainly composed of pectins. Along with this, other substances like proteins and lignin can also be found in this layer.

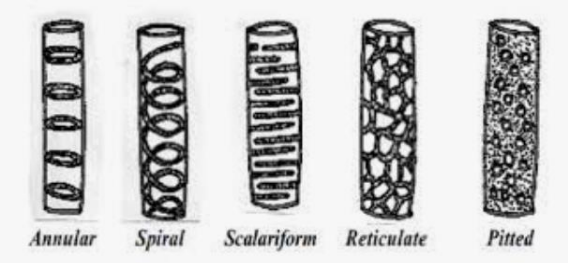


Structure of plant cell wall.

Thickening of cell wall: The cells increase in size and become mature. At this stage, the cells become modified according to the function they have to perform. During the process of their maturation, the cells undergo thickening, deposition of new materials such as cellulose, lignin. The cells of certain parts undergo heavy thickening of their walls. The thickening materials of the cells are secreted by the protoplasm. These materials are deposited in the cell walls in such manner that cell wall becomes stratified in appearance.

1) **Annular thickening:** These are ring like thickening present on the inner side of primary wall. The rest of the wall is thin. Ex. Protoxylem
2) **Spiral or helical thickening:** These are spiral or helical thickening of secondary wall materials. There may be more than one helix. Ex. Protoxylem.

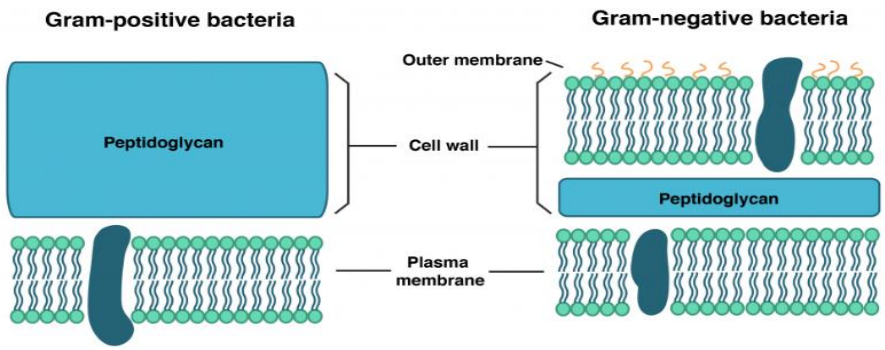
3) **Scalariform thickening:** The thickenings appear as parallel transverse bands like the rungs of a ladder. Ex. Protoxylem.
4) **Reticulate thickening:** The secondary wall appears as a network as the meshes remain thin. Ex. Metaxylem.
5) **Pitted thickening:** These are more or less circular areas, called pit, where secondary wall materials are not deposited. Ex. Metaxylem.



Functions of cell wall

- They determin the morphology,growth and development of plant cells.
- They protect the protoplasm from the invasion by viral,bacterial and fungal pathogens.
- They are rigid structures and thus help the plant in withstanding the gravitional forces.
- They are involved in the transport of materials and metabolites.
- They withstand the turger pressure which develops within the cells due to high osmotic pressure.
- They helps in preventing water loss from the cell.
- It acts as a barrier between the interior cellular components and the external environment

CELL WALL OF BACTERIA: -Bacteria has gram positive and gram-negative cell walls contain an ingredient known as **peptidoglycan** (also known as **murein**). This particular substance hasn't been found anywhere else on Earth, other than the cell walls of bacteria. Peptidoglycan is a polysaccharide made of two glucose derivatives, **N-acetylglucosamine (NAG)** and **N-acetylmuramic acid (NAM)**, alternated in long chains. The chains are cross-linked to one another by a **tetrapeptide** that extends off the NAM sugar unit. The four amino acids that compose the tetrapeptide are: **L-alanine, D-glutamine, L-lysine or *meso*-diaminopimelic acid (DPA),** and **D-alanine**.



STRUCTURE OF BACTERIAL CELL WALL

Gram positive bacteria: -The cell walls of gram-positive bacteria are composed predominantly of peptidoglycan. Peptidoglycan can represent up to 90% of the cell wall, with layer after layer forming around the cell membrane. Gram positive cell wall is **teichoic acid**, a glycopolymer, which is

embedded within the peptidoglycan layers. Teichoic acid is believed to play several important roles for the cell, such as generation of the net negative charge of the cell, which is essential for development of a proton motive force. Teichoic acid contributes to the overall rigidity of the cell wall, which is important for the maintenance of the cell shape, particularly in rod-shaped organisms. teichoic acids participate in cell division, by interacting with the peptidoglycan biosynthesis machinery. It constitutes about 50% of dry weight of cell wall. It is the major surface antigen of gram positive bacteria.

Gram negative bacteria: -The cell walls of gram-negative bacteria are more complex than that of gram-positive bacteria, with more ingredients overall. They do contain peptidoglycan as well, although only a couple of layers, representing 5-10% of the total cell wall. What is most notable about the gram-negative cell wall is the presence of a plasma membrane located outside of the peptidoglycan layers, known as the **outer membrane**. This makes up the bulk of the gram-negative cell wall. The outer membrane is composed of a lipid bilayer, very similar in composition to the cell membrane with polar heads, fatty acid tails, and integral proteins. It differs from the cell membrane by the presence of large molecules known as **lipopolysaccharide (LPS)**, which are anchored into the outer membrane and project from the cell into the environment. LPS is made up of three different components:

1) the **O-antigen or O-polysaccharide**, which represents the outermost part of the structure,

2) the **core polysaccharide**,

3) **lipid A**, which anchors the LPS into the outer membrane. LPS is known to serve many different functions for the cell, such as contributing to the net negative charge for the cell, helping to stabilize the outer membrane, and providing protection from certain chemical substances by physically blocking access to other parts of the cell wall.

Difference between gram positive and gram-negative bacteria

Gram positive bacteria	Gram negative bacteria
Distinctive purple appearance after gram staining	Pale reddish colour after gram staining
Bacteria include all staphylococci, all streptococci and some listeria species	Bacteria include Enterobacter species, salmonella species and pseudomonas species
Thick peptidoglycan layer	Thin peptidoglycan layer
No outer lipid membrane	Outer lipid membrane present
No O-specific side chains present	O-specific side chains present
Teichoic and lipoteichoic acids present	Teichoic and lipoteichoic acids not present