Microbiology 1

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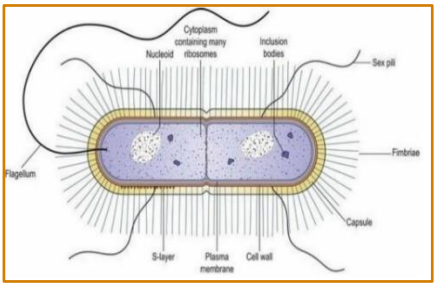
Bacterial Structure and Morphology

- **Revision:**
  - *Medical microbiology*
    - ✓ Is science of studying micro-organisms that are associated with *human disease*
  - *Agents of infection* include cellular organisms belonging to 2 of the 3 recently defined domains of life:
    - ✓ *Bacteria* (prokaryotes)
    - ✓ *Eukaryote*: fungi and protozoa.
    - ✓ The subcellular entities *viruses*, *viroids* and *prions* also cause infection but depend on host cells and tissues for propagation.
  - *Bacteria:*
    - ✓ *Prokaryotes cells*: have no nucleus, no organelles (Endoplasmic reticulum, mitochondria, Golgi apparatus, lysosomes).
    - ✓ Size range from *0.2 to 6* μm
    - ✓ *Unicellular*
    - ✓ Divide-*binary fission asexual*

- **The importance:**
  - Understanding bacterial structure and physiology properties is crucial for :
    - ✓ *Diagnosing* and treating infections
    - ✓ Developments in *genetic manipulation* combined with advances in fluorescence and electron microscopy

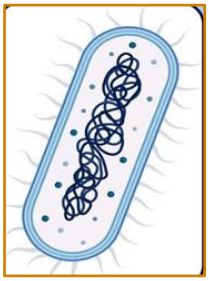
- **Bacterial structure:**
  - *Essential components such as*
    - ✓ Cell wall
    - ✓ Cytoplasmic membrane
    - ✓ Ribosome
    - ✓ Nucleoid



  - *Accessory components (not every bacteria has):*
    - ✓ Capsule
    - ✓ Pilus or fimbria
    - ✓ Flagella
    - ✓ Spores
    - ✓ Plasmid
    - ✓ Transposons

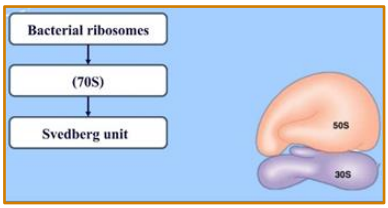
  - *Cytoplasm: (Essential)*
    - ✓ Is a predominantly aqueous environment
    - ✓ Contains the nucleoid, ribosomes, and other complexes, as well as cytoskeletal structures
    - ✓ Have *cytoskeletal structures*(filamentous proteins and filament systems)
    - ✓ The *importance* of these cytoskeletal structures:
      - Determining cell shape, division and spore formation antimicrobials targeting.

➢ ***Nucleoid*** (*Essential*) characteristic:



- ✓ Area of cytoplasm *where* bacterial DNA(Bacterial chromosome)is located without *nuclear membrane*
- ✓ Double stranded
- ✓ Circular
- ✓ Supercoiled
- ✓ *Function*: carry genetic information for growth and survival

➢ ***Ribosomes*** (*Essential*)

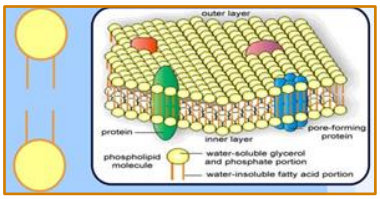


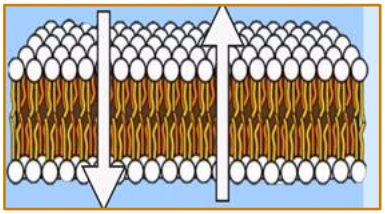
- ✓ They have a sedimentation coefficient of **70S**, being *composed of* a 30S and a 50S subunit (80s in eukaryotes)
- ✓ *Function*: Sites of protein synthesis

➢ ***Inclusion bodies*** (*Essential*)

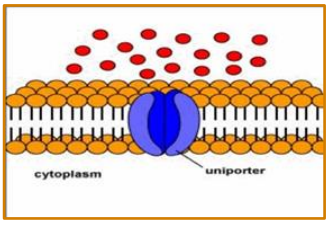
- ✓ *Function*: Food and energy storage granules
- ✓ Example: storage glycogen and starch

➢ ***Cytoplasmic membrane*** (plasma membrane) (*Essential*)

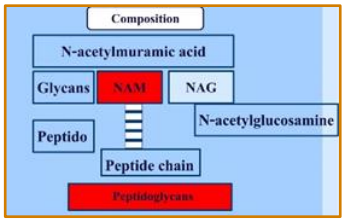




- ✓ Thin, permeable and elastic membrane
- ✓ *Composed of*: phospholipids, protein and mesosomes
- ✓ ***Functions:***
  - Synthesis of precursors of cell wall polymers and membrane lipids.
  - Selective permeability and active transport of molecules into cells.
  - Energy generation by oxidative phosphorylation.
  - Excretion of enzymes and toxins.



➢ ***Cell wall*** (*Essential*)

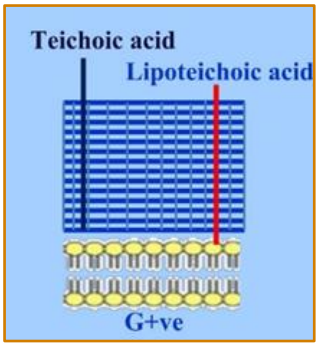


- ✓ *Components*: Peptidoglycan is composed of:
  - *Glycan:* N-acetyl glucosamine and N-acetylmuramic acid molecules linked alternately in a chain
  - *Protein*
- ✓ In almost ***all*** bacteria have cell wall ***except*** Mycoplasma.
- ✓ Many antibiotics (penicillins, and cephalosporins) stop bacterial infections by interfering with cell wall synthesis
- ✓ It has *no effect* on human cells, as they lack a cell wall and have only a cell membrane.
- ✓ ***Function:***
  - Bacterial *rigidity* and *shape*
    - Bacterial Shape (morphology) is ***determined by*** cell wall and cytoplasmic cytoskeleton
  - *Protection against* osmotic changes
  - *Porous* to allow nutrients passage
  - *Structure differs* in gram positive & negative bacteria

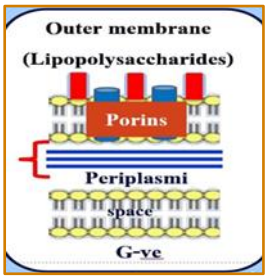
The differences in the cell wall structure are used to identify bacteria

- The cell wall contains *peptidoglycan* with its thickness varying between bacteria; Gram-positive bacteria have a thick layer, while Gram-negative bacteria have a thin layer. This distinction was discovered by Christian Gram:

  - ***The gram-positive cell wall***
    - ✓ Composed of:
      - *Peptidoglycan layer:* thick, and the constitutes almost 95% of the cell wall
      - *Polymer of ribitol* or *glycerol phosphate* complexed with sugar residues:
        - Teichoic acid interspersed with the peptidoglycan
          - *Function:* attachment and antigenic function
        - Lipoteichoic acid is linked to lipids buried in the cell membrane.
      - Gram positive appear violet/blue in staining

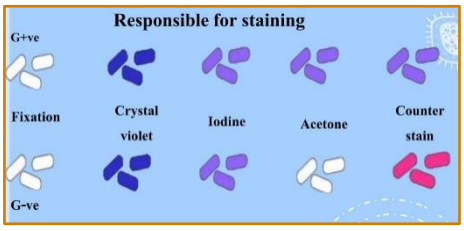


  - ***The gram-negative cell wall***
    - ✓ Composed of:
      - *Peptidoglycan layer:* Thin and constitutes as little as 5-10% of the cell wall
      - *Outer membrane:* 2 layers of lipids, Outer layer-Lipopolysaccharide (endotoxins causing endotoxic shock) consists of 3 regions
        - Lipid A (toxic effect)
        - Core polysaccharide
        - O antigen (antigenic properties)



- **Function** of outer membrane:
  - It *protects* the peptidoglycan from the effects of lysozyme (a natural body defense substance that cleaves the link between N-acetylglucosamine and N-acetylmuramic acid.
  - It *impedes* the entry of many antibiotics.
    - ***Transmembrane proteins:***
      1. *Porins proteins* for selective permeability
      2. *Integral proteins* that help in attachment
    - ***Gram negative appear pink in staining***

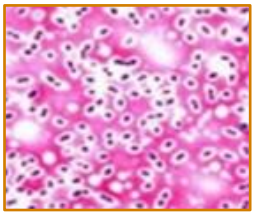
- **Gram stain:**
  - *Crystal violet:* primary stain
  - *Iodine:* fixation
  - *Acetone:* decolonization
  - *Safranin:* counter stain



  - ✓ The cell envelope, rich in hydrophobic lipid mycolic acid, requires the *Acid-fast stain* (Ziehl-Neelsen stain) for identification.
    - Examples: *Mycobacterium* and *Corynebacterium*
  - ✓ Some bacteria, like *Chlamydiae* and *Rickettsiae*, *cannot be stained* because they are intracellular, requiring alternative identification methods.

- Bacteria is described by gram stain and shape e.g Gram positive cocci, Gram negative rods or bacilli

➢ ***Capsule*** *(Non-Essential)*



✓ *Composition:*

- Usually Polysaccharides *Exception*: Polypeptides (B. anthracis)

✓ *Function:*

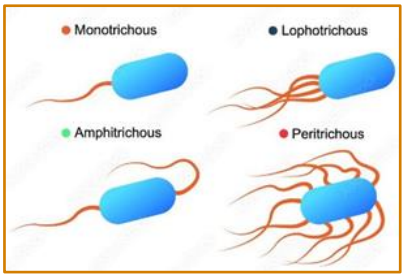
- *Protect* Cell wall: Bacteriophage, Complement, lysozyme
- *Prevent* phagocytosis (Virulence)
- *Adherence* (initial step of infection)
- *Development* of vaccine (Antigenic)
  - Example: vaccines Streptococcus pneumoniae)

✓ Useful for *diagnosis* using antiserum against capsular polysaccharide (quellung reaction)

The different between capsule and Free slime / Glycocalyx

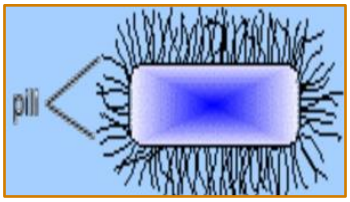
- **Glycoclayx is:**
  - ➢ Polysaccharide coat similar to capsule but secreted extracellularly
  - ➢ Cover the surfaces like a mucoid film.
  - ➢ *Function*: Allow firm adherence to structures
    - ✓ Example: heart valves, skin, catheters, surface of the teeth (S. mutans in dental caries)

- ***Flagella*** *(Non-Essential)*
  - ➢ A *long*, *filamentous* whip-like locomotor appendages
  - ➢ Flagella consist of a many subunits of protein called *flagellin*
  - ➢ Originate from cytoplasm and cytoplasmic membrane and protrude via the cell envelop to the surrounding environment
  - ➢ Movement in response to chemotaxis involves bacteria moving toward food, cells, and other attractants or away from immune responses.
  - ➢ Types:
    - ✓ Monotrichous
    - ✓ Amphitrichous
    - ✓ Lophotrichous
    - ✓ Peritrichous



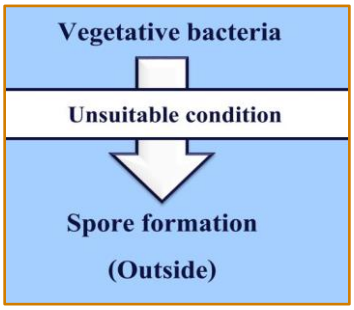
  - ➢ Function:
    - ✓ Motility of bacteria
    - ✓ Pathogenesis (E. coli in urinary tract infection)
    - ✓ Identification of Bacteria: specific antibodies against flagellar protein

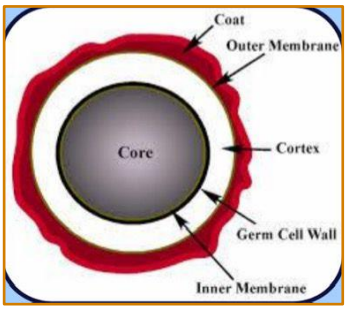
- ***Pilus*** **or** ***fimbria*** **(***Non-Essential)*
  - ➢ Filamentous appendages made of pilin protein subunit
  - ➢ More numerous and straight than flagella



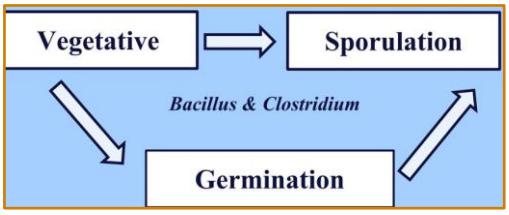
  - ➢ Function:
    - ✓ Fimbriae: *adhesion* between the bacterium and host cells
    - ✓ Pilli: *conjugation* (genetic material transfer) and act as *receptor* sites for certain bacteriophages described as being 'donor specific'

- ***Spores*** *(Non-Essential)*
  - Dormant cell, highly resistant structures are formed to adverse conditions such as shortage or lack of nutrients.
  - ***Spore formation:***
    - ✓ Vegetative bacteria - Unsuitable condition - Spore formation (Outside)
  - Forming highly resistant resting phase (Endospores) in VITRO: Bacillus, Clostridium

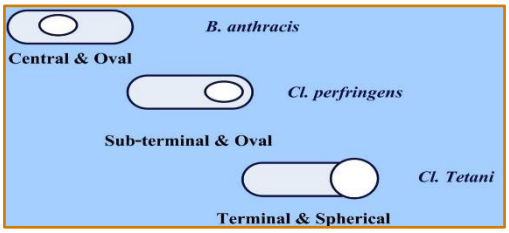




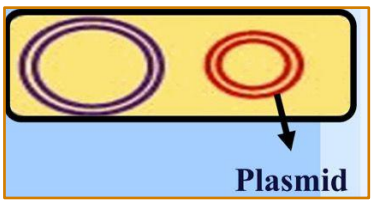
  - Occur to *unfavorable conditions* (resistance):
    - ✓ High temp
    - ✓ Drying
    - ✓ Cold
    - ✓ Irradiation
    - ✓ Boiling
    - ✓ Depletion of nutrition
  - Formed outside the body (in VITRO), Stained by different stains e.g ZN stain, malachite green
  - Only moist heat e.g 120 C for 20 minutes will kill them
  - ***Spore re-formation steps:***
    - ✓ DNA replication
    - ✓ Multiple membrane:
      - Cortex: calcium dipicolinate and keratin layer
      - Spore coat
      - Exosporium



  - ***Position of spores:***
    - ✓ Central and oval e.g: B.anthracis
    - ✓ Sub-terminal and oval e.g: Cl.perfringens
    - ✓ Terminal and Spherical e.g: Cl. Tetani



- ***Plasmid*** *(Non-Essential)*
  - Characteristic:
    - ✓ EXTRA chromosomal dsDNA
    - ✓ Replicate autonomously (Independent of bacterial chromosome)
    - ✓ Types: Transmissible or non-transmissible plasmids
    - ✓ *Function* contain genes that confer some properties such as :
      - Antibiotic resistance
      - Virulence factors (exotoxin)
      - Genes for pili



- ***Transposons*** *(Non-Essential)*
  - Pieces of DNA that moves from one site to another either within or between the DNAs of bacteria, plasmids and bacteriophages "*Jumping genes*"

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