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Lec. 1

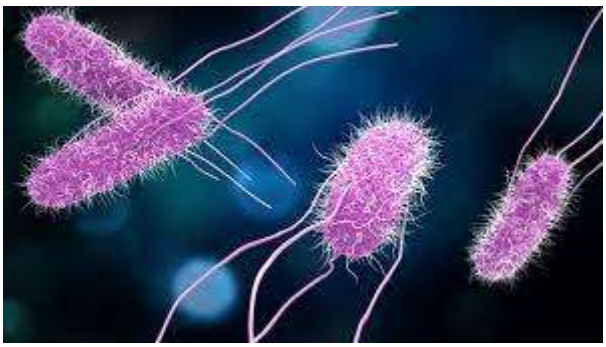
Biology: study of life & process associated with the living things.

Biology includes many fields or branches such as:

Ecology, evolution, genetic, medicine molecular biology, physiology, cytology, Mycology.

Sometimes biology divided into:

1. Zoology
2. Botany
3. Microbiology divided in to:
    a) Mycology such as fungi eg: yeast
    b) Parasitology eg: protozoa
    c) Bacteriology eg: bacteria



Microbiology: study of organisms that are too small to see with the Naked eyes which need machine such as light microscope & E.M or stain or culture in media to see them such as bacteria viruses, fungi.

Characteristic of organisms:

1. Organization.
2. Metabolism.
3. Growth
4. Reproduction
5. Response or respond to environment.
6. Adaptation - long term changes in an organism survive changes in the environment.

Microbes- Organism too small to See with the Naked eye.

All Microorganisms has genus and species eg: *E coli*

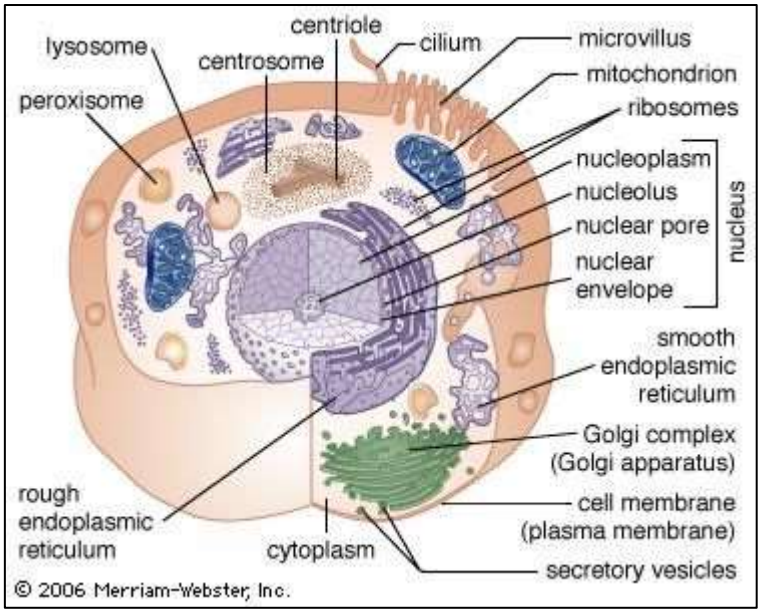
Microbiome microbiota: These organisms that live on in other organism such as human and plant live on skin, hair virginal system or intestinal

system urinary system & respiratory system or other part of Human body which has some benefits.

Cell: The smallest living unit of organism that perform all live process.

There are two broad categories of cell:

1. Eukaryotic cells: They have organelles which Include the nucleus other special part & membrane enclosed organelles & more advance complex cells such as plants & animals.
2. Prokaryotic cells unicellular organismic without nucleus & membrane enclosed organelles, they have genetic material but it's not contained within a nucleus, such as bacteria.



Unicellular: one cell organism (single cell)

Multicellular: comprised of many cells.

Asexual reproduction: single parent reproduces with interaction with another organism No egg (orgemetes).

Budding (yeast)

Binary fission (bacteria): single parent divided into two similar cells eg: bacteria.

Sexual reproduction requires fusion of two parent's female and male gametes such as egg & sperm to produced new generation from a parent.

Chromosome of mail + chromosome of female = New generation Fusion of DNA.

Genotype = genetic make-up of an organism what genes are found in its genome.

Phenotype = an organism gene that expressed in observable characteristic of organism

Glycoprotein = protein contains sugar or carbohydrates

Proteoglycan - subgroup of glycoproteins, have carbohydrate with amine group bond.

amino group = NH_2

All cells have a cell membrane which separates the inside of the cell from its environments.

Cytoplasm: is a jelly-like fluid & DNA which is the cell genetic material.

What are organelles. (Mean little organelles are specialized parts of a cell that have unique jobs to perform the nucleus, placed in the center of the cells & contain DNA or genetic materials. DNA dictates what the cell is going to do & how it's going to do it.

Chromatin the tangled, spread out from of DNA found inside the nuclear membrane when a cell is ready to divide DNA condensed into structure known as chromosome.

The Nucleus also contain a nucleolus, which is a structure where ribosomes are made after ribosomes leave the nucleus. They will have the important jobs of synthesizing or making proteins.

Outside the nucleus the ribosomes & the rest of the granules float around in cytoplasm, which is the jelly-like substances.

Ribosome may wonder freely within cytoplasm or attach to the endoplasmic reticulum, sometimes abbreviated as "ER".

There are two types of ER.

1. Rough ER-has ribosomes attached to it (rER).
2. Smooth ER doesn't have ribosomes attached to it.

The Endoplasmic reticulum is a membrane enclosed passageway for transporting materials such as proteins synthesis by ribosome>

Proteins & other materials emerge from the endoplasmic reticulum. in small vesicles where the Golgi apparatus, sometimes called the Golgi body receive them as protein move through the Golgi body they're customized into forms, that the cell can use the Golgi body does this by folding the proteins into usable shapes or adding other materials on to them such as lipids or carbohydrates vacuoles are Sac-like structures that store different materials in plant.

Vacuoles store water in animal cell you will see organelle called a lysosome which are the garbage collectors that taken in damaged or worn-out cell parts they are filled with enzymes that break down this cellular debris.

The mitochondria is an originals that is the powerhouse for both animal & plant cells during process called cellular respirations.

The mitochondria make the ATP molecules that provide the energy for all the cell activities.

Cell that needs more energy. have more - mitochondria, the cell maintains the shape through cytoskeleton, the cytoskeleton includes the thread like microfilament which are made of protein and microtubules, thin hollow tubes, some organisms that are photoautotrophic meaning capture sunlight for energy have cell with an organelle called a chloroplast.

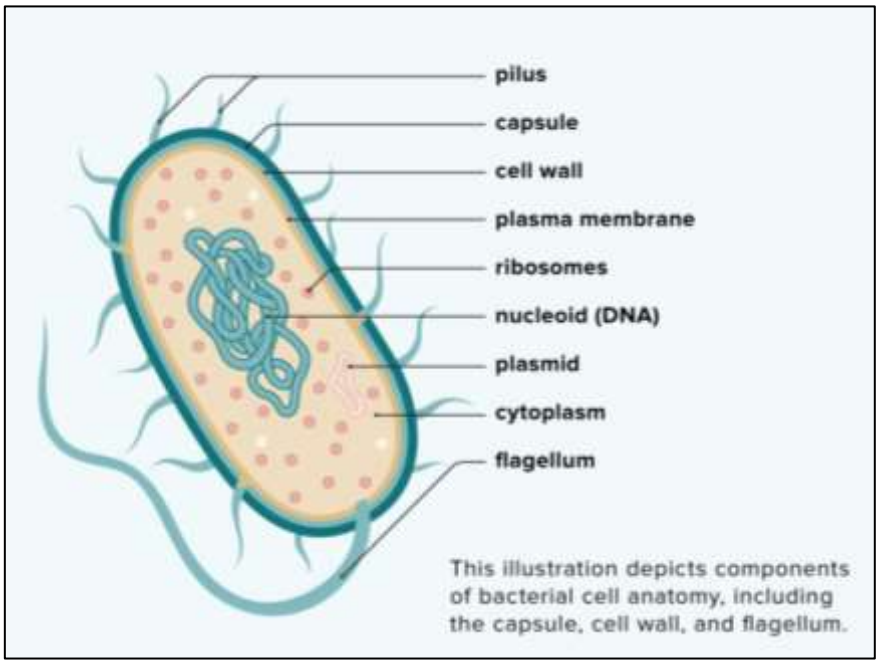
The chloroplast is where photosynthesis happen, which is green because it has pigment called chlorophyll, plant cells also have cell wall outside cell membrane that give shape support & protect the plant cell.

Animal cells- don't have cell wall.

Bacteria

1. Bacteria are relatively simple in structure.
2. They are procaryotic organism.
3. Simple unicellular organism with no nuclear a membrane, Mitochondria, G. bodies, endoplasmic reticulum.
4. Bacteria reproduce a sexually by Binary fission.
5. The nucleus consists of single chromosome which is circular double strand DNA (helix)
6. Bacteria have cell membrane which surround the cytoplasm and all metabolic activity found in it.
7. There are extra circular chromosomal DNA in the cytoplasm called plasmid.
8. All Bacteria have cell membrane, which is differentially permeable and very important for protection and called the spirt of the cell, the cell membrane Contain mesosomes which support the cell by energy
9. 99% of Bacteria have cell wall which is rigid & rough in structure but some do not have this wall permeable for water solution and nutrient the
10. The chemical structure of the cell wall is peptidoglycan which accessory specific material + Amino group & techoic acid.
11. The cell wall give protection for bacteria and give its shape, the shapes of Bacteria differ from each other.

The Bacterial arrange as single cell such as micrococcus or double cell united pneumococcus or as chain such as streptococcus, or clusters staphylococcus or spiral as spirillum such as Nocardia.



Discovery of Bacteria

1. Antony van Leeuwen hoek (1632) the first observed bacteria using single lens microscope designed by himself.
2. Pasteur (1822) used pasteurization & to indicate that bacteria were produced in the air & later called the father of microorganisms.
3. Robert Koch (1843): pointed out that the bacteria causes disease.

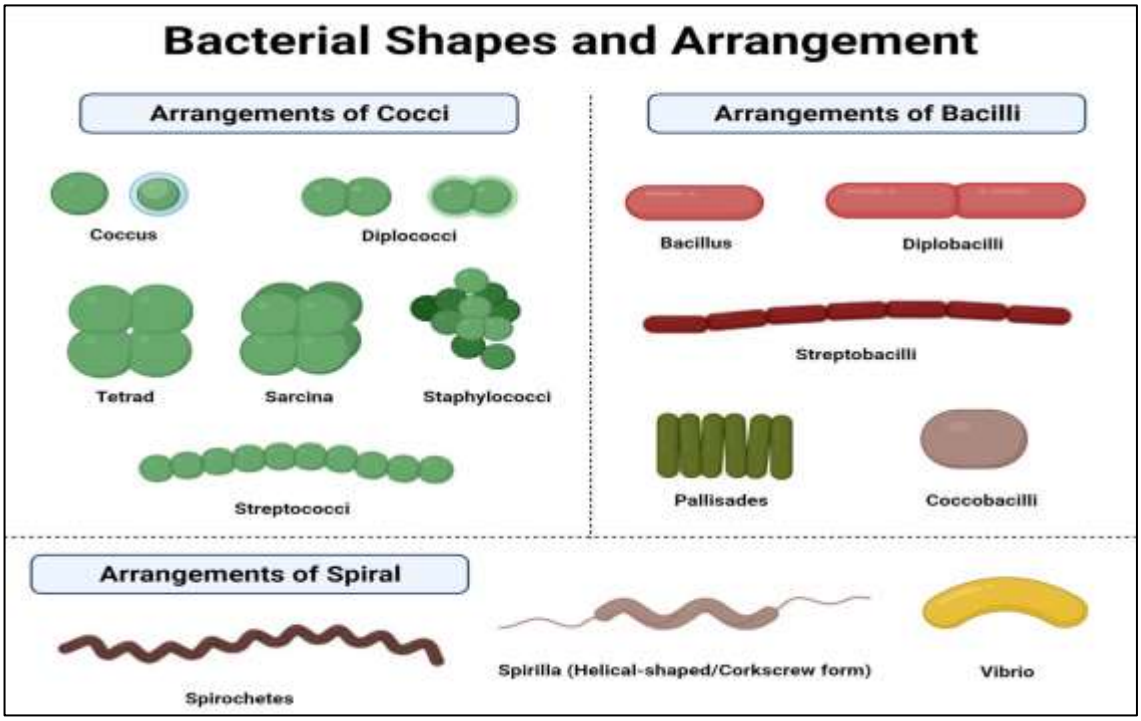
Classification of bacteria

Classification of bacteria is mainly based on the following:

1. shape
2. composition of cell wall
3. mode of respiration
4. mode of nutrition

Classification based on shape:

1. Coccus (spherical) or round e.g *Streptococcus pneumoniae*
2. Bacilli. Rod shaped e.g *Escherichia coli* (E-coli)
3. Vibrio curved *Vibrio cholerae* or (comma shaped) e.g *Vibrio cholerae*
4. Spirilla (spiral)-rigid & short int length contain flagella in end e.g *Nacardia*.
5. Spirochetes - which is helix-Filament similar to corkscrew in which cell body is wrapped around a central fiber called the axial filament. with internal flagella or end flagellum. e.g *Spirillum volutans*



Bacterial arrangements:

The arrangement of bacteria defends the position & organization of bacteria that strongly depend upon the type of cell division the bacteria are groped in to 4 types based of cell arrangement & cell number.

Coccus (spherical) or such as Monococcus or found in airs as (diplococci) including *Streptococci pneumoniae* → *Neisseria gonorrhoniaea* which causes asexually transmitted disease gonorrhea.

Some coccal bacteria is square or tetrads e.g micro coccus or cubical packet e.g *Sarcina ventriculi* or in symmetrical arrangement.

aruaru which cell division occur.

in 2 planes of division

e.g streptococci specie.

Some streptococci resemble along linear shape strand of beads (apart from diplococci or arrange in a long chain or linear cells e.g streptococcus viridans, this happened when cell division occur in one plane.

The staphylococci form random clumps or cluster of grapes or filamentous branching sun ray appearance e,g Actinomycetes when cell division occur in different planes, and the bacteria don't separate from one another after cell division form characteristic cluster which help in their identification.

Some uncommon bacteria:

1. *Mycoplasma*: have no cell wall.
2. *Actinomycetes* filaments bacteria.

Classification of bacteria based on composition cell wall:

1. Peptidoglycan Gram+ve bacteria
2. Lipopoly Saccharide Gram -ve bacteria

Classification of bacteria based on the mode of nutrition:

1. Autotrophic bacterial *Cyanobacteria*
2. Heterotrophic bacteria e.g all diseases causing bacteria

Classification of bacteria based on the mode of respiration

1. Anaerobic bacteria e.g *Actinomycetes*
2. Aerobic bacteria e.g *Mycobacterium tuberculosis*

Useful bacteria

Not all bacteria are harmful to humans. There are some bacteria which are beneficial to in different way:

1. Convert milk into curd, *Lactobacillus* or Lactic acid bacteria.
2. Ferment food products, *Streptococcus* & *Bacillus*
3. Help in digestion & improving the body's immunity system a *Actinobacteria* - Firmicutes *proteobacteria*.
4. Production of antibiotic, which is used for treatment prevention of bacterial infections.
5. Soil bacteria - Nitrogen fixation. *Rhizobium*

Harmful bacteria: Those bacteria cause illness & responsible for infectious disease like *Pneumonia, Tuberculosis, Viridians*.

How bacteria reproduced: bacteria reproduced through a process called binary fission. In this process, a single bacterium divided into two daughters' cells, these daughter cells are identical to parent cell as well as to each other.

Binary fission

Binary fission is the processes through which asexual reproduction happen in bacteria.

There are four steps to binary fission in bacteria:

1. DNA replication.
2. Cell growth.
3. Genome segregation.
4. Cytokinesis.

genome segregation: accurse continuously as the bacteria cell grows & DNA chromosome replication.

Cytokinesis: begin with formation of protein ring the protein used to synthesizing new cell wall & plasma membrane & a structure called a septum form as in plant function to cell plate.

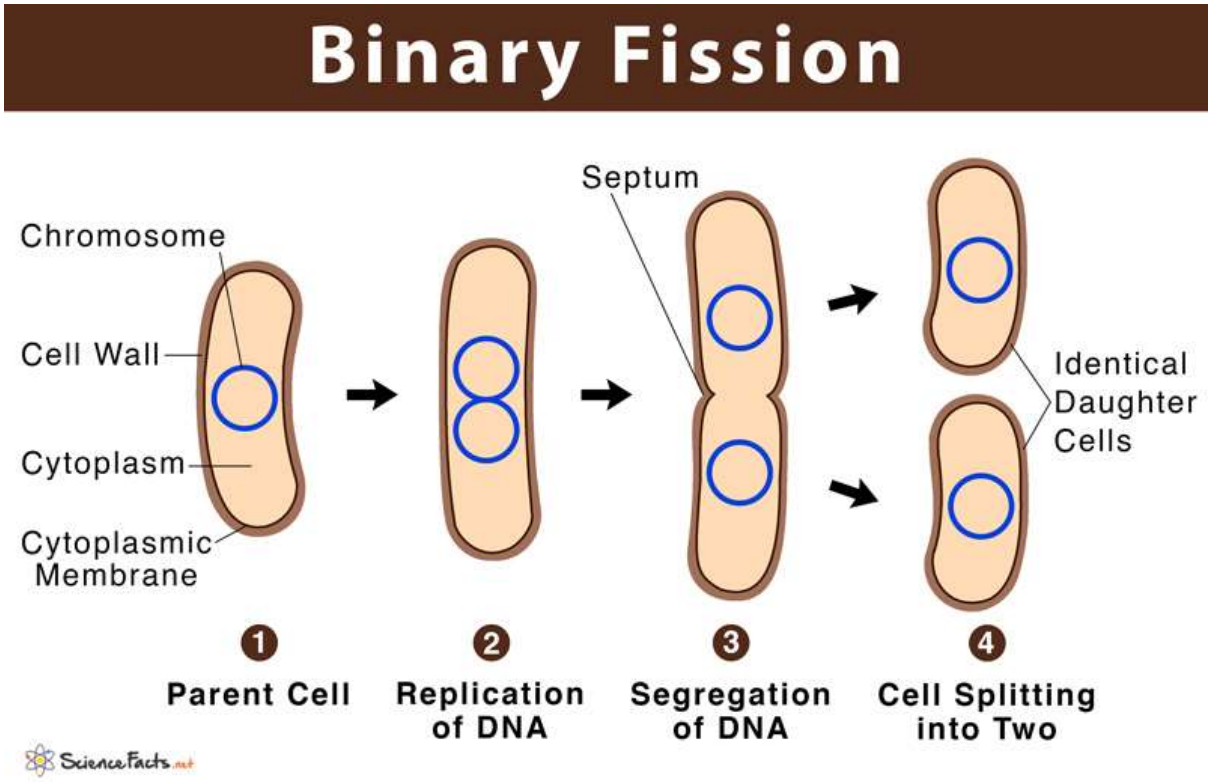
finally separating the daughter cells & completing cell division such as *E.coli* which reproduced every 20 minutes.

Structure of bacteria

Cell wall

1. The bacterial cell wall is an important structure that is a rigid & non living envelope around the cell.
2. Present above the cell membrane & give a specific shape to cell, because of this cell wall the bacteria can survive the harshest environments condition like drought heat, chemical exposure & pressure.
3. The bacterial cell wall is made of monopolysaccharide & monopeptides.

The mucopeptide (peptidoglycan is a polymer of N-acetyl muramic acid (NAM) & N-acetyl glucosamine (NAG), beside them an amino acid called diaminopimelic acid & polysaccharide called Muramic acid are present in cell wall.



The structure of the bacterial cell wall of two types:

1. One type of cell wall presents in G+ve bacteria.
2. Other present in G-ve bacteria.

G+ve = The cell wall thick layer of peptidoglycan that is a combination of protein and carbohydrate molecules, because of high amount of peptidoglycan layer the bacteria show blue color when stained with gram stain & make it susceptible to antibiotics - cell wall of gram-ve bacteria peptidoglycan layer is very is very low

but the outer membrane is made of lipoproteins or lipopolysaccharide & teichoic acid.

Function of bacteria cell wall:

1. help to provide a fixed shape to cell
2. facilitates the movement of gasses & water into & outside the cell.
3. prevent the cell from getting dried during hot condition.
4. protects from chemical & other of environmental condition when we use heat, sterilization to kill bacteria.

Genetic material of bacteria:

Genome: All gene in bacterial chromosome.

Gene- segment of chromosome give specific character. genome includes Bacterial chromosome & plasmids.

Bacterial chromosome: Is circular and double strand DNA 1mm(helix) composition of phosphate & sugar it's function for:

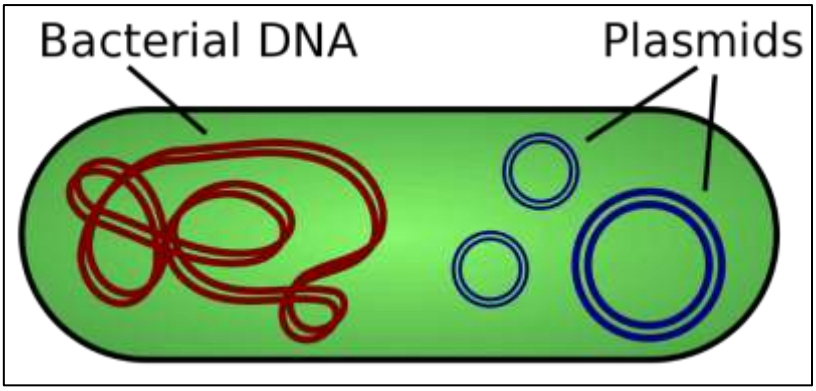
1. Replication
2. Gene expression (protein Synthithes)

Plasmid: A plasmid is a small extrachromosomal DNA molecule within a cell that is physically separated from chromosomal DNA can replicate independently & found as a small circular double stranded DNA molecule in bacterial cytoplasm sometimes present in archaea and eukaryote organisms & carry genes that benefit for survival of organism.

Plasmid is less than 5% the size of bacterial chromosome

There are two types of plasmids:

1. F- plasmid or (F factor) or (fertility) play a major role in conjugation of bacteria.
2. R. Plasmid (resistance plasmid) to antibiotic & other factors.

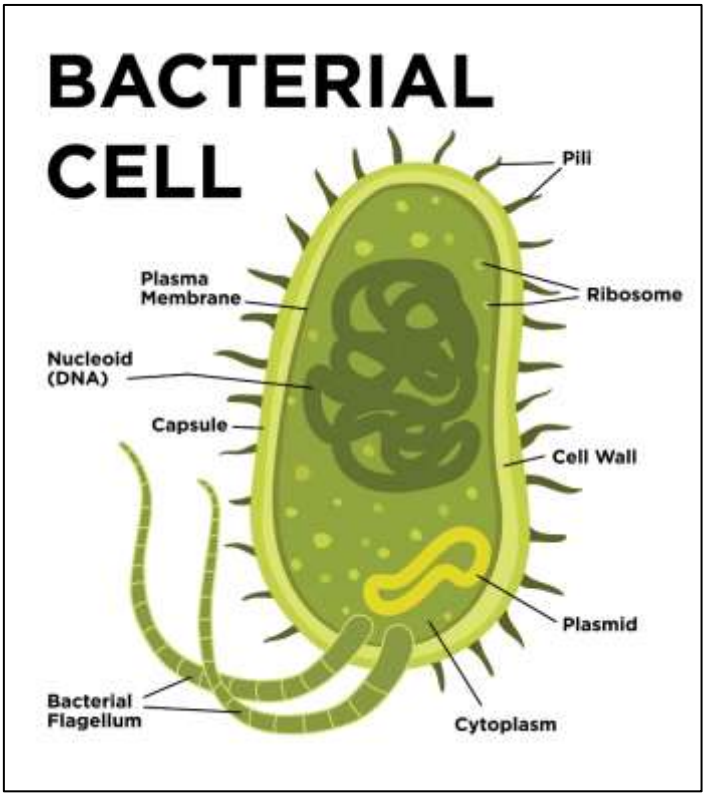


Cell membrane: also known as the plasma membrane or cytoplasmic membrane found in all cell and separate the interior of the cell from the outside environment. The cell membrane consists of lipid bilayer made of two layers of Phospholipids with cholesterols which control diffusion of molecules from inside to outside the cell.

Capsule: is a covering layer or an envelope formed by a viscous substance or sticky gel around cell wall of bacteria it is 0.2 Micro meter thickness.

The gelatinous layer made of 98% Water & 2% polysaccharide or glycoprotein e.g *Pneumoniae* & *Klibsilla*, *Meningitis* there are two types of capsules:

- **Microcapsule**: has thickness of less than 0.2 MM visible to E.M
- **Macro capsule**: has thickness of less than 0.2 MM or more it can be visible under light microscope.



Function of Capsule:

1. protect bacteria from phagocytosis.
2. prevent bacterial cell from lysis.
3. prevent from Bacteriophages.
4. prevent from the drying.
5. capsule virulence factor induces infection of disease & give bacterial toxic property in infection.
6. formation of biofilm to be hidden under tissue

Appendages:

Flagella. Fimbriae, pili

Flagella: is a hairlike appendage or thin - long - tubular that help in movement or motility of an organism. Mostly are unicellular & A flagellum having 15-20 nm in diameter, flagella are filamentous structure made of microtubules & usually found in eukaryote & some prokaryote, Bacteria flagella composed of protein flagellin.

Types of flagella.

1. Monotrichous single polar Flagellum can rotate following & backward movement of bacteria or allow the bacteria to move on different side e.g: (*Vibrio cholerae*).
2. Amphitrichous: one flagellum is present in each pole of the cell e.g *Faecalis*
3. Lophotrichous: many flagella present in one of both polar of the cell (*Spirillum* e.g).
4. Peritrichous: Numerous flagella are present all over the bacterial body. e.g *Salmonella typhi*.

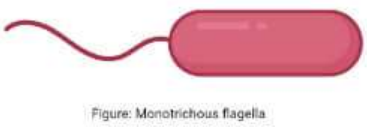


Figure: Monotrichous flagella

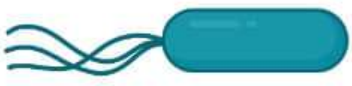


Figure: Lophotrichous flagella


Figure: Amphitrichous flagella

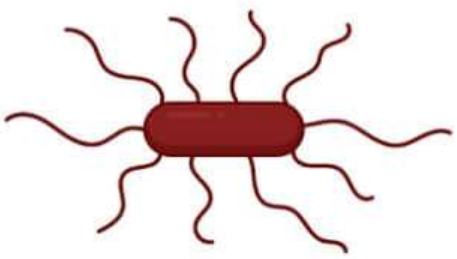
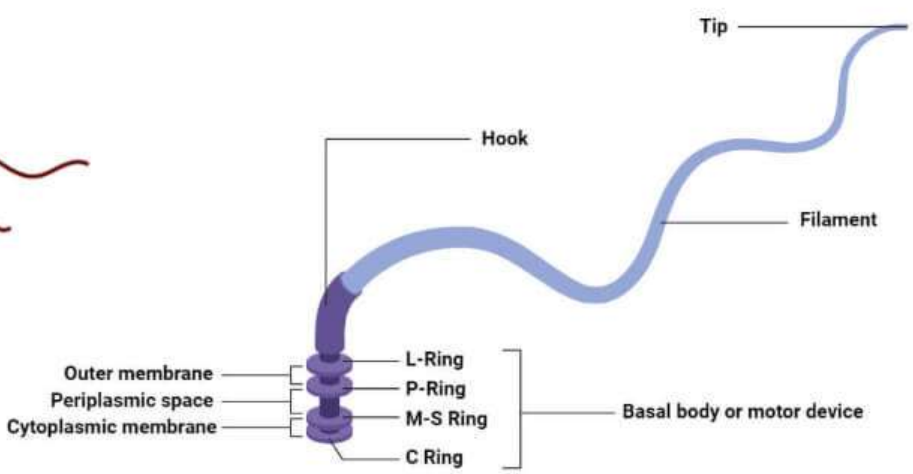


Figure: Peritrichous flagella



Flagella

Figure: Structure of Flagellum of Gram Negative Bacterium

Flagellum structure:

1. Filament
2. Hook
3. basal body

Filament made of protein flagellin which is cylinder & Hollow connected to the hook. The hook is short structure connect the filament with the basal body, the hook placed near the surface of the organism to keep it in place & the basal body is circular or rings structure embedded in the envelop. Some bacteria have 4 rings other have 2 rings e.g G-ve bacteria.

Fimbriae:

Fimbriae and pili are proteinaceous hair like structure or appendages that extend from the cytoplasmic membrane of a variety of bacteria compared as flagella. but they are shorter thinner in size & have several functions.

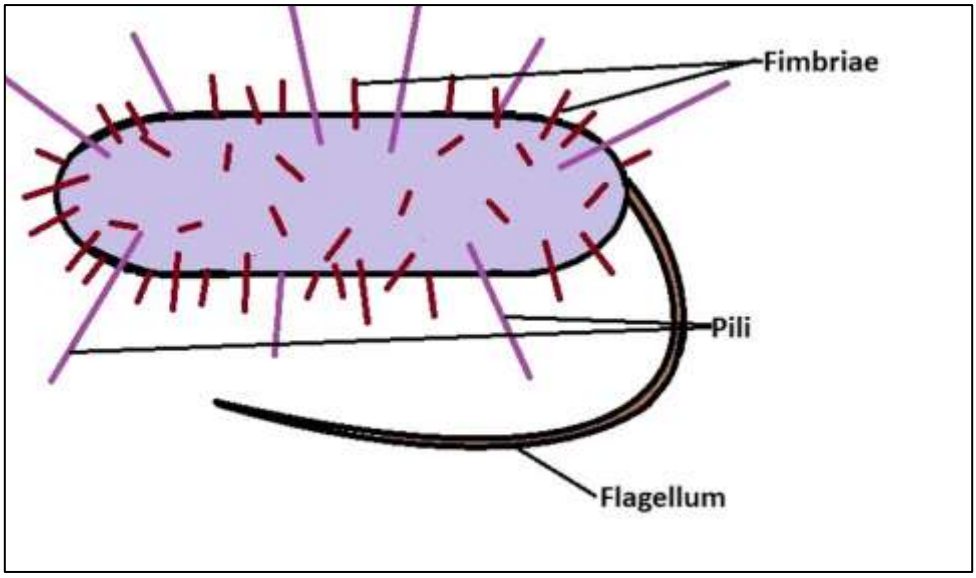
Fimbriae: shorter & thinner & large in number form from the bacteria DNA chromosome as in Gram + ve & Gram – ve bacteria.

Pili- Longer thicker - less in number form from the bacterial plasmid. very necessary in bacterial conjugation & transfer of plasmid from F+ cell to F-cell seen in G- ve bacteria & rare in Gram+ ve bacteria. This is: also, necessary for replication of DNA & Resistance of antibiotic

Types of pili

There are 2 types of pili (pilus)

1. conjugative pili also known as sex pili which are the most common in bacteria & composed of protein called Pilin. which are shorter & thinner than flagella and can be found around the surface of the cell localized to one or both poles. The conjugative pili has the function of transferring the DNA plasmid from one cell to another.
2. Common pili for adhesion and attachment of bacteria to human tissue & give virulence factor.



Function of pili

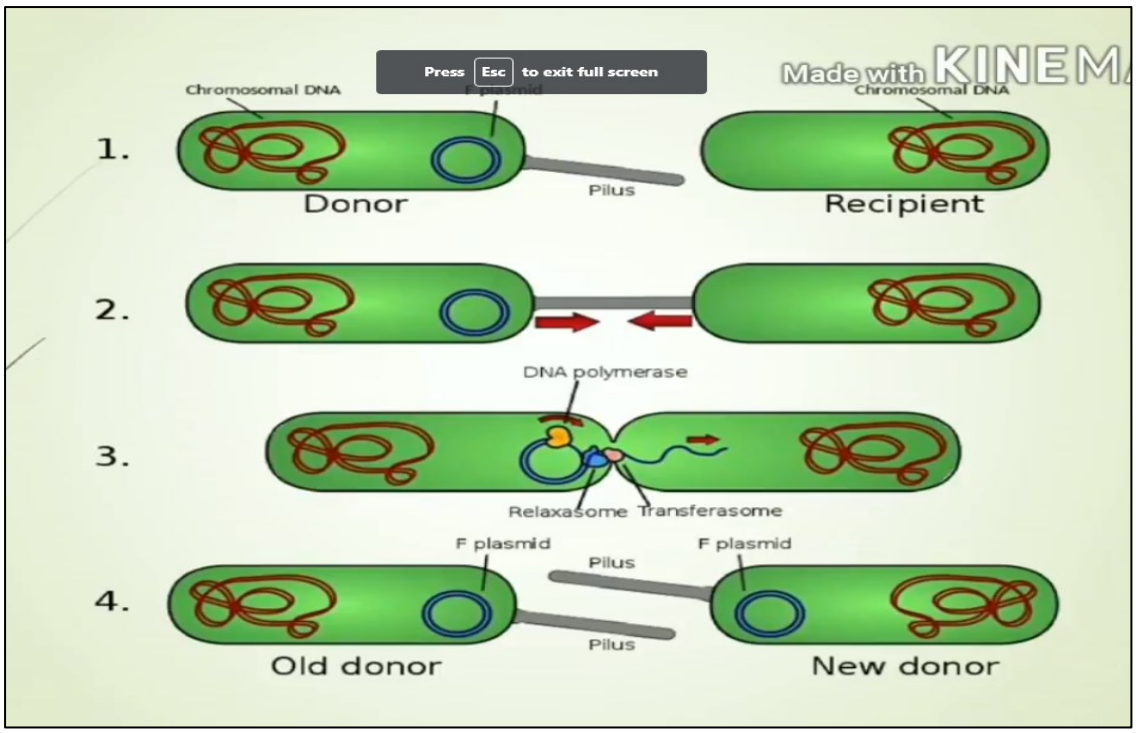
1. Adhesion
2. motility, Biofilm. Formation.

1/ Bacterial conjugation: is the process by which one bacterium transfers genetic material to another through direct contact.

Bacterial conjugation was first postulated by J. Lederberg and Edward Tatum.

During conjugation, one bacterium serves as the donor of the genetic material and the other services as the recipient.

1. The F^+ (donor) cell produced the pilus, which is a structure that projects out of the cell & begins contact with an F-(recipient) cell.
2. the pilus enables direct contact between the donor & the recipient cells.
3. Because the F- plasmid consist of a double stranded DNA molecule forming a circular structure, i.e it is attached on both ends, an enzyme (relaxase or relaxosome) when it forms a complex with other proteins nicks one of the two DNA strands of the F-plasmid and this strand (also called T- strand) is transferred to the recepient cell.
4. In the last step, the donor cell & the recepient cell containing single-stranded DNA replicate this DNA & this end up Forming a double-stranded plasmid identical to the original F- plasmid. Given that the F-plasmid contains information to synthesize pili & other proteins, the old recepient cell is now a donor cell with the F - plasmid & the ability to form pili) & both cells are donor cells or F^+.



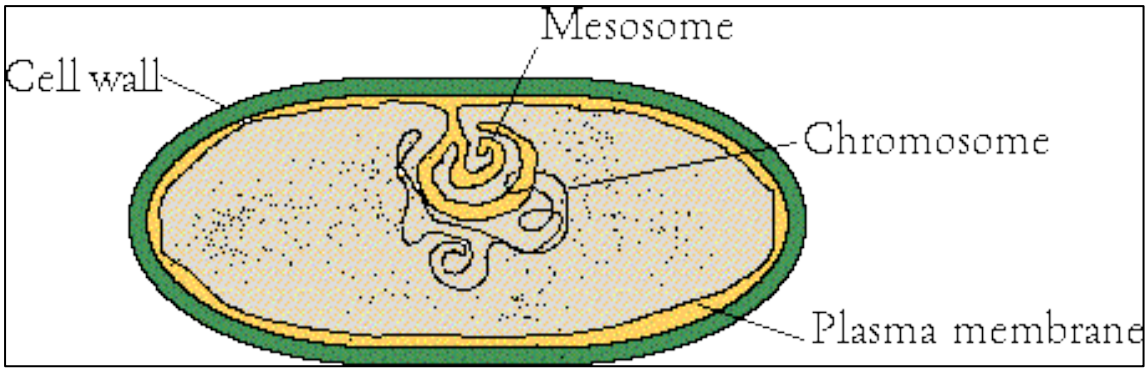
2/ Function of the cell membrane

1. protects the cell by acting as a barrier.
2. regulates the transport of substances in &out of the cell.
3. receives chemical messengers from other cells.
4. acts as a receptor.
5. cell mobility. secretion and absorption of substances.
6. Energy generation by oxidative phosphorylation.
7. secretion of enzymes & toxins

Glycocalyx: is known as pericellular matrix, which is a glycoprotein & glycolipid covering & surrounding the cell membrane of bacteria & other cells which allow the bacteria to adhere firmly to various structures e.g oral mucosa, teeth, heart Valves & catheters & also act as barrier to passage of protein such as albumin.

3/ Mesosome

mesosome or chondroids are invaginated or structures formed by the localized infoldings of plasma membrane. The invaginated structures comprise of vesicles, tubes of lamellar, mesosome are found in association with nuclear area or near the site of cell division. They are absent in Eukaryotes. Some of the lamellae are formed by flat vesicles when arranged parallel & connected to cell membrane-mesosome supposed to take part in respiration, because respiratory enzymes have been seen in cell membrane & components of electron transport such as Atpase, cytochrome & play a role in reproduction also during binary fission. formation of septum.

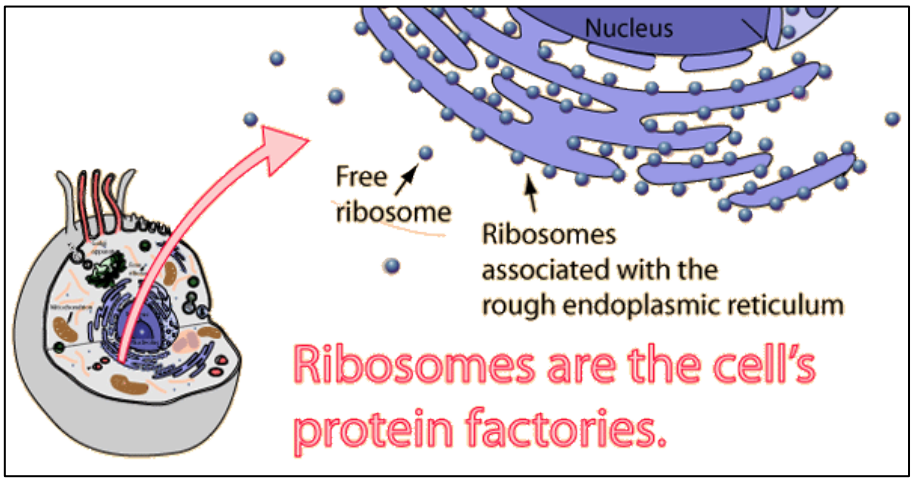


4/ Ribosomes are small particles that are consist of RNA & associated proteins-ribosome in bacteria consist of two subunits with densities 50s & 30s.

Function: is to synthesize proteins from amino acid during process called protein synthesis & found in prokaryote & Eukaryote cells found in the cytoplasm

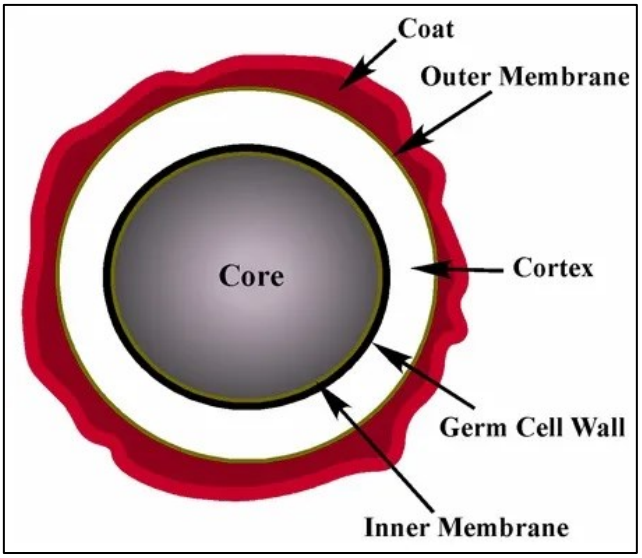
The small ribosomal subunits mRNA

The large ribosomal subunits which form polypeptide chain of amino acids.



5 -Endospore

Spore formation takes place in some bacterial genera to with stand unfavourable conditions - All bacteria cannot forms spores only few bacterial genera, including *Bacillus Clostridium* produce sporulating structure inside vegetative cells called endospore

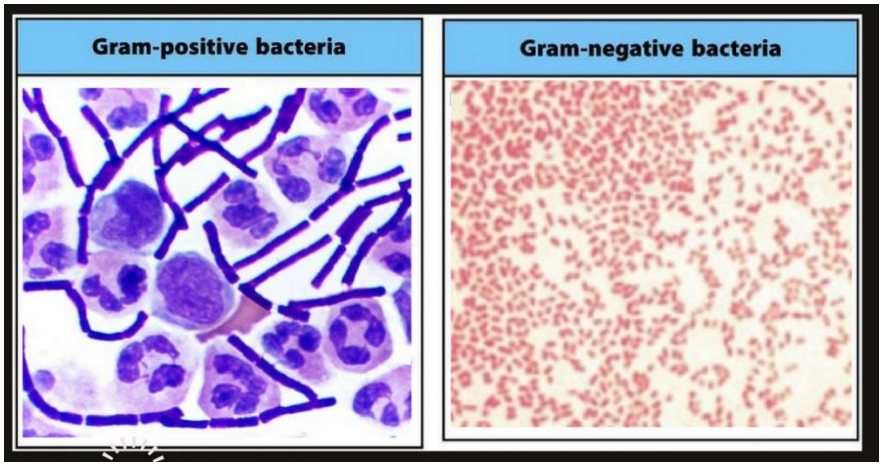


6/ Types of staining in microbiology

1. Simple staining: coloration of microorganisms by applying single dye to fixed smear (crystal violet)
2. differential staining: This used to distinguish the organism & structures of bacteria, flagella, Capsules & stain.
3. Gram staining: it is one of the most important & widely used in bacteria.
4. Acid fast staining: It is another important differential staining to distinguishes various types of microbial & bacterial groups. This is used to identify *Mycobacterium* spp. These bacteria have cell wall with high lipid content such as mycolic acid, which prevent dyes from readily binding to cells.

7/ Examples of G+ve bacteria & G-ve bacteria

1. Gram +ve bacteria cocci (round) *Staphylococcus aureus*
2. Gram -ve bacteria cocci *Neisseria meningitis*
3. Gram +ve bacteria bacilli (rod) *Bacillus anthraus*
4. Gram -ve bacteria bacilli *Escherichia Ecoli*



Difference between gram positive and gram-negative bacteria

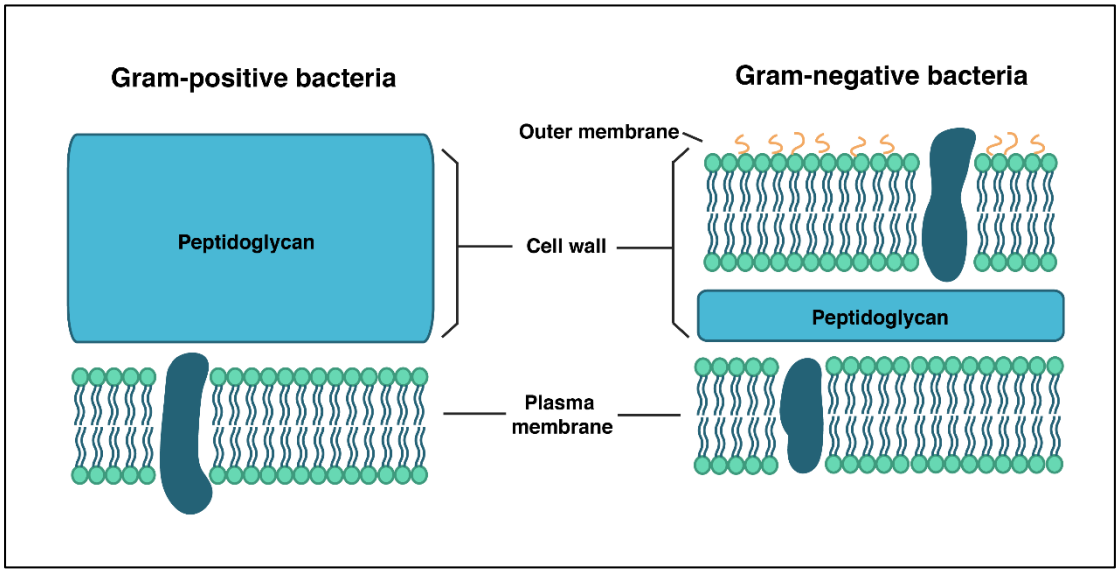
Gram-Positive bacteria	Gram-Negative bacteria
Cell Wall	
A single-layered, smooth cell wall	A double-layered, wavy cell-wall
Cell Wall thickness	
The thickness of the cell wall is 20 to 80 nanometres	The thickness of the cell wall is 8 to 10 nanometres
Peptidoglycan Layer	
It is a thick layer/ also can be multilayered	It is a thin layer/ often single-layered.
Teichoic acids	
Presence of teichoic acids	Absence of teichoic acids
Outer membrane	
The outer membrane is absent	The outer membrane is present (mostly)
Porins	
Absent	Occurs in Outer Membrane
Mesosome	
It is more prominent.	It is less prominent.
Morphology	
Cocci or spore-forming rods	Non-spore forming rods.
Flagella Structure	
Two rings in basal body	Four rings in basal body

Lipid content	
Very low	20 to 30%
Lipopolysaccharide	
Absent	Present
Toxin Produced	
Exotoxins	Endotoxins or Exotoxins
Resistance to Antibiotic	
More susceptible	More resistant
Examples	
Staphylococcus, Streptococcus, etc.	Escherichia, Salmonella, etc.
Gram Staining	
These bacteria retain the crystal violet colour even after they are washed with acetone or alcohol and appear as purple-coloured when examined under the microscope after gram staining.	These bacteria do not retain the stain colour even after they are washed with acetone or alcohol and appear as pink-coloured when examined under the microscope after gram staining.

Cell Wall of Bacteria

Bacterial Cell wall: Structure, Composition and Types

- Cell wall is an important structure of a bacteria. It give shape,rigidity and support to the cell.
- On the basis of cell wall composition, bacteria are classified into two major group ie. Gram Positive and gram negative.



Types of cell wall

1. Gram positive cell wall

Cell wall composition of gram-positive bacteria.

1. Peptidoglycan
2. Lipid
3. Teichoic acid

2. Gram negative cell wall

Cell wall composition of gram-negative bacteria

1. Peptidoglycan
2. Outermembrane:
    - Lipid
    - Protein
    - Lipopolysaccharide (LPS)

Function of the cell wall

1. protection.
2. give shape
3. Taxonomic marker
4. structure

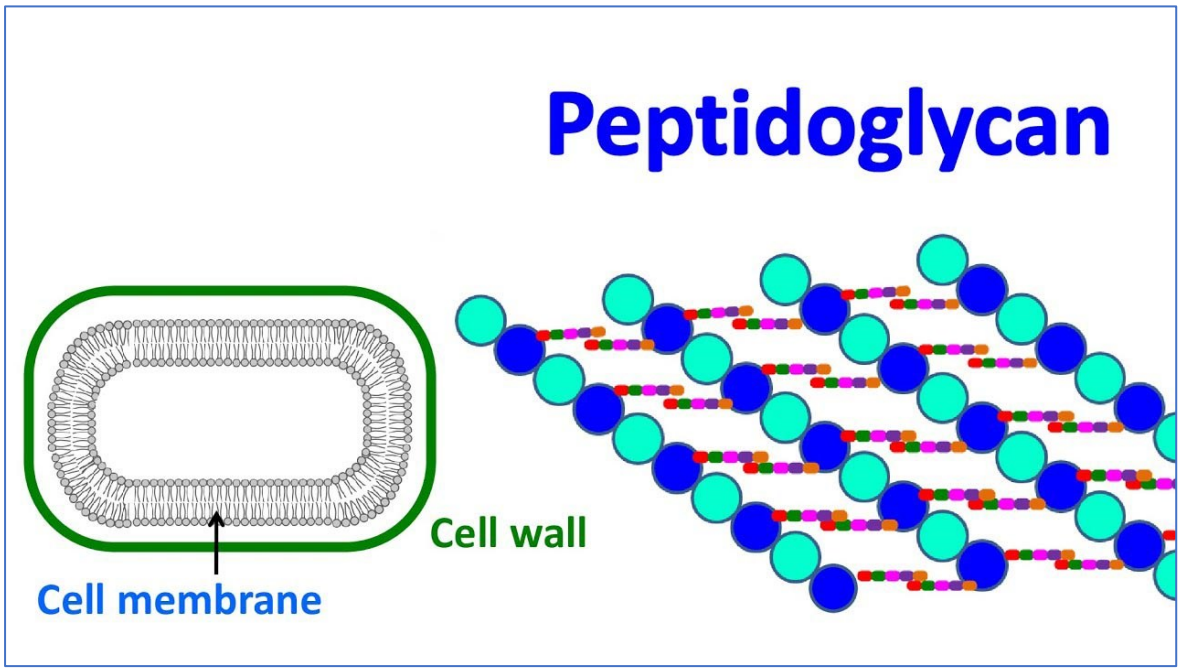
Cell wall of bacteria is made up of peptidoglycan which forms a protective coat outside the cell. peptidoglycan which is a complex of amino acids & sugar, unit, shields the cytoplasmic layer of both G+ve & G-ve bacteria & form multiple functions like provides protection shape.

Gram +ve (C. wall)

→ Multilayer = very thick
→ Contain peptidoglycan (peptide - glycan)

structure: N-acetyl glucosamine (NAG)

N-acetyl muramic acid (NAM)



Peptidoglycan also called murein, is a polymer that makes up the cell wall & forming linear chains of two alternating amino acid sugar namely N-acetyl glucosamine (NAH) & N-acetyl muramic acid (NAM).

Function of peptidoglycan cell wall:

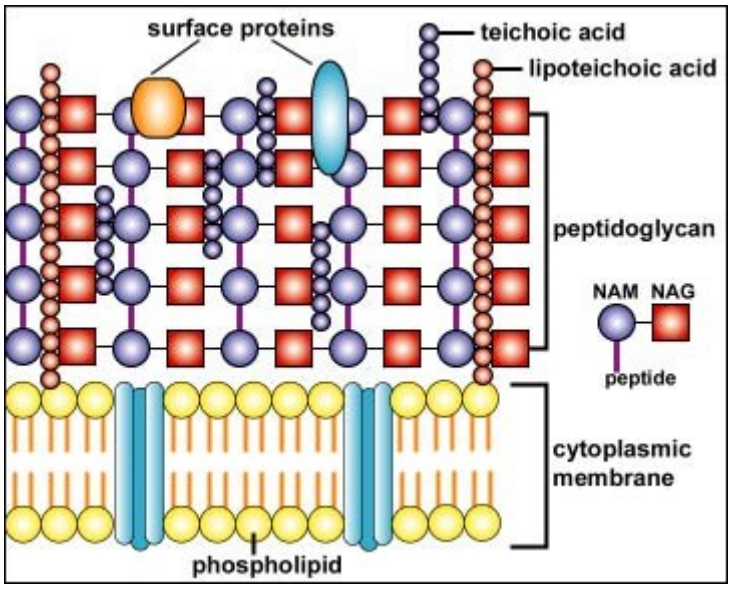
1. Prevents osmotic lysis.
2. Synthesis of peptidoglycan in order for bacteria to increase their sized of bacteria following binary fission.
3. Provide structural strength & mechanical rigidity.

Teichoic acid (lipoteichoic acid): make the cell wall stronger.

Chemical compound of bacterial polysaccharide derivatives of glycerol phosphate or ribitol phosphate linked via phosphodiester bonds, found in G+ve bacteria.

G+ve surface protein

1. Enzyme: break down the large molecule & change it to small molecule to be absorb by the cell.
2. Adhesions: to be attach to the host tissue & replicate to make colonies.
3. Invasion: Invade the tissue & penetrate to the tissue fluid.
4. Antiphagocytic: prevent the immunity system from phagocytosis or prevent phagocytosis process. all these factors called virulence factors, to infect the tissue & cause the disease.



G-ve bacteria. cell wall monolayer (thin) or 2-3 layer.

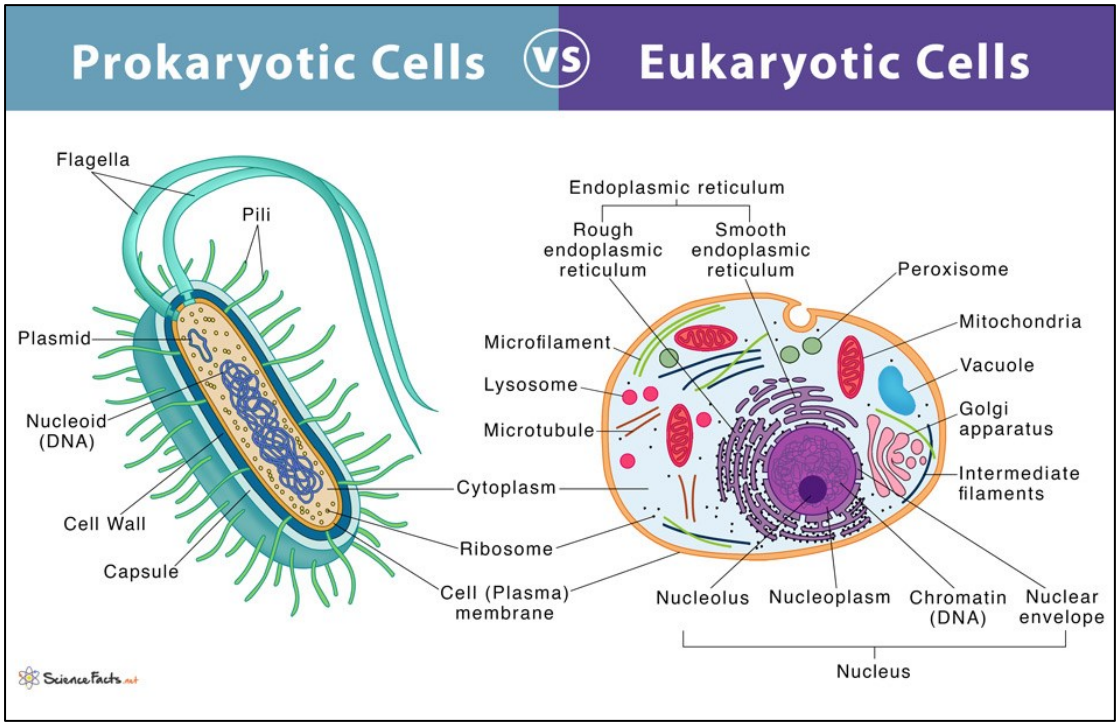
Cell wall of Gram-positive bacteria (Gram=variable)

1. Age of bacteria
2. Alcohol duration.

The Difference between Prokaryotic and Eukaryotic Cells

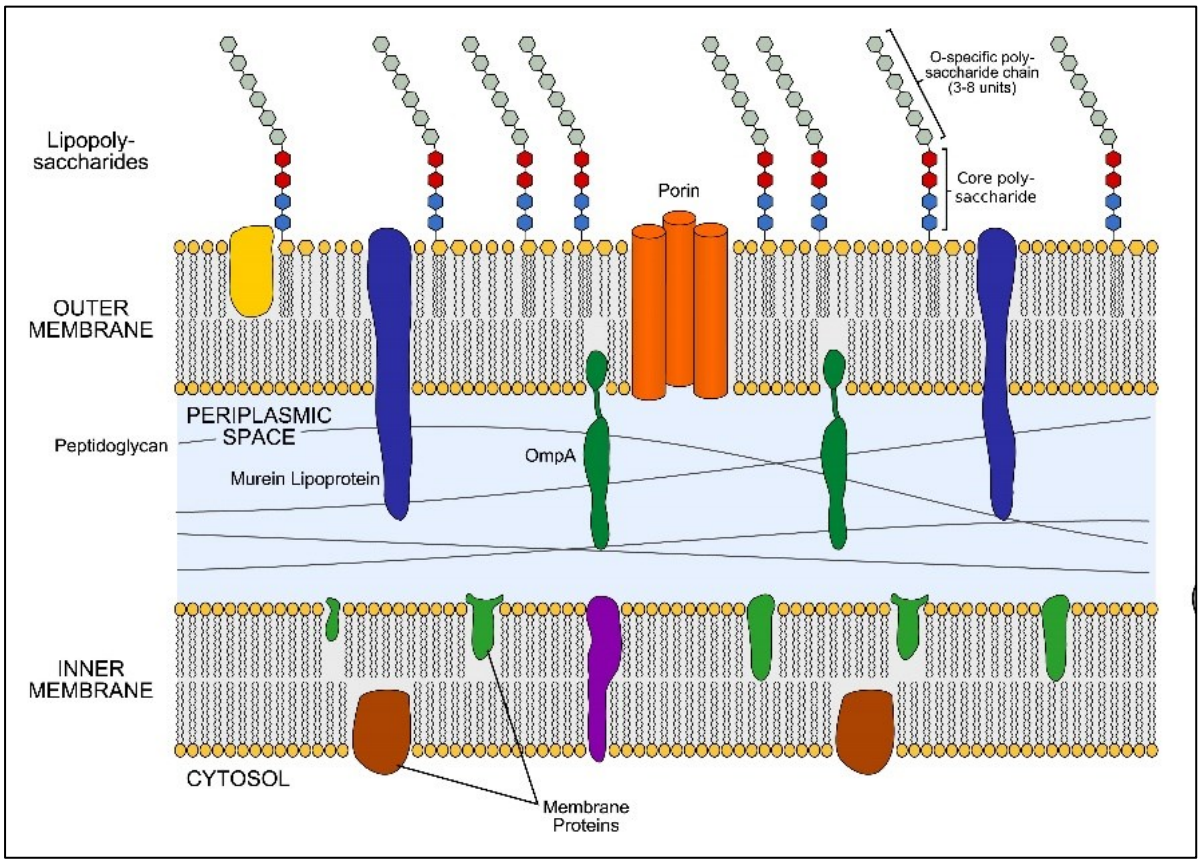
Basis	Prokaryotic Cell	Eukaryotic Cell
1. Examples	Cells of bacteria, archaea or archaebacteria, and cyanobacteria or blue-green algae	Cells of plants, animals, fungi, algae, and protozoa (protists)
2. Type	Unicellular	Unicellular or multicellular
3. Size (in diameter)	0.1 to 5.0 µm	10 to 100 µm
4. Type of Organization	Simple	Complex
5. Cell Wall	Usually, present Made of peptidoglycan or mucopeptide	Usually absent If present (in plants and fungi) made of cellulose
6. Nucleus	Absent. Instead, have a nucleoid that is devoid of the membrane	Present and membrane-bound
7. DNA	Circular, double-stranded Found freely in the cytoplasm	Linear, double-stranded Found within the nucleus
7. Chromosome Number	Single haploid (n) chromosome	Paired diploid (2n) chromosome
8. Plasmid	Present.	Absent.
9. Mitochondria	Absent	Present
10. Endoplasmic Reticulum	Absent	Present
11. Golgi Apparatus	Absent	Present
12. Lysosomes	Absent	Present

Basis	Prokaryotic Cell	Eukaryotic Cell
13. Mesosome	Present	Absent
14. Flagella	Microscopic in size Simple in structure, made of protein, flagellin	Absent
15. Cell Division	Asexually by binary fission and sexually by conjugation, transformation, and transduction	Through mitosis



Outer membrane of G-ve bacteria

The Gram-negative Bacteria the cell wall is composed of a single layer of - peptidoglycan surrounded by a membranous structure called the outer membrane. The gram-negative bacteria do not retain crystal violet but are able to retain a counterstain, commonly safranin, which is added after the Crystal violet. The safranin is responsible for the red or pink color seen with a gram-negative bacterium. The Gram-negative's cell wall is thinner (10 nanometers thick) and less compact than that of Gram-positive bacteria, but remains strong, tough, and elastic to give them shape and protect them against extreme environmental conditions. The outer membrane of Gram-negative bacteria consist of phospholipids by layer polar head & non polar tail invariably also contains a unique component, lipopolysaccharide (LPS) in addition to phospholipids. The LPS molecule is toxic and is classified as an endotoxin that elicits a strong immune response when the bacteria infect animals and human body.



Outer membrane of gram-negative bacteria

gram negative bacteria contain a double membrane serves for both protection & for providing nutrients for viability & cell adhesion & waste

export for pathogenic strains the O.M has symmetrical distribution of liped & the inner leaflets containing phospholipid & the outer leaflets is composed of Lipopolysaccharide LPS highly negatively to charged molecule into the bacterial environments. This layer was synthesized in the cytoplasm o About 50% of the outer membrane mass consist of protein either in the form of integral membrane proteins or as lipoproteins that are anchored to the membrane or cell wall of bacteria to make it stronger.

Porins: are pores consist of protein present in the O.M. of G-ve bacteria that form channels to allow the entry of antibiotic and certain the pores has certain diameter Vancomycin molecules reduction in the number of porins decrease the influx of drugs in to bacteria allowing them to develop Resistance against different antimicrobials.

In *Neisseria gonorrhoeae* the outer membrane contains 30% of pores porius is Hamotrimeric molecule which form pores & act as channel to allow some compound to exit out side the cell.

Lipopolysaccharides (LPS): are large molecule consisting of a lipid & embedded in the O.M. lipopolysaccharide that are bacterial toxins. They are composed of:

Core polysaccharide (Inner core) & outer polysaccharide has antigenic character called O. Antigen or Antigen determinant.

Lipid A → endotoxin → pyrogen

1. Increase the body temperature.
2. Hypertension

Function of O.M

1. Act as molecular sieve.
2. LPS Increase the strength of outer membrane like techoic acid in G+ve
3. Outer membrane protecting the bacteria from certain kinds of chemical attach.
4. O.M increase the negative charge of the cell membrane & helps stabilize the membrane structure.
5. Prevent surface adhesion of some bacteriophage to some strain of bacteria.
6. The activation of porins in the O.M depend of Ca+ absorption of certain molecules

On the surface of the outer membrane found protein which act as carriers or for transportation.

Endospore:

Vegetative bacteria is active bacteria or the type of bacteria that are replicate reproduce & grow very well in the media. Some strain or genera of G+ve bacteria like *Bacillus clostridia* when the environmental conditions not suitable or abnormal started to charge from the vegetative state to dormant state (endospore).

This endospore has some DNA of the bacterial cell & compound for energy & some enzyme to live until the environmental conditions changed & return to the normal state (vegetative).

Endospore: Is the most resistance form of bacteria which resist to:

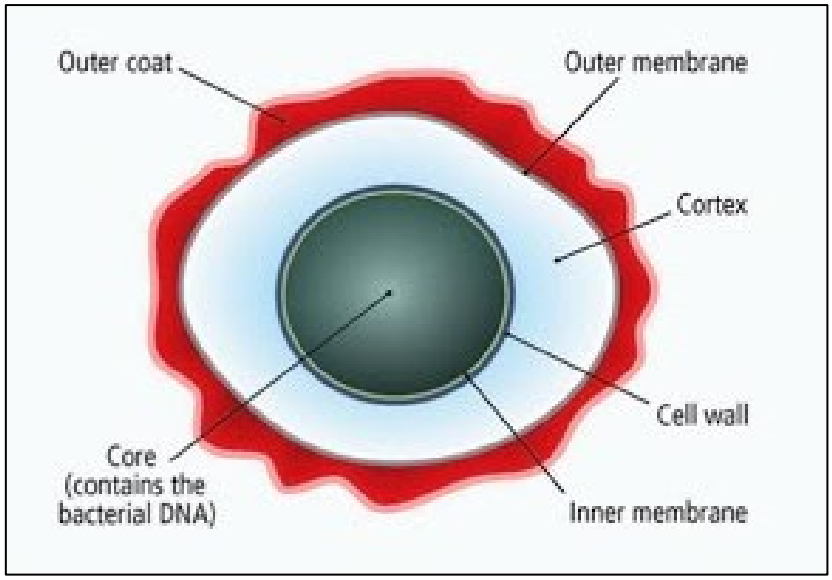
1. heat & temp.
2. Radiation
3. Chemical e.g Antibiotic
4. Detergents.

all these factors can't affect the endospore i.e is very strong structure.

Structure of endospore from inside to outside:

1. Core- contain G.M (DNA) + 3-phosphoglycerate (energy source) instead of ATP + enzyme e.g Di picolinic acid synthetase which react with dipicolinate to form salt Ca- dipicolinate.
   A) No free water or H_2O. (Heat resistance)
   B) Ca- dipicolinate. (Heat resistance)

2. Wall
3. Cortex
4. Coat
5. Exosporium
6. Endospore don't stain by Gram stain and have special stain.

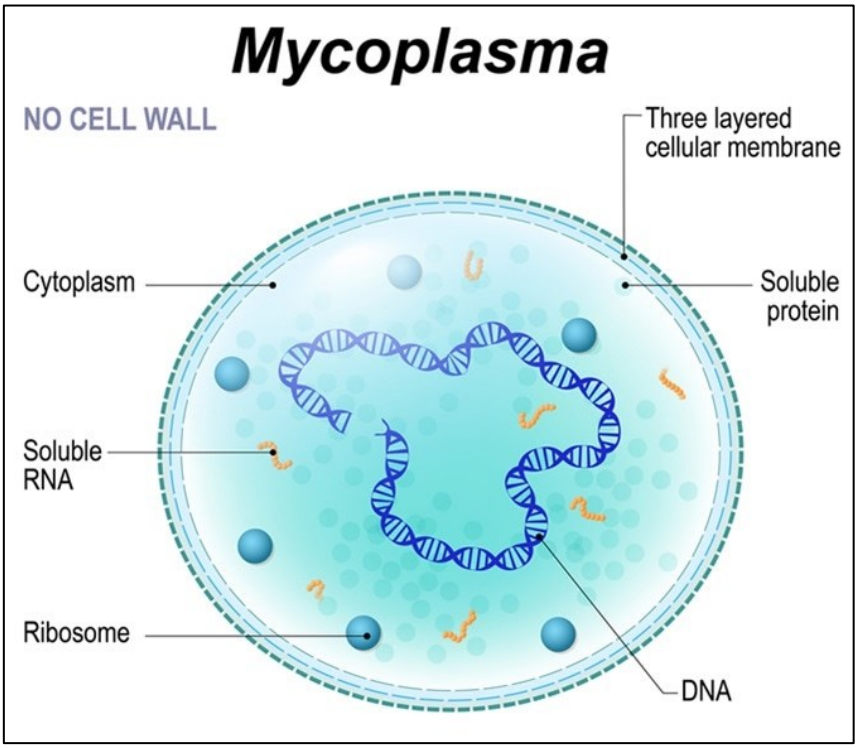


Bacterial forms:

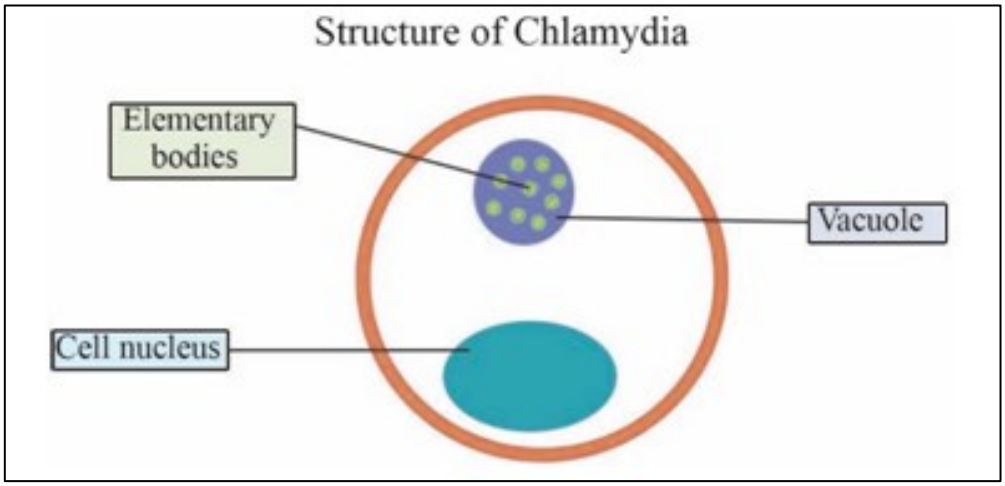
1) Protoplast = to remove the cell wall of G+ve bacteria by enzyme called lysozyme.

enzyme: This enzyme breaks down the peptidoglycan bonds when the cell started to lose the cell wall this called protoplasts & this cell have only cell membrane.

Some bacteria in the nature without cell wall this bacterium is *Mycoplasma* & have thick cell membrane strengthen by cholesterols & give shape of the bacteria.



2) spheroplast: G-ve bacteria have outer membrane so the lysozyme enzyme is not enough to remove the cell wall & added EDTA in the media sometimes antibiotic such as B-lactams (Penicillin) play a good role to breakdown the cell wall in the G-ve bacteria e.g of G-ve bacteria found in the nature is *Chlamydia* called spheroplast. The Isotonic solution (the body fluid is isotonic) keep these cells live long time without lysis in the media.



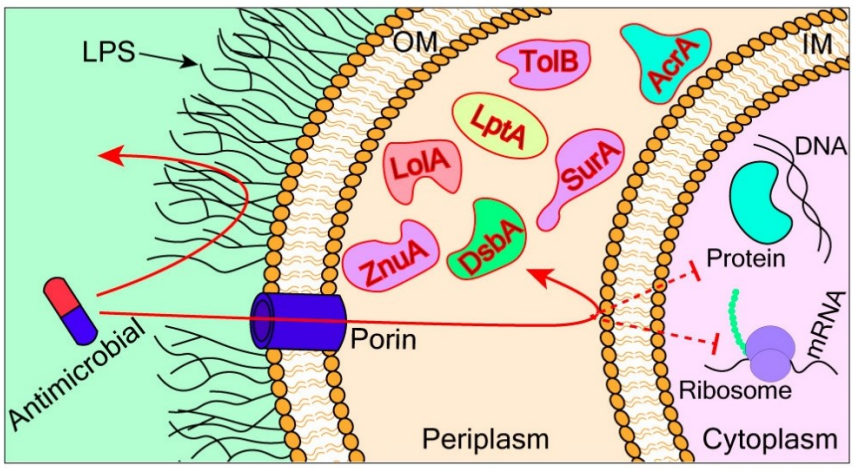
Periplasm = is the space between the cell wall & cytoplasmic membrane this space contain:

1) proteins: acts as Carriere's or receptors for transport the substance from outside to inside the cell.

2) Enzyme:

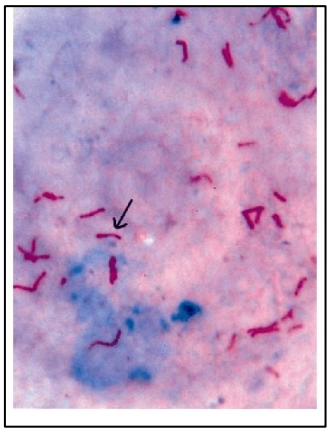
a) This change & break down large molecule & some nutrients to small molecules & make it able to absorb by bacteria.

B) The enzyme also plays a good role for building the structure of cell wall & the cytoplasmic membrane.

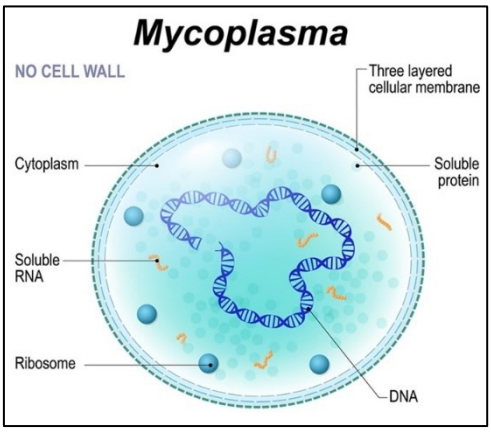


Microorganism with special cell wall

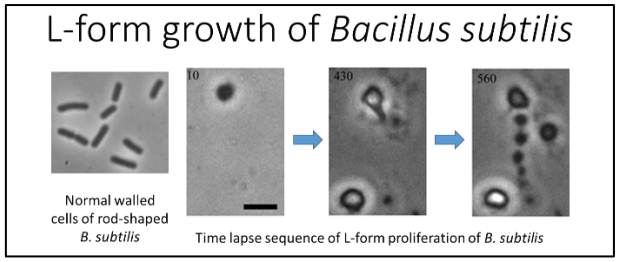
1. Acid fast bacteria *Mycobacterium tuberculosis*. (T.B). The cell wall is thick & consists of glycolipid type Mycolic acid which resists the antibiotic & Gran stain.



2. *Mycoplasma* doesn't have cell wall, only cell membrane, the chemical composition of C.M. is cholesterol which makes it strong & resist to treatment & staining.



3. L form bacteria or bacteria L form.



This *Streptococcus* bacteria lives inside the body and causes disease to the human body.

This bacterium is sensitive to A.B penicillin, if the patient takes low dose of A.B. the bacteria lose the C.W. After the A.B excreted from the body

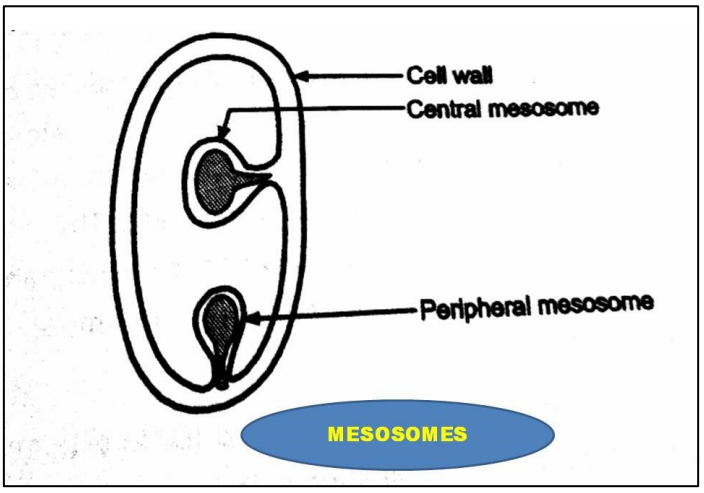
the bacteria started to make the C.W. this happens if the solution inside the body isotonic or the body fluid is isotonic.

Cell membrane

Is the spirt of the bacteria cell all the biological activities happen inside it contains:

A. Phospholipid bilayers.
B. Protein.
C. Glycocalyx (Glycoprotein, Glycolipid)

Cell membrane contains mesosome initiated by invagination of the cell membrane mesosome are two types (central mesosome & peripheral mesosome)



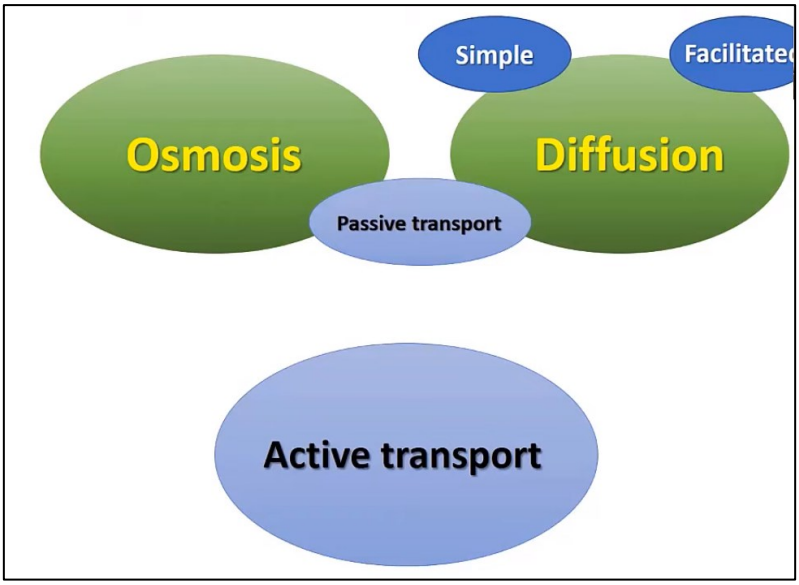
Types of solutions

1. Hypertonic
2. Hypotonic
3. Isotonic

Transport across cell membrane

There are two types of transports:

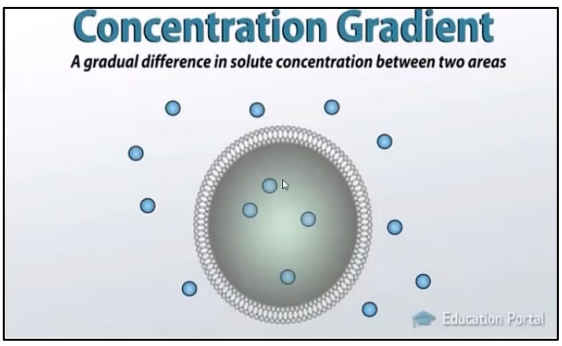
1. Passive transport
2. Active transport

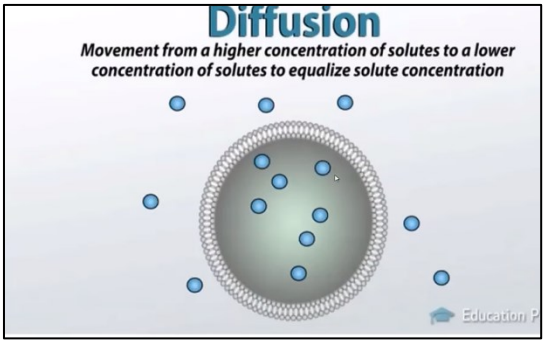


Passive transport: Is a biological process, energy is not required for transporting the molecules, as the biochemical move from a region of higher concentration to region of lower concentration, all particles are easily soluble and transported through passive transport & the processes carried out to maintain the balance & equilibrium level in a cell. Water & Co_2 is separated & moved out of the call membrane using passive transport. in these processes the molecules move along the concentration gradient.

Passive transport is the movement of molecule & ions across the cell membrane without requiring energy. along the concentration gradient

Concentration gradient: a gradual difference in solute concentration between two areas:





Passive transport divided into:

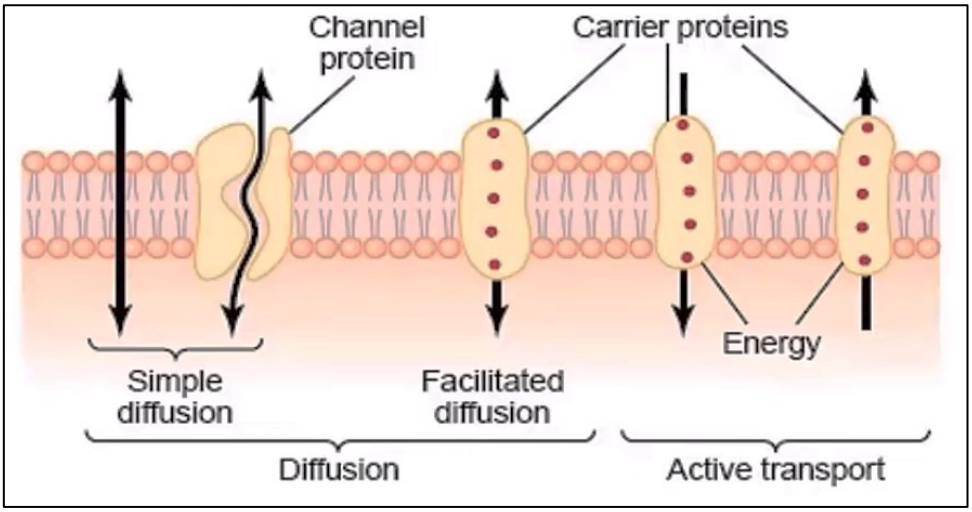
1. Osmosis
2. Diffusion

Osmosis: In this process the water molecules are transported directly through the selectively permeable cell membrane from high concentration to low concentration until become equal no need of energy.

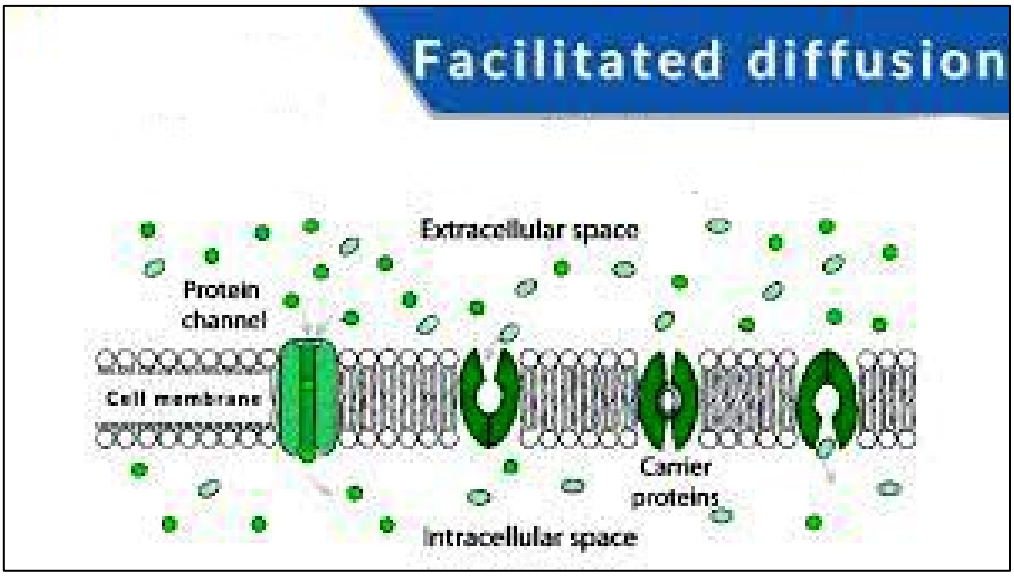
Diffusion: movement from a higher concentration of solutes to a lower concentration of solutes to equalize solute concentration.

Diffusion divided into two types?

1. Simple diffusion.



2. Facilitated diffusion.



Simple diffusion: transport of special substances & ions from high concentration to low concentration directly through the cell membrane which consists of phospholipid bilayer or protein channel no need of energy:

Facilitated diffusion: transport of substances & ions to the cell from high concentration to low concentration by some carrier or receptor called protein carriers which carry the ions and substances to enter the cell & do not need energy.

Some factors affecting transport of molecules such as

1. solubility
2. size
3. charge.

The substance divided into:

1. lipid soluble
2. water soluble (Hydrophilic, Hydrophobic)

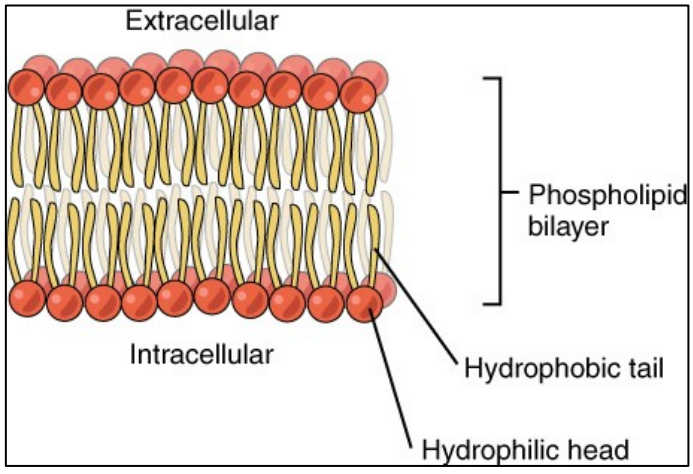
if the molecules and ions have small size & lipid soluble, they are transport directly through phospholipids bilayer of the cell membrane. Through the small pores in the wall e.g steroids, fat & vitamin (simple diffusion).

but if the substance & ions are water soluble & have a small size of molecules, they transport through protein channel (simple diffusion) if the molecules &ions have large size & water-soluble transports occur through carriers or facilitated diffusion.

Small unchanged polar molecules such as waste, urea & alcohol

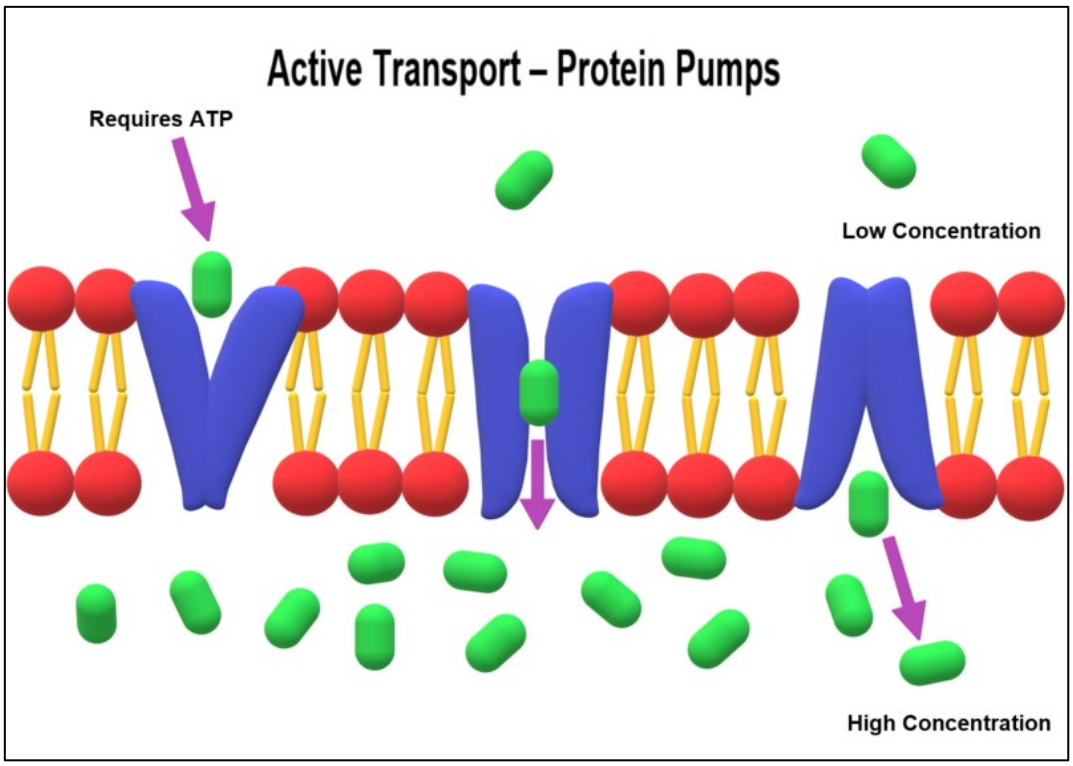
Non-polar - hydrophobic molecule (O_2, Co_2, Cl_2, N2).

Polar = H_2O, NH_3, CH_3CooH



Active transport: Is the movement of molecules across a membrane from a region of lower concentration to a region of higher concentration against the concentration gradient. often assisted by energy or enzymes. these processes used ATP to pump molecules through a concentration gradient.

Complex sugar. ions, large molecules, proteins & other particles transported in this process.

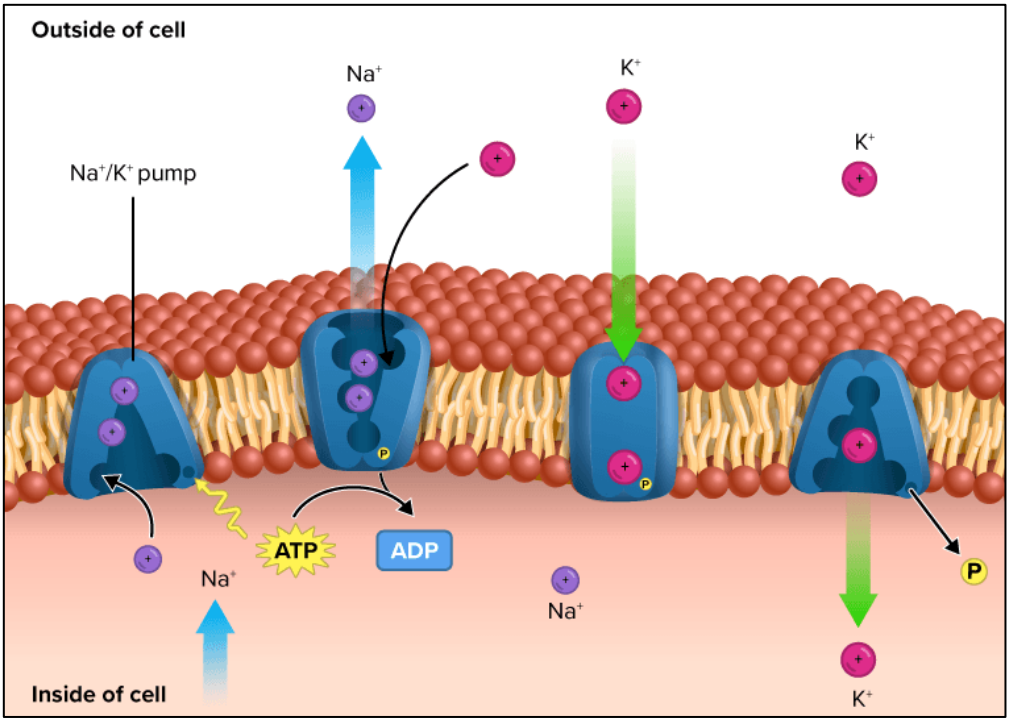


There are two types of Active transports:

1. Primary active transport.
2. Secondary active transport.

Primary active transport: called direct active transport. directly chemical energy (such as adenosine triphosphate or ATP, in case of (c.m.) to transport all species of solutes.

one of the most important pumps in animal and human cells is the sodium-potassium pump, which moves Na^+ out of cells and k^+ into the cell because this transport process uses ATP. most famous examples of primary active transport is $3Na^+ / 2k^+$ = pump = protein pump.



Cell membrane impermeable to:

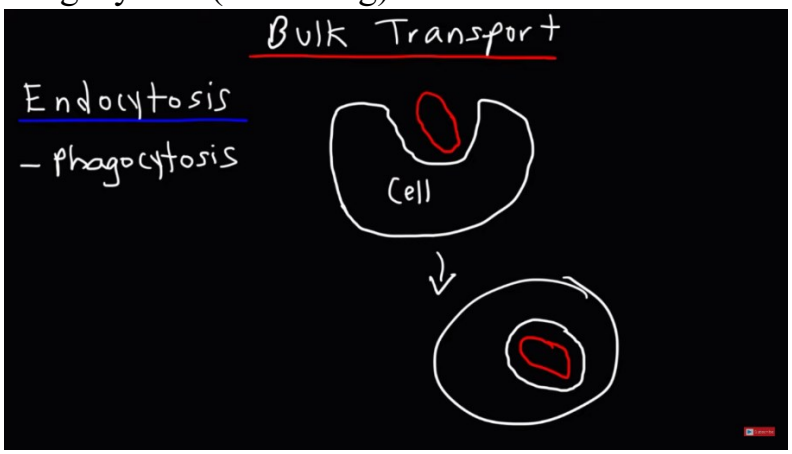
1. Large polar molecules (glucose).
2. Charged inorganic ions (Na^+) need carrier protein or pump.

Secondary active transport: a kind of active transport that uses electrochemical energy conversion of chemical energy to electrical energy by reaction of substances & transferring electrons.

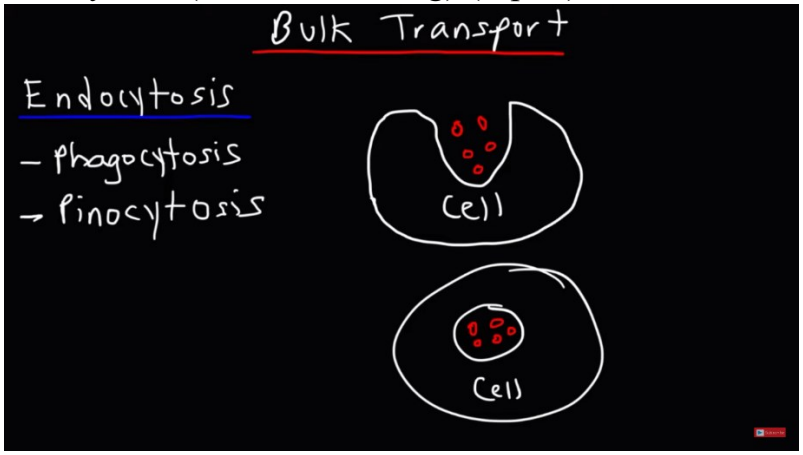
It takes place across a biological membrane whereas transporter protein which moves nutrients, waste products.

Active transport example:

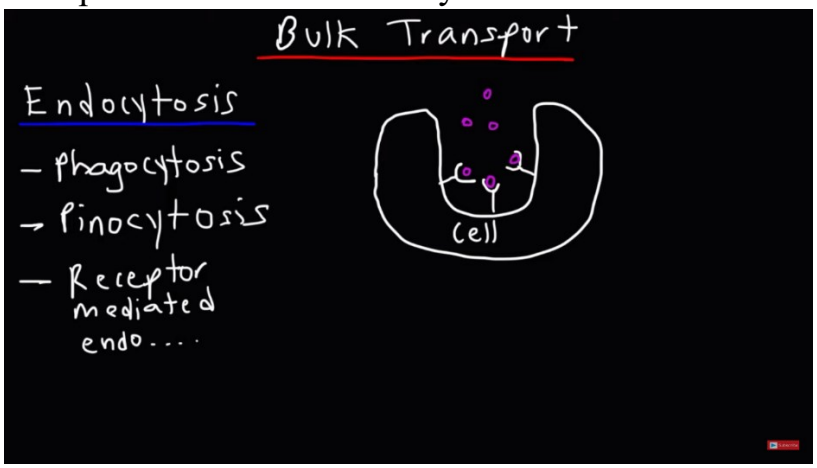
1. Na+ k+ pump or protein pump
2. Endocytosis: is the process of active transportation of molecules into the cells by action of engulfing it along with the membrane.
    a. Phagocytosis (cell eating) solid.



    b. Pinocytosis (cellular drinking) (liquid).

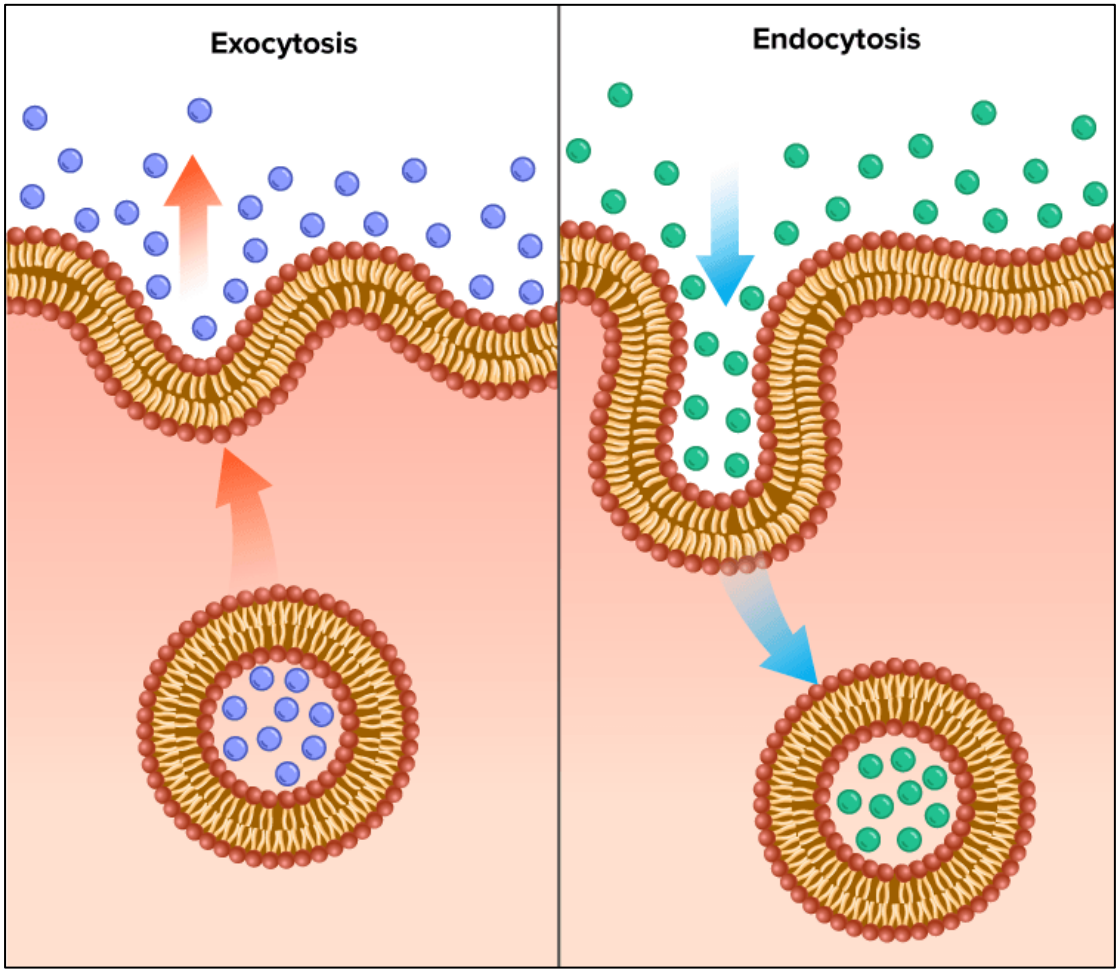


    c. Receptors or mediated endocytosis.



3. Exocytosis - like excretion

exocytosis: is a form of active transport requires energy to transport material from inside the cell to the exterior of the cell which is the contents of a cell vacuole are released to the exterior through fusion of the vacuole membrane with the cell membrane or plasma membrane.



Rate of diffusion depend on:

1. The magnitude of concentration gradient.
2. Permeability of membrane.
3. Temperature - higher temperature faster diffusion rate
4. Surface area of the membrane Microvilli increase surface area

Key points on active & passive transport:

1. Active transport requires energy for movement of molecules, whereas passive transport do as not require energy for movement of molecules.
2. In active transport, the molecules move against the concentration gradient, whereas the passive transport the molecules move along the concentration gradient.
3. Up take of glucose in the human intestine works on the principle of active transport.
4. Simple diffusion, facilitated diffusion, Osmosis is exp. of passive transport.

Differences between Active and Passive transport

Active Transport	Passive Transport
Active transport Requires cellular energy.	Passive transport does not require cellular energy.
It flows from lower concentrated areas to the higher concentrated areas	It flows from the higher concentrated areas to the lower concentrated areas
Active transport is involved in transporting all the molecules including complex sugars, proteins, large cells, ions, etc.	Passive transport is usually involved in transporting stuff like soluble molecules which includes water, oxygen, carbon dioxide, monosaccharides, lipids, hormones.
It involves the transportation of different molecules in the cell.	It is involved in maintaining the equilibrium level in the cell.
It Occurs in one direction.	It occurs bidirectionally.
It is Affected by temperature.	It is not affected by temperature.
It requires carrier proteins.	It carrier proteins are not involved
Example: Endocytosis, exocytosis, cell membrane, or the sodium-potassium pump, are different types of Active Transport.	**Example:** Osmosis, diffusion, and facilitated diffusion are different types of Passive Transport

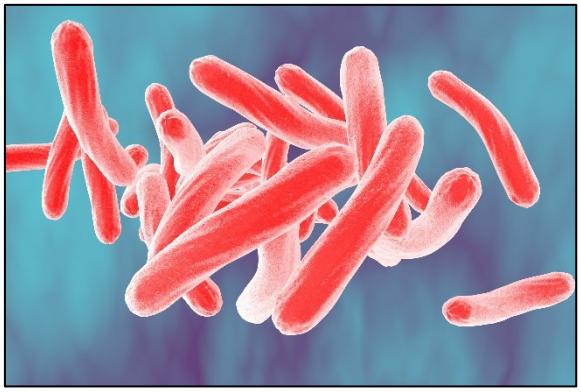
Cultivation of bacteria

Nutritional requirements

1. Energy (source)
   → Phototrophs (light)
   → Chemotrophs (chemical reaction)
2. Electron (source)
   → Lithotrophs inorganic
   → organotroph
3. Carbon (source)
   → source air (atmosphere)
   → autotrophs (air)
   → Heterotrophs (organic).
4. Nitrogen- for synthesis of amino acid purines, pyrimidine, carbohydrate, lipid and nucleotide.
5. O_2 - S. amino acid (cysteine and methionine)
6. Phosphorus: Nucleotides, phospholipids (ATP.)
7. Metal ions: Ca^{+2}, k^{+2}, Mg^{+2}, Cu^{+2}
8. Trace element (ions): Zn, Ni, Co, Mo, I, Se, Mn (low amount).
9. H_2O
10. Vitamins: coenzyme (organic NAD, FAD) & cofactors (metal Mg^{+2})
    Vitamins B1 this must add to the media if the bacteria cannot create it because it is very important for the growth of the bacteria.

Obligate intracellular bacteria (Leprosy)

This type of bacteria like viruses which cannot grow and replicate outside the living tissue or body (intracellular) & cannot culture in nutrient media need living tissue or animal body to grow & replicate e.g: *Mycobacterium leprae* which live in the mouse foot, another example Chlamydia, *Rickettsia*, *Spirochetes* also live-in tissue.



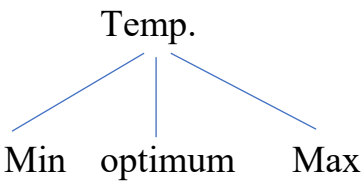
Mycobacterium leprae

Cultivation of Bacteria

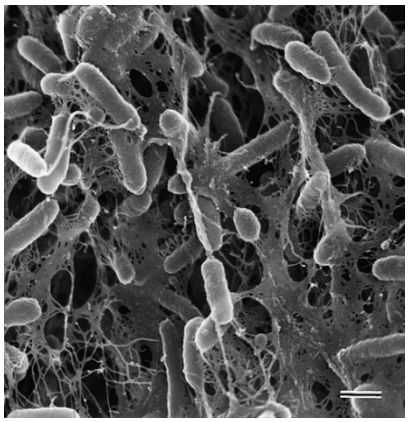
Environmental Requirements for growth.

Physical conditions:

1. Temperature:

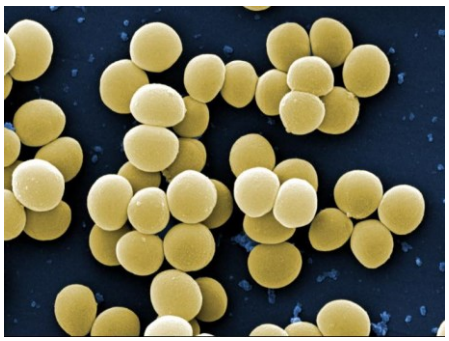


1. Psychrophiles (0-20º C): Bacteria can grow at 0 º C or below, but the optimum temperature of growth in 15 º C or below & maximum temperature is 20 º C, these bacteria have polysaccharides & fatty acid in their cell membrane which gives fluid nature to the cell membrane even at lower temperature e.g *Vibrio marinus*.



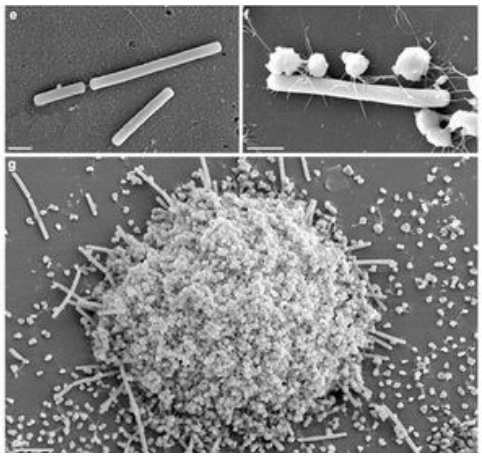
Vibrio marinus

2. Mesophiles (25 - 40ºC): These bacteria can grow best between 25-40ºC but optimum temperature for growth is 37ºC. Most of the human pathogen's bacteria are mesophile in nature e.g: *E. coli, Klebsiella, Staphylococci & Salmonella.*



Staphylococci

3. Thermophiles**:**
    - Moderate thermophiles 55-65ºC: grow between this range of temperature:
    - Hyperthermophiles 80-113ºC: the optimum temperature of growth above 80ºC, mostly Archeobacteria are hyperthermophiles, this type more resistance to heat they adopt to grow in higher temperatures because contain saturated fatty acids in their cell membrane & the cell membrane does not become so fluid even in higher temperatures Thermophilic bacteria are those that thrive within high temperatures, usually between 45 and 80 C (113 and 176F) and are found in environments such as hot springs, peat bogs, and near deep-sea. One type of "hyperthermophile", *Methanopyrus kandleri*, can even survive temperatures up to 122°C.



Methanopyrus kandleri

2. pH = physical condition

1. Acidophiles 0.1 - 5
    - These bacteria grow best at an acidic pH.
    - The cytoplasm of these bacteria is acidic in nature.
    - Examples: *Thiobacillus*.
2. Neutrophiles 6.5 - 7.5: most of the laboratory bacteria
3. Alkaliphiles 7 - 11.5: These bacteria grow best at an alkaline pH e.g: *Vibrio cholerae* optimum pH of growth 8.2.

3. Osmotic pressure

1. Non-Halophiles: do not grow in salt.
2. Halophiles: require moderate to large salt concentration.

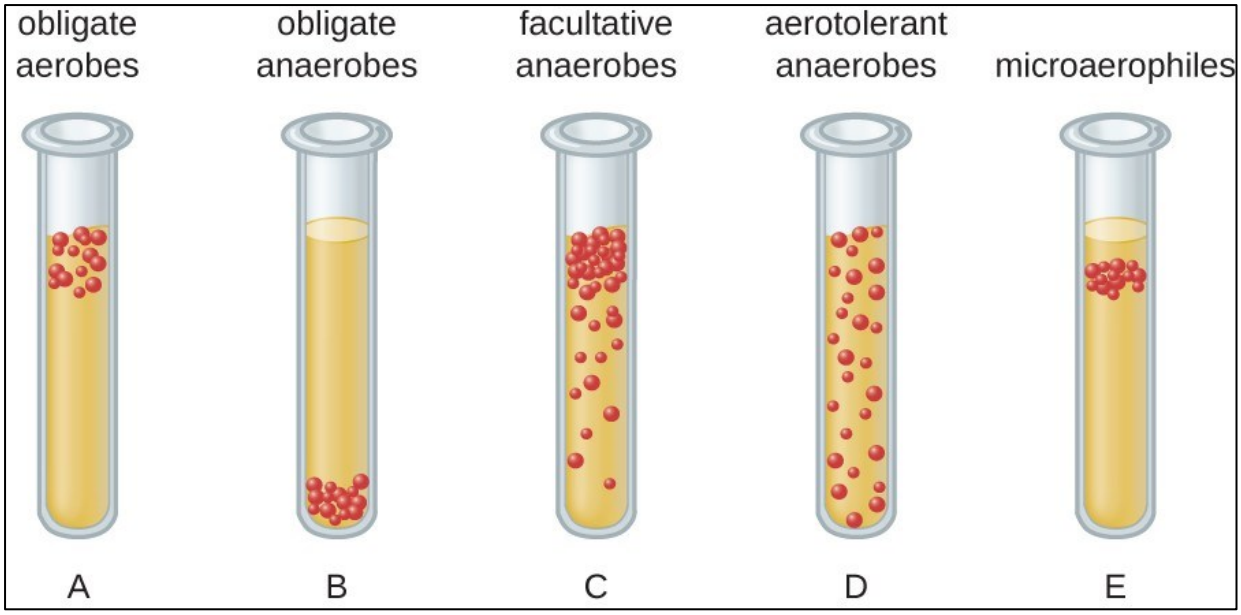
- Cell membrane of halophilic bacteria is made up of glycoprotein with high content of negatively charged glutamic acid and aspartic acid.
- Ocean water contains 3.5% salt. Most bacteria are present in the oceans (marine bacteria).

marine bacteria

3. Extreme or obligate Halophiles:
    - Require a very high salt concentration (20 to 30%).
    - Bacteria in dead sea, brine vats.
4. Osmotolerant: can live with or without salt.
5. Osmophilies: like sugar media
6. Xerophilies: live in dehydrated media.

O_2 requirement

A. Obligate aerobes: organisms that require 21% O_2 & small amount of CO_2 0.03% to live and need O_2 for aerobic respiration to generate energy e.g: *Mycobacterium tuberculosis* (T. B.) which causes tuberculosis if O_2 it is not available die.
B. Obligate anaerobes: Organisms that die in the presence of O_2. Generate energy via fermentation or anaerobes respiration e.g *Clostridium tetani*.
C. Facultative anaerobes: Survive both in presence & absence of O_2 generate energy by toggling between aerobic respiration if O_2 present and fermentation or anaerobic respiration e.g *Escherichia coli*, *Staphylococci*.
D. Aerotolerant Anaerobe: Survive in presence of O_2, but don't use it to produce energy generate energy via fermentation. e.g: *Streptococcus pneumoniae*.
E. Microaerophiles: Can survive with the little of O_2 if the organism live in air die do not need high concentration of O_2 e.g *Lactobacilli*.
F. Capnophiles: These bacteria require high concentration of Co_2 (5% - 10%) or loving high concentration of Co_2 e.g *Neisseria gonorrhoeae*.


obligate aerobes
obligate anaerobes
facultative anaerobes
aerotolerant anaerobes
microaerophiles
A
B
C
D
E

Composition of culture media

- Water
- Carbon source (glucose)
- Nitrogen source (protein)
- Mineral salts (NaCL)
- Special growth factors (Vitamins, hormone,….)

What is Agar ?

Agar: a solidifying agent which is a poly saccharide obtained from algae.

It melts at 100C and solidified at 45C

الاكار : هو المادة المسوولة عن تصلب الوسط وهو عبارة عن سكريات متعددة نحصل عليها من الطحالب .
يذوب بدرجة 100ويتصلب بدرجة 45 درجة مئوية

Types of culture media

Types of culture media

1- Classification based on physical state (Solidity)

a) Liquid medium
b) Semi solid medium
c) Solid medium

Classification according to solidity

A- Liquid media (broth): contain all ingredients except agar ex: Nutrient broth.

B- Semi-solid media

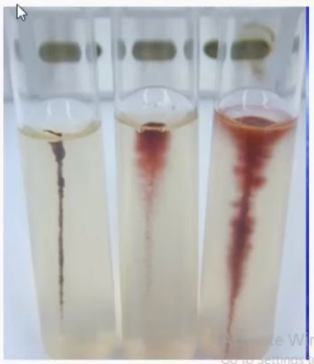
contain all ingredients + **0.2 % Agar**

media are soft and useful in

distinguish bacterial motility

and separating motile from non motile strains

Ex: Semisolid mannitol



C-Solid medium (contain 1.5-2 % Agar)

contain all ingredients + 1.5 - 2 % Agar

ex: Blood Agar, MacConky Agar

2- Classification based on the ingredients (function)

- a) Simple media
- b) Enriched media
- c) Selective media
- d) Differential media

2-Classification based on the ingredients

a-Simple media

contain simple nutrient

eg: Nutrient broth and Nutrient agar

b-Enriched media

contain additional materials to enhance the growth of bacteria

Substances like blood, serum,

egg are added to the simple medium.

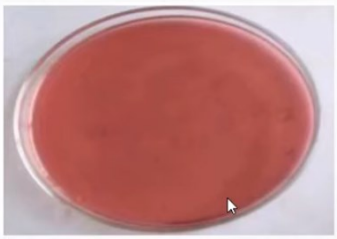
eg: Blood Agar and Chocolate Aga

3-Selective media

The inhibitory substance is added to a solid media to inhibit commensal or contaminating bacteria such as :

- Antibiotics , Dyes
- Chemicals, Alteration of pH

Ex: MacConkey Agar (growth only gram Negative bacteria)

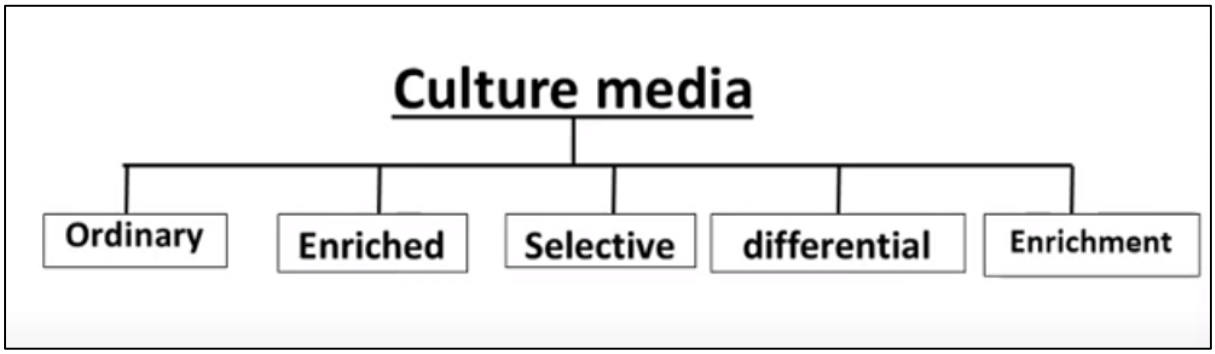


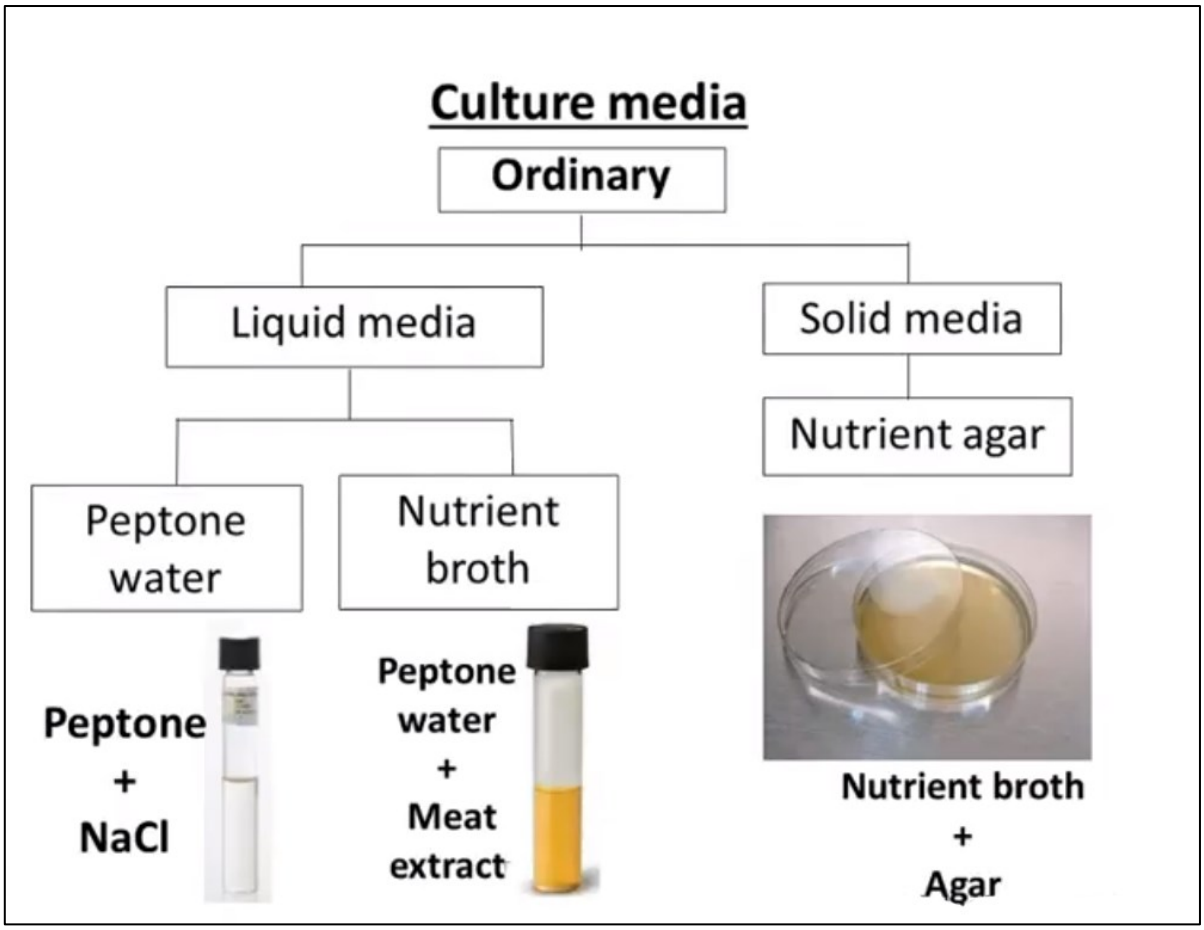
4-Differential media

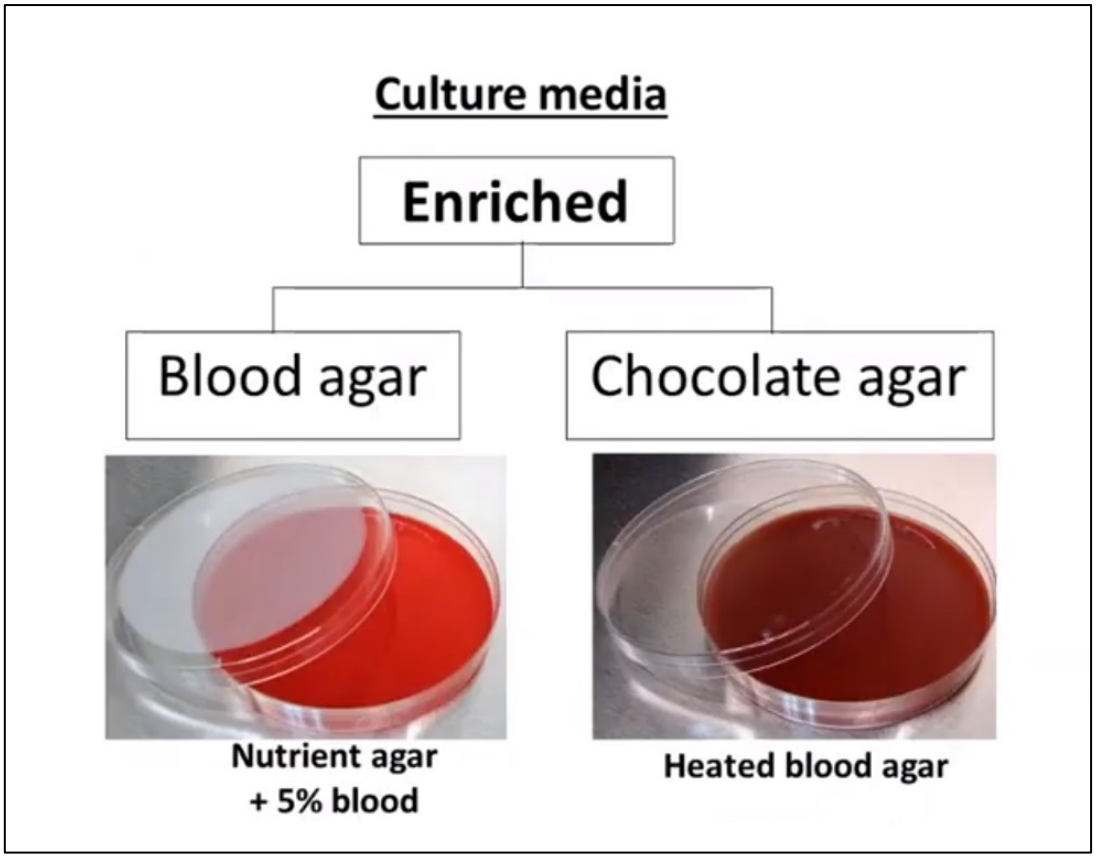
Used to differentiate between 2 groups of bacteria

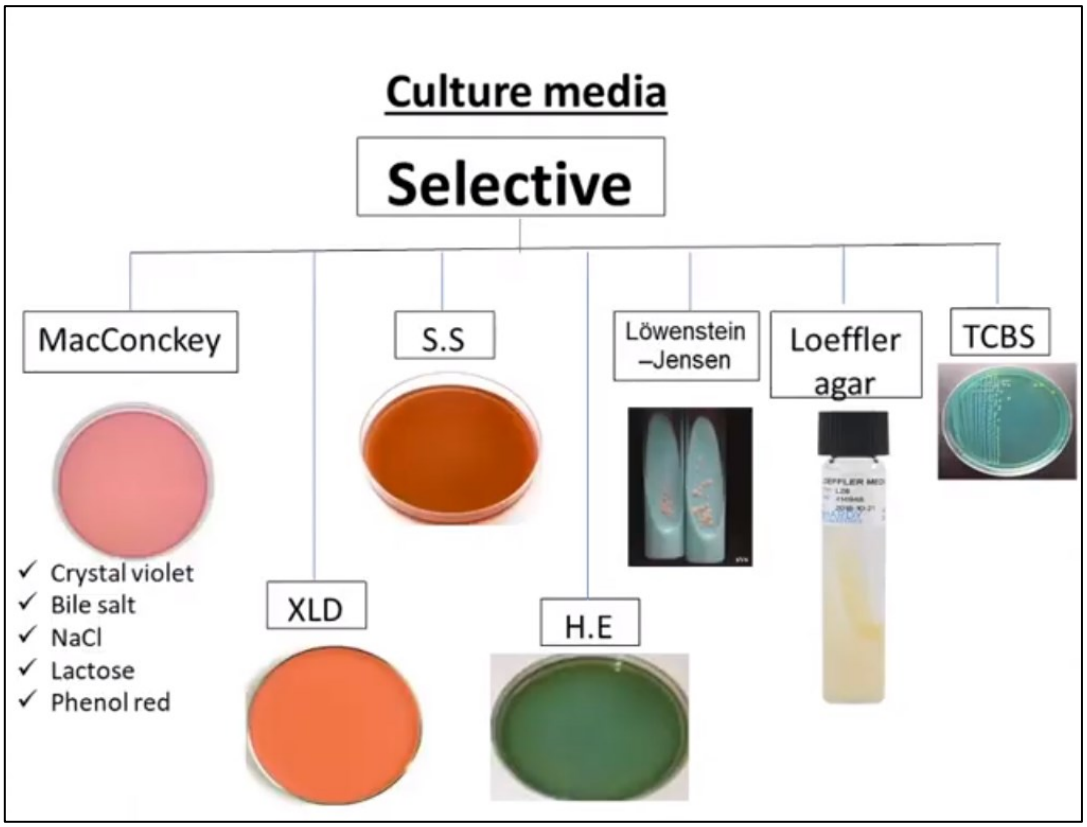
Ex: MacConkey's agar Distinguish between lactose fermenters & non lactose fermenters

Types of media (Culture media)





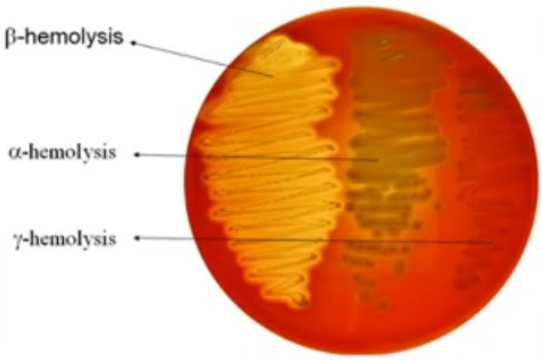

Culture media
Enriched
Blood agar
Chocolate agar
Nutrient agar
+ 5% blood
Heated blood agar


Culture media
Selective
MacConckey
S.S
Löwenstein –Jensen
Loeffler agar
TCBS
✓ Crystal violet
✓ Bile salt
✓ NaCl
✓ Lactose
✓ Phenol red
XLD
H.E

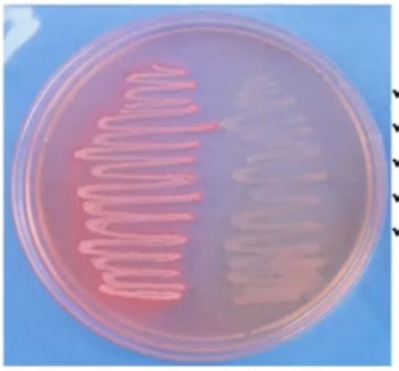
Culture media

differential

Blood agar



MacConckey agar



- ✓ Crystal violet
- ✓ Bile salt
- ✓ NaCl
- ✓ Lactose
- ✓ Phenol red

Culture media

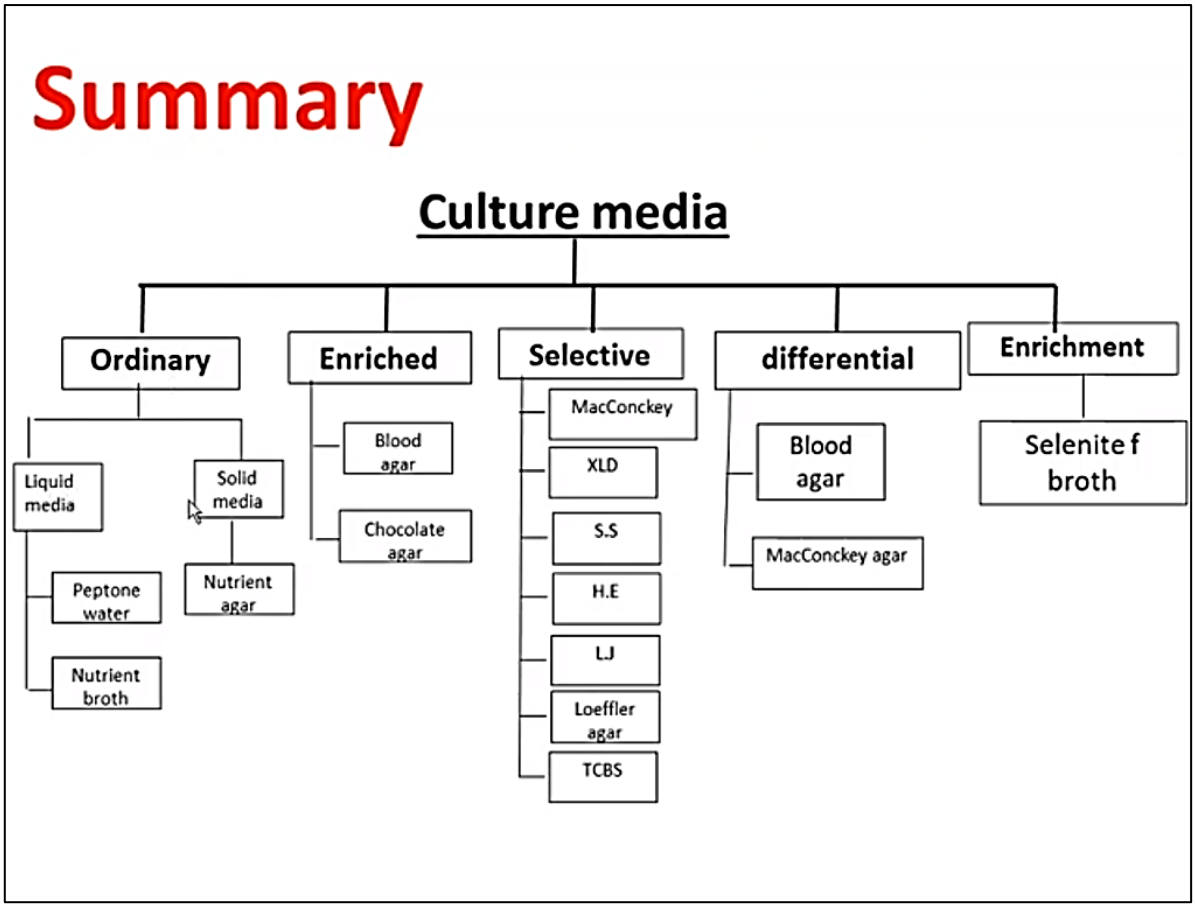
Enrichment

↓

Selenite F broth

Salanite F broth is an enrichment media for the isolation of *Salmonella* and some species of *Shigella*

Sodium selenite inhibits many species of gram-positive and gram-negative bacteria including enterococci and coliforms.


Summary
Culture media
Ordinary
Liquid media
Peptone water
Nutrient broth
Solid media
Nutrient agar
Enriched
Blood agar
Chocolate agar
Selective
MacConckey
XLD
S.S
H.E
LJ
Loeffler agar
TCBS
differential
Blood agar
MacConckey agar
Enrichment
Selenite f broth

Bacterial Metabolism

- Metabolism is the chemical activity by which an organism synthesizes its constituents and converts energy from outer sources to energy rich chemical bonds.

- It is the sum of biochemical processes that occur within a living cell that cause production and consumption of energy that helps in building cell components or fulfils functional requirements such as:
  1. Motility.
  2. Transport of molecule across the cytoplasmic membrane.
  3. Growth.
  4. Reproduction.
  5. others.

1- Catabolism or Dissimilation

- It is intracellular degradation of complex organic components to simpler molecules, which could be organic or inorganic.
- This process is usually accompanied by release of energy in the form of ATP (adenosine triphosphate), the cell stores this energy until in need.
- This is an energy producing reaction.

2- Anabolism or Assimilation:

- The process of utilizing the energy stored in ATP to synthesize and assemble the subunits, or building blocks, of macromolecules that make up the cell.
- This process consumes energy.

The enzymes

- Enzymes are proteins of very important functions; they are responsible for catalyzing biochemical reactions.

- Enzymes control and accelerate the rate of biochemical (metabolic) reactions in the cell, and in order to do so they must function under specific physiological conditions.

- Every enzyme catalyzes a specific biochemical reaction and some enzymes are highly specific towards their substrates (the substance acted upon by an enzyme) to produce an end product.

Enzyme classification

- Enzymes are classified according to their mode of biochemical reaction; they are divided into six main categories:

1. Oxidizing and reducing enzymes (Oxidoreductases).
2. Transferring enzymes (Transferases).
3. Hydrolyzing enzymes (Hydrolases).
4. Enzymes that catalyze addition or deletion of groups from double bonds (Lyases).
5. Enzymes that catalyze isomerization (Isomerases).
6. Enzymes that bind or remove free groups (Ligases).

Structure and activity of the enzyme

- Sometimes the enzyme activity depends on the protein part only known as the apoenzyme, while in other enzymes; to be active they must consist of another part known as a cofactor; a small non-protein agent that activate the enzyme.

Structure and activity of the enzyme

- The cofactor could be:
  1. an inorganic substance such as metallic ions: Fe, Mg, Cu, Mo, Co, Zn (known as prosthetic Group) or hydrogen ions
  2. or it could be an organic substance known as a coenzyme such as a vitamin.
- The apoenzyme with the cofactor is known as the holoenzyme.
- Cofactors bind to a specific site on the three dimensional structure of the enzyme known as the active site this is the site where the substrate binds to start a reaction.

The energy

- In a microbial cell, energy can exist in a many forms. Of these forms are the energy rich chemical bonds found in ATP, which when hydrolysed produces high energy consumed by the cell for biological function.
- Energy is the ability to accomplish work.
- It exists in many forms in nature; it could be heat, radiation, electric or light energy.

Living organisms can utilize two forms of energy and according to the source of energy they can be divided into:

1. Phototrophic microorganisms: which utilize light as a source of energy and convert it to chemical energy by photosynthesis.
2. Chemotrophic microorganisms: Those obtain their energy by biological oxidation through chemical reactions where energy is transferred from organic or inorganic compounds to specific acceptor molecules.

Energy production in microorganisms

- Microorganisms can be divided into two groups according to their nutritional requirements of carbon sources; autotrophs and heterotrophs.

ENERGY PRODUCTION BY HETEROTROPHS

- In these cells energy production depends on oxidation-reduction reactions where some molecules donate electrons (oxidized) and other molecule accept those electrons (reduced).
- Along this process energy is released and electrons are transferred from the more negatively charged compounds to the more positively charged (i.e. the negatively charged is oxidized and the positively charged is reduced).
- Most heterotrophic microorganisms can generate ATP through many metabolic pathways depending on the electron acceptors.

- Energy-producing pathways include Fermentation, Respiration, and Photosynthesis.

Fermentation

- In fermentation, organic substance serves both as electron donor and acceptor; however the yield of energy is lower than in respiration.
- It is also an anaerobic process where oxygen is not included.
- Fermentation is considered as an incomplete oxidation process of which its end products contain (low) considerable amounts of energy, the end products could be organic acids or alcohols and all are released to the surrounding environment.
- An important intermediate that serves as a terminal electron acceptor and which is of importance in energy production is pyruvate.

Glycolysis

- The best-known process by which energy is obtained from glucose anaerobically also known as Embden-Meyerhof pathway.
- In this pathway one molecule of glucose is converted to two molecules of pyruvate and two NADH and a net of two ATP molecules.
- The overall equation for glycolysis by Embden-Meyerhof pathway could be written as:

Glucose + 2 ATP + 2 NAD → 2 Pyruvate + 2 NADH + 2 ATP

Phosphogluconate pathway (pentose phosphate pathway):

- Glucose metabolism proceeds by decarboxylation when glucose-6-phosphate is converted to ethanol, lactic acid, and CO_2.
- Only one pyruvate and one ATP molecule are generated.

- while ribose-5-phosphate is of importance in nucleic acids biosynthesis.

Entner-Doudoroff pathway:

- Glycolysis by this pathway results in net production of one ATP molecule per molecule of glucose metabolized. The equation could be written as:

G-6-p + 2 NAD + ADP + Pi → 2 Pyruvate + 2 NADH + ATP +

Ethanol

Fates of pyruvate

- Microorganisms have evolved a variety of pathways through which pyruvate has a key role in principle fermentations; depending on different nutritional conditions and available enzymes the pathways are:

1. Lactic acid fermentation: this pathway is characteristics in *Lactobacillus* and *Streptococcus* bacteria.
2. Alcoholic fermentation: This fermentation is characteristics of yeasts and uncommon in bacteria.
3. Mixed acid fermentation: is a characteristic of most Enterobacteriaceae.
4. Other types of fermentation are methane fermentation as by Methanobacterium, and acetoin fermentation by *Bacillus* spp., and *Enterobacter*.

- Pyruvate could be completely oxidized through the Krebs cycle or (Tricarboxylic acid (TCA) cycle), which is considered to be of the most important pathways for producing ATP in aerobic bacteria.

Respiration

- In respiration, the electron acceptor is usually O_2 (aerobic respiration).
- By respiration, electrons are donated by one organic or inorganic source leading to oxidation of these compounds.
- Electron acceptors are inorganic compounds that will be reduced.

Anaerobic respiration

- The terminal electron acceptor is an inorganic substrate other than O_2 such as nitrate (NO_3), nitrite (NO_2), sulphate (SO_4), or carbonate (CO_3).
- Some common enzymes that participate in reducing these molecules are: nitrate reductase that reduces nitrate to nitrite and nitrite reductase that reduces nitrite to molecular nitrogen (N2), while sulphate reductase reduces sulphate to H_2S.
- According to types of respiration bacteria fall into several groups:

Photosynthesis

- Energy from light is used to provide cellular energy such as ATP molecules.
- The light is absorbed by special pigments (chlorophyll) in which electrons are transferred through a chain of electron carriers similar to that in phosphorylation.
- Photosynthesis occurs in eukaryotes (plants) and prokaryotes (cyanobacteria, purple and green bacteria).
- In eukaryotes O_2 is released by photosynthesis; while in prokaryotes no O_2 is released.

II- ENERGY PRODUCTION BY AUTOTROPHS

- This type of microorganisms could be divided into two groups:

1. Chemoautotrophs (chemolithotrophs): the sources of energy of such microorganisms are chemical inorganic substrates such as H_2, ferrous, ammonia, nitrate, and sulphate.

2. Photoautotrophs: are photosynthetic bacteria that convert light energy into chemical energy which, in turn, converts CO_2 into organic compounds in order to synthesize cellular constituents via photosynthesis.

Antibiotic:

Antibiotic: is a chemical substance produced by microorganism that inhibit the growth or kills another microorganism.

Antimicrobial: Antibacterial (Bacitracin), antiviral (Zidovudine), Antifungal (Penicillin, Cephalosporin), Antiprotozoal (Metronidazole).

Some antibiotic produced by molds, e.g penicillin while others produced by bacteria exp. tetracycline erythromycin, chloramphenicol.

A.B uses:

1. Narrow spectrum antibiotics: agents acting only on single or limited groups of microorganisms Exp. T.B. (Isoniazid and Rifampicin)
2. Extended-spectrum antibiotic: agents acting or effective against gram +ve organism & also against gram -ve bacteria. 2 or 3 types exp. Penicillin.
3. Broad-spectrum antibiotics-antibiotic: that effective against large oral -ve & +ve bacteria.

Antimicrobial: B-lactam, Aminoglycosides A.B kill the bacteria & affecting many different types of G+ve & G-ve bacteria in our body including useful bacteria in our guts e.g Quinolones & trimoxazole, some A.B are inhibitors some are killer.

Bacteriostatic - drugs arrest the growth of bacteria, so it limits the spread of bacteria EXP: Erythromycin, Tetracycline chloramphenicol, Sulfonamide, Trimethoprim

Choice of antimicrobial agents: -

This depends on:- Patient factors, infecting organism & drugs.

1. Patient factors: Age 8-12 or 18 years, Drug allergy, Renal & hepatic function, pregnancy & lactation aminoglycosides such as Gentamycin & streptomycin toxic for pregnancy & lactation except penicillin & erythromycin. Gentamycin & streptomycin infect G-ve bacteria by inhibition of the cell wall, also Tetracycline cause tooth pigmentation & sometimes affected the intestinal system & skin redness and kill Enterobacteriaceae.
2. Organism related considerations. clinical diagnosis. M.O. culture.
3. Drug factors:
    a. spectrum activity.
    b. Site of infection.
    c. Safety & efficiency.

d. Coast: Some antibiotic works on *Staphylococcus aureus*. In the same activity but differ in coast of A.B exp. Cefazolin, Vancomycin, Clindamycin, Linezolid, Daptomycin. the cost depends on the source of the drug and the raw material, production and manufacturing.

It is a visible to treat patient with a single agent that is most specific to the infecting organism this strategy:

1. Reduce the possibility of super infection.
2. Decrease the emergency of resistant of organisms.
3. Minimize toxicity.

Hypersensitivity: - reaction of antimicrobe frequency occur e.g. the penicillin cephalosporins can cause serious hypersensitive problem ranging from urticaria to an anaphylactic shock. Some reactions may be related to the rate of infection, such as Redman syndrome, seen with rapid Infusion of Vancomycin.

Some patients died after 5 minutes other the symptoms appear after 3 days.

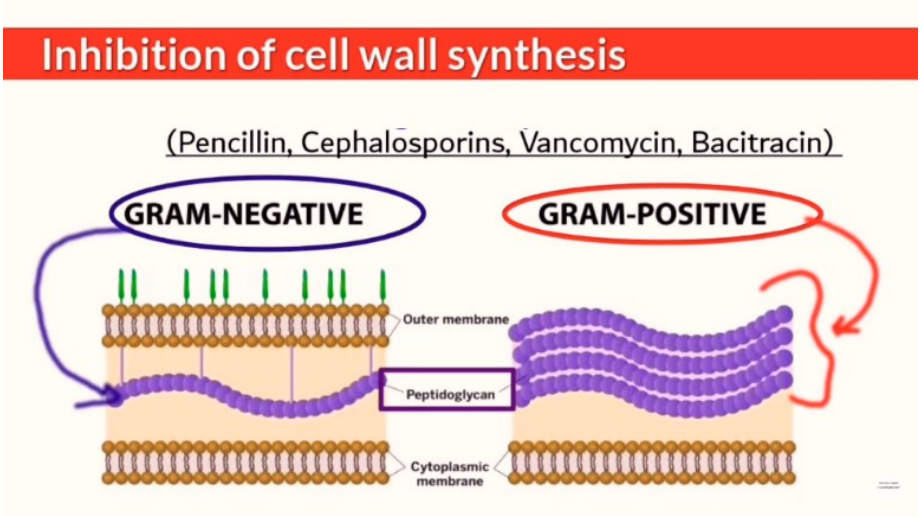
Classifications of Antimicrobial: Antimicrobial drugs can be classified according to :-

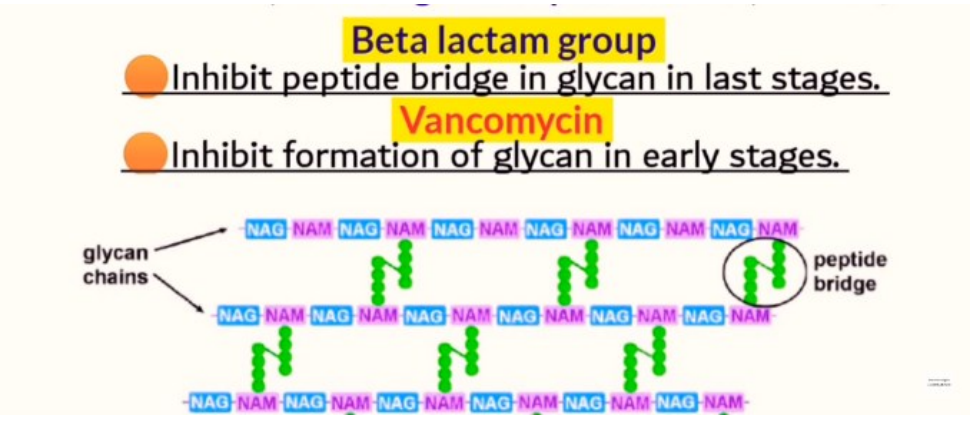
1. Chemical structure. (B-lactam or amino glycosides)
2. Mechanism of action of A.B.
    a. Inhibition of cell wall synthesis.
    b. Inhibition of protein synthesis.
    c. Disruption of cell membrane.
    d. Inhibition of Nucleic acid synthesis.
    e. Inhibition of metabolic pathway.

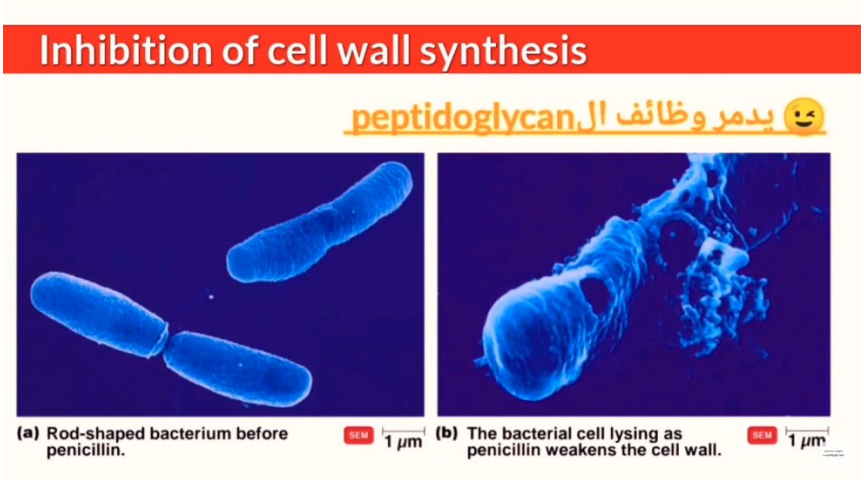
3. Acting against particular types of organisms exp. (Bacteria, Fungi- Viruses).

Inhibition of cell wall synthesis

1. Beta-lactam groups inhibit peptide bridge in glycan component of the cell wall in last stages e.g penicillin, cephalosporins & Bacitracin but Vancomycin. Inhibit formation of glycan in early stages i.e inhibit synthesis of N-acetyl glucose amine & N-acetyl muramic acid which are the two types of sugar in peptidoglycan & also breakdown the cross linkage of bonds between sugar & amino acids, peptide bonds & glycosidic bound. this type of A.B are more effective to -ve bacteria & +ve bacteria. such as *Staphylococcus* & *Streptococcus* bacteria also Bacitracin inhibit transporting peptidoglycan precursor via cytoplasmic membrane. i.e damage the cell wall function so it is bacteriosidal.







2. The cell wall of bacteria acts for protection of cell component and strengthen the cell & give elasticity for bacteria to move in the media & tissue.

3. **Inhibition of protein synthesis**: protein is synthase in ribosome the ribosome is the unit of protein synthesis consist of large subunit 50s & small subunit 30s & the mRNA strands passes through them. bacteria without ribosome classified as a virus which is the vital particle in the bacterial cell. because viruses do not have ribosome that's bacteria differ from viruses. the polypeptide bond connects the amino acid in the peptidoglycan cell wall e.g Azithromycin, Erythromycin affected the connection of the bond and also the 50s subunit of the ribosome inhibited by A.B e.g Macrolides which prevent continuation of protein synthesis, Some other A.B. inhibit. 30s subunit in ribosome exp. Aminoglycoside which block initiation of translation of protein. Tetracycline blocks the attachment of tRNA to ribosome. So, it prevents protein synthesis, it is bacteriostatic.

So, the function of ribosome in bacteria:

a. Gives the activity to the cell
b. Translation of protein synthesis in bacteria.

Inhibition of Protein synthesis

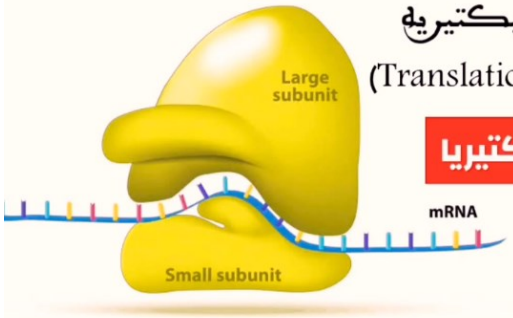
RIBOSOME

وظيفه الريبوسوم

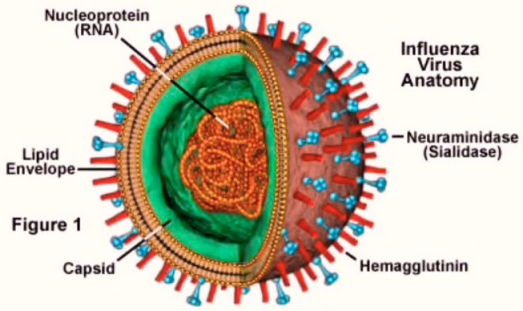
١- يعطي الحيويه والنشاط للخليه البكتيريه

٢- المسئول عن تخليق البروتين (Translation)

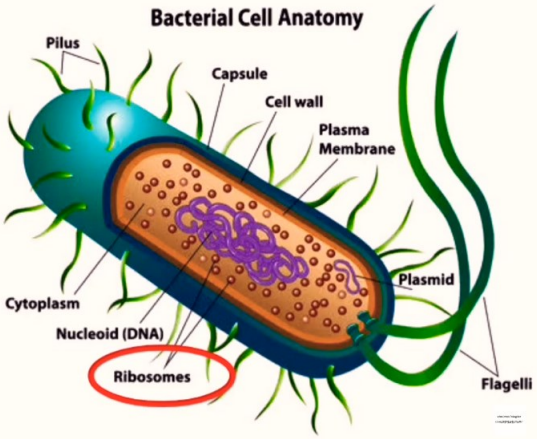
المسئول عن حيويه وحياه البكتيريا

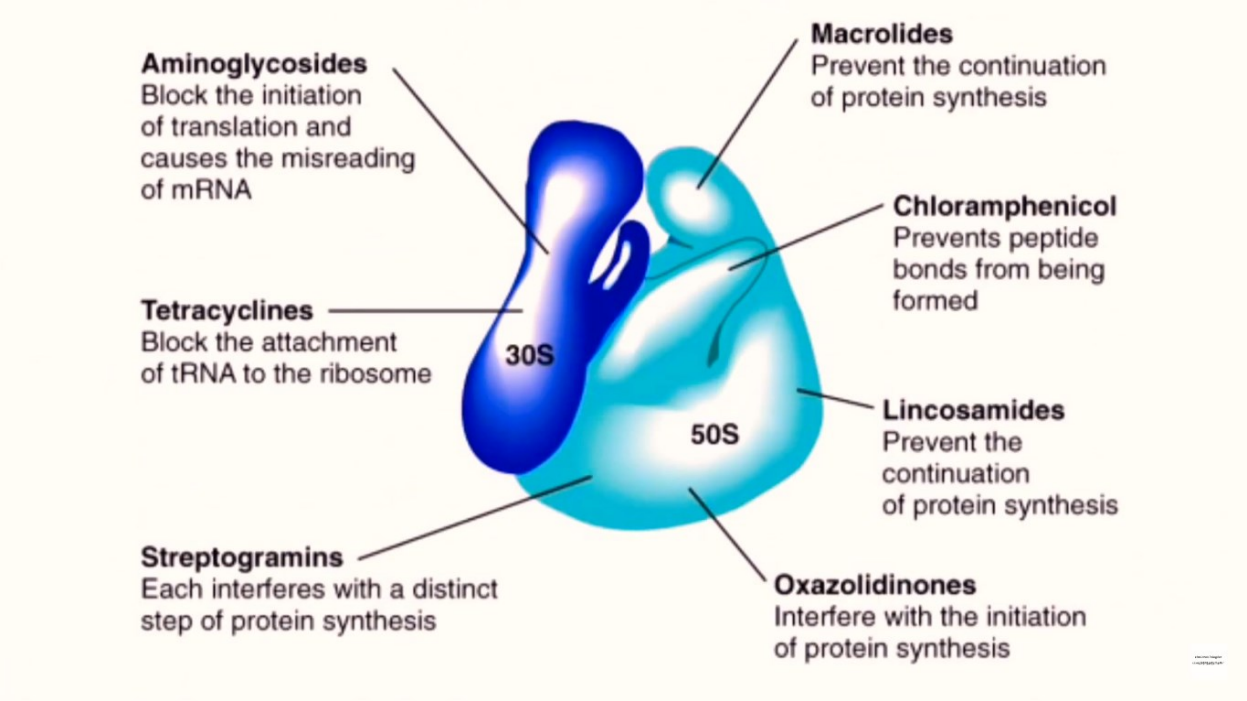


Inhibition of Protein synthesis



تركيب الفيروس





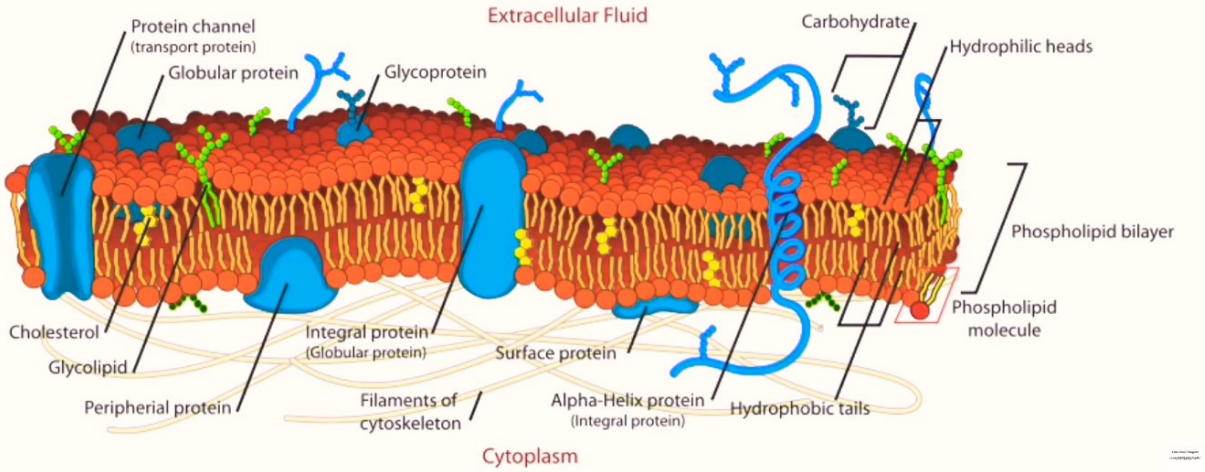
Disruption of cell membrane synthesis: A.B causes disruption to cell membrane i.e the phospholipid layer in G+ve & G-ve bacteria but it is more effective to G-ve bacteria i.e the cell membrane consist of two layers of phospholipid, and also alter permeability of the cell membrane which affected the Osmotic balance pressure and passages of molecules through cell membrane & Lead to leakage of cell membrane i.e the components transported outsides the cell & kill the bacteria (bactericidal), which become toxic to the cell & cause cell death.

e.x Polymyxin more effective against G-ve because it has two layer of lipid while G+ve bacteria has only one layer & cell membrane hidden udert thick layer of peptidoglycan.

Cell membrane is the same in Bacteria & Human cell.

Inhibition of cell membrane

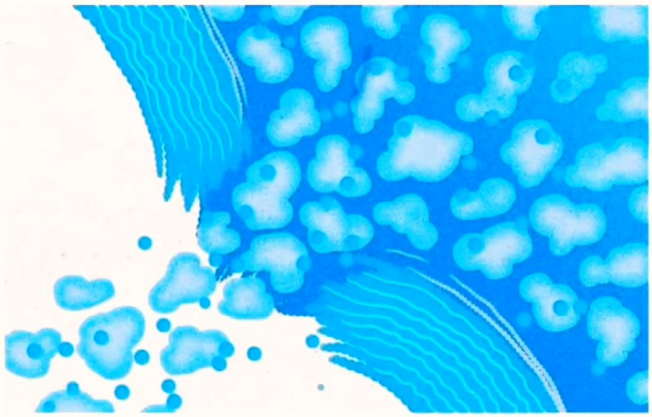
Causes disruption to cell membrane & alter permeability

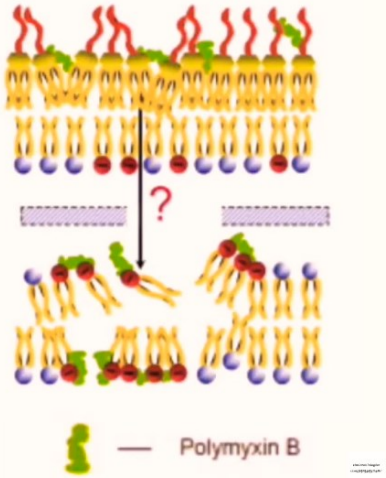


Inhibition of cell membrane

Causes disruption to cell membrane & alter permeability

- leads to leakage of cell & cell death.



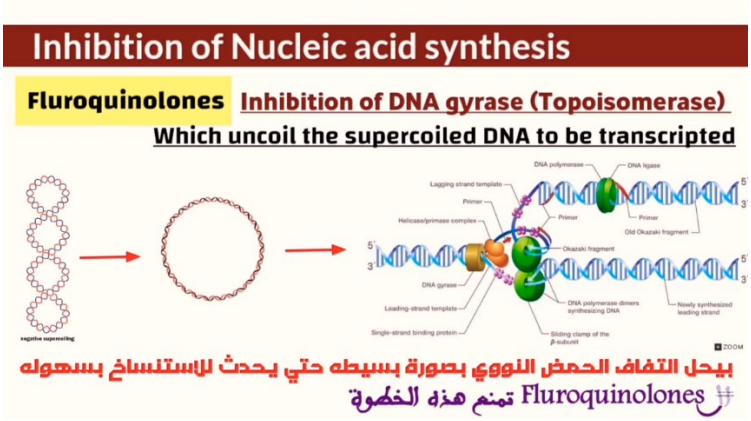


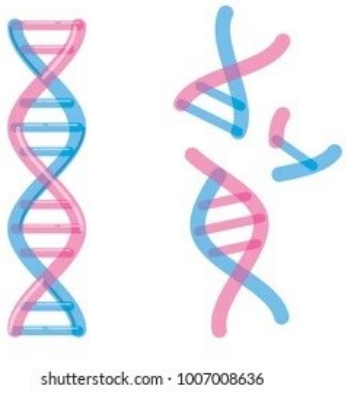
Inhibition of Nucleic acid-:

Exp. Fluroquinolones - Inhibition of DNA gyrase (topoisomerase) which uncoil the supercoiled DNA to be transcribed & change the DNA complicated into DNA (simple) or non-complicated & also inhibit the enzymes involved in DNA replication and Inhibit protein synthesis.

Fluroquinolone connect to this enzyme (DNA) gyrase & stop its activity & process, of gyrase for (transcripted) & the DNA become segmented this group of A.B act against G +ve & G-Ve bacteria.

Rafimycins- Inhibit bacterial DNA- dependent RNA synthesis by inhibiting bacteria DNA dependent RNA polymerase i.e inhibition of RNA polymerase

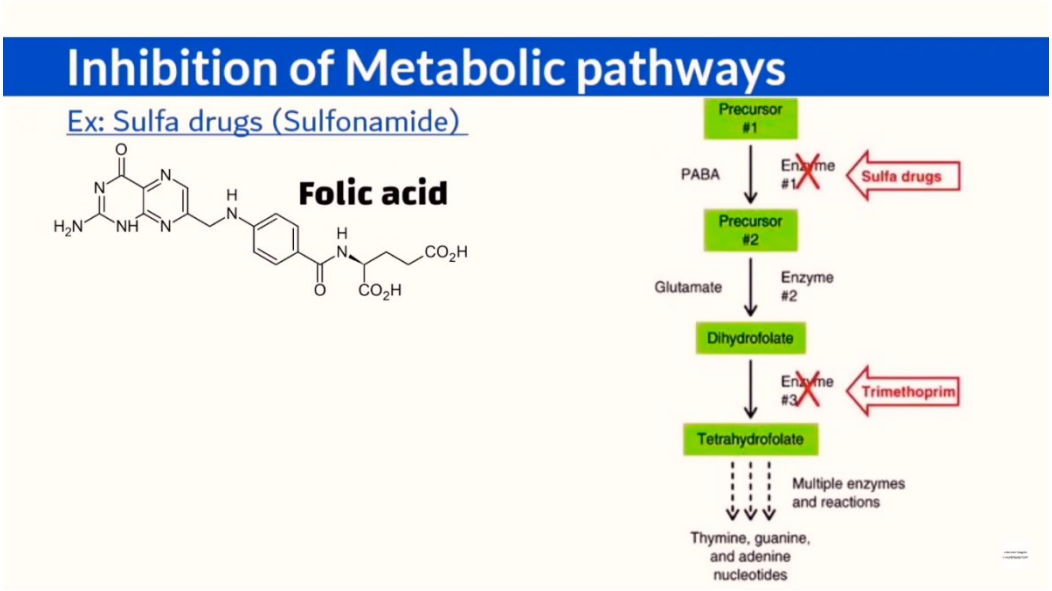




Inhibition of Metabolic pathways:

e.g sulfa drugs (sulfonamide)

Folic acid is very important acid for the bacteria because the bacteria used it for synthesis of purines such as adenine & quinine which needed for bacterial reproduction & multiplication para-aminobenzoic acid. (PABA) which is precursor of folic acid synthesis. the A.B is sulfonamide which is the same for folic acidy the substance found in A.B (sulfonamide) interfere with para-amino benzoic acid but the enzyme cannot change it to folic acid & this inhibit the metabolic activity in the bacterial growth and replications.



How A.B work

Pathogenic bacteria in the body cause infection which can be treated by A.B.

A.B. can be bacteriostatic or bactericidal cidal

static = to stop cidal = to kill

Bacteriostatic A.B slow the growth of bacteria by interfering with the processes the bacteria need to multiply.

Bactericidal A.B kill the bacteria for e.g by preventing the bacteria from making a cell wall.

Penicillin is bactericidal for sore throats Amoxicillin for chest infection & Flucloxacillin for skin infections A.B. can be so called broad spectrum affecting many different bacteria in your body. including useful bacteria in your gut., Some are narrow spectrum affecting one or two types of bacteria. A.B do not work on viruses' infection because viruses have different structure.

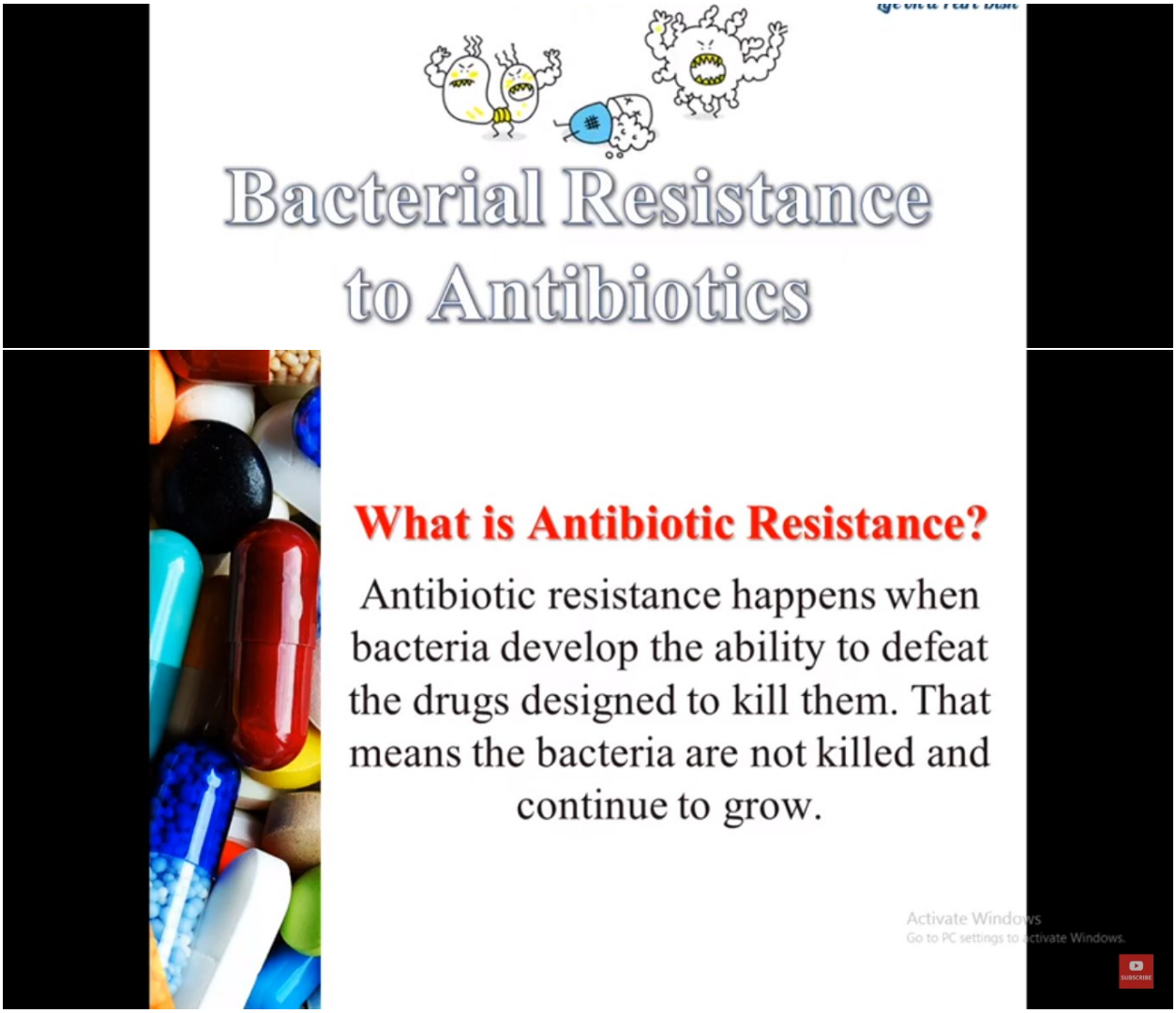
The first scientist discovers A.B is Alexander Fleming 1928 Scottish physician and microbiologist.

Types of A.B in dentistry:

Dentists prefer to prescribe amoxicillin and metronidazole or co-amoxiclav to control dental infections. Moreover, clindamycin is an alternative drug in penicillin-allergic patients in case of necrosis & localize acute apical abscess when the infection area swelling and pain & sometimes in urgent situations root canal and incision for drainage.

Tooth bleaching (whitening):

1. Hydrogen peroxide (H_2O_2) 35% continuation.
2. Carbamide peroxide ($CH_6N_2O_3$) 10-20% for 8 continuation hours per day.


Bacterial Resistance to Antibiotics
What is Antibiotic Resistance?
Antibiotic resistance happens when bacteria develop the ability to defeat the drugs designed to kill them. That means the bacteria are not killed and continue to grow.
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Go to PC settings to activate Windows.


Types of
Resistance
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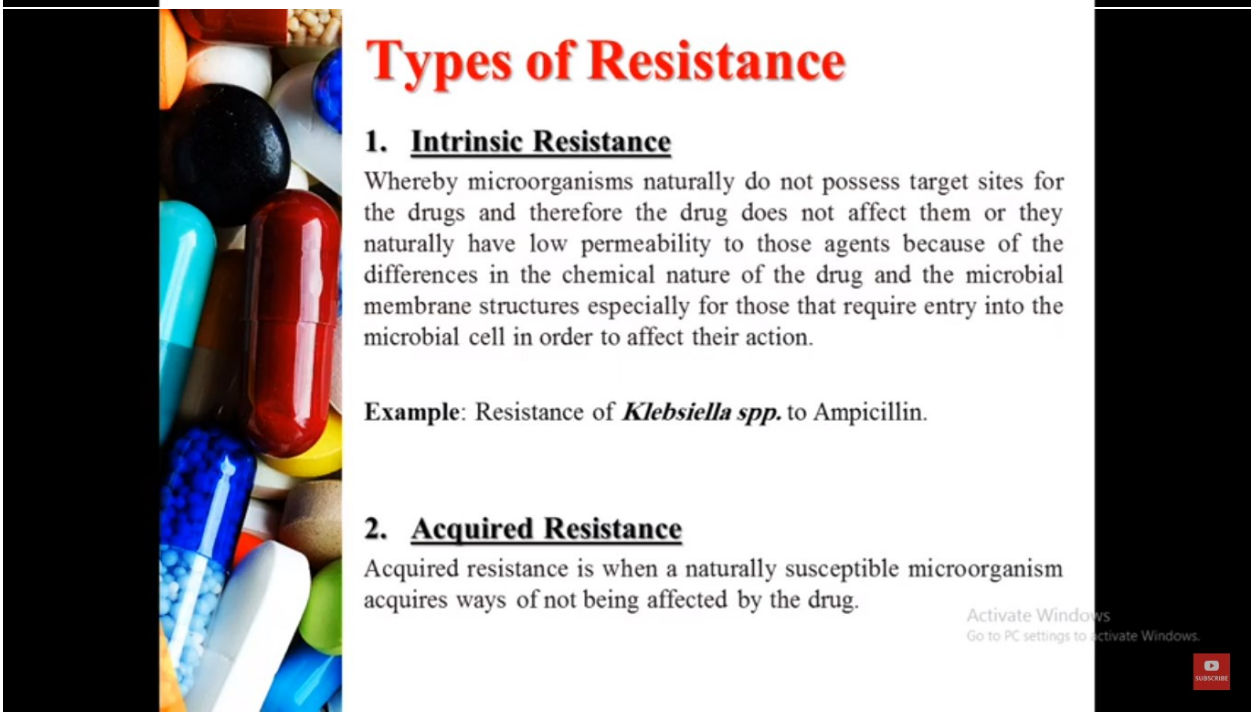
Types of Resistance
1. Intrinsic Resistance
Whereby microorganisms naturally do not possess target sites for the drugs and therefore the drug does not affect them or they naturally have low permeability to those agents because of the differences in the chemical nature of the drug and the microbial membrane structures especially for those that require entry into the microbial cell in order to affect their action.
Example: Resistance of Klebsiella spp. to Ampicillin.
2. Acquired Resistance
Acquired resistance is when a naturally susceptible microorganism acquires ways of not being affected by the drug.
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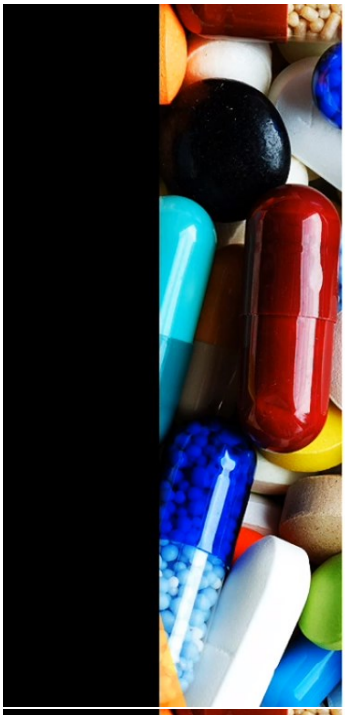
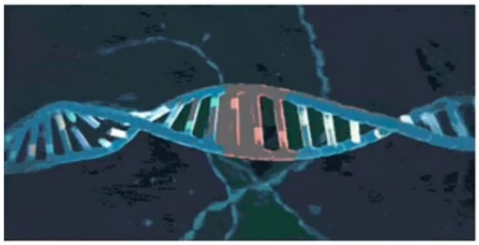
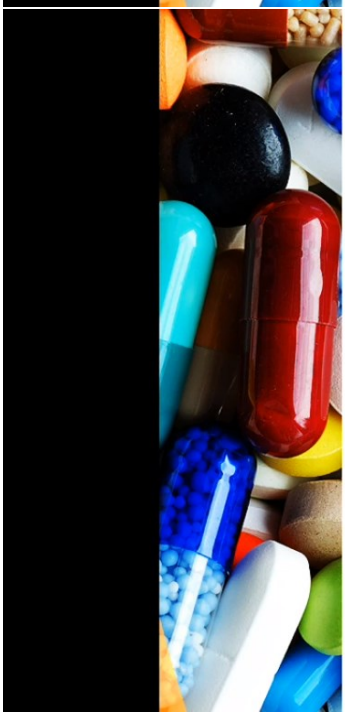


Acquired Resistance

- **Mutation**

Changes in the composition or structure of the target in the bacterium (resulting from mutations in the bacterial DNA) can stop the antibiotic from interacting with the target. Alternatively, the bacteria can add different chemical groups to the target structure, in this way shielding it from the antibiotic.



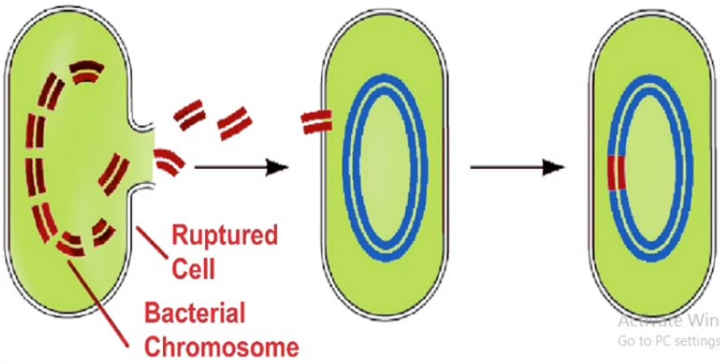


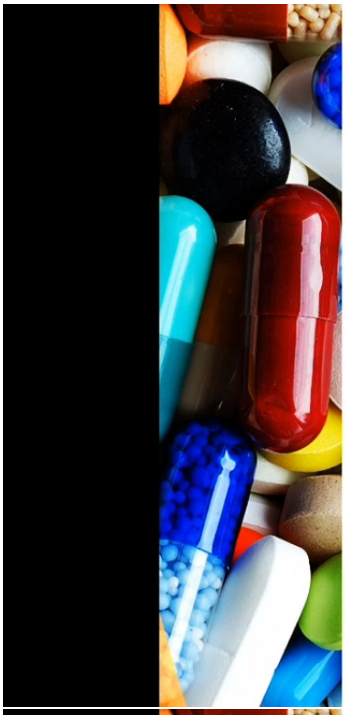
Acquired Resistance

- **Horizontal Gene Transfer**

A. Transformation

Transformation refers to the ability of microorganisms to utilize snippets of free DNA from their surroundings. DNA from dead cells gets cut into fragments and exits the cell.

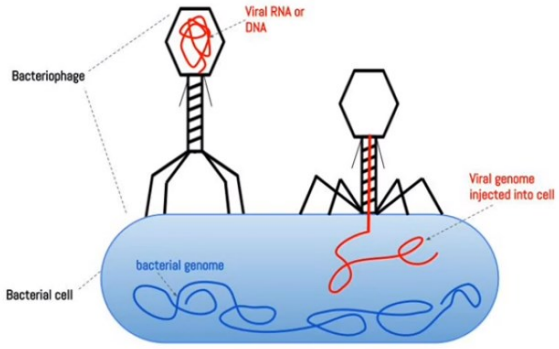


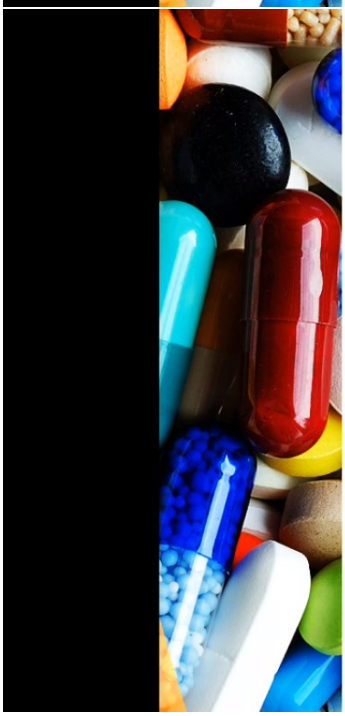


Acquired Resistance

B. Transduction

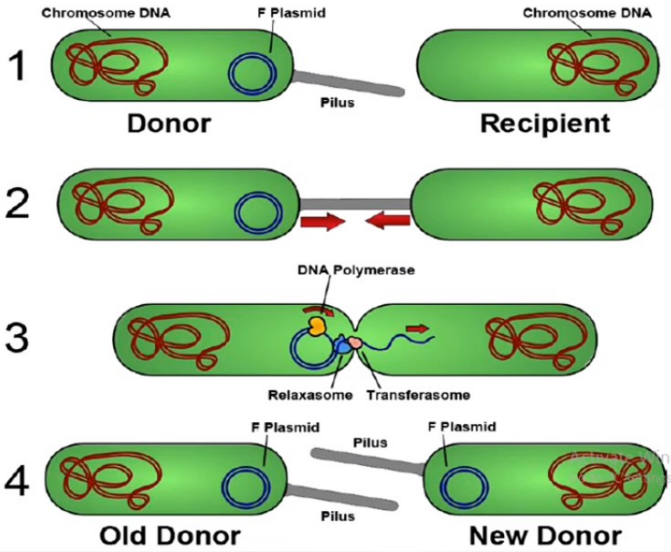
Transduction is the process by which viruses that prey upon bacteria, known as bacteriophages, can transmit genetic material from one organism to another.





Acquired Resistance

C. Conjugation




Resistance
Mechanisms
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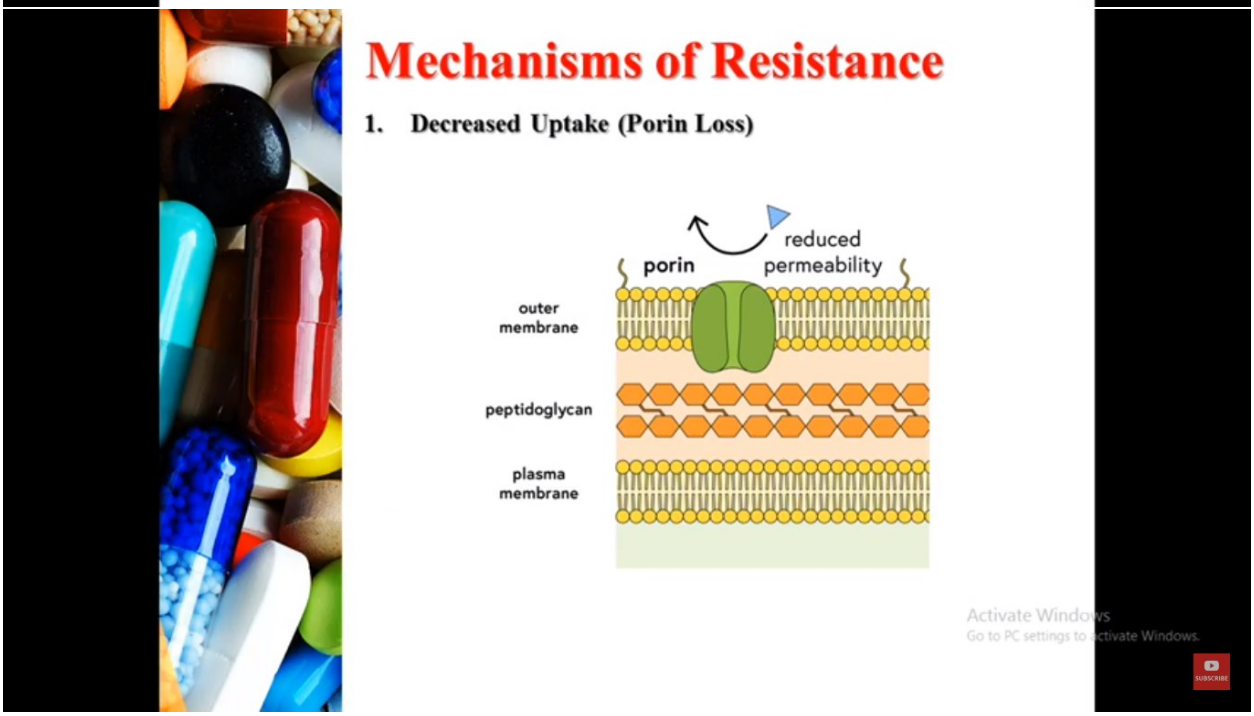
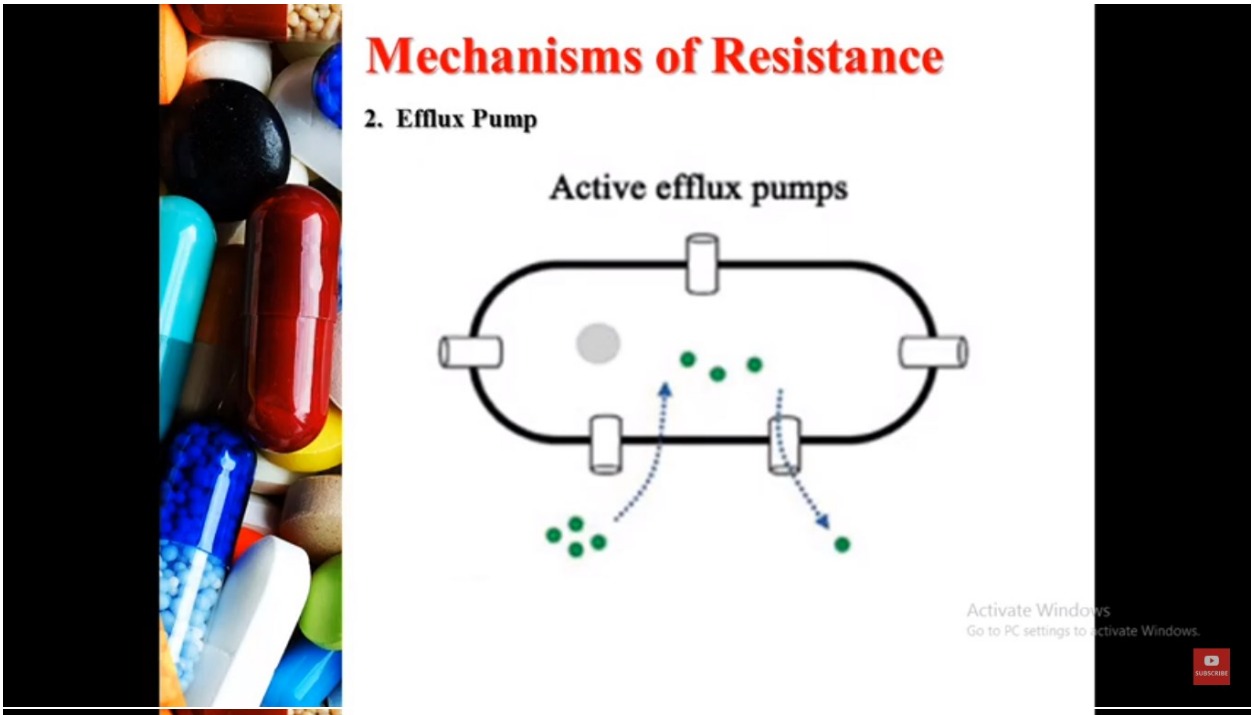

Mechanisms of Resistance
1. Decreased Uptake (Porin Loss)
porin
reduced permeability
outer membrane
peptidoglycan
plasma membrane
Activate Windows
Go to PC settings to activate Windows.


Mechanisms of Resistance
2. Efflux Pump
Active efflux pumps
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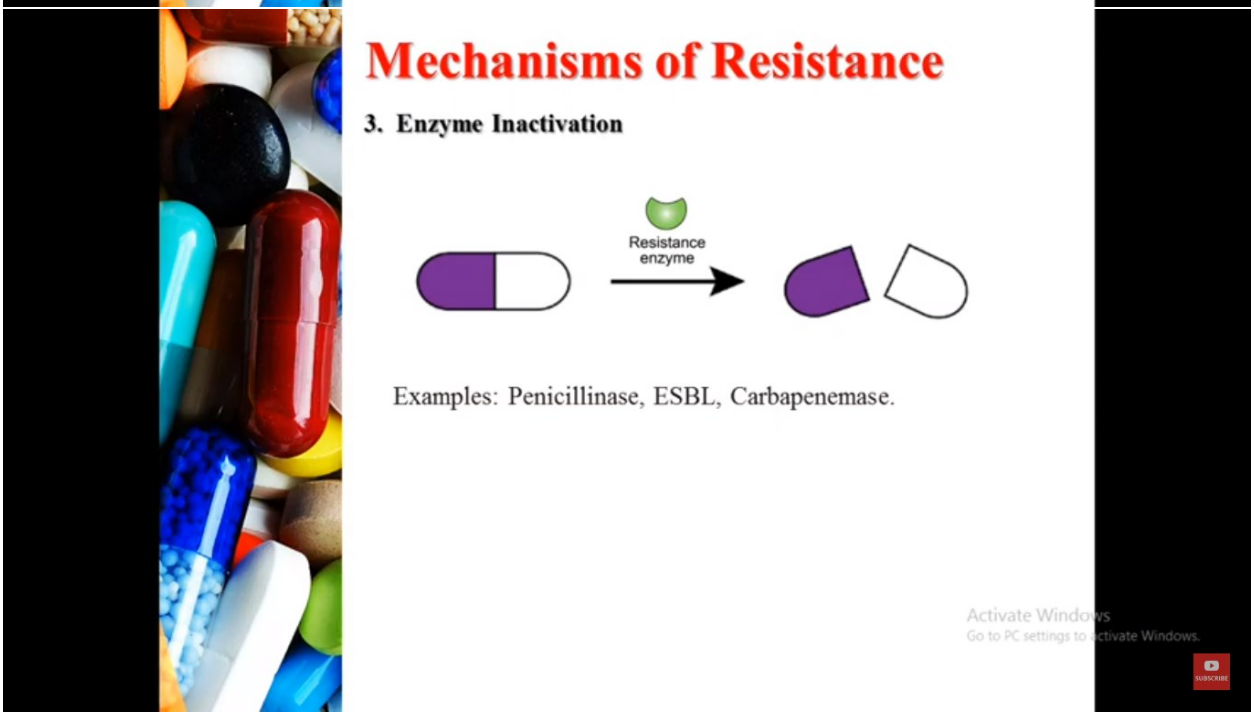
Mechanisms of Resistance
3. Enzyme Inactivation
Resistance enzyme
Examples: Penicillinase, ESBL, Carbapenemase.
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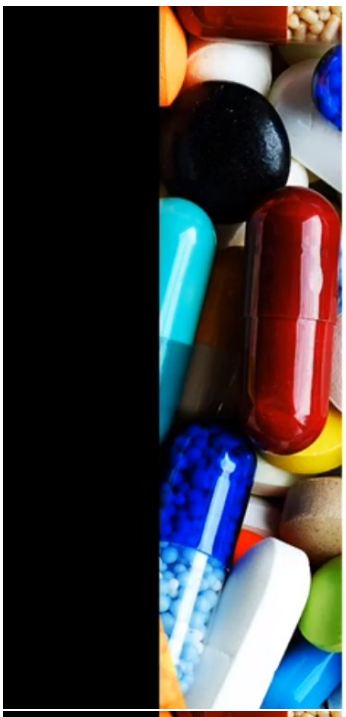
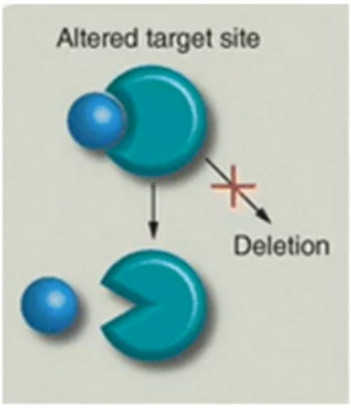
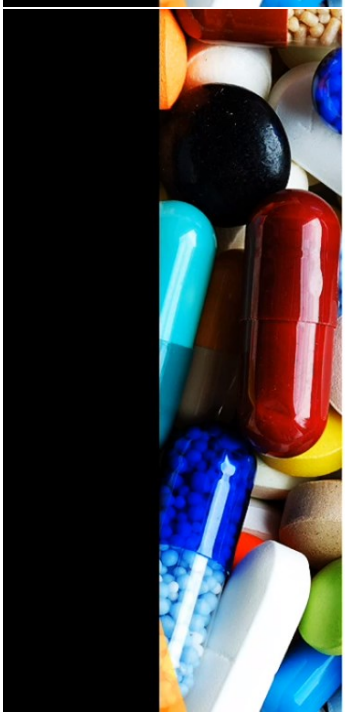


Mechanisms of Resistance

4. Altered Target

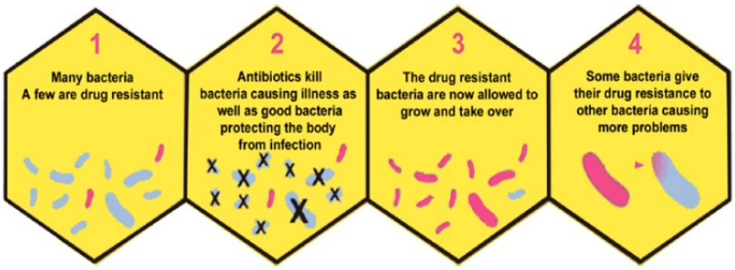


Example: MRSA.



Mechanisms of Resistance

5. Selection



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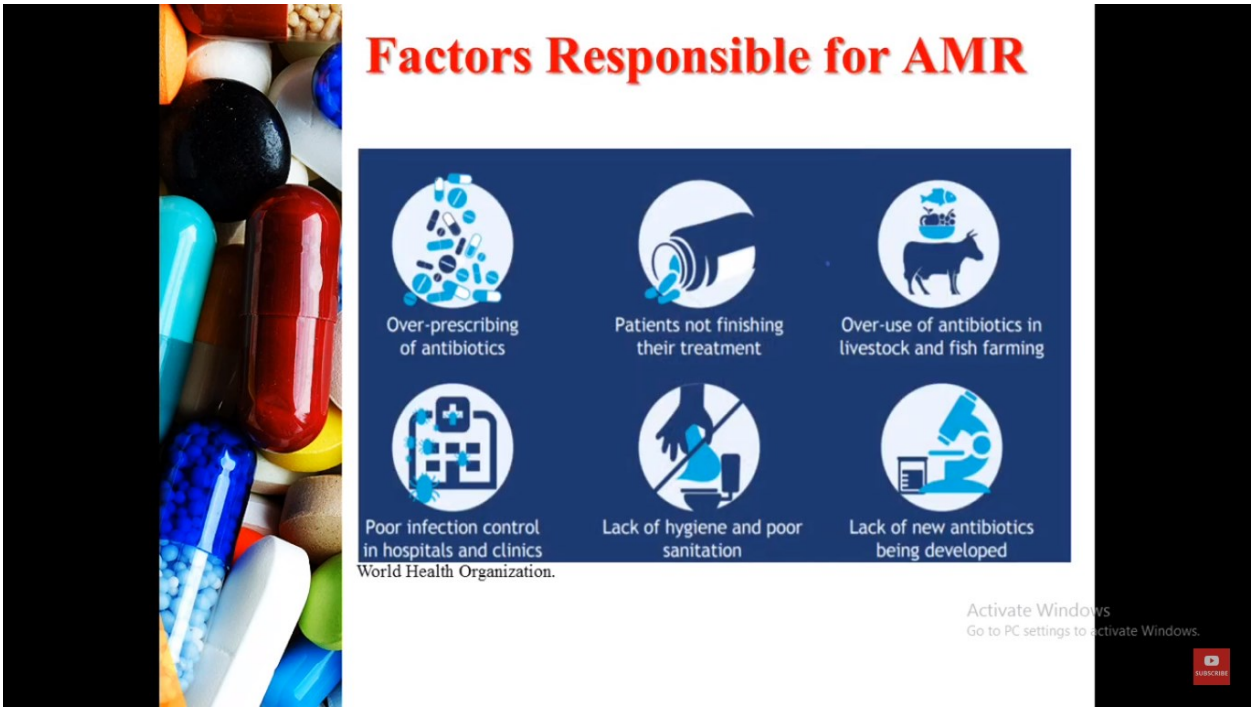
Factors Responsible for AMR
Over-prescribing of antibiotics
Patients not finishing their treatment
Over-use of antibiotics in livestock and fish farming
Poor infection control in hospitals and clinics
Lack of hygiene and poor sanitation
Lack of new antibiotics being developed
World Health Organization.
Activate Windows
Go to PC settings to activate Windows.

Antibiotics

Antibiotics are a group of medicines that are used to treat infections caused by some germs (bacteria and certain parasites). They do not work against infections that are caused by fungi or viruses - for example, the common cold or flu.

Correct use of antibiotics is absolutely essential to help reduce antibiotic resistance. Germs become resistant to antibiotics over time, which then makes them less effective.

What are antibiotics?

Antibiotics are sometimes called antibacterials or antimicrobials. **Antibiotics can be taken** by mouth as liquids, tablets, or capsules, or they can be given by injection. Usually, people who need to have an antibiotic by injection are in hospital because they have a severe infection. Antibiotics are also available as creams, ointments, or lotions to apply to the skin to treat certain skin infections.

There are various antibiotics available and they come in various different brand names. Antibiotics are usually grouped together **based on how they work. Each type of antibiotic only works against certain types of bacteria or parasites.** The main types of antibiotics include:

- The discovery of the first true antibiotic—penicillin—in 1928 was one of the most life-changing events of the 20th century. Now, there are more than 100 antibiotics to fight the war against bacterial infections. Here is a look at common antibiotic names and the types of antibiotics your doctor may prescribe.

1- Penicillins

Penicillins are derived from a specific mold (a type of fungi)—*Penicillium*. They are **widely useful antibiotics** that are often a doctor's first choice for several types of infections. This includes skin, respiratory, ear, STDs (sexually transmitted diseases), and dental infections. They are highly effective against familiar organisms, such as staph and strep. **Rashes and allergic reactions** are common with penicillins. Other common side effects include **diarrhea, nausea, and abdominal pain.** Examples of penicillins include:

- Amoxicillin
- Ampicillin
- Penicillin G
- Penicillin V

2- Cephalosporins

Cephalosporins are related to penicillins. They both belong to a larger class called **beta lactams**. Like penicillins, cephalosporins originally came from a fungus—C*ephalosporium*. There are five generations of cephalosporins. Each generation covers different types of bacteria. As a result, the class can treat a variety of infections, from strep

throat and skin infections to very serious infections like meningitis. side effects include **diarrhea, nausea, heartburn, and abdominal pain.** Examples of cephalosporins include:

- Cefixime
- Cefpodoxime
- Cefuroxime
- Cephalexin

3-Macrolides

Macrolides are a completely different class of antibiotics from the beta lactams. But they effectively treat many of the same infections. **This includes respiratory, ear, skin, and sexually transmitted infections**. So, **they are very useful for people with allergies to beta lactams.** They are also useful when bacteria develop resistance to beta-lactam antibiotics. Common side effects include **nausea, vomiting, stomach pain, and diarrhea**. Examples of macrolides include:

- Azithromycin (‘Z-pak’)
- Clarithromycin
- Erythromycin

4- Fluoroquinolones (broad-spectrum antibiotics)

Fluoroquinolones—or quinolones—are **active against a very wide variety of bacteria**. This makes them useful for treating infections when other antibiotics have failed. They are also an alternative when people have allergies to other antibiotics. They can treat anything from eye infections to pneumonia to skin, sinus, joint, urinary and many more. However, this class can be a problem for people with certain heart conditions and with some other medicines. Common side effects include **stomach upset or pain, diarrhea, headache and drowsiness**. Examples of fluoroquinolones include:

- Ciprofloxacin
- Levofloxacin
- Moxifloxacin

5- Sulfonamid

Derived from the chemical sulfanilamide, 'sulfa drugs'. Technically, sulfonamides don't kill bacteria the way other antibiotics do. Instead, they are bacteriostatic—they stop bacterial growth and your immune system does the rest. They are very good topical treatments for **burns and vaginal or eye infections.** They can also **treat UTIs (urinary tract infections) and traveler's diarrhea.** Common side effects include **diarrhea, nausea, rash, and sun sensitivity. Allergies** are also common with the group.

Examples of sulfonamides include:

- Sulfacetamide
- Sulfadiazine
- Sulfamethoxazole-Trimethoprim

6- Tetracycline

These antibiotics come from a species of bacteria called *Streptomyces*. Tetracyclines are bacteriostatic, like the sulfonamides. They treat various infections, such as **respiratory, skin and genital infections. They also treat unusual infections, including Lyme disease, malaria, anthrax, cholera, and plague.** Common side effects include **stomach pain or upset, sun sensitivity, and yeast infections.** Examples of tetracyclines include:

- Doxycycline
- Minocycline
- Tetracycline

7- Other Types of Antibiotics

Doctors have several other antibiotic choices if none of these classes will work. Others just don't fit into the main groups, but are very useful. This includes antibiotics like clindamycin, metronidazole (Flagyl) and.. You need to take some on an empty stomach and others with food. With all antibiotics, it's important to finish the entire course your doctor prescribes. This ensures adequate treatment and prevents antibiotic resistance.

How do antibiotics work?

Some antibiotics work by **killing germs** (bacteria or the parasite). This is often done by interfering with the structure of the cell wall of the bacterium or parasite. Some work by **stopping bacteria** or the parasite fr

om multiplying.

there are three main antibiotic targets in bacteria:

1. The cell wall or membranes that surrounds the bacterial cell
2. The machineries that make the nucleic acids DNA and RNA
3. The machinery that produce proteins (the ribosome and associated proteins)

However, you do need antibiotics if you have certain serious infections caused by bacteria, such as meningitis or pneumonia. In these situations, antibiotics are often life-saving. When you are ill, doctors are skilled at checking you over to rule out serious illness and to advise if an antibiotic is needed. Urine infections also commonly need antibiotics to prevent spread to the kidneys.

Antibiotics can also be prescribed to treat acne - a less serious condition. For acne, antibiotics can be taken by mouth or applied directly to the skin.

Which antibiotic is usually prescribed?

Because each antibiotic is effective only against certain bacteria and parasites. For example, if you have pneumonia, the doctor knows what kinds of bacteria typically cause most cases of pneumonia. He or she will choose the antibiotic that best combats those kinds of bacteria.

There are other factors that influence the choice of an antibiotic. These include:

- How severe the infection is.
- How well your kidneys and liver are working.
- Dosing schedule.
- Other medications you may be taking.
- Common side-effects.
- A history of having an allergy to a certain type of antibiotic.
- If you are pregnant or breastfeeding.
- Pattern of infection in your community.
- Pattern of resistance to antibiotics by germs in your area.

Even if you are pregnant or breastfeeding there are a number of antibiotics that are thought to be safe to take.

Immune system

The immune system is the network of cells throughout your body (in skin, in blood, elsewhere). that work together to prevent or limit infection from potentially harmful pathogen & prevent damage from noninfectious agents (like sunburn & Cancer)

How the immune system works.

There are several components of the immune system, including the following- :

1. The skin can keep many germs from entering body.
2. Mucous membrane: There are the most inner linings of place, such as the mouth, nose & lungs that produce mucous & other substances that capture & combat germs.
3. White blood cells: The body produces these to fight infection & other diseases.
4. Organs & tissues of lymph system: The thymus spleen, tonsils - lymph nodes, lymph vessels & bone marrow are parts of the body that make, store & carry white blood cells.

Scientists categorize the various immune cells into two groups:

1) Innate immune cell & specific immunity when foreign invaders like bacteria or viruses enter your body, they multiply & attack & lead to infection, disease & illness. innate immune cells, are the first line of defense against the invaders such as skin mucous membranes.

That keep Some pathogens from entering the body. The innate immune system also includes some cells & chemicals that identify microbes to get rid of them.

Types of white blood cells.

1. Monocyte
2. Lymphocytes
3. Eosinophils
4. Basophils
5. Neutrophils

2) Acquired or specific immunity is not present at bith but it is part of our immune system as the lymphoid system develops.

Immunity system: protects the body from outside invaders. These include germs such as bacteria, viruses, and fungi, and toxins (chemicals made by microbes).
Immunity system = Antibodies + immune cells

1) Anatomical barriers

A) Mechanical factors skin – cilia movement (respiratory system) flushing action from tears and salvia. washing eyes from infection of bacteria.

- Chemical factors sweat decrease the pH & the condition of the microorganism growth become low (pH) so it cannot grow in this condition because it is not suitable.
- Sebaceous glands act as fungicidal activity all the body have sebaceous glands especially feet and hands which allow the fungi to grow because it does not secret fatty acid to kill the fungi.
- Mucous in nose have special effects on viruses so it is, Antiviral
- lysozyme enzyme in salvia and tears which affect the cell wall of G+ve bacteria, this enzyme is large enzyme but do not affect G-ve bacteria, can not enter from the pores in the O.M. of G-ve bacteria.

B) Biological factors normal flora (Microbiota) live inside the body & occupied the space in the intestine & do not allow any bacteria to grow their & consume or eat all the nutrient found in the tissue as well as secreted substance bacteriocin to kill infectious bacteria that causes diseases.

2) Antimicrobial agents

→ B-lysin from coagulation affect G+ve bacteria

→ lactoferrin & transferrin chemical substance which attach the Fe & make it not available for bacterial growth so the bacteria died.

→ interferon founded in three types: (α, β, ϰ)
α and β interferon defense the cell against viruses & produce antiviral protein, ϰ interferon simulate lymphocyte, macrophage & neutrophils to be ready for phagocytosis.

3) Nonspecific immune cells

Phagocytes divided into:

- Macrophages
- Neutrophile
- NK. = Natural killer cells, cancer & viral infected cells. (Nonspecific method to destroy the viral cell & cancer cell). The second line of defense.

Bone marrow stem cells

WBCS RBCS Platelets (responsible for coagulation)

Granulocyts
Neutrophils
Eosinophils
Basophils

Agranulocytes

Monocytes in blood → Macrophages → In tissue

Thymus → T.C

Lymphocytes

Bone marrow → B.C

N.K cells

T cells

Th helper

Tc cytotoxic

Ts suppressor

M.O → II) Specific immunity → I) Nonspecific = innate immunity

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Acquired

(Natural) first line of defense & present in birth

Antigen (Ag)

1) Foreign

AB

Ag

Antigen determinate epitope

2) Large M. wt

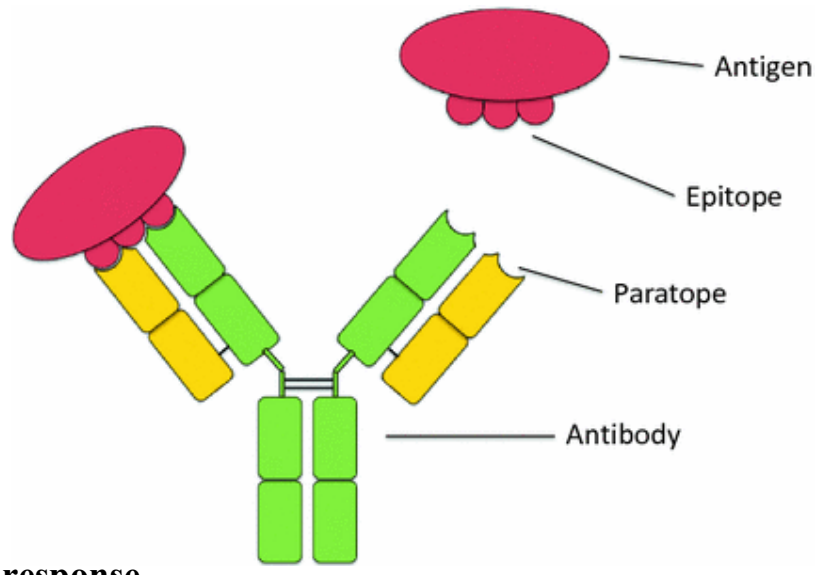
Exp. Protein

Low M. wt (Ag)

Hapten (binding with)

Protein carrier

Haptein carrier conjugate Immune response

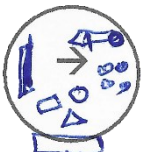


Specific immunity (aquirred)

Humeral immunity
External Ag
Antibody

Cell mediated or cellular imm.
Endogenous Ag. (T-cytotoxic)
As in cancer & viral infected cells

MHCII =mager histocom patibility



Apc = Ag presenting cells
dendritic macrophages

THR

I L 1

Th

Th clones

I L 2

IL

MHCI

VV
VV

Viral infected cell

TCR

TC

Kill the cell (lysis)

Make pores

TC

Effector TC.

perforin

Granzymes = Apoptosis

antigen

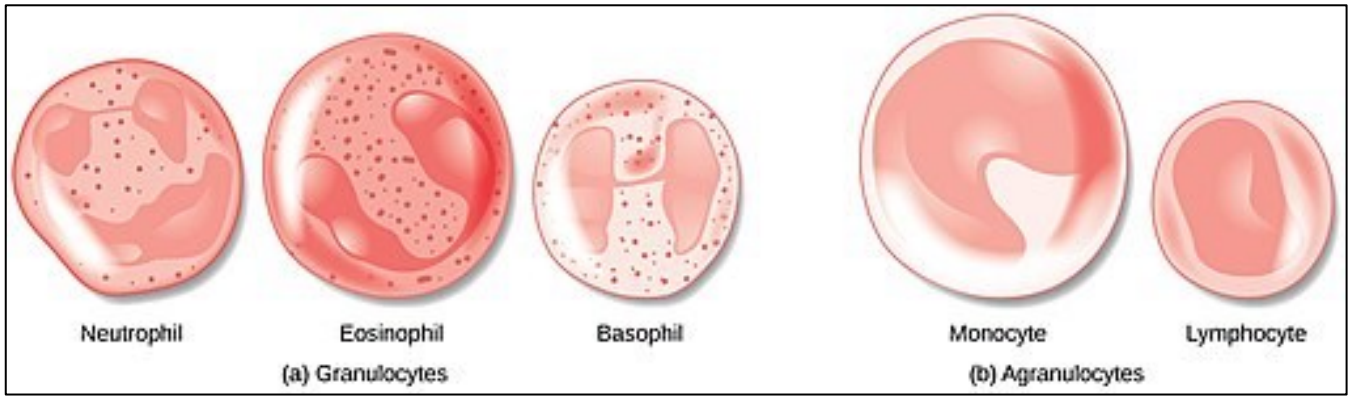
antigen

B-Cells

B. memory cells

Plasma cells (antibodies)

Cytokines → protein → IL1, IL2, INF, IF



Antigen (Ag): Any molecules that can be specifically recognize by the adaptive immune system.

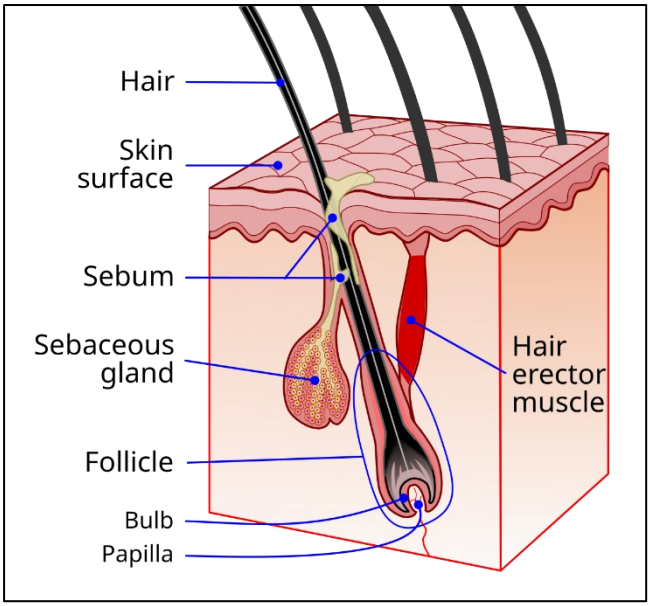
Epitope: Is restricted part of antigen that bind with antibody.

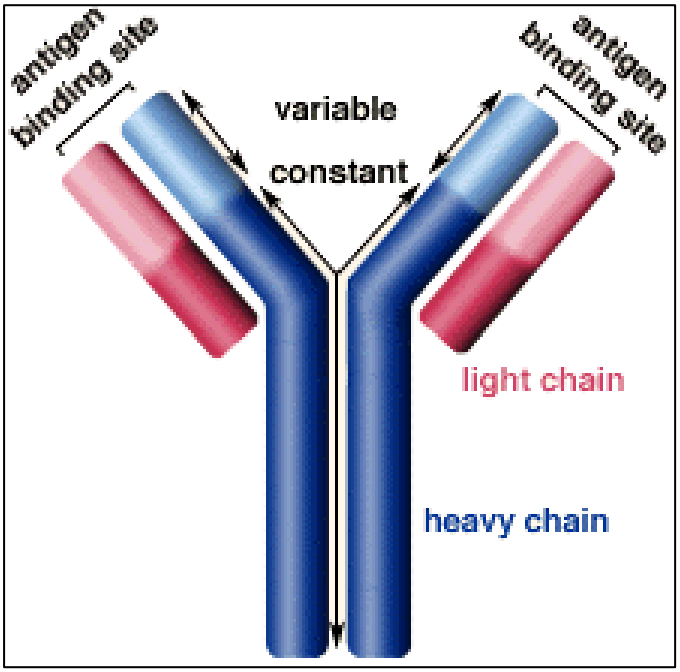
i.e. short sequence of sugar or amino acid.

Hapten: Ag with low molecules weight.

Antibody = globulin

1. like Y shape.
2. Consist of two chains:
   A) Light chain contains 220 A.A
   B) Heavy chain contains 440 A.A
3. Have two antigen binding side differ from one type to another.



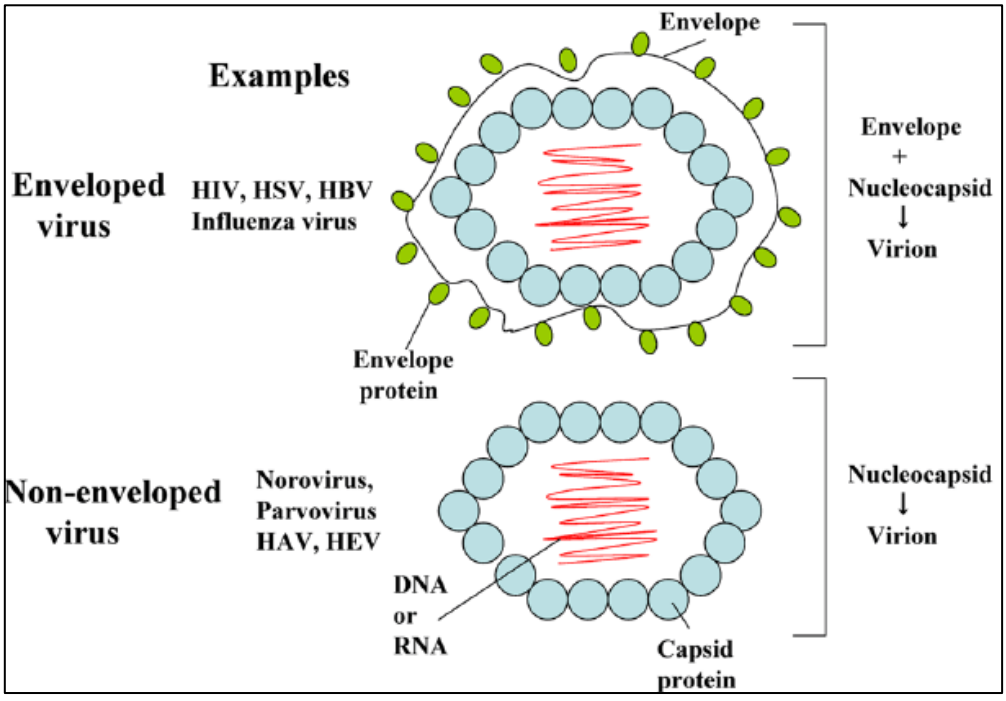


Virology

Virology: Is the study of viruses.

Properties of viruses:

1. Viruses are small obligate intracellular parasites.
2. Biological structure containing DNA or RNA not both. (sometimes called genomes)
3. Don't have a nucleus, cytoplasm, mitochondria, or ribosome.
4. Viruses size ranging from 20-300 nm in diameter.
5. Viruses do not have the genetic capability to multiply by division.
6. Viruses can replicate only inside living cells not on in animate media.
7. Viruses cannot make energy or posses active protein synthesis apparatus.
8. Viruses are metabolically inert (outside the cell) or environment.
9. Viroid consist of a single molecule of circular RNA without proten coat or envelope causes several plants diseases such as CMV, TMV.
10. Viruses composed of single or double strands DNA or RNA may be circular or linear.



HSV: Herps simple varus, causing sores most commonly.

HBV: Hepatitis B virus, affecting liver

Structure of viruses

1) Genome: Consist of one type of nucleic acid ether RNA or DNA and carry the genetic information required for virus replication & function.

2) Capsid: The protein coat or shell that enclosed or surrounding the nucleic acid or genome.

- Provides structure symmetry.
- Participates in attachment to susceptible hot.
- Facilitates transfer of viral nucleic acid in to host cell.
- Protects the viral genome from nucleases in blood stream.
- **Capsomeres**: the structural units making up capsid: consist of one or several proteins.
- The nucleic acid capsid is termed as nucleocapsid.

3) **Envelope**: some viruses have an enveloped outside the capsid.

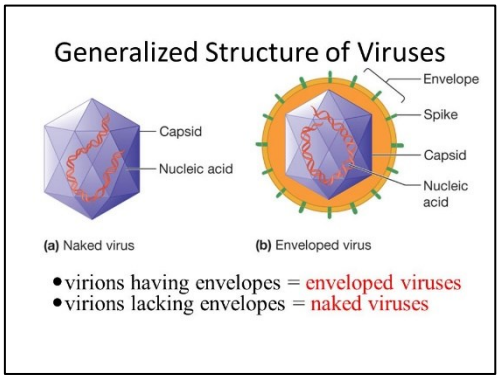
Enveloped is membrane consist of lipid obtained from the cell membrane of the host cell. e.g: as HBV, HCV, HIV, Influenza viruses & corona viruses.

Virion-complete virus divided into 2 types:

Viruses enveloped or non-enveloped (naked)

Naked virus: contain nucleic acid (DNA or RNA) surrounded by coat or capsid such as poliovirus & adeno virus.

Spikes: Glycoprotein compound which attach the receptors of the cells such as lungs, kidney & liver e.g influenzas virus, & coronavirus.

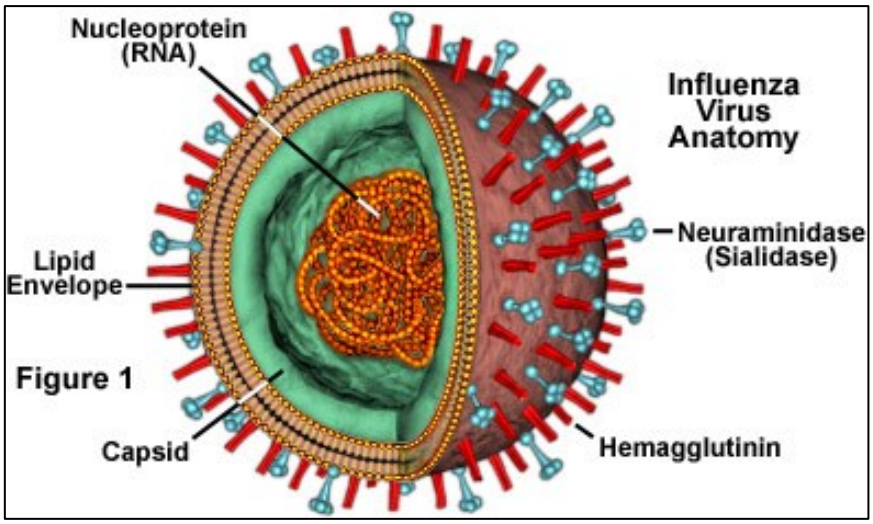


Virion = Extracellular form or state cannot replicate outside the cell or in the environment.

Viruses = intracellular form.

Agent damaged the envelope (lipid solvent) such as alcohol & detergent result in a loosing of effectively.

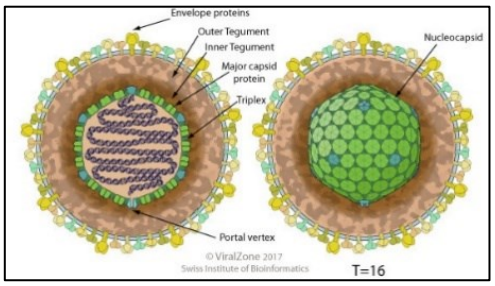
Most human viruses are enveloped. Viruses are unstable & sensitive to heat, drying & detergent.



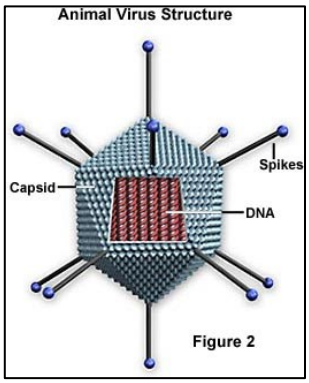
The nucleic acid is the genome that contain the information necessary for viral function & multiplication.

There are three types of viruses:

1) Human Viruses

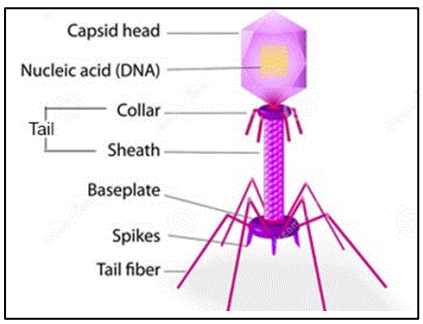


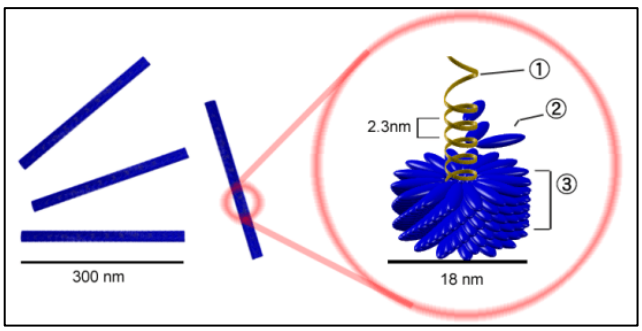
2) Animal viruses



3) Plant viruses

4) Bacterial viruses (Bacteriophage)



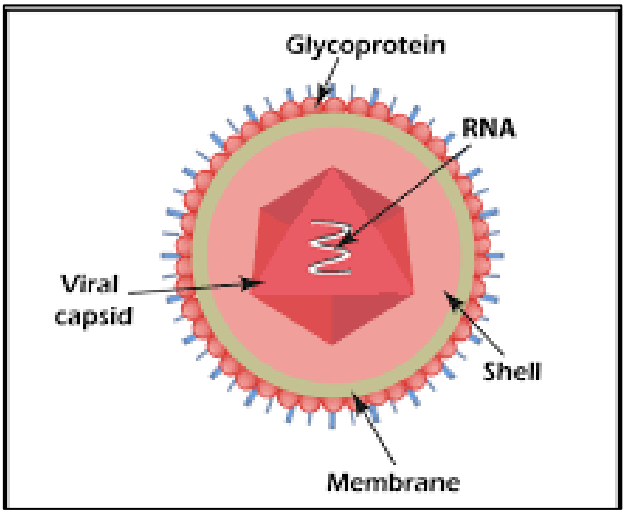


Differences between viral DNA & Plasmid:

Viral DNA: Extra & Intra cellular DNA.
Cannot replicate without cell or tissue. i.e: depends on host cell for replication.
Plasmid: Intra cellular DNA can replicate independently of the cell.

Polio virus: smallest animal virus.

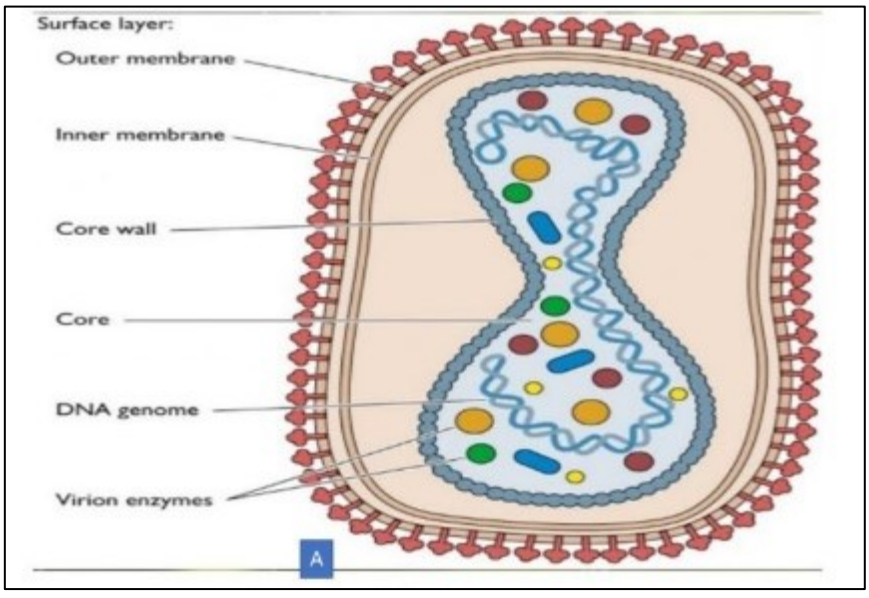
can spread from person to person is known to infect the spinal cord which causes paralysis.



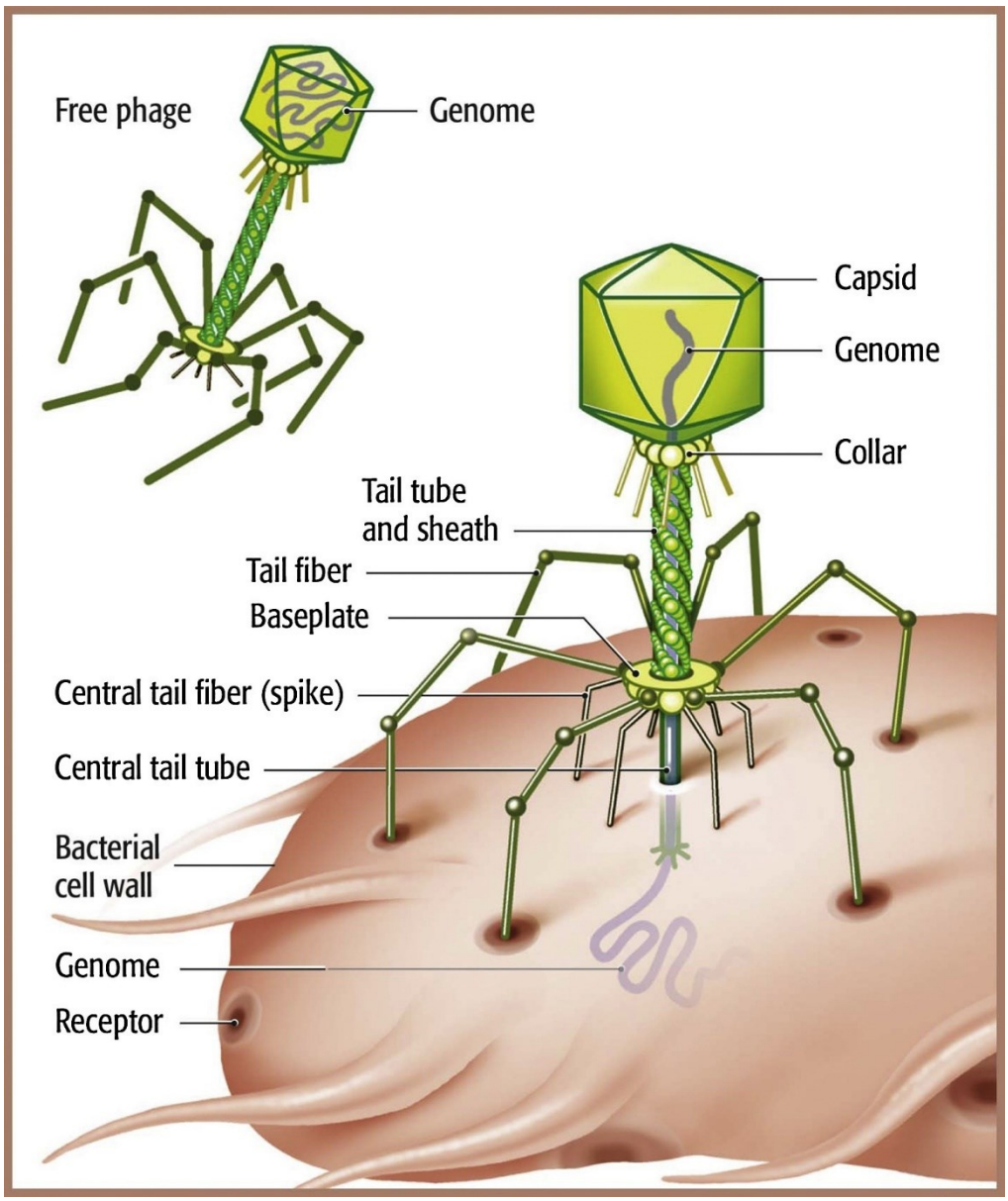
Small pox virus: largest animal virus & considered to be one of the deadliest diseases also called variola virus, large viruses visible under light microscope.

Replicate in the host cell cytoplasm. & Encode for enzyme required for mRNA & DNA synthesis in their genome.

Transfer from person to another person by Saliva.



Bacterial virus: infect the bacteria. The smallest viruses (bacteriophages)



Treatment of virus: Enveloped virus easier to treat than naked virus.

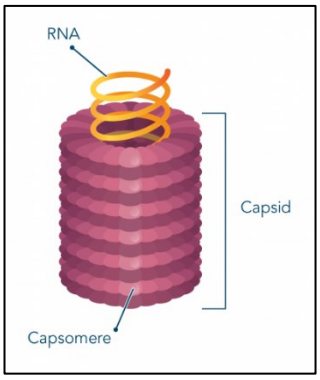
uses of different detergents such as alcohol, ether, organic solvents and bleach.

Shapes of viruses (Viral symmetry): -

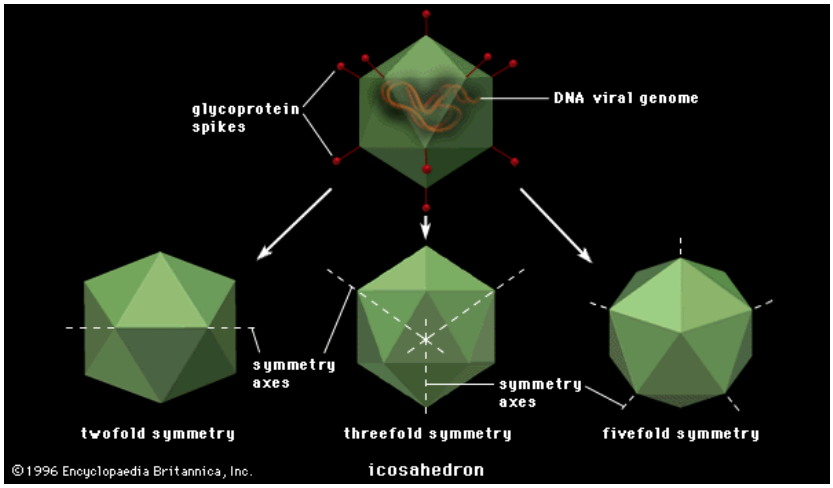
1. **Helical:** Contain protein coat +N. A. and the virus shape is rod e.g: rabies viruses.

   Width = Number and the size of the capsomers

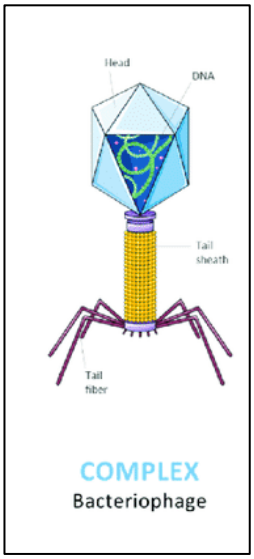
   Length = The length of genetic material



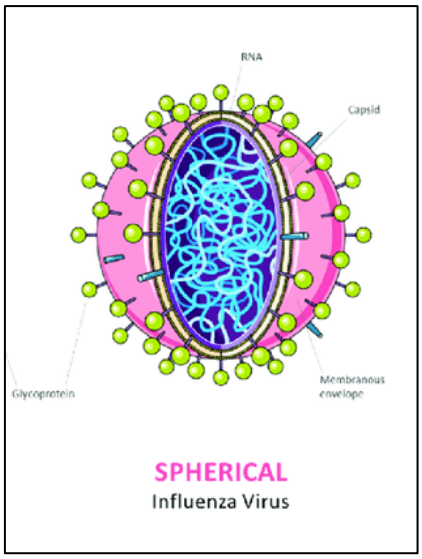
2. **Icosahedral**: The head is polyhedral & the genetic material inside the head e.g: influenza viruses & adeno viruses.



3. **Complex viruses**: like bacteriophages which infect and kill the bacteria. This virus is complex in structure without enveloped and composed of head (polyhedral) & N. A. (DNA), Tail (spiral or helical) and tail fibers ended by protein that attach the cell membrane so that can transfer the genetic material to the host cells.



4. **Spherical viruses**: like famous corona viruses DNA or RNA is helical surrounded by protein coat or capsid & the viruses enclosed in a membrane known as an envelope, have fibers or spiked ended by receptors consist of glycoprotein which are the key for entry to the host cell can determine host range, the function of the fibers for attachment of the host cells or invasion.

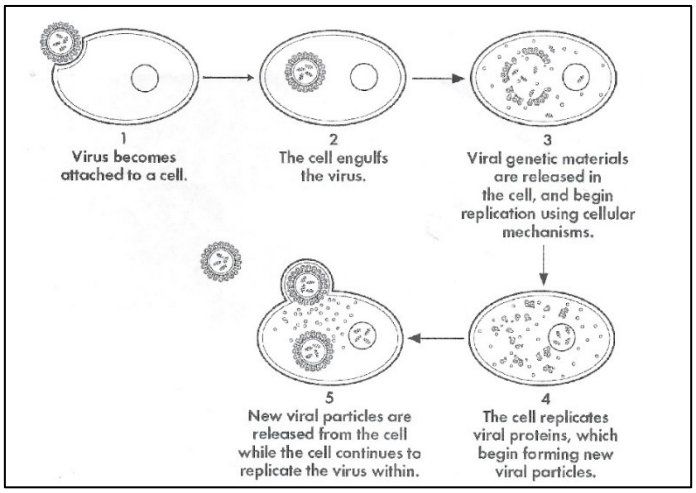


Bacteriophage 3 types.

1. **Lytic phage**: The virus penetrated to the cell & replicate after that the cell lysis & the virus spread outside the cell to infect another organism.
2. **Mutator phage**: The virus make mutation with the DNA of the bacteria & cause mutation for many species.
3. **Temperate phage or prophage**: Virus DNA integrated with bacterial DNA and stay as (Dormancy period) this state called lysogenic stage, some response happened when the bacteria exposed to U.V light or master gas the virus started to replicate and change from lysogenic state to lytic stage & the cell lysis & allow the virus to release & infect another cell.

Viral replication cycle

1) Attachment or adhesions to specific receptors of the bacterial cell.
2) penetration then uncoating endocytosis or fusion
3) Synthesis of Viral replicating enzymes
4) Replication
5) synthesis of viral protein coat.
6) Assembly Nucleocapsid
7) cell lysis viral release.



Viral protein (3 types)

1. Early enzyme of Replication
2. Late protein of protein Coat.
3. Lytic cause cell lysis

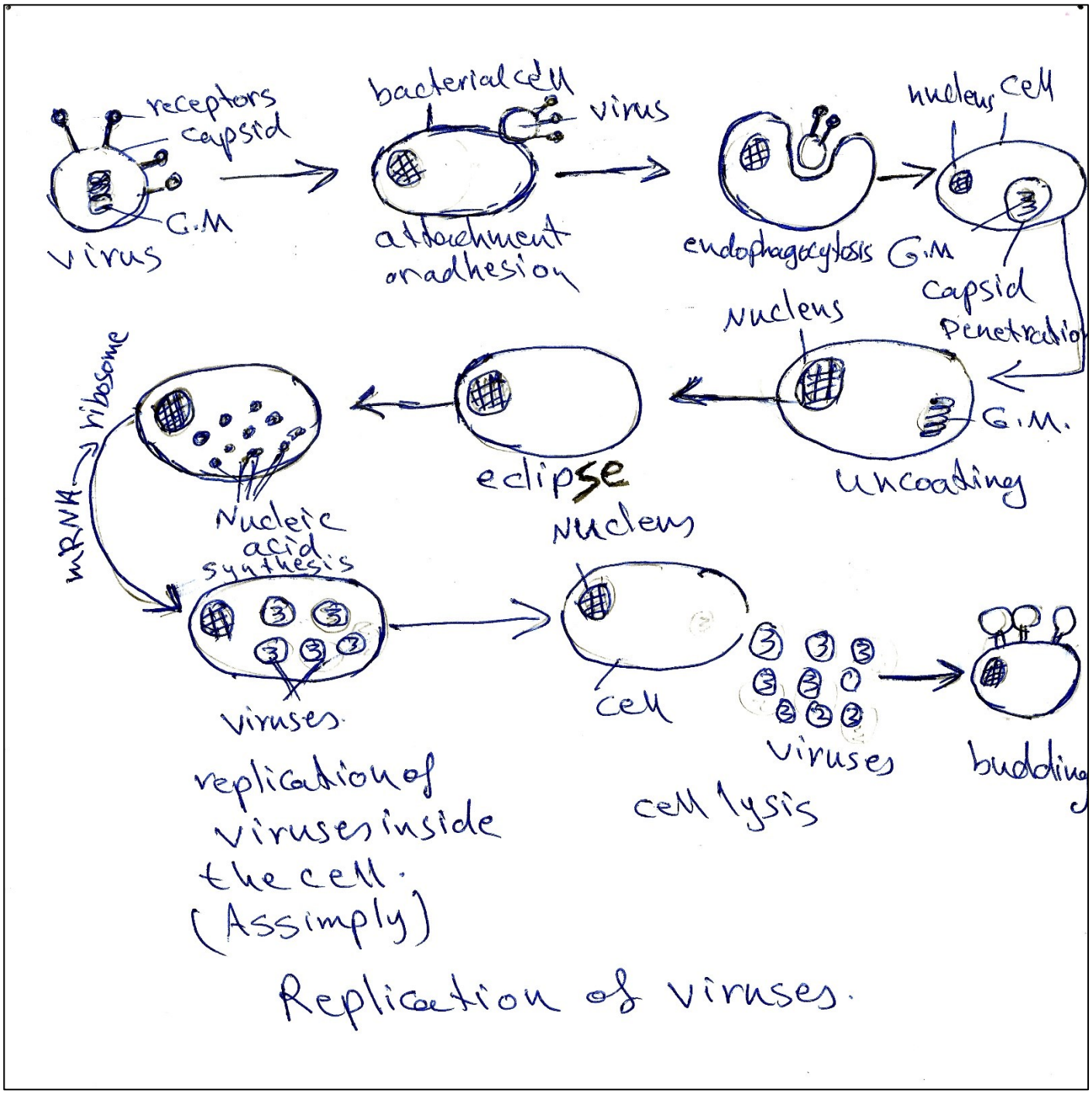
Cultivation of viruses:

1. Animal inoculation: rabbit, monkey, mouse & pig.
2. Chick embryo & egg.
3. Tissue culture: Organ's kidney, thyroid gland and placenta & liver.

Diagnosis of viruses:

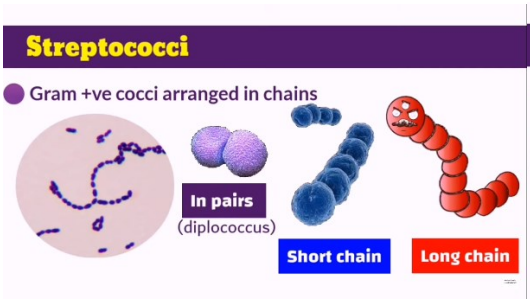
1. Electron microscope.
2. PCR
3. Analysis of antibodies.

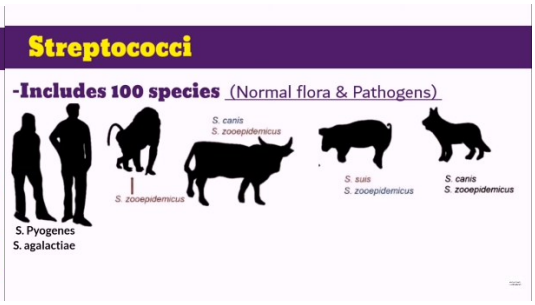
- Viruses are resistant to antibiotics.
- Do not grow in media or agar.
- do not pass from bacterial filter.

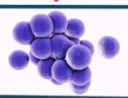

receptors
capsid
G.M
virus
bacterial cell
virus
attachment
or adhesion
endophagocytosis
nucleus
cell
G.M
Capsid
Penetration
Nucleus
G.M.
uncoating
ribosome
mRNA
Nucleic acid synthesis
eclipse
Nucleus
viruses
cell
viruses
budding
replication of viruses inside the cell. (Assimply)
cell lysis
Replication of viruses.

***Streptococci* family**

1. G+ve bacteria spherical in shape arrange in chain, short chain & long chain
2. In pairs (diplococci) such as *pneumonia*.
3. Widely distributed in nature & have 100 types.
4. Some live as Normal flora, Microbiota, pathogenic.
5. Cause disease for human, such as pharyngitis, Tonsilitis, septicemia, Meningitis, oral cavity infection, osteomyelitis & skin infection
6. Have many genes the most common genera *Streptococcus*, *Enterococcus*.
7. Some facultative anaerobic other obligate anaerobic.
8. The most common found in hospital *Staphylococcus*, *Streptococcus*, *Enterococcus* and *Pseudomonas*.
9. Found in upper respiratory tract, in mouth in mucous tissue, saliva of every human in vaginal system. and urinary tract.
10. Some streptococcus produced enzyme called streptokinase which use to save brain patient (desolve the clot in the brain & heart).
11. Fastidious microorganism cannot be easily cultured in media. need Enriched media such blood agar serum, tissue fluid.
12. Size range between 0.5-0.8 Mm.
13. *Streptococcus* belong to family streptococcaceae, order lactobacillus, most streptococci are oxidase-negative.





Comparison	Staph.	Strepto.
Gram Staining		
Catalase test	+ve	- ve
Growth	Can grow in any types of media In Low or much nutrients, Simple & Enriched	Fastidious Microorganism Can not be easily cultivated in media Enriched media Blood Agar Blood, serum, tissue fluids
Colony size	(1.0 Mm)	Smaller (O.5 - O.8 Mm)

Classification according to:

1) Hemolysis on blood agar:

A. Complete hemolysis (Beta) clear zone surrounding colonies pyogenes, agalactiae, S. canis, S. equi

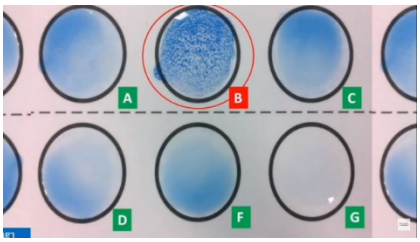
B. partial hemolysis (Alpha). Greenish zone surrounding colonies

S. Viridans, S. preumonia

C. No hemolysis (Gamma). No clear zone or no Greenish Zone surrounding the colonies.

2) Lancefield classification streptococci include 20 different serotype carbohydrate presents on the surface of the cell wall which are differ from one species to another.

S. Pyogenes (group A Lancefield)
S. agalactiae (group B Lancefield)
S. equi (group C Lancefield)
S. bovis & Enterococcus (group D Lancefield)
S. porcinus (group E, P.U.V Lancefield).



3) DNA and rRNA (genotype) classification

Ex. Enterococcus (formally streptococcus group)

streptococcus faecalis (Enterococcus faecalis)

Because it differs in rRNA & type of infection

Enterococcus infect urinary tract

Streptococcus infect skin, throat & respiratory system.

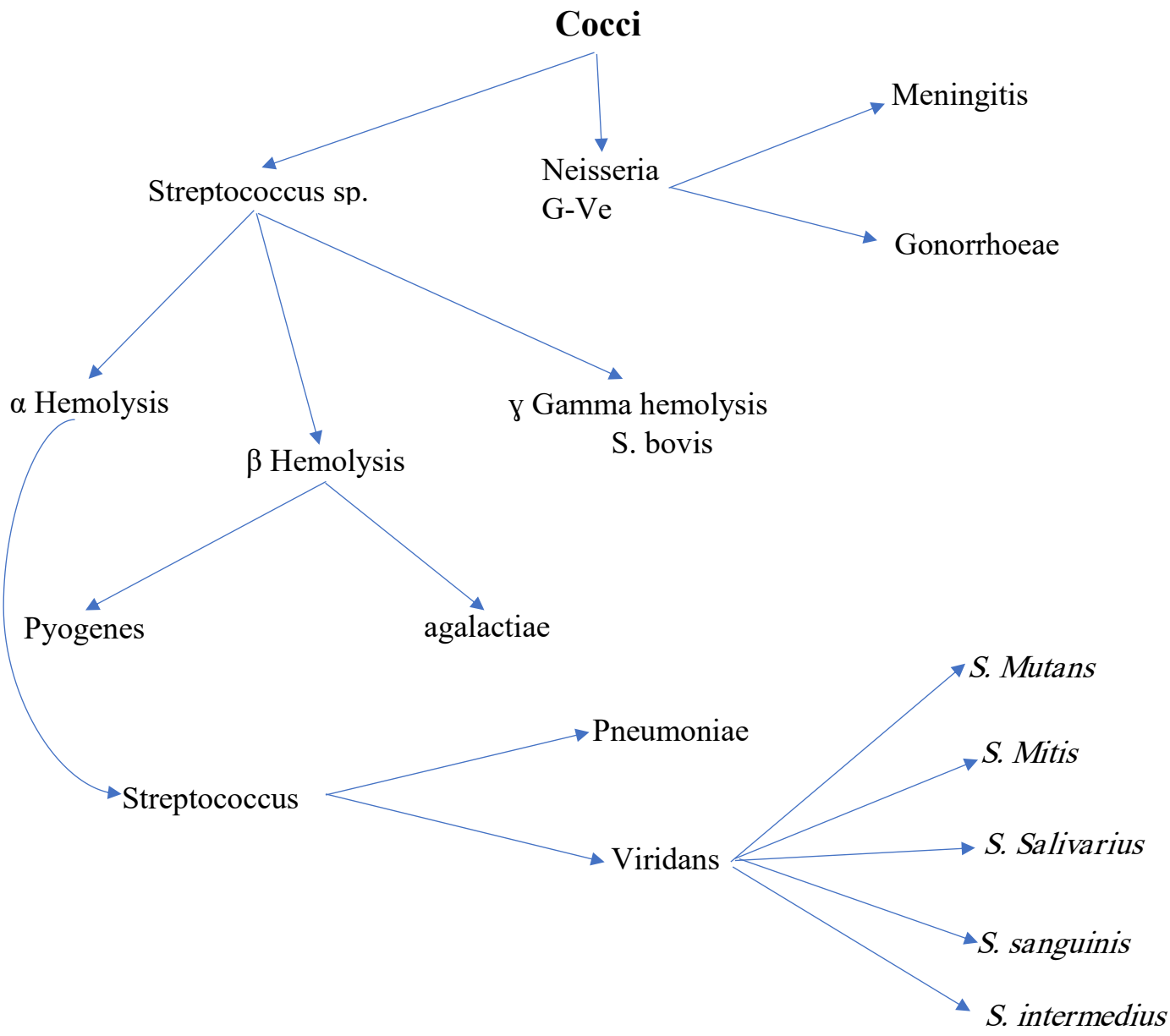
4) Main habitant (Host).

S. pyogenes (Human).

S. Canis – Dogs + livestock + horses

S. Suis (pigs)

S. Agalactiae = Human + Camels


Cocci
Streptococcus sp.
Neisseria
G-Ve
Meningitis
Gonorrhoeae
α Hemolysis
β Hemolysis
ɣ Gamma hemolysis
S. bovis
Pyogenes
agalactiae
Streptococcus
Pneumoniae
Viridans
S. Mutans
S. Mitis
S. Salivarius
S. sanguinis
S. intermedius

Streptococcus viridians

Gram positive, Facultative anaerobic

Catalase negative

Fastidious M.O. (Enriched media, BA)

Viridans = Green.

because it produces alpha hemolysin of R.B.C.

Normal flora in oral cavity**.**

It causes dental caries or tooth decay in bad oral hygiene persons due to acid production. From sugar fermentation that decay teeth and hydrolysis the upper layer of the teeth if the infection is very deep & reach the nerve of the teeth or if there is dental surgery or extraction of teeth or removal of tonsilitis. the bacteria move from the oral cavity to the heart and causes subacute bacterial Endocarditis (SBE) mainly in patient with abnormal or damaged heart valves or prosthetic & structural heart defects the bacteria have ability to produce dextran's completed sugar synthesized from glucose which allows them to adhere to fibrin platelet aggregates at damaged heart valves.

Another virulence factor: dextran's provide foundation layer for the formation of complex biofilm known as dental plaque. Biofilm that promotes oral adhesion causing gingivitis & this stimulate to cause periodontal infection. Dental plaque = saliva components + microorganism + product of microorganism, waste of foods + carbohydrate.

Another virulence factor: Polysaccharide Dextrans. which allows them to adhere to fibrin platelet aggregates at damaged heart valves. Dental caries = removal of mineral & cause cavity in the teeth.

Prevention

Doses of clindamycin or Amoxicillin three days before & after dental surgery.

Strain S. viridans causing dental caries is *S. mutans*

Strain of *S. viridans* causing endocarditis is S. Sanguinis

Strain of *S. viridans* causing abscess is S. intermedius

S. viridans	S. pneumoniae
Optochin resistant	Optochin sensitive
Bile salt resistant Tolerant	Bile salt sensitive Soluble
Inulin fermentation negative	Inulin fermentation positive
No capsulated	Capsulated

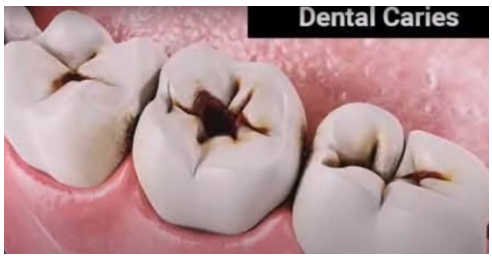
Treatment

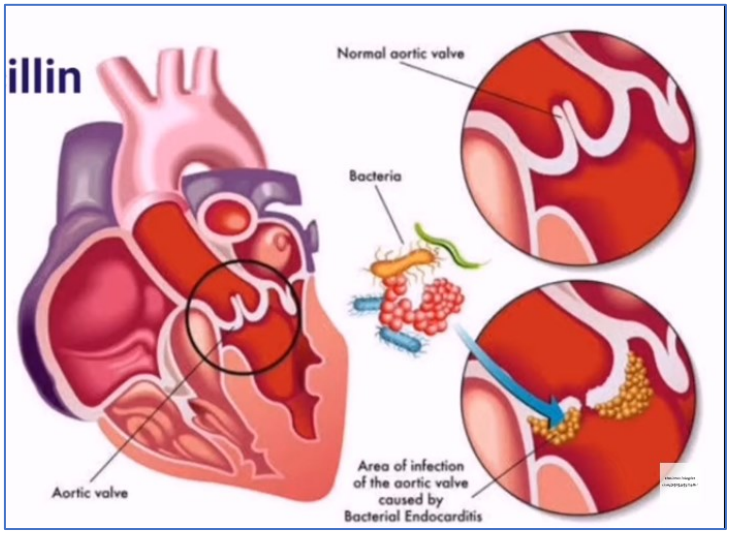
1. Relatively resistant to penicillin.
2. Beta-Lactam + Dextranase enzyme
3. Combination of penicillin + Gentamycin.

Prevention methods:

1. Oral hygiene, since dental caries do not progress without the bacteria present in dental plagues.
2. Daily plaque removed by brushing-flossing &rinsing.
3. If left untreated will eventually result in ultimately tooth loss.
4. Fluoride prevents dental caries by inhibiting demineralization of the crystal structures inside the tooth & enhancing remineralization.

oral cavity habitat = Lips + cheeks, palate, tongue, Mucosal surface & teeth.





Diagnosis

- blood culture
- 5-10 ml blood
- 50 -100 broth
- incubated for 378º & subculture on blood agar for 48 hours.

Types of Bacteria found in the mouth

1. Streptococcus Viridans (mutans & mitis).
2. Staphylococcus.
3. Enterococcus
4. Spirochetes
5. Lactobacilli
6. Actinomycetes.

Mechanisms

1. Saliva + Bacteria.
2. Adhesion / Attachment (salvia, polysaccharide)
3. Colonization + Accumulation. of more Flora in the mouth.
4. Acid production (fermentation)
5. Demineralization → Dental carries

Causes

1. Injury in mucosal membrane
2. Infection by viruses
3. Smoking.
4. Nutrition deficiency
5. Inflammation in epithelial cell of month
6. Heard brushing of teeth. which make bleeding.
7. Exogenous source & endogenous changes eruption of teeth.

Clinical conditions

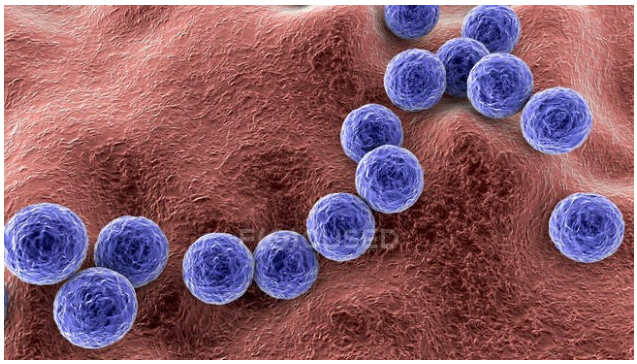
1. Dental caries (most common S. mutans)
2. Periodontal infection.
3. Subacute bacterial endocarditis
4. Septicemia when patient have anemia & fever which allow the bacteria to multiply & secreted poising in the blood.

Streptococcus pyogenes

It has a very medical impotance in medicine

- Chain of cocci
- Beta hemolytic Streptococci
  Clear zone surrounding colonies
- Group A Streptococci (GAS)

- pyogenes = Pyogenic = Fever (High temperature)



It causes Pharyngitis (Sore throat, Tonsilitis)
Skin infections (impetigo , scarlet fever, Cellulitis)
Ear infections (Otitis media)

Disease complications (Invasive infections)

- Rheumatic fever
- Acute Endocarditis
- Puerperal fever (Glomerulonephritis)

Streptococcus pyogenes [Virulence factor]

It produces several enzymes, toxins that make it leathal

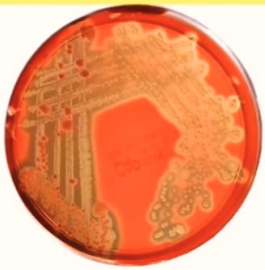
Streptokinase Stronger 10 times more Staphylokinase

Kinase is used to dissolve the fibrin matrix of blood clots

Hemolysins = Streptolysins

Complete lysis to RBC hemoglobin

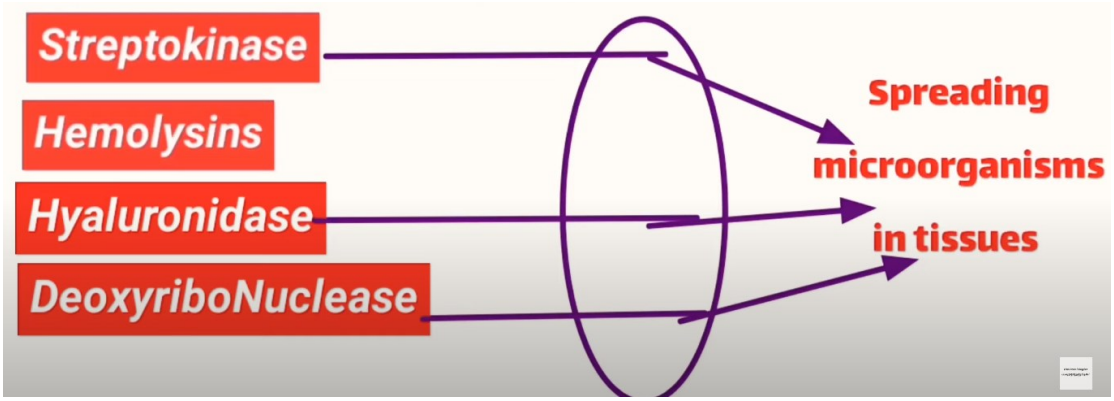
Streptolysin O & Streptolysin S



Streptococcus pyogenes

Streptolysin O	Streptolysin S
Oxygen labile (inactive in presence of Oxygen)	Oxygen Stable (active in presence of Oxygen)
Immunogenic	Non Immunogenic

- **Streptokinase** — dissolve the fibrin matrix of blood clots
- **Hemolysins** — Lysis & destroy RBC hemoglobin
- **Hyaluronidase** — makes tissues more readily permeable
- **DeoxyriboNuclease** — hydrolyzing phosphodiester bonds that link nucleotides



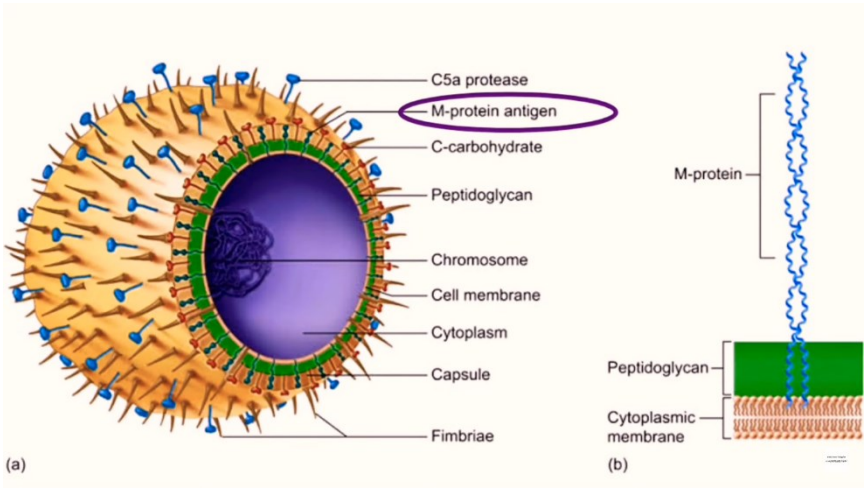
Erythrogenic toxins

damage the plasma membranes of blood capillaries under the skin and produce a red skin rash

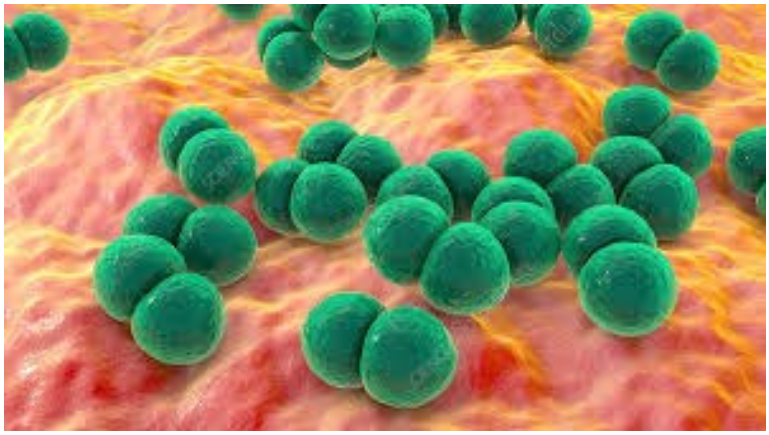
M-Protein provides antiphagocytic functions critical to survival in human tissues and fluids

M-Protein
Protein-F
Lipoteichoic acid

adherence to epidermal keratinocytes, microcolony formation and invasion of epithelial cells



Streptococcus pneumoniae



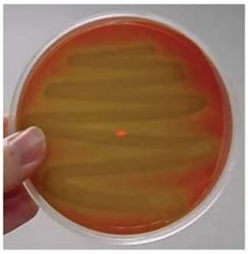
Streptococcus pneumoniae

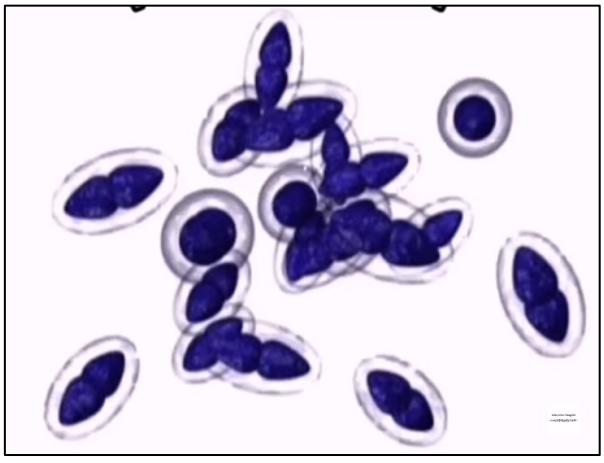
Gram positive diplococci ●● (Pneumococcus)
Lancet shaped Capaulated (90 Antigenic serotype)
(Antiphagocytosis)

Like all streptococci, Staphylococcus pneumoniae is a fastidious Microorganism
Thus, it grows best on Enriched media (ex: Blood Agar)

Producing alpha hemolysis

Greenish gray color surrounding the colonies





Streptococcus pneumoniae

Habitat Normal flora of upper respiratory tract.

Opportunistic bacteria

Secondary infections with respiratory viral diseases in healthy people and may cause infections more easily in children, old people, alcoholic, spleen removal (splenectomy) and sickle cell anemia

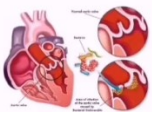
Streptococcus pneumoniae

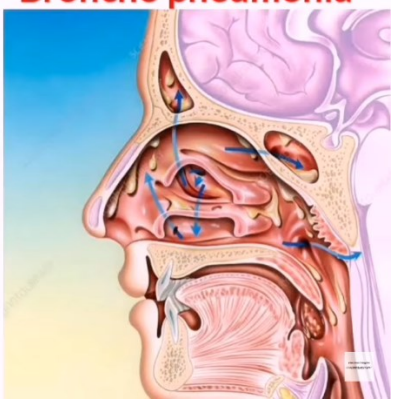
Pathogencity Lobar pneumonia, Broncho pneumonia

- Sinusitis
- Otitis media
- Conjunctivitis

Septicemia (Bacteria + Toxin)

Meningitis 

Endocarditis 



Streptococcus pneumoniae

Virulence factors

1. Polysaccharide Capsule
2. Autolysin & Pneumolysin Toxins

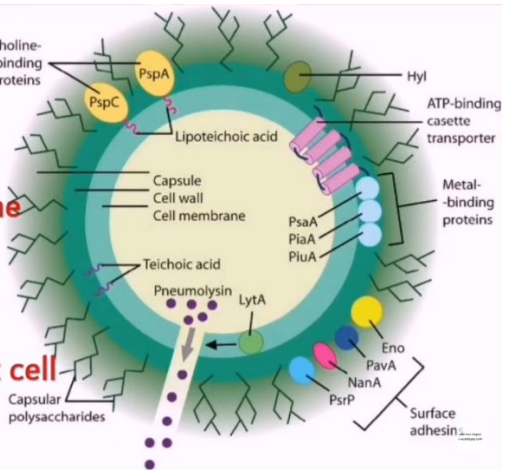
3.

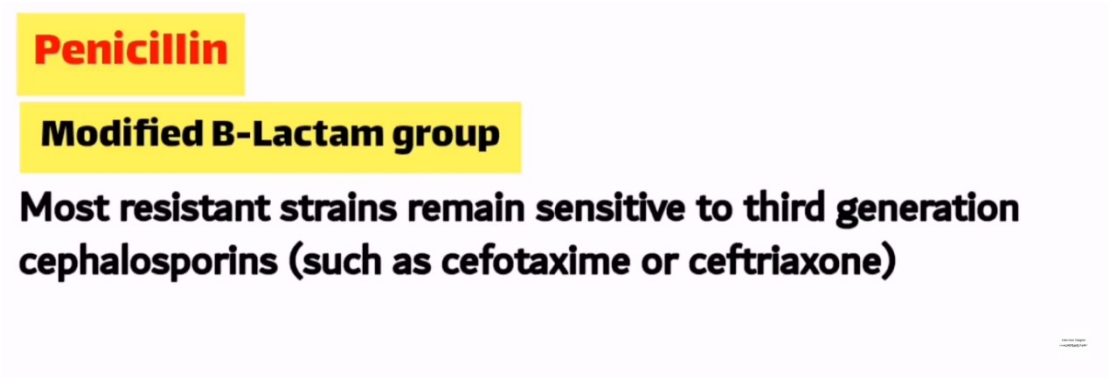
Autolysis

Peptidoglycan hydrolase (Lyt)
Hydrolyze peptidoglycan
when there's danger outside
In order to destroy cell membrane
by secreting Pneumolysin toxin

Pneumolysin

Destroy cell membrane of host cell





Vancomycine have high activity against this type of bacteria

Staphylococcus aureus

gram positive (grape like shaped), Non motile

staph = grape coccus-spherical, aureus golden due to staphyloxanthin pigment

All staphylococci are catalase positive streptococci are catalase negative coagulase positive facultative anearobs.

Habitant: Normal microbiota.

on skin, mucous membrane & upper respiratory tract

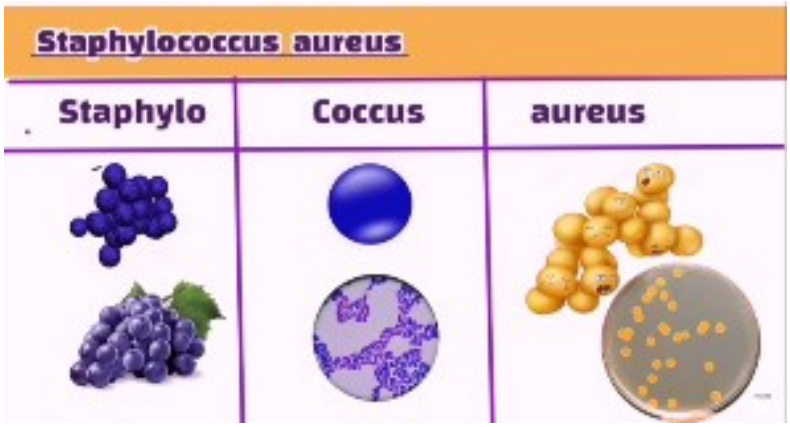
This type of bacteria change from normal flora to opportunistic pathogen when there is change of Humidity, change in PH , Sweating, scratch / injury

Most infection of this type is superficial infections. on skin e.g: impetigo, abscesses & if the infection is deep, it may cause osteomyelitis.

When the bacteria transfer to the blood cause Bacteremia (septicemia in blood)

Meningitis in brain , Endocarditis in heart, pneumonia in lung.

any medicine or drugs exposed to skin & mucous membrane must detect the absence of *S. aurus*. such as otrivin, voltarin, MEBO, because infect the skin when the natural condition of the skin is changed.



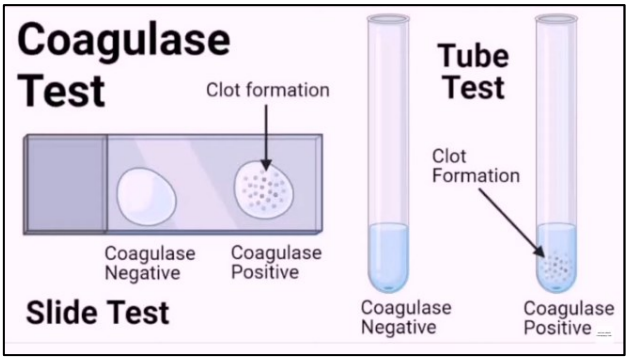
virulence factors of *S. aureus*

Staph aureus is very dangerous bacteria.

1) **Enzyme** Ex-Coagulase, staphylokinase Hyalurinidase., Lipase , D Nase.

A) Coagulase

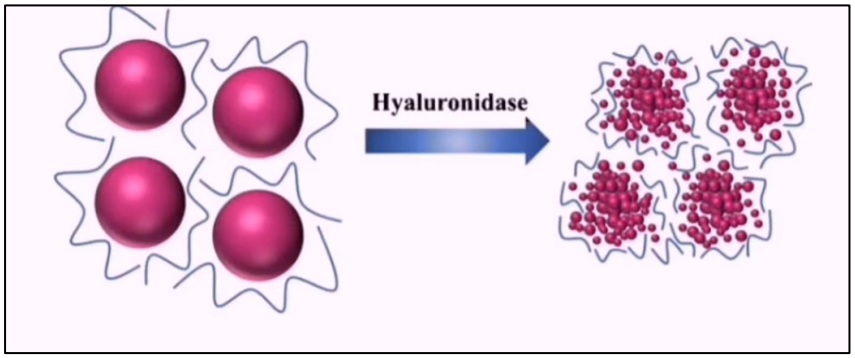
This is common enzyme for *S. aureus*, which make clot in the blood, change fibrinogen (liquid)→ fibrin (solid & participated). The bacteria started to multiply inside the cell until the cell lysis.



B) Staphylokinase

This enzyme hydrolyze the aggregation of clot & the bacteria move to another cells & multiply to affect a big area.

C) Hyaluronidase: - break down the connective tissue of the skin & make clot in the skin to infect a big area in the tissue.



D) Lipase: The skin have glands which secreated fatty acid the bacteria use this enzyme to change fat to fatty acid & use it as source of carbon which help the bacteria to grow faster inside the skin & infect most of area.

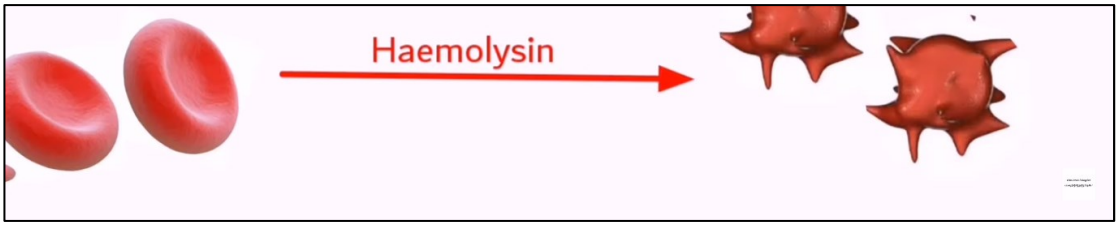
Fat $\xrightarrow{\text{Lipase}}$ fatty acid + Glycerol.

E) DNase - break down Deoxyribonuclease to control the cell.

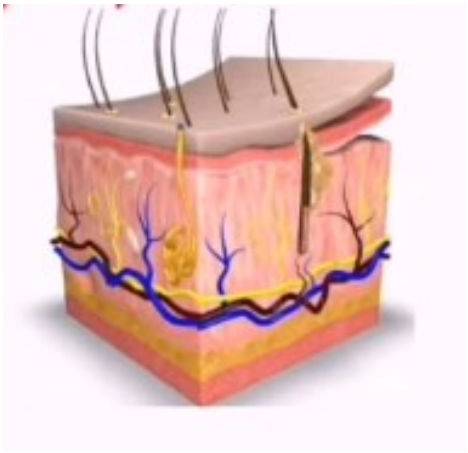
2) Toxin:

1. TSS - toxin -APC recognize bacteria and the immune system started to attach Antigen but *Staphylococci aureus* have TSS toxin which connected with APC & the immune system cannot recognize it & cause infection sometimes leads to lysis of the cell.

2. Leukocidin- Attach the Leucocyte and Neutrophil which are responsible for destroying the foreign bodies such as bacteria & viruses & make lysis of the cell.
3. Haemolysin: - Attach the R.B.C by Haemolysin enzyme & make complete hemolysis to the blood.



4. Exfoliative toxin-Infection of *S. aureus* cause separation of the upper epidermis from the inner dermis to be in deep area under the skin & cause infection.



5. Enterotoxin, bacteria infect the intestinal system & cause food poisoning accomplished by Diarrhea, intestinal inflammation and vomiting.

3) Biofilm in *staphylococcus aureus* Biofilm formation was a good reason of isolated the tissue from the external environments so the immune system cannot recognize it and A.B which is very difficult to enter the Biofilm & make gene resistant for it. So the bacteria resist to A.B such as Beta lactam.

- Penicillin resistant *S. aureus*.
- Methicillin resistant *S. aureus*.

Treatment

Augmentin, Amoxicillin + Clavulanic acid

Vancomycin → sensitive t& effective *S. aureus*

Tetracycline ↗

Media for *S.aureus*:

1. Mannitol salt agar source of C
2. Blood agar.
3. Toluidine Blue DNA agar.
4. Tryptone agar.

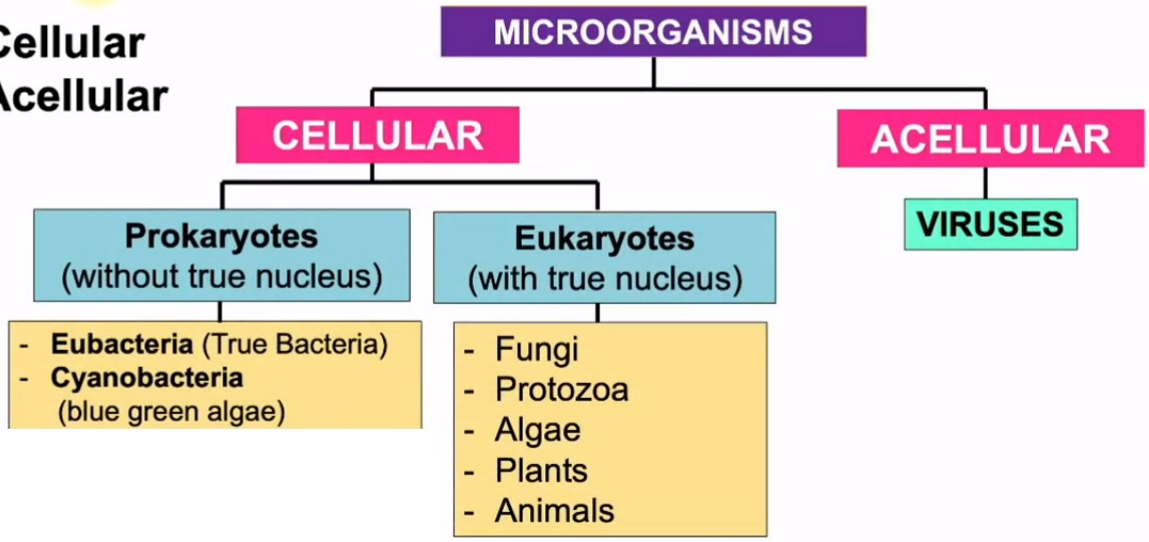
FUNGI

(a) (b) (c)

MYCOLOGY

Categories of Microbes:

1. Cellular
2. Acellular



Distinguising Characteristics of Fungi

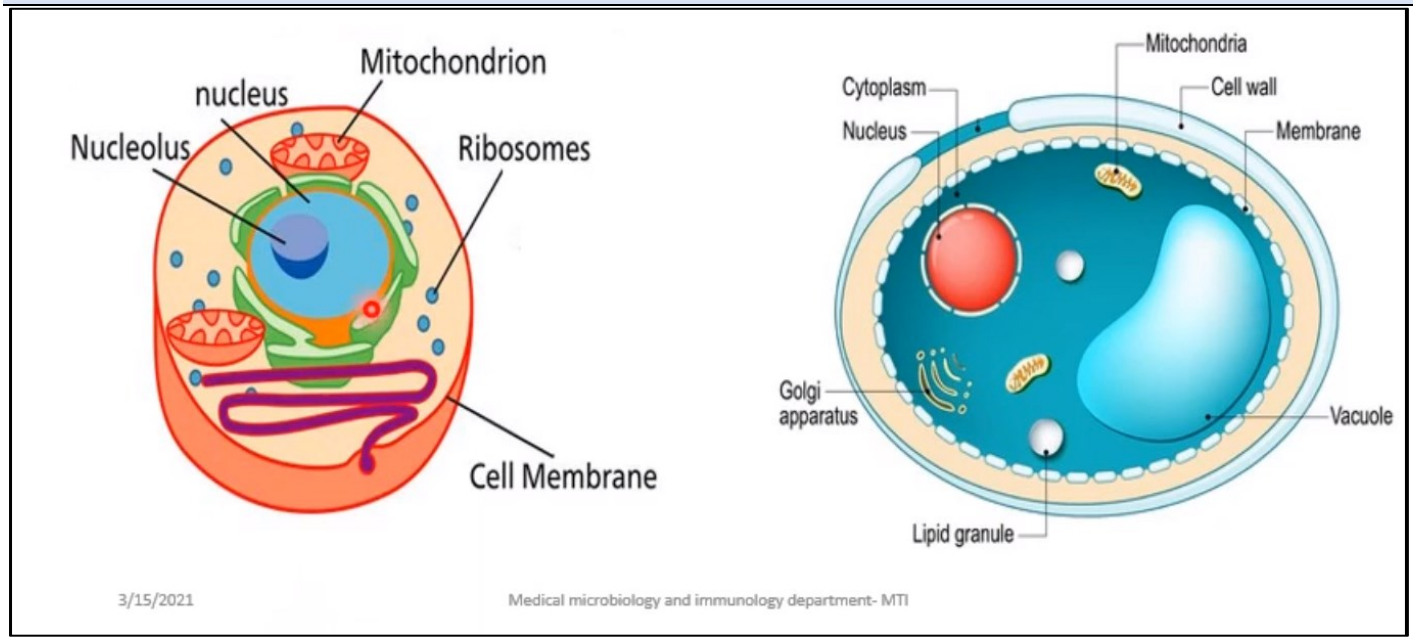
1. Eukaryotic and non-vascular
2. Don't have chlorophyll, non-motile
3. Cell wall is made up of chitin
4. Obligate aerobes and grow best a a neutral pH
5. Needs moist environment which are necessary for their growth

6. Chemo-organo-Hetero trophic organism.

7. Release digestive enzyme on food then absorb the nutrients.

8. Store foods as glycogen like animal cells.

9. Reproduced by sexual & asexual reproduction.



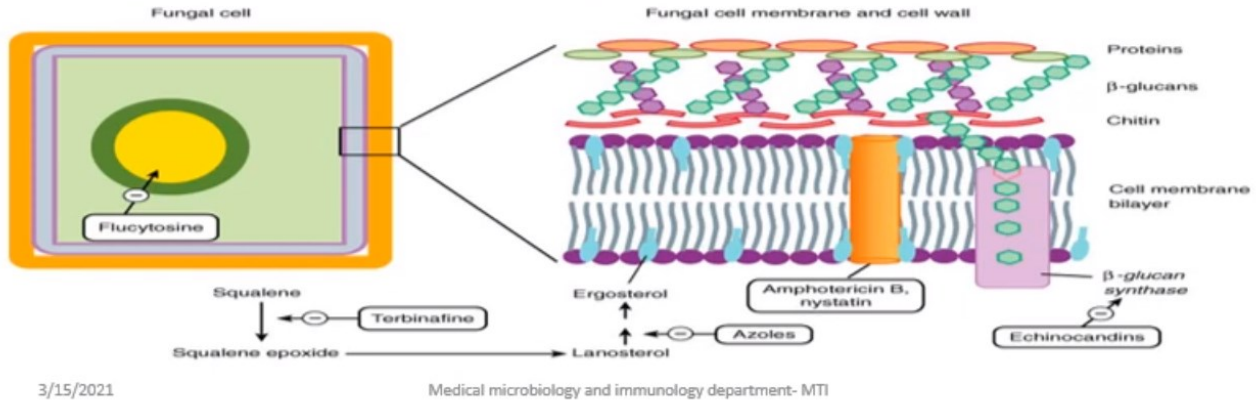
Cell wall of Fungi is consist of:

- **Chitin**
  - – responsible for very rigid cell wall of fungi

Mannoproteins

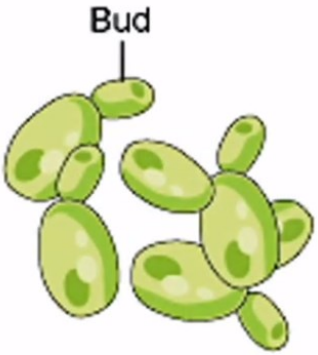
1-The fungal **cell wall** consists of polysaccharides **chitin** (insensitive to antibiotics) and **β- glucan.**

2- The fungal cell membrane contains **ergosterol**, in contrast to the human cell membrane, which contains **cholesterol.**



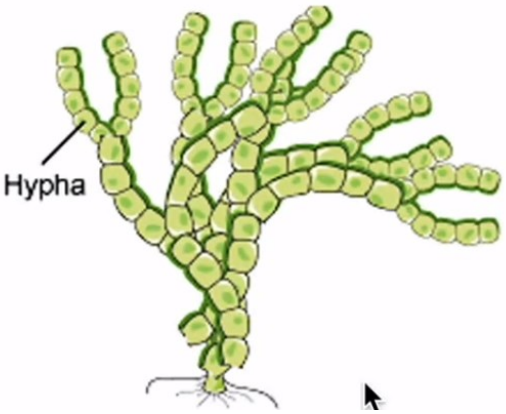
FUNGI EXIST IN 2 FORMS:

Yeast



Unicellular

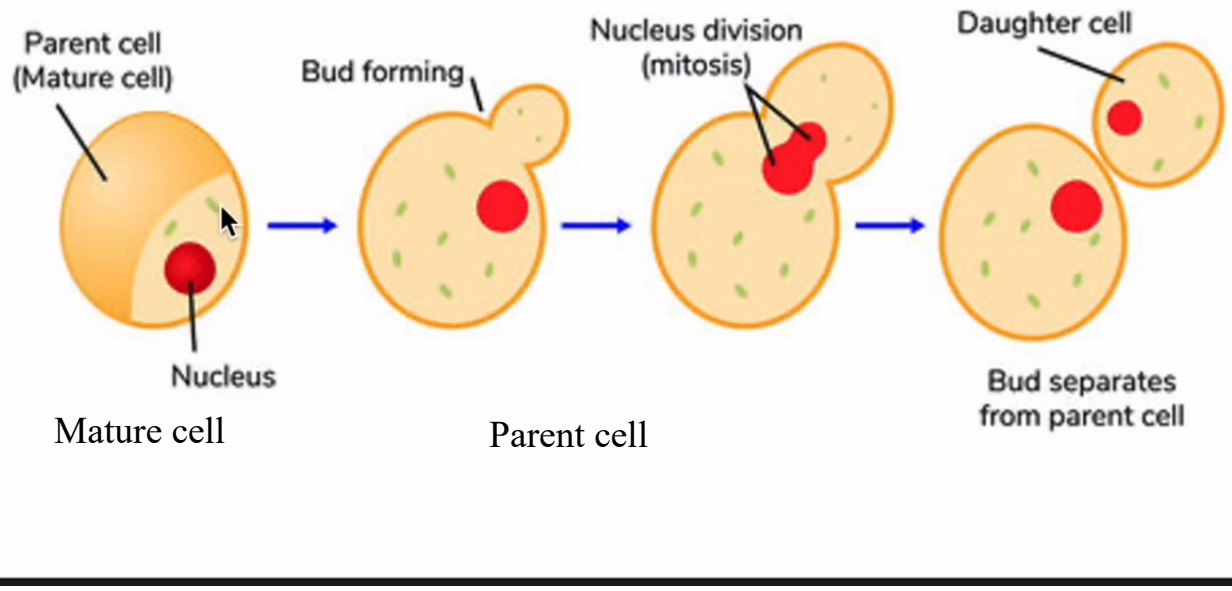
Molds

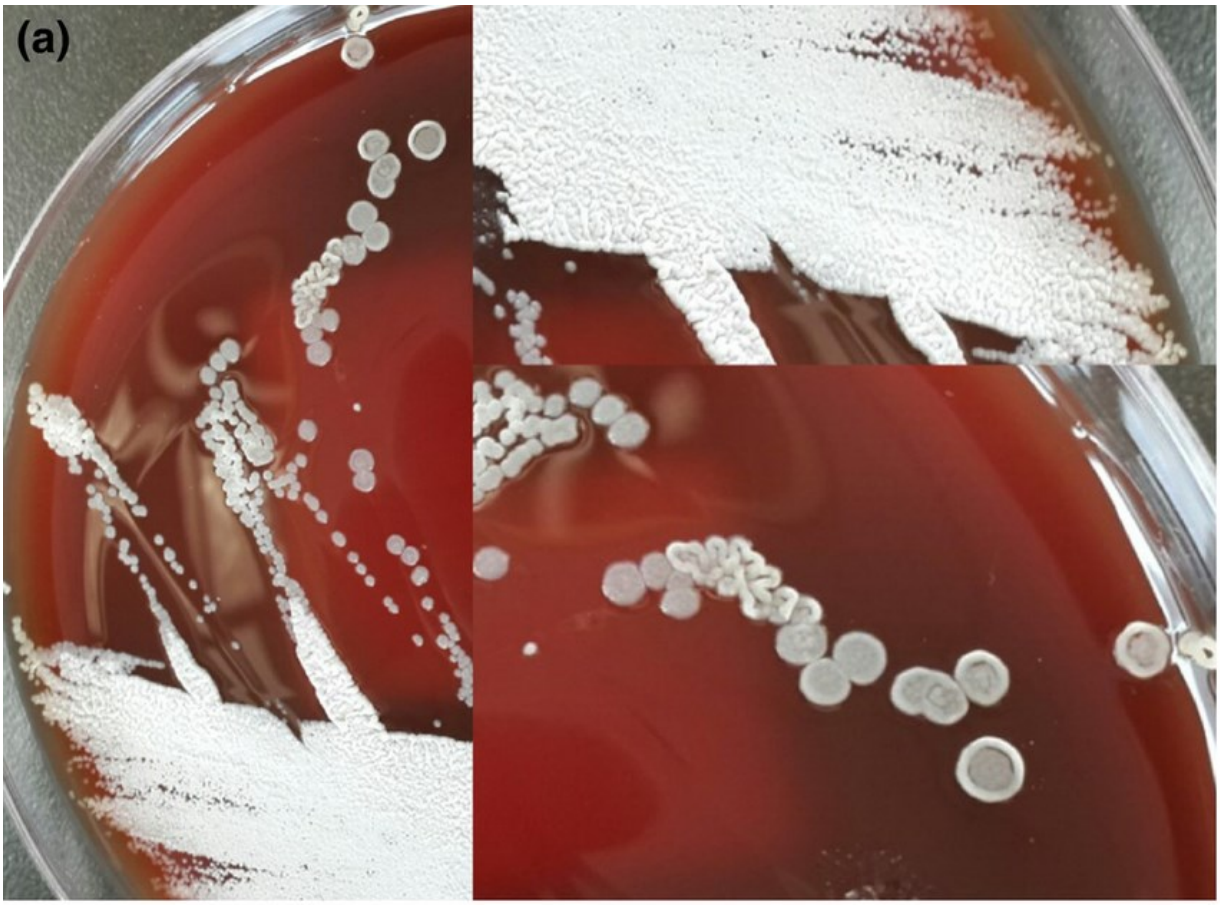


Filamentous

yeast

- Single vegetative cell (unicellular)
- Typically produces **smooth, creamy colonies** on culture medium
- Morphologic appearance of all yeast are somewhat similar look exactly the same
  - Identification is based on the result of **biochemical testing**
- They reproduce by **budding**

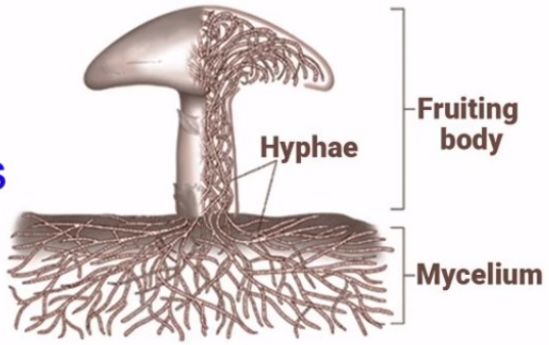




colonies of yeast in culture media in human gut or mouth

molds

- Fuzzy / wooly appearance which is due to **mycelium**
  - the collection of long strands of root-like structures called **hyphae**

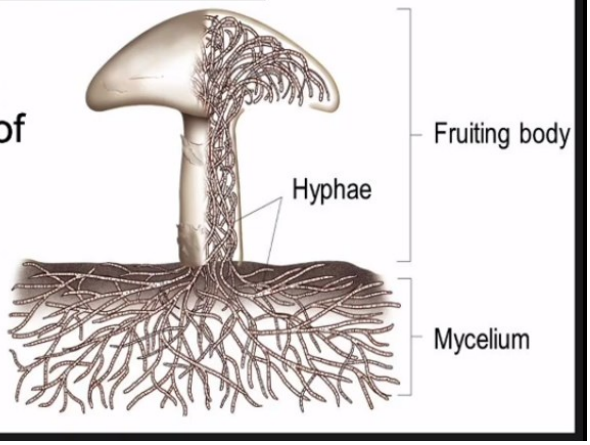


Hyphae – fundamental unit of fungi

- thread-like chains of cells that form the **Fruiting body** and **Mycelium**

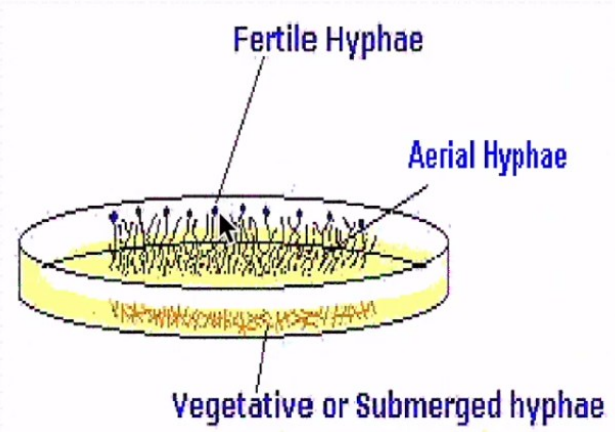
Mycelium : Underground network of hyphae that have grouped together

Fruiting body : reproductive structure of a fungus and grows above the ground.



3 Types of Mycelium

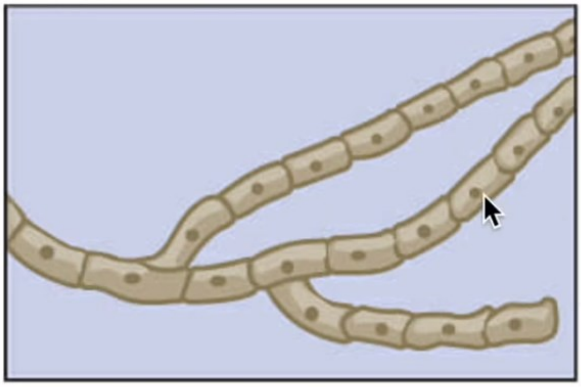
1. **Vegetative** – are those that penetrates the surface of the medium and absorbs nutrients.
2. **Aerial** – are those that grow above the agar surface
3. **Fertile** – are aerial hyphae that bear reproductive structures such as conidia or sporangia.



2 Types of Hyphae

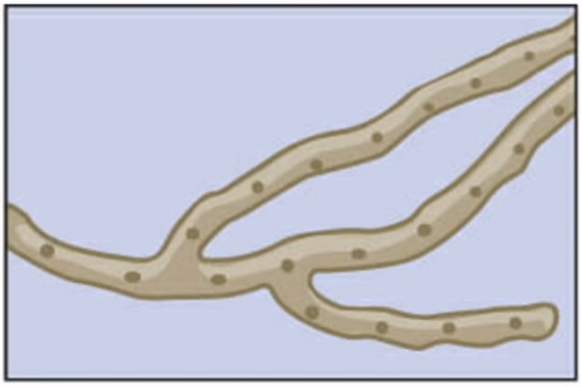
Septate

– contains septa/crosswalls



Aseptate

– no septa/crosswalls



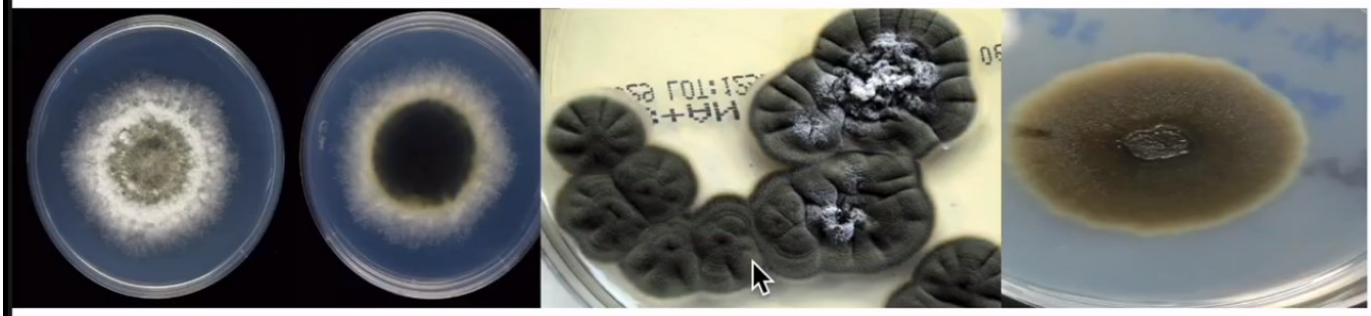
Septate hyphae the cross wall have pores which transfer the food or Nutrient from cytoplasm to cytoplasm or from one cell to another.	in lower fungi no cross wall & many nuclei e.g Zygomycota

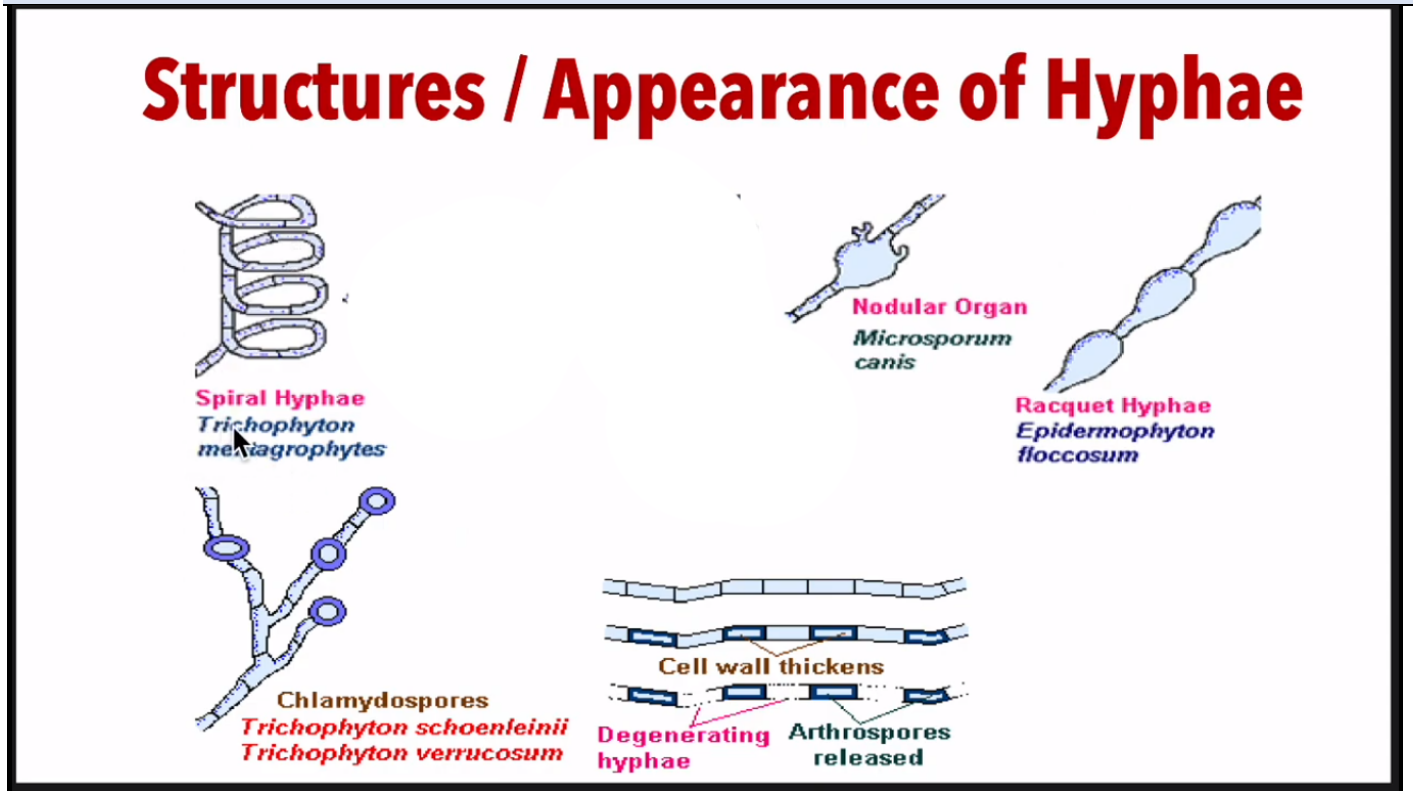
Types of Hyphae based on pigmentation

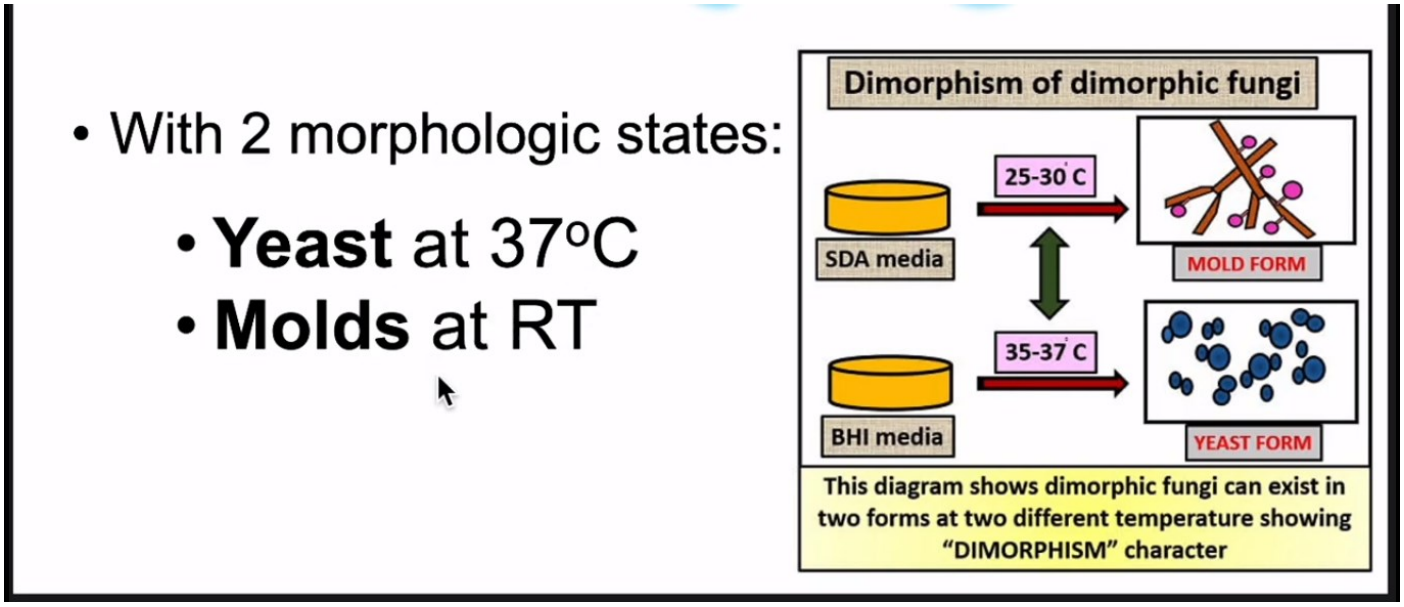
- **Hyaline** – don't possess any pigment in their cell wall (transparent)

- **Phaeoid or dematiaceous** – fungi that possess melanin pigments in their cell wall (pigmented)
  - **Colonies are grey, black or olive.**
  - **Ex.** Bipolaris, Cladosporium, Exophiala

Bipolaris **Cladosporium** **Exophiala**



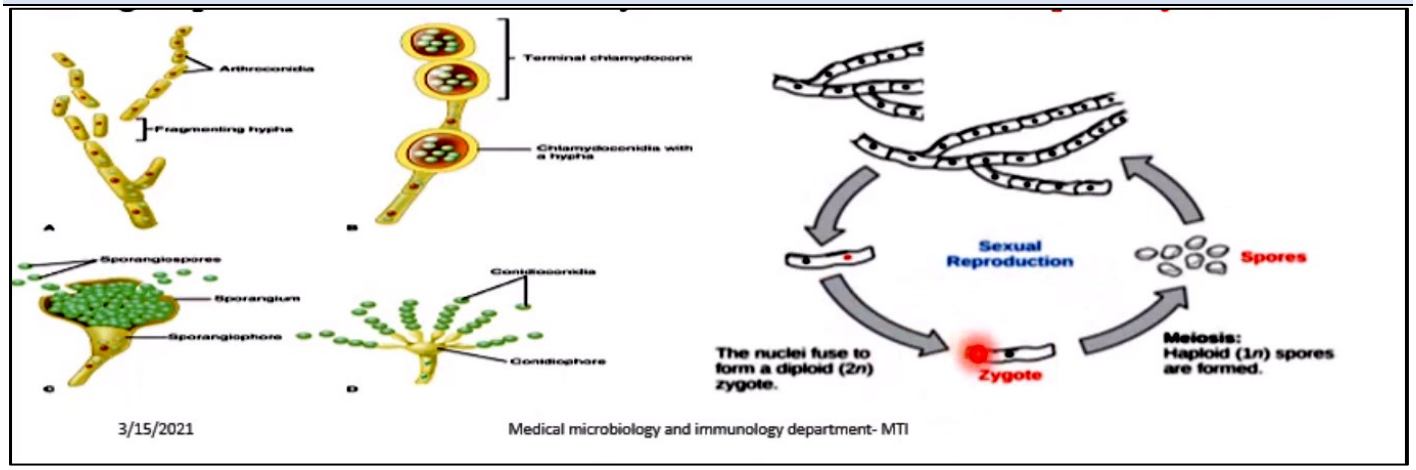




Asexual Reproduction

Fungi reproduce asexually by fragmentation, budding, or producing spores. Fragments of hyphae can grow new colonies. Mycelial fragmentation occurs when a fungal mycelium separates into pieces with each component growing into a separate mycelium.

Arthrosporic: formed by fragmentation
Chlamydospore: formed within hypha. e.g *Candida*
Sporangiospores: formed within sac. e.g *Rhizopus*
conidiospores: without sac e.g penicillium *notatum*
blastospores: spore like blaster stick on the hypha & called butt.



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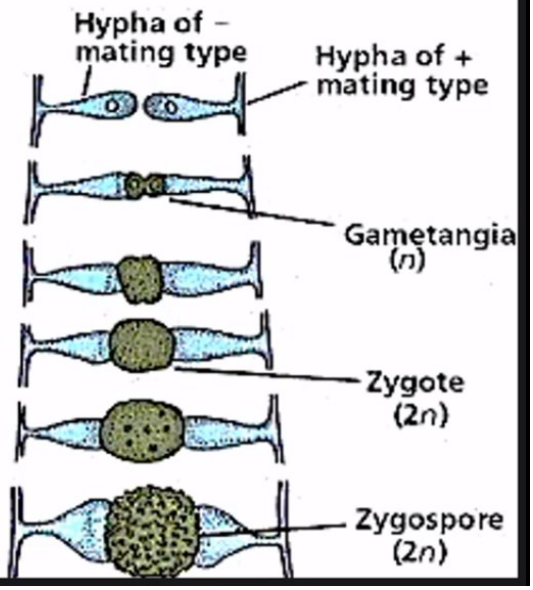
Sexual Reproduction

- Involves 2 homogenous hyphae and these hyphae must be **identical** in nature
  - Joining of **2 nuclei** from compatible ***matching strains*** followed by **meiosis**

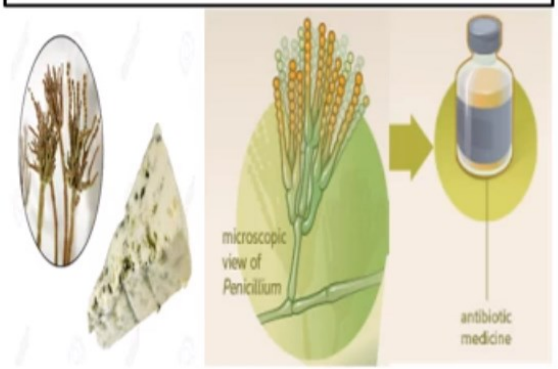


Fungi could be:

Pathogenic and cause fungal infections in humans.

Saprophytic: in the nature. used in the production of foods or produce bioactive metabolites as antibiotics.

Commensals and are part of normal human flora.



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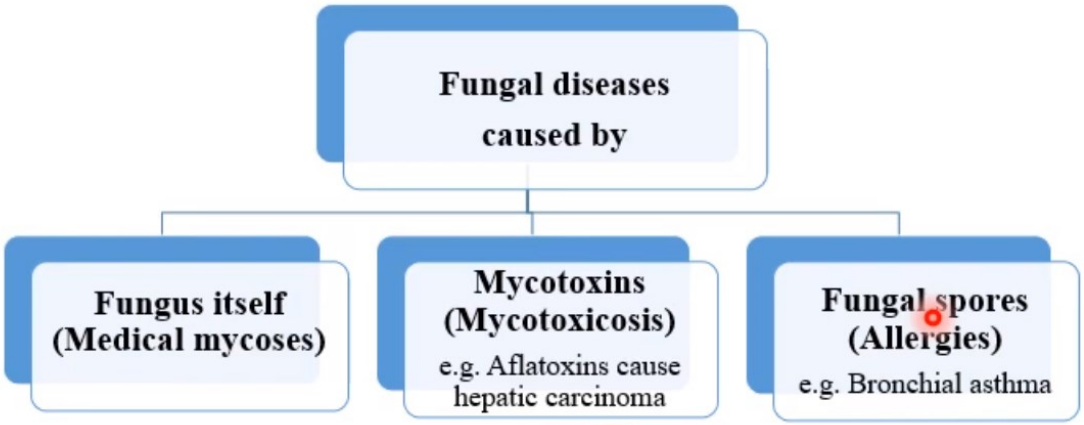

Oral cavity & vagina

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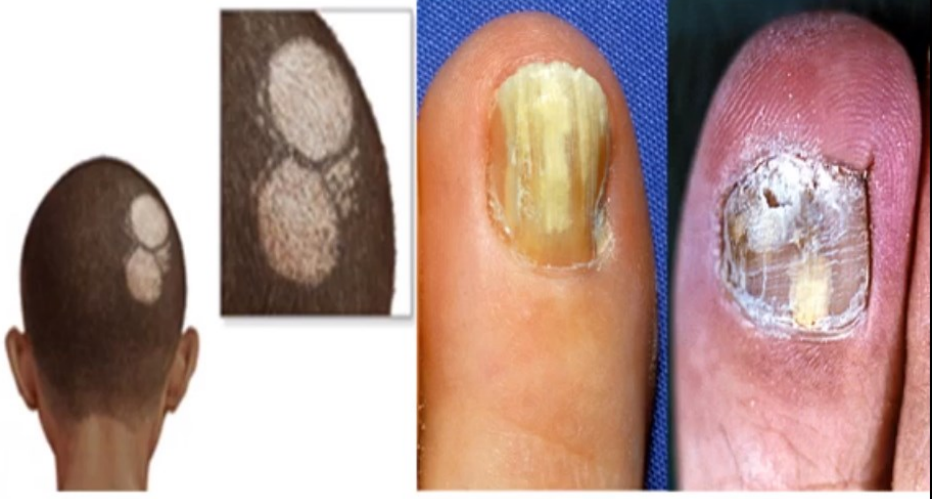
Medical mycoses

Cutaneous mycoses: involves only **superficial keratinized structures** (skin, hair, nails).



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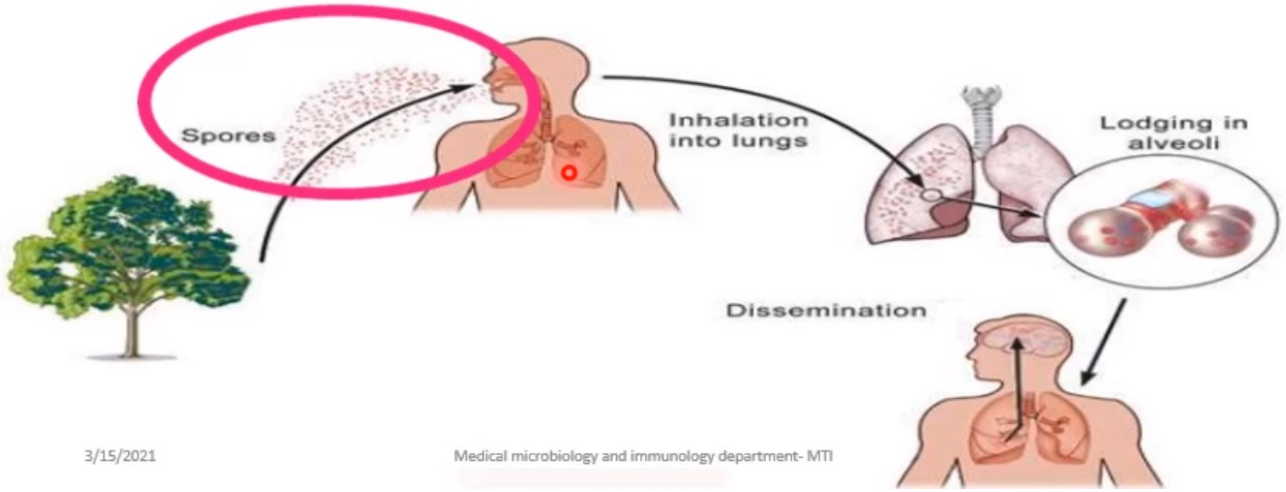
Medical mycoses

Subcutaneous mycoses: Fungi that grow in soil introduced into **subcutaneous tissue** through **trauma**.

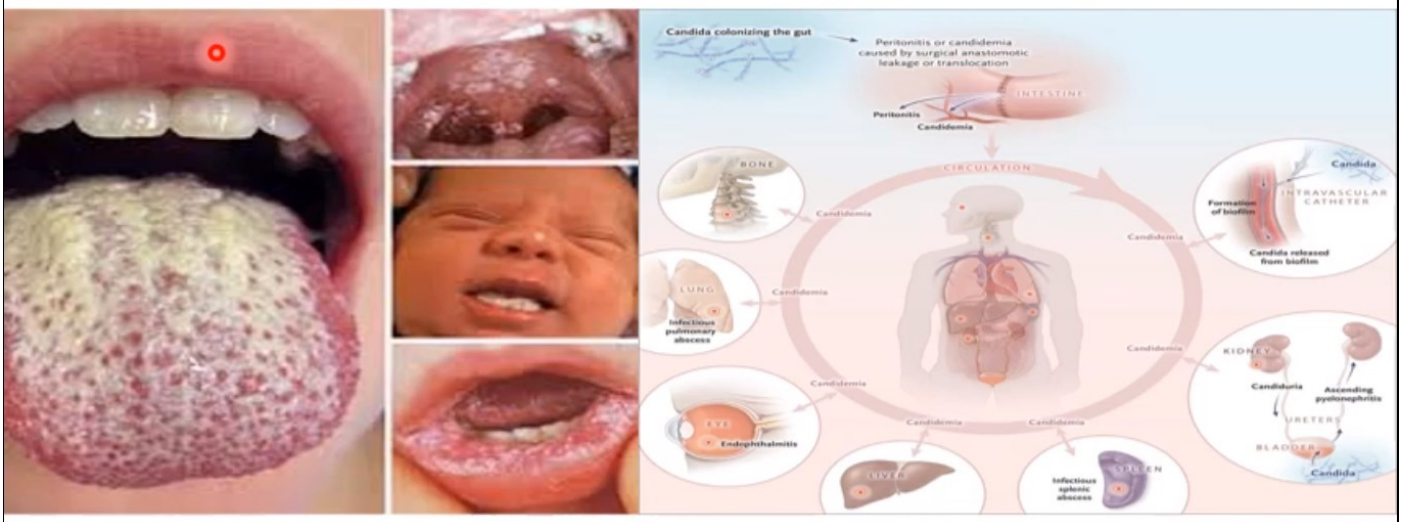
Medical mycoses

Systemic mycoses: inhalation of spores found in soil causes **primary lung lesions** that may **disseminate to other body organs**. *Aspergillus*



Medical mycoses

Opportunistic mycoses: Fungi present in the soil or in normal human flora induces disease in **immunocompromised host**.

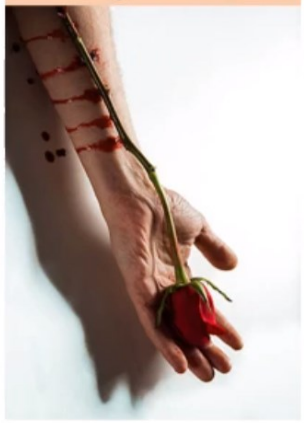


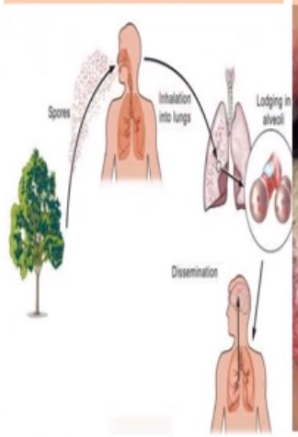
wrap-up

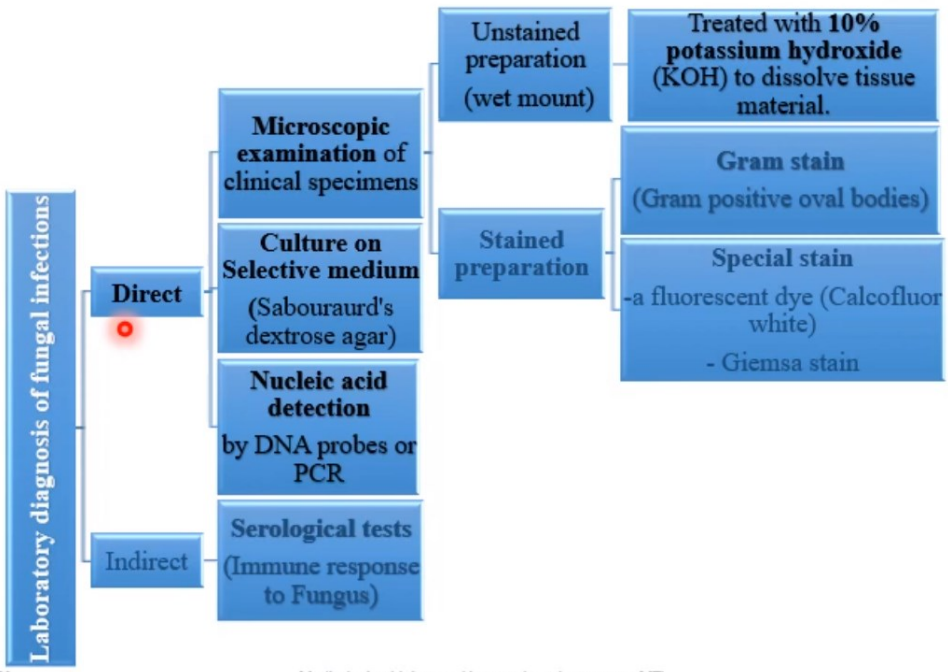
Medical mycoses

wrap-up

Cutaneous mycoses	Subcutaneous mycoses	Systemic mycoses	Opportunistic mycoses



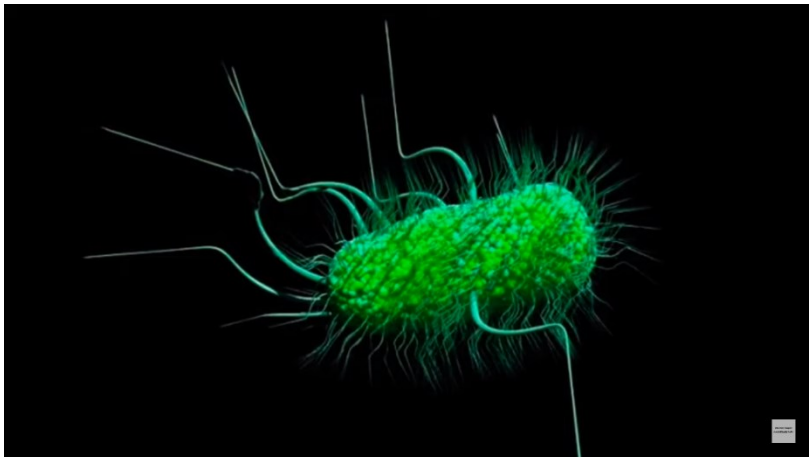




- ✓Fungi are **eukaryotic organisms**.
- ✓Fungi could be pathogenic, saprophytic or commensals.
- ✓The fungal cell membrane contains ergosterol, in contrast to the human cell membrane, which contains cholesterol.
- ✓The fungi classified as yeasts, molds and some of them are dimorphic.
- ✓The fungal spores results from sexual or a sexual reproduction and aids in the identification of fungal species.
- ✓The fungal diseases are caused by the fungus its self or mycotoxins or fungal spores.
- ✓Medical mycosis could be cutaneous, subcutaneous, systemic or opportunistic.

Enterobacteriaceae:

The largest family in Gram negative bacilli consist of more than 30 genera and 110 species E-coli, *Shigella, Salmonella, Citrobacter, Klebsiella Enterobacter, proteus.*



General characteristics:

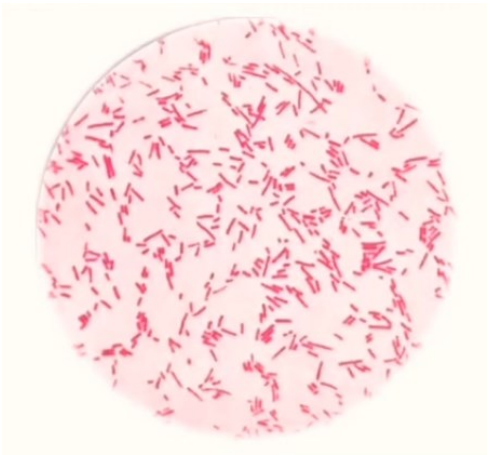
Commonly in the intestinal tracts of Human and animals results in their wide distribution in soil, water, and sewage. (Environmental)

Enterobacteriaceae: Enteric bacteria, gram negative bacilli color red, facultative anaerobic bacteria (38 ATP aerobic, 2ATP Anaerobic) all Enterobacteriaceae oxidase negative, Ferment sugar.

All Enterobacteriaceae ferment glucose & produce lactic acid, reduce nitrate to nitrite $No_3 \rightarrow No_2$ Not all Enterobacteriaceae can ferment lactose.

Lactose fermentation is very critical in identification in the family of Enterobacteriaceae.

Lactose fermentation. Enterobacteriaceae Coliforms e.g: E.coli, klebsiella, Enterobacter	Non lactose ferment or Enterobacteriaceae, e.g: Salmonella, shigella Proteus



Culture media used for them 2 types:

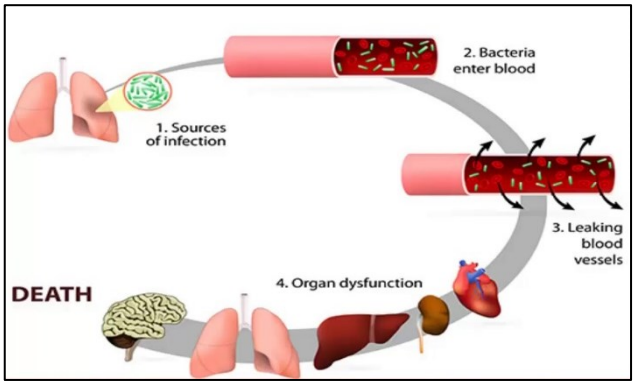
1. Violet red bile glucose agar selective all members 110 species of Enterobacteriaceae. glucose is source of carbon.
2. Violet, red bile lactose agar selective for Enterobacteriaceae & differential for coliforms. lactose is source of carbon.

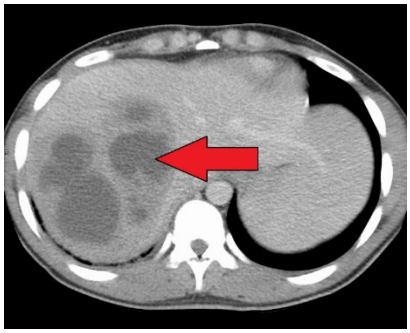
lactose very essential in identification of Enterobacteriaceae family as shown in MacConkey agar, Eosin, methylene agar, TSI agar.

Pathogenicity:

Gastrointestinal tract infection. (GIT) urinary tract infection (UTI) cause kidney stone as a result of secreted urease enzyme specially with proteus & Klebsiella.

Septicemia (Toxin in blood) sometimes reach the organs & caused Meningitis (brain), pneumonia in lung, Endocarditis (heart), Abscess (liver)





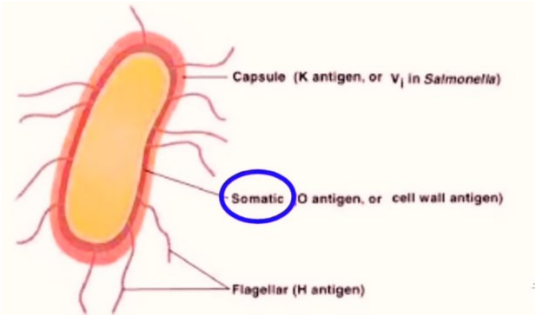
Transmission:

1. Contaminated food & water (*Salmonella spp. shigella spp. Escherichia coli*).
2. Endogenous infection (urinary tract infection Primary bacterial peritonitis, abdominal abscess.
3. Abnormal host colonization (nosocomial *Pneumonia*) transfer between debilitated patients.

Classification.

1. according to pathogenicity
    a. obligate pathogens e.g *Salmonella, Shigella, E.coli, Klebsiella*.

    b. opportunistic pathogen e.g E.*coli., klebsiella*, natural *Enterobacter* or *Proteus*. If there is change in habit.
    c. Rare pathogenic (nonpathogenic) e.g *Citrobacter*, *Hafnia*.
2. Antigenic structure:
    a. Somatic antigen (O-Ag). Heat stable LPS. present in outside of the cell wall.
    b. Flagellar antigen (H-Ag). Heat labile protein exist in bacteria have Flagellium or fimbriae.

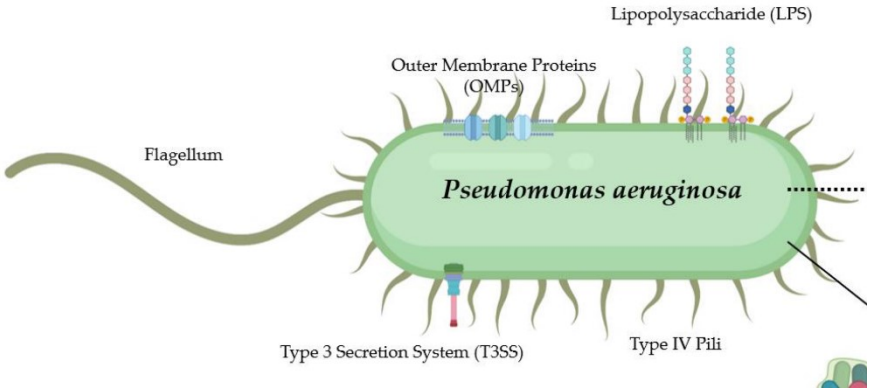


c. Capsular antigen (K-Ag) exists in bacteria have capsule. The three types of Ag differ from one species of bacteria to another.

3. Lactose fermentation.
    a. Rapid lactose fermentation *E.coli*, *Kleb*. *Enterobacter*.
    b. Late lactose fermentation *Citrobacter*, *Serratia*.
    c. Non lactose fermentation, *Salmonella*, *Shigella*, *Proteus*.
4. Biochemical test e.g indole, urease citrate Hydrogen sulfide.

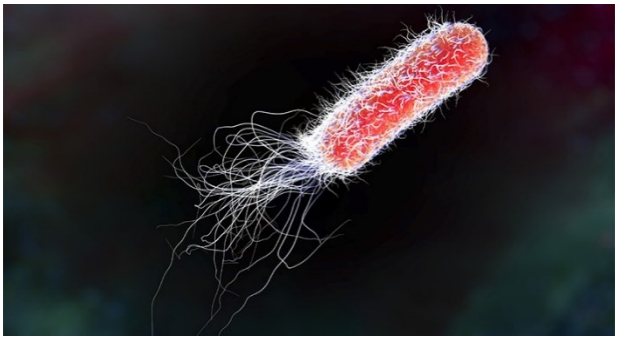
Multi-drug resistant

Pseudomonas aeruginosa & *Bacteroides* species are non-Enterobacteriaceae but G-Ve bacilli & found in intestine because they are obligate aerobes, oxidase (+) glucose ferment in aerobic method only, reduce nitrate (+). Single polar flagellum, biochemical test by PCR or DNA test.



Escherichia coli

Escherichia coli (*E. coli*) inhabits the intestines of healthy human and most warm-blooded animals.



Importance:

1. Help in digestion
2. Protects from harmful microbes & prevent multiplication of other pathogenic bacteria.
3. Provides essential vitamins K & B12 but some strain causes severe infections such as:
    1. It causes diarrhea & GIT infectious
    2. It causes urinary tract infection (UTI)
    3. Severe sepsis
    4. Neonatal meningitis.

***E.coli* Transmission.**

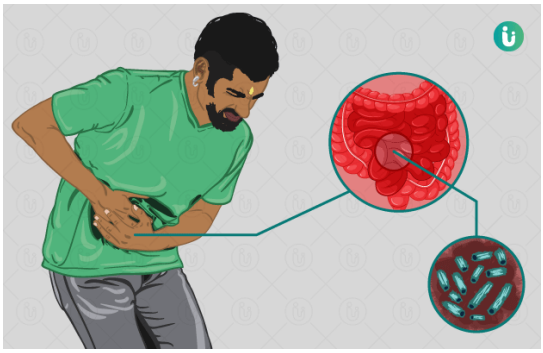
1. Via contaminated food as raw or uncooked meat products & raw milk.
2. Faecal contamination water
3. Bad hygiene.

General characteristic:

1. Most famous member of Enterobacteriaceae.
2. G-ve bacteria.
3. Rod shaped & appear red in gram stain.
4. Facultative anaerobic.
5. Ferment sugars (glucose).
6. reduce $No_3 \rightarrow No_2$
7. Non-capsulated. Extraterrestrial strain are encapsulated e.g E. coli which are capsulated and case (UTI)
8. Motile (peritrichous flagella) except *Shigella* & *Klebsiella*
9. grow on bile salt media which prevent G+ve from growing.

Disease:

1. Watery diarrhea according to Enterotoxin & type of strain of bacteria. The bacteria interfere with the pathway of water absorption and ion exchange which causes adhesions of bacteria with host cell by pili & fimbriae and destroy the cell.
2. Bloody diarrhea, Dysentery accomplished with blood, which invade mucus Epithelial cell of the intestine.



3. Hemorrhage colitis. which is the most dangerous infection caused by E. coli bacteria. The bacteria secreted cytotoxin which has hemolytic infection on blood or RBC and cause bloody diarrhea & characterized by abdominal cramping & fever.

4. Hemolytic uremic syndrome occur when blood vessel in the kidney become damage & cause clots in the vessels & lead to kidney. failure & causes

Infections cause by *E. coli* strains

1. Intestinal infection (GIT).
2. Extra intestinal infection (UTI). cystitis pyelitis, pyelonephritis, urethritis
3. Fatal sepsis (toxin in blood)
4. Neonatal meningitis.
5. Wound infection after surgery.
6. Peritontis.

Endotoxin & exotoxin = are two types of toxins produced by bacteria. Endotoxin is a lipopolysaccharide while exotoxin is a protein.

Endotoxin seen in G-ve bacteria (Pathogenic) such as *E. coli, Salmonella*, *Shigella, Neisseria*.

Exotoxin act as enzymes which catalyze many biochemical reactions.

Exotoxin are more toxic than endotoxin e.g *Clostridium tetani* produce tetanus toxin which can destroy the host cell or inhibit their function**.**

Salmonella

Characteristic:

Gram negative, short rod, motile, ferment glucose but not lactose Calalase + ve, grow on MacConkey agar.

The major habitat of Salmonella is intestinal tract of mammals such as poultry, birds, reptile pathogenic for Humans: is S. Typhi, S. Paratyphi. This transfer to human by direct contact or indirect contact. by eating raw meat, chicken & egg.

or contaminated waters. Salmonella outbreak linked to onions.

Classification into 2 types

1. *Salmonella* enterica
2. *S. bongori*

} sub species

These 2 types contain 2500 genotypes. *Salmonella enterica* cause *Salmonella* Typhi (serotype Salmonella are associated with contact with animals & foods e.g (egg, poultry, lizards) & transmitted via Fecal-oral routes.

Causing intestinal (Gastroenteritis, Localized infections) & Extraintestinal infection Enteric (Typhoid) fever systemic infections

Symptom

Nausea; vomiting, abdominal cramping & Darrhea No blood.

Generally with 48 hours of ingesting contaminated foods or water, but if the bacteria transfer to the epithelial cells of the intestine the infection will be systemic not localized & cause Typhoid fever and S. paratyphi.

Symptoms: Enteric fever 39 - 40° C with chills, sweats, headache weakness, sore throat, Cough & myalgia with rash on the trunk.

Sometime reach the liver & spleen & gall bladder. by blood circulation & cause bacteremia.

Treatment: - Typhoid fever & paratyphoid fever:

1. Ceftriaxone
2. Ciprofloxacin or combination between Trimethoprim & Sulfamethoxazole

in case of Salmonellosis & food poisoning.

A.B are not normally used. but for all older age must have A.B that mention before in case of spread the bacteria to the blood.

Prevention: good hygiene (wash hands after treatment with animals)

Adequate cooking meat, eggs & other foods.

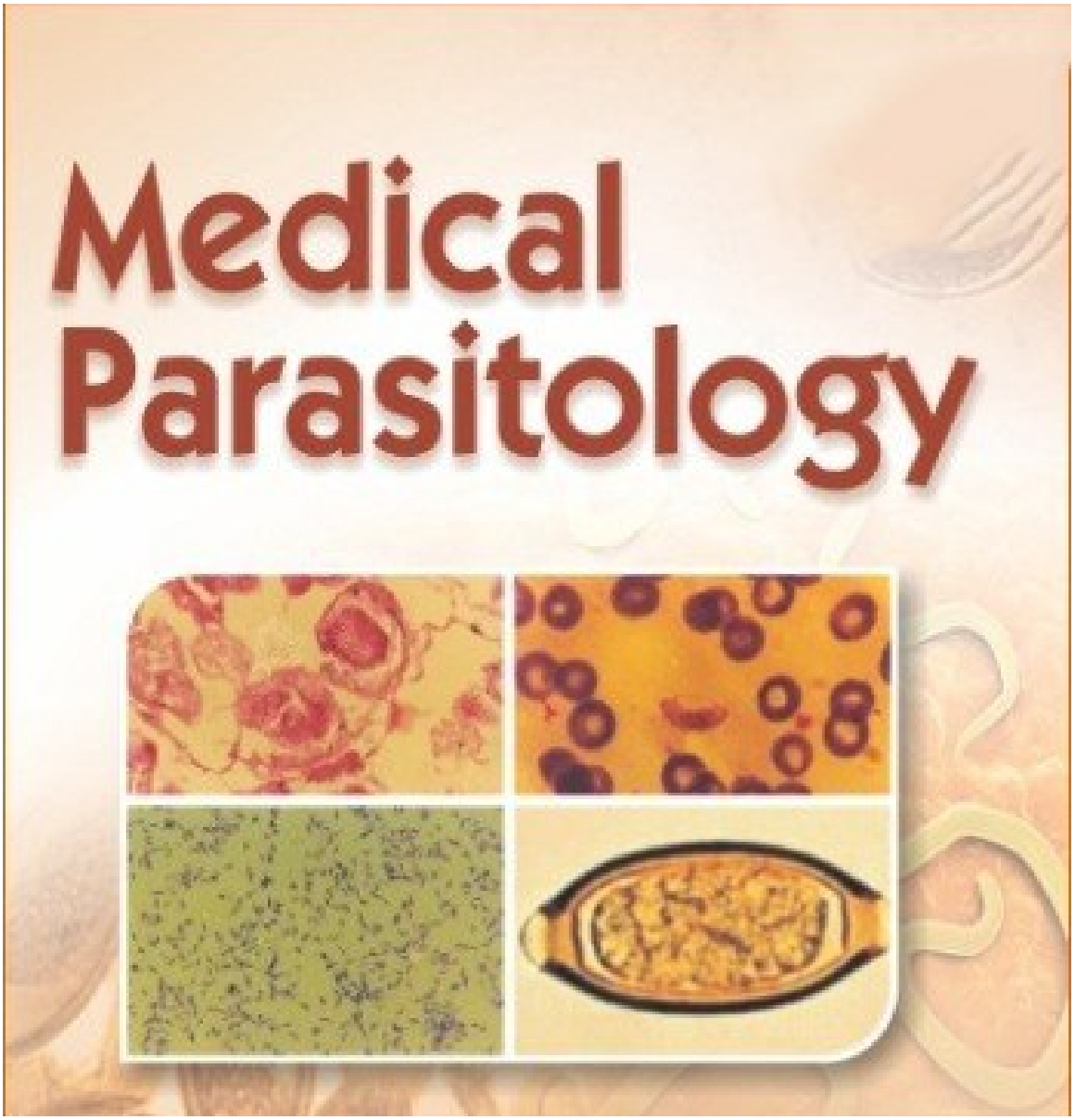
Treatment water well before agriculture crops.

Investigation for carrier food handle

Vaccines = Vi capsular for all people except children.

subcutaneous injections.

MEDICAL PARASITOLOGY



Parasitology

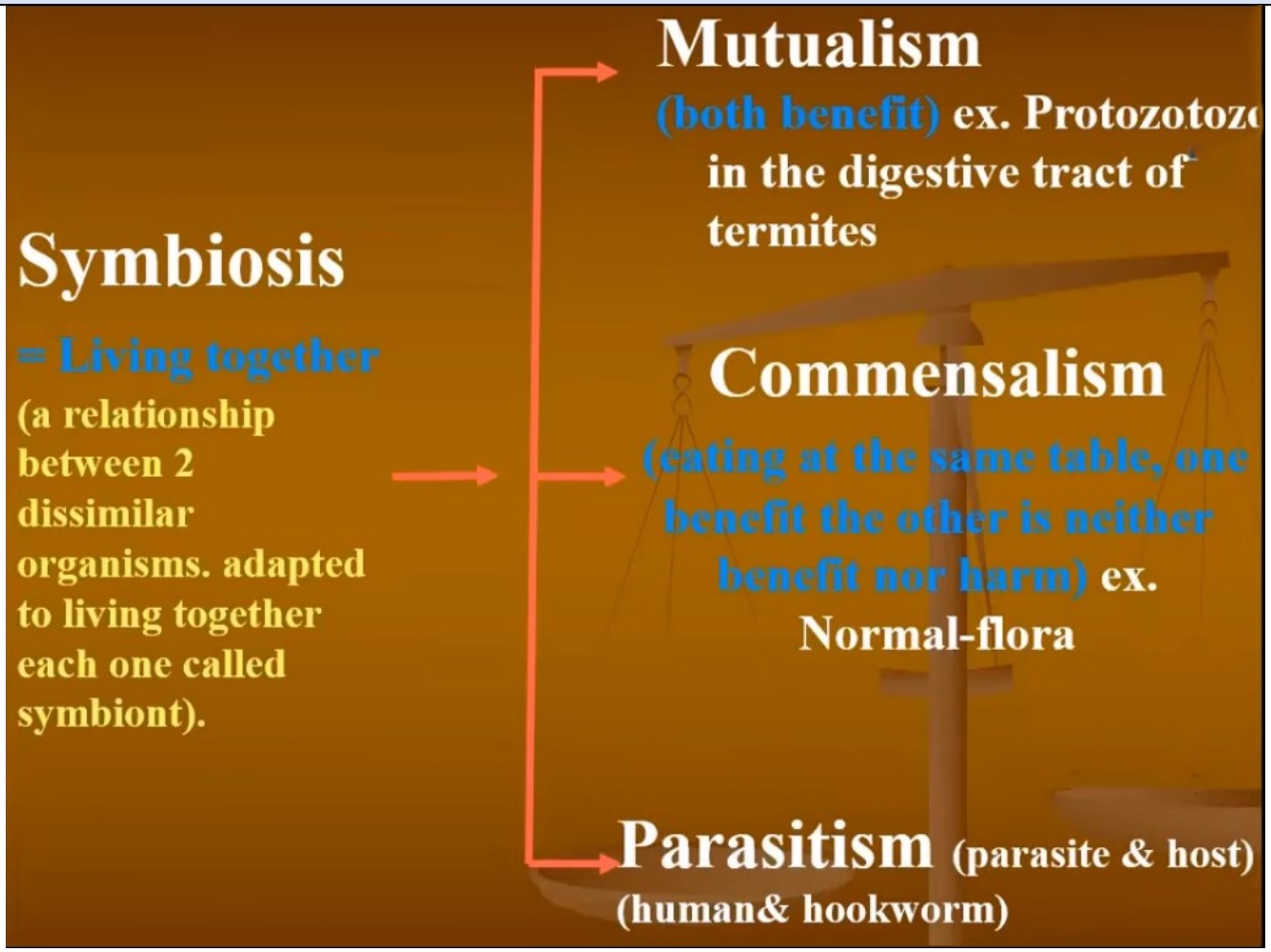
It is the science that deals with the study of parasites.

The parasites such as viruses, bacteria, fungi & parasites belonging to the animal kingdom.

- **Medical parasitology** deals with the parasites, which cause human infections and the diseases they produce. It included three major groups of animals:
- Parasitic protozoa.
- Parasitic helminthes (worms).
- Arthropods that directly cause disease or act as vectors of various pathogens.

Some definitions:

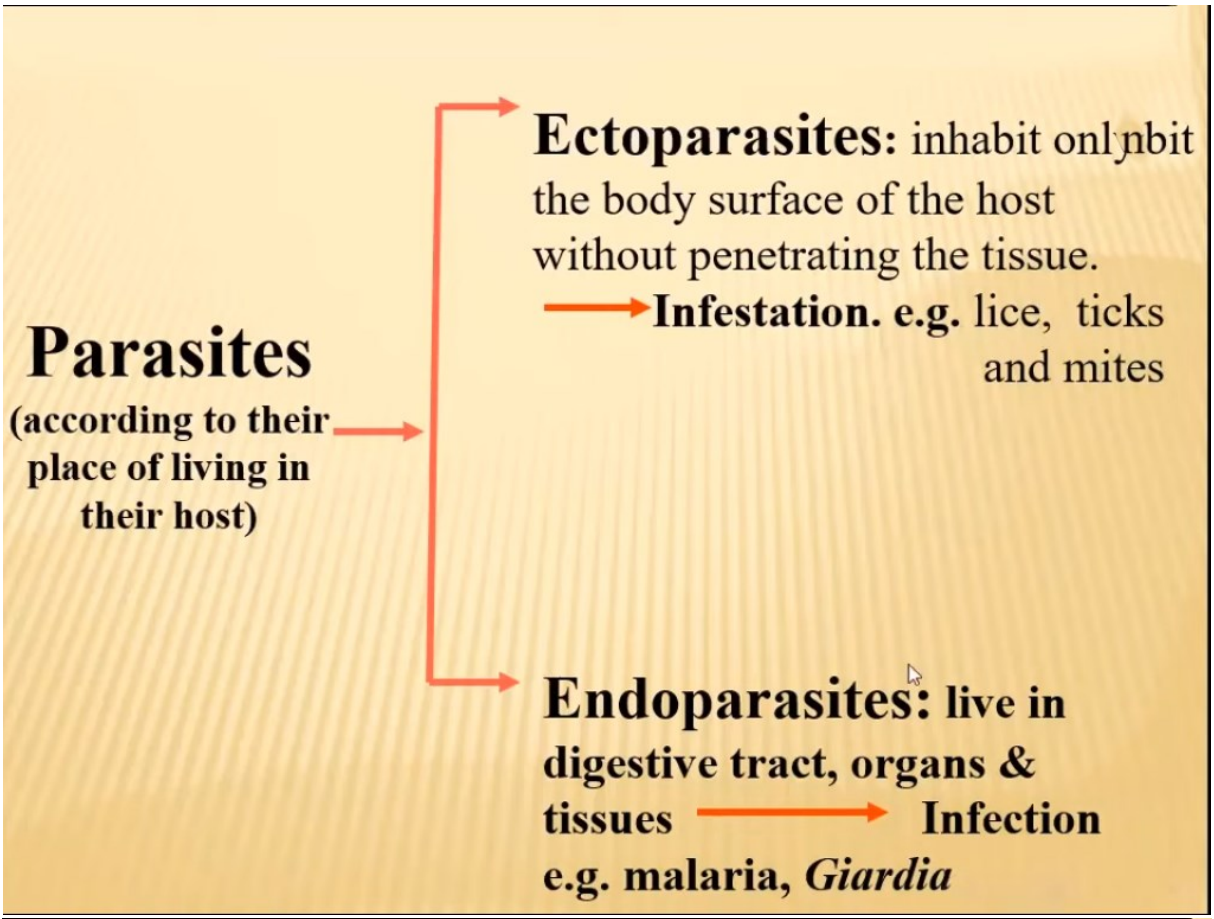
- **Parasite:** is a living organism, which depend o a living host for their nourishment and survival. They multiply &/or undergo development in the host. Parasites may be simple unicellular protozoa or complex multicellular metazoa.
- **Eukaryote:** a cell with a well-defined chromosome in a membrane-bound nucleus. All parasitic organisms are eukaryotes.
- **Protozoa:** unicellular organisms, e.g. *Plasmodium* (malaria).
- **Metazoa:** multicellular organisms, e.g. helminths (worms) and arthropods (ticks, lice).

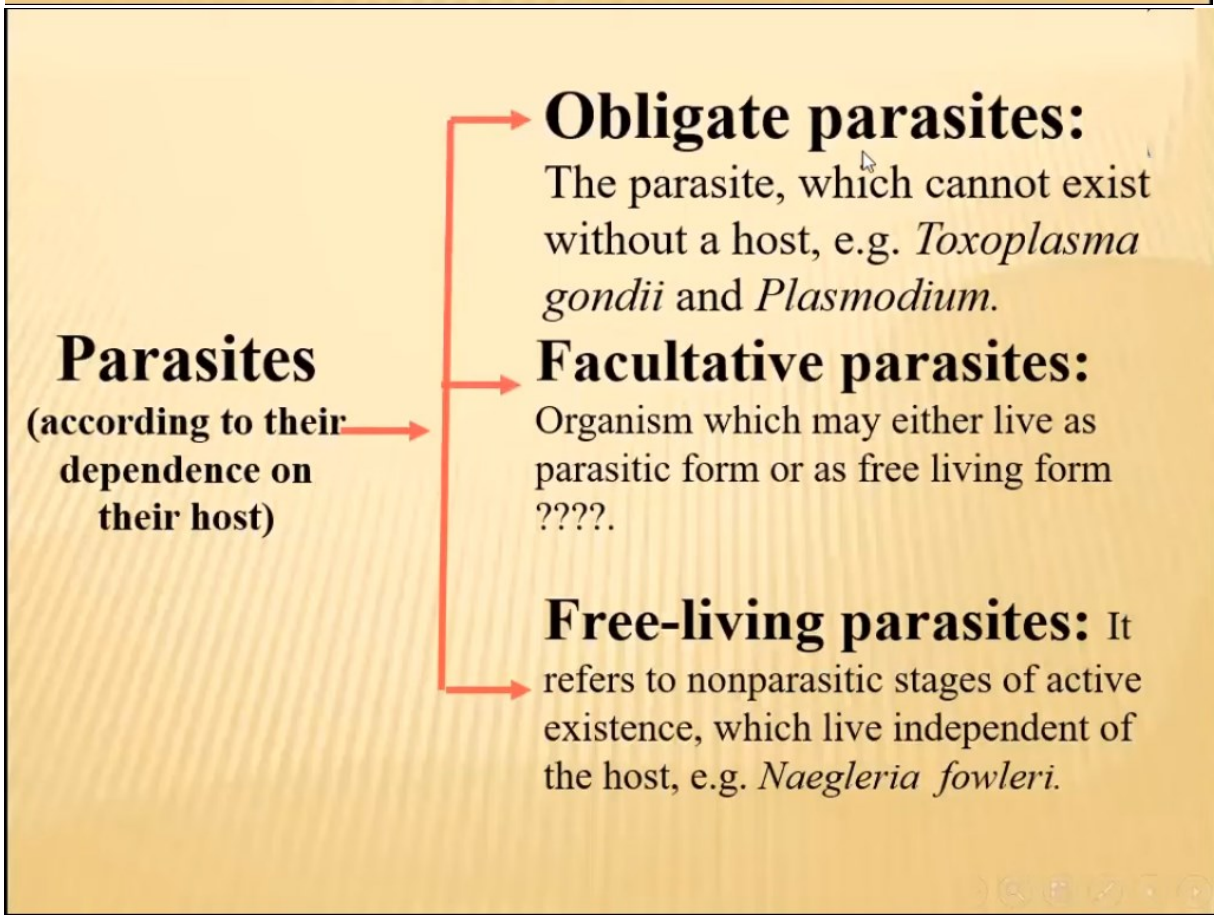


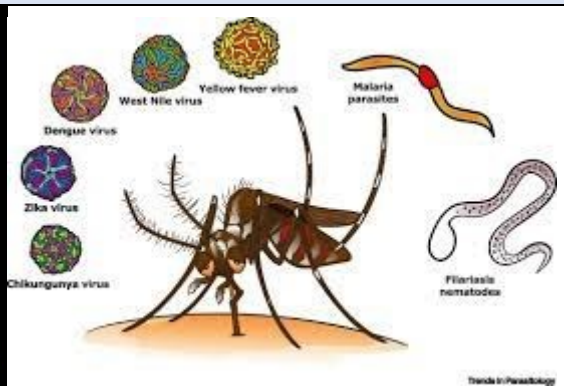
- **Host:** is an organism, which harbors the parasite and provides nourishment and shelter to latter and is relatively larger than the parasite.

Host & parasite interact with each other resulting in:

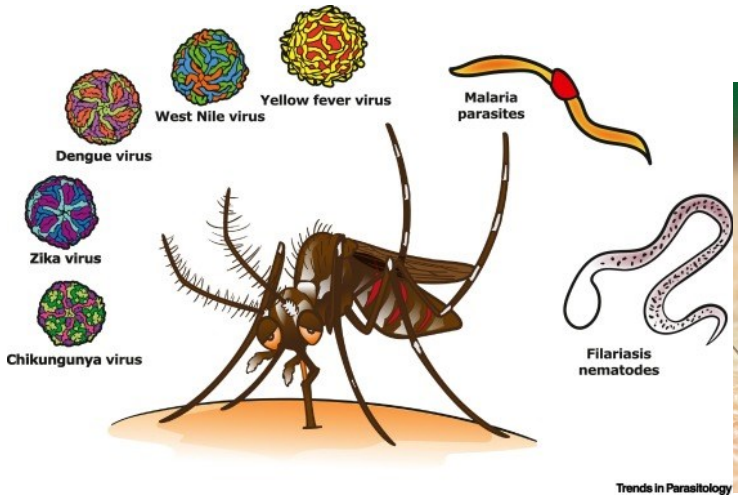
- ✓ Destruction of the parasite.
- ✓ Infection or disease of the host.


Parasites
(according to their place of living in their host)
Ectoparasites: inhabit onl nbit the body surface of the host without penetrating the tissue.
Infestation. e.g. lice, ticks and mites
Endoparasites: live in digestive tract, organs & tissues
Infection
e.g. malaria, Giardia


Parasites
(according to their dependence on their host)
Obligate parasites:
The parasite, which cannot exist without a host, e.g. Toxoplasma gondii and Plasmodium.
Facultative parasites:
Organism which may either live as parasitic form or as free living form ????.
Free-living parasites: It refers to nonparasitic stages of active existence, which live independent of the host, e.g. Naegleria fowleri.


Dengue virus
West Nile virus
Yellow fever virus
Malaria parasites
Zika virus
Chikungunya virus
Filariasis nematodes
Trends in Parasitology


ROUNDWORM
HOOKWORM
FLUKE
TAPEWORM
NEMATODE
NEMATODE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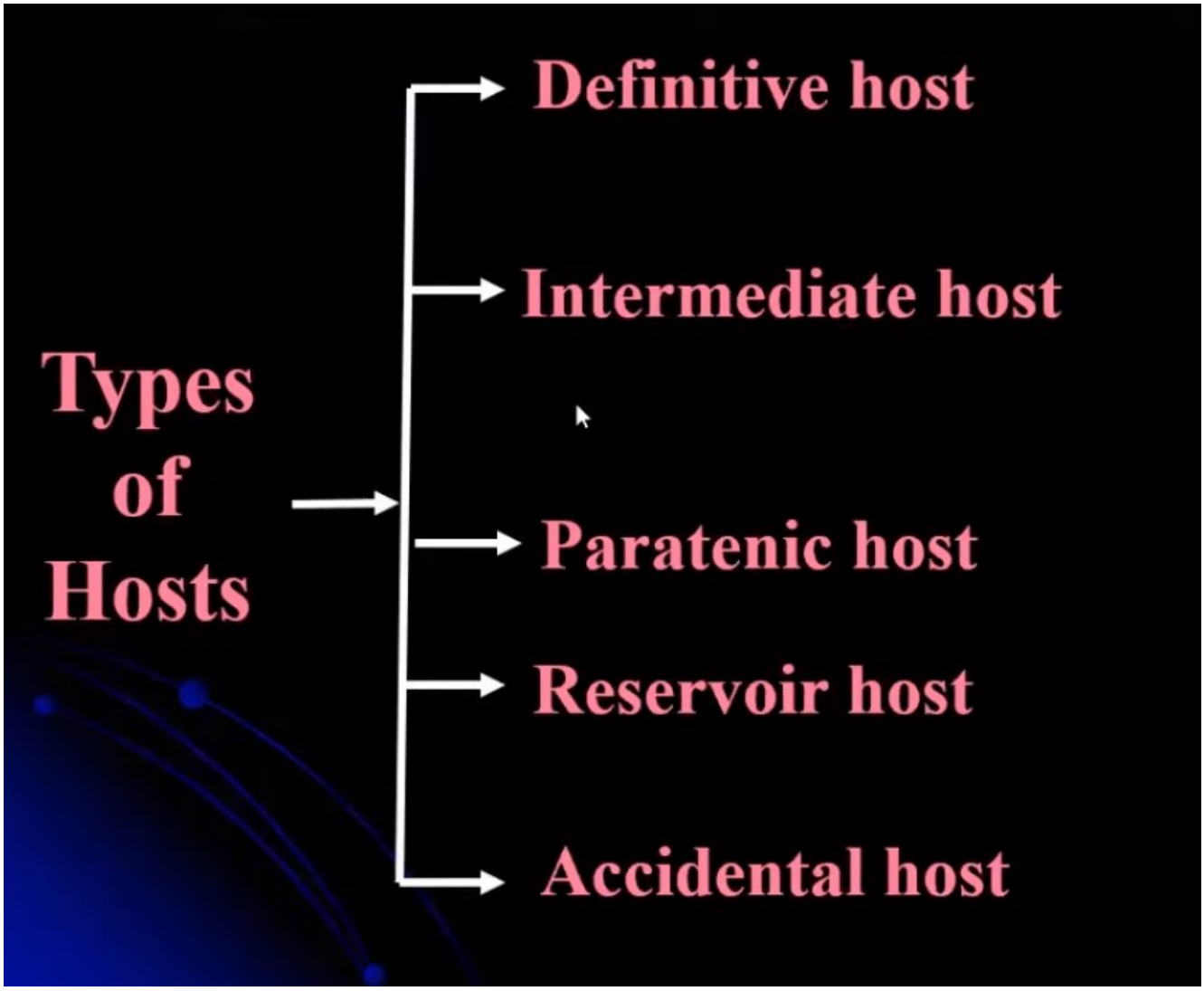

Types of Hosts
Definitive host
Intermediate host
Paratenic host
Reservoir host
Accidental host

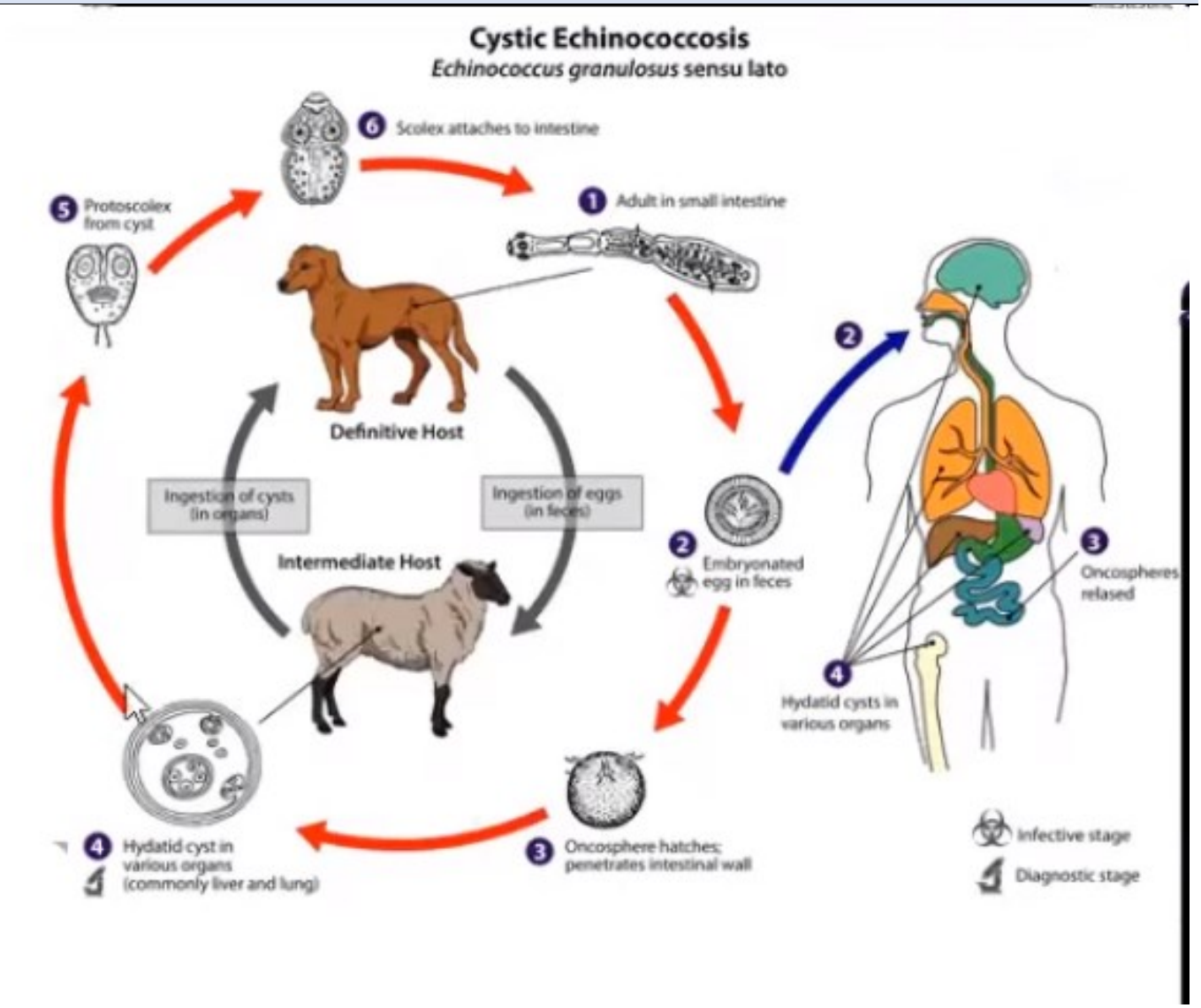
- **Definitive host:** The host, in which the adult parasite lives and undergoes sexual reproduction, e. mosquito acts as definitive host in malaria. The definitive host may be a human or any other living being. However, man is the definitive host for e.g. filaria, roundworm, & hookworm.
- **Intermediate host:** The host, in which the larval stage of the parasite lives or asexual multiplication takes place. In some parasites, 2 different intermediate hosts may be required to complete the larval stages. These are known as **first and second intermediate hosts**.

- **Paratenic host:** A host, in which larval stage of parasite remains viable without further development(the parasite neither gain nor loses its infectivity). Such host transmits the infection to another host.
- **Reservoir host:** an animal species on which the parasite depends for its survival in nature. Its an important source of infection in an endemic area to other susceptible hosts, e.g. dog is the reservoir host of hydatid disease.

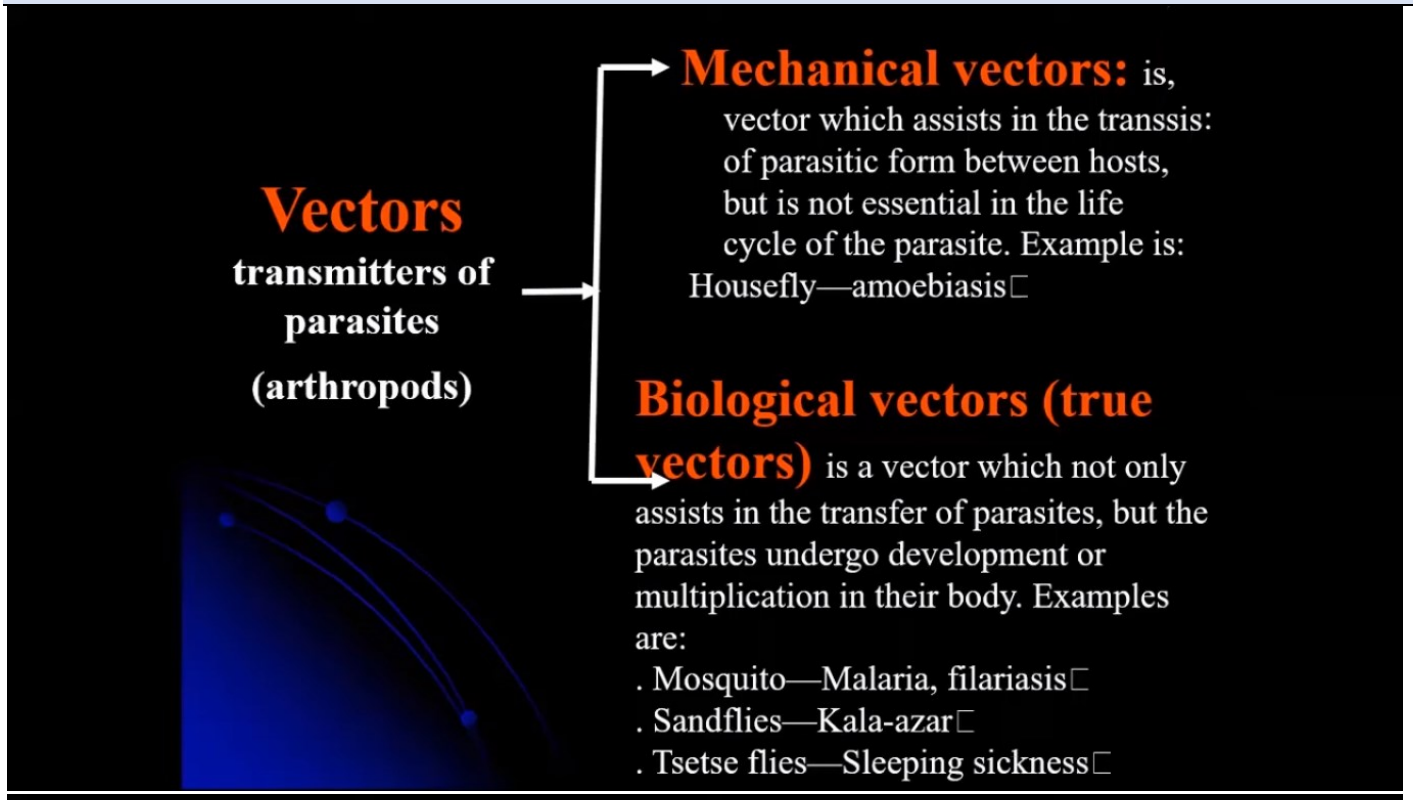
- **Accidental host:** The host, in which the parasite ısite not usually found, e.g. man is an accidental host for echinococcosis or hydatid disease.

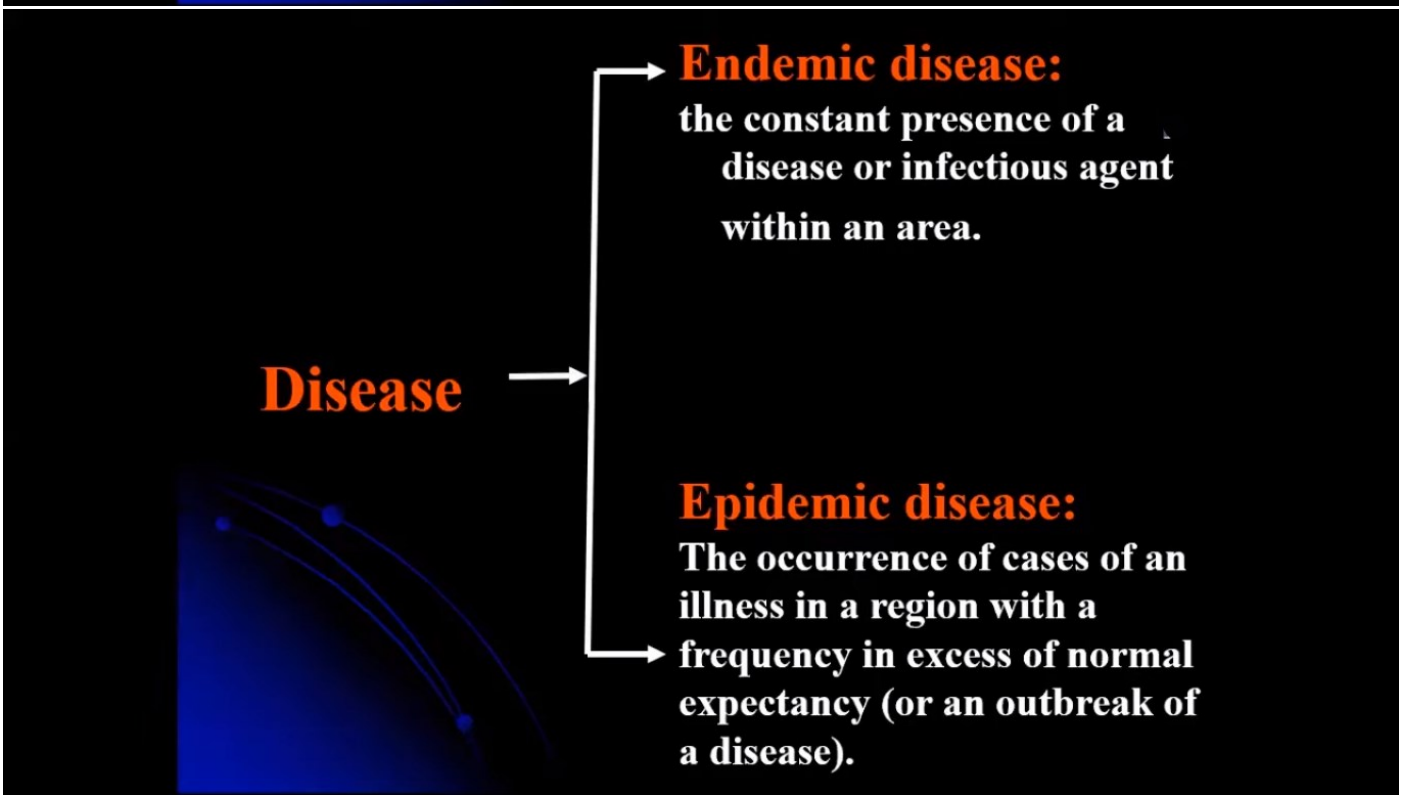
Life cycle and type of life cycle

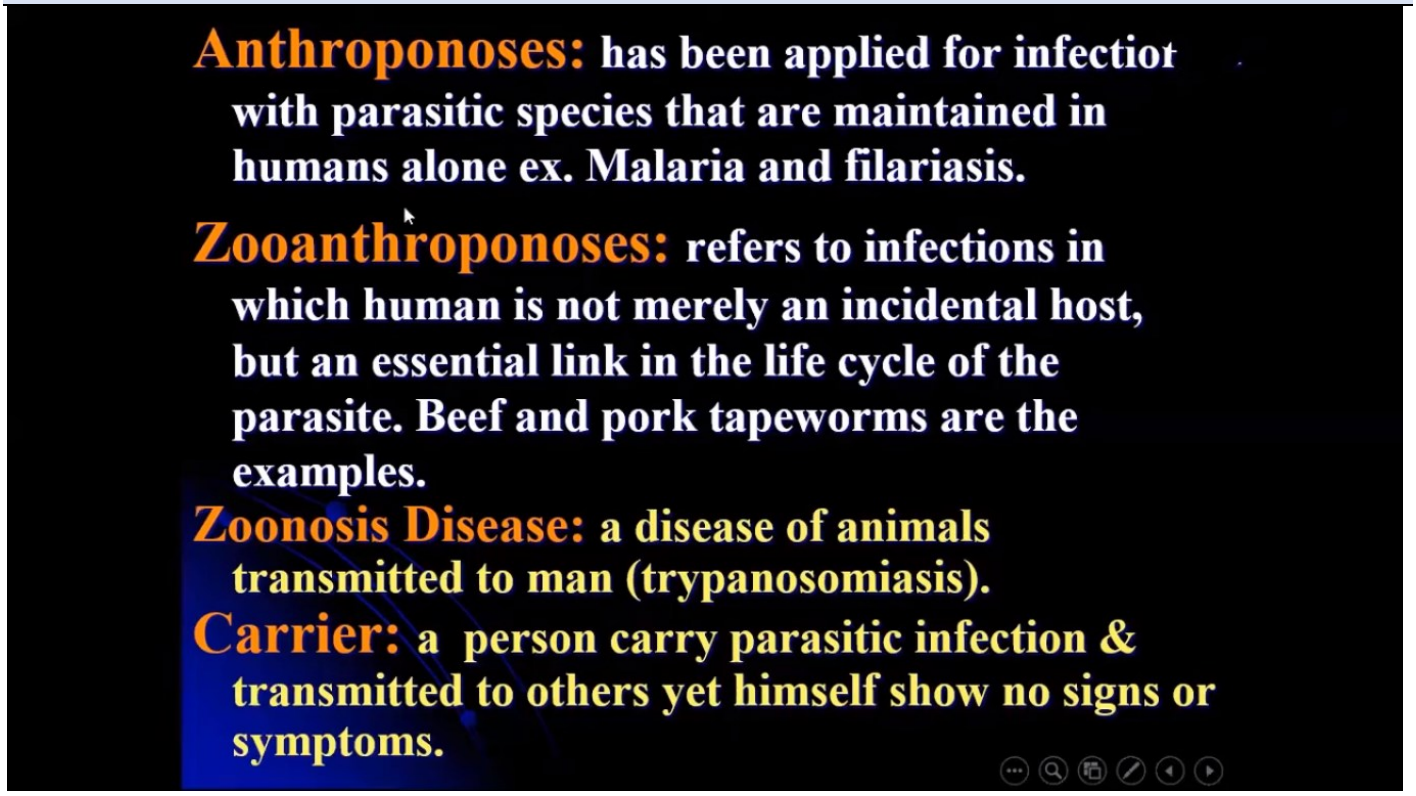
- Life cycle : Is the whole process of parasite growing and developing.
- The direct life-cycle : Only one host (no intermediate host).
- The indirect life cycle : Life cycle with more than one host (intermediate host and final host).



Vector: a living carrier (e.g. an arthropod) that transports a pathogenic organism from an infected to a non-infected host. A typical example is the female *Anopheles* mosquito that transmits malaria.


Vectors
transmitters of parasites
(arthropods)
Mechanical vectors: is, vector which assists in the transsis: of parasitic form between hosts, but is not essential in the life cycle of the parasite. Example is:
Housefly—amoebiasis
Biological vectors (true vectors) is a vector which not only assists in the transfer of parasites, but the parasites undergo development or multiplication in their body. Examples are:
. Mosquito—Malaria, filariasis
. Sandflies—Kala-azar
. Tsetse flies—Sleeping sickness


Disease
Endemic disease:
the constant presence of a disease or infectious agent within an area.
Epidemic disease:
The occurrence of cases of an illness in a region with a frequency in excess of normal expectancy (or an outbreak of a disease).


Anthroponoses: has been applied for infectiot with parasitic species that are maintained in humans alone ex. Malaria and filariasis.
Zooanthroponoses: refers to infections in which human is not merely an incidental host, but an essential link in the life cycle of the parasite. Beef and pork tapeworms are the examples.
Zoonosis Disease: a disease of animals transmitted to man (trypanosomiasis).
Carrier: a person carry parasitic infection & transmitted to others yet himself show no signs or symptoms.

Modes of Infection

- **Filth-borne or contaminative -** where personal hygiene and community sanitation lacking. Infectious stages remain viable for long periods in contaminated soil.
- **Soil or water-borne -** water or dirt which can contain eggs, etc.; Larvae can penetrate skin of bare feet or enter skin in infested water.
- **Food-borne -** inadequately cooked beef, pork, fish, shell fish.
- **Arthropod-borne -** the most difficult of all to control. Mosquitoes transmitting malaria, etc.
- **Sexual –** Transmission via direct sexual intercourse