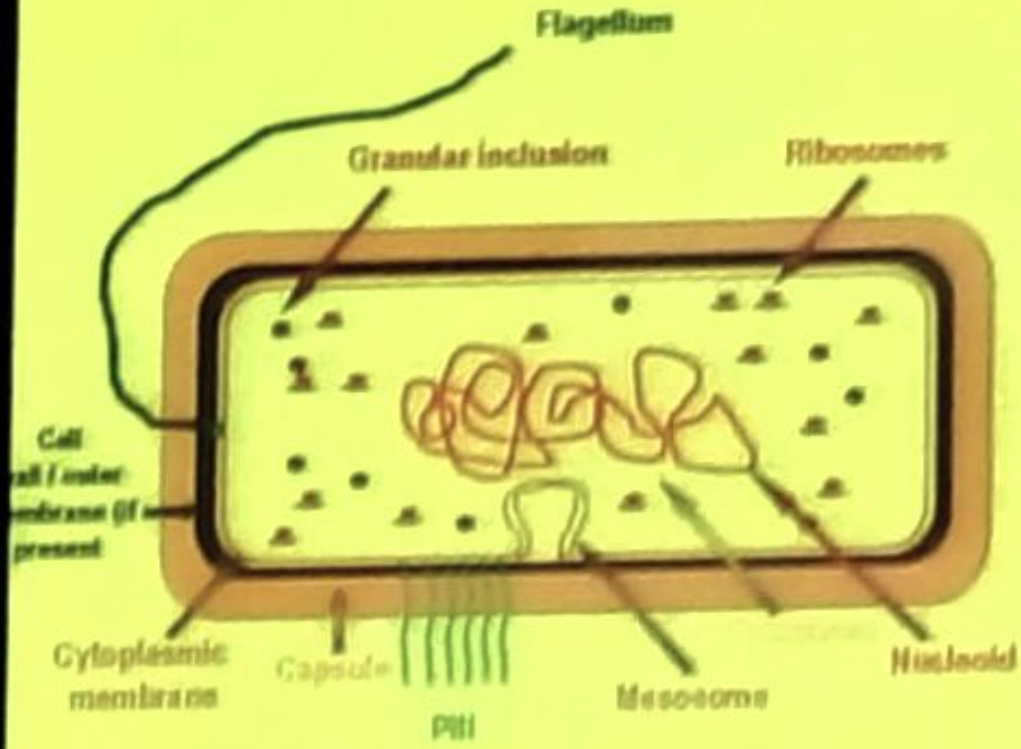
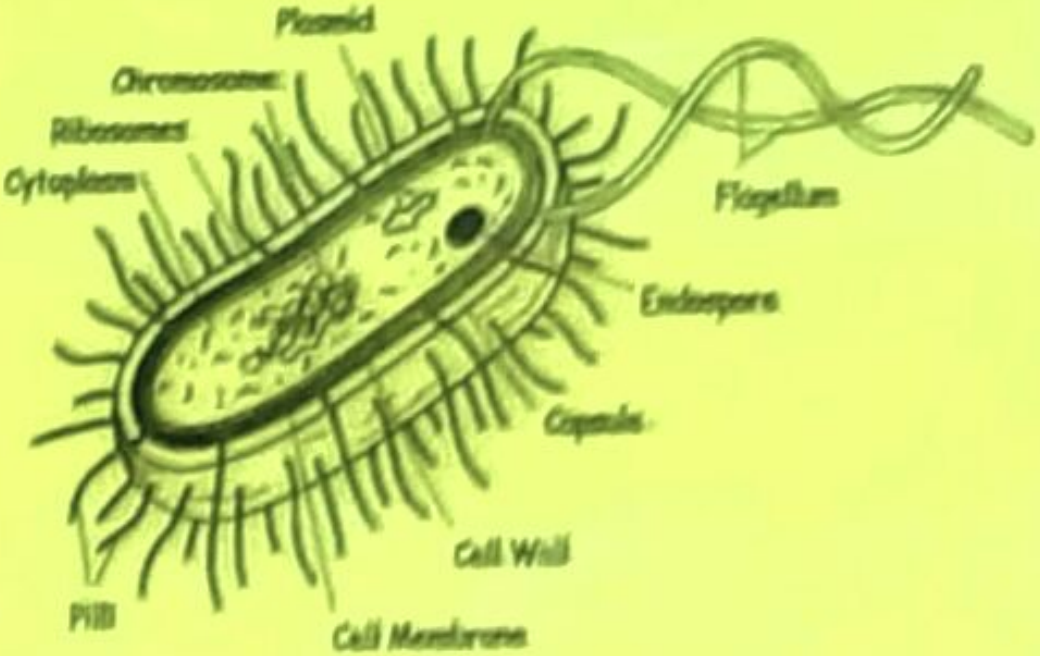
Bacterial anatomy


Flagellum
Granular inclusion
Ribosomes
Cell
present
Cytoplasmic
membrane
Capsule
Pili
Mesosome
Nucleoid


Plasmid
Chromosome
Ribosomes
Cytoplasm
Flagellum
Endospore
Capsule
Cell Wall
Pilli
Cell Membrane

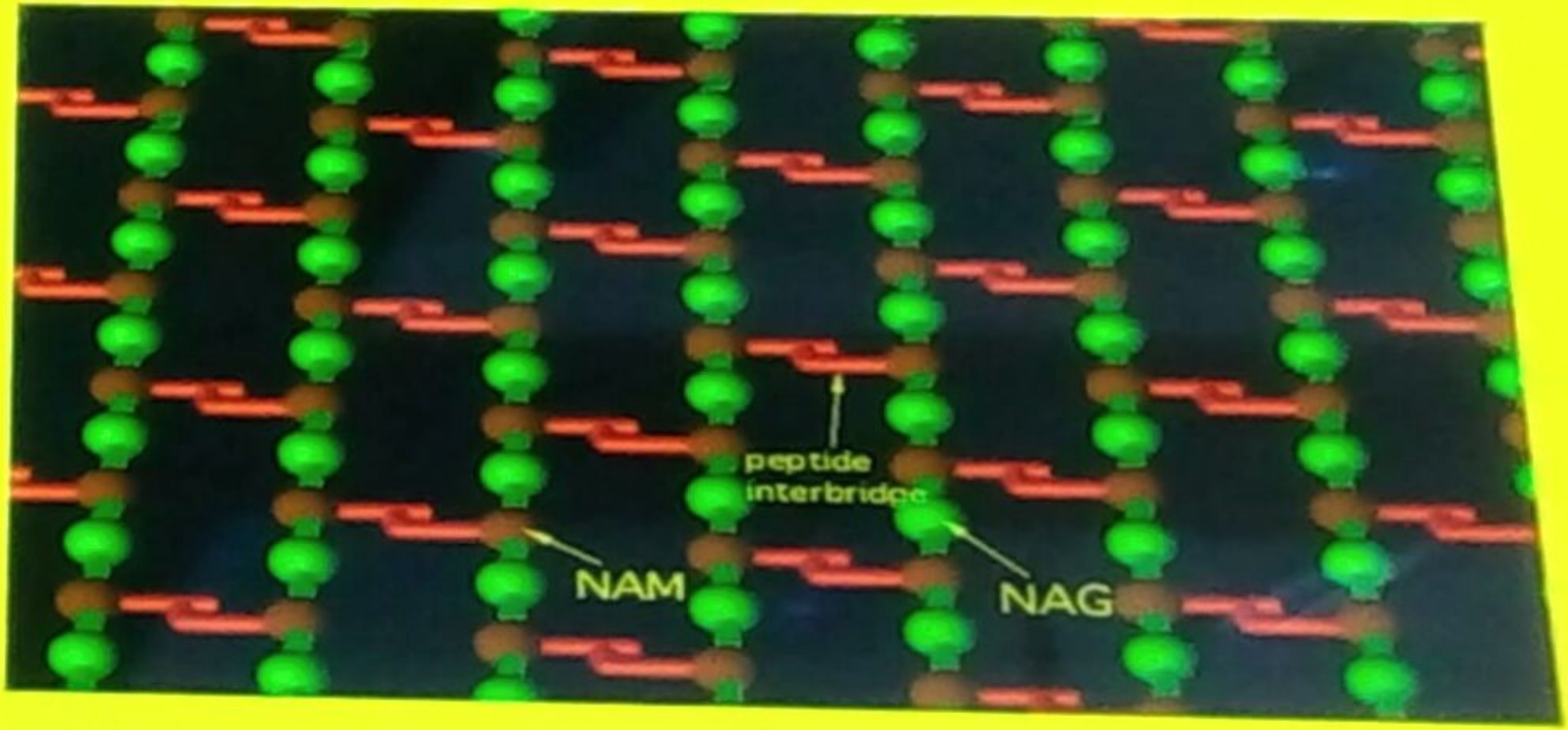
Capsule/Glycocalyx/Slime layer

- Polysacharride Structures surrounding the outside of the cell envelope.
  - helps in the formation of biofilms on inert surfaces such as catheters, teeth and heart valves.

Significance of capsules

- Antiphagocytic
- Growth in a biofilm prevents access of host cells or antibiotics
- Prevent cell from drying out
- used as antigens in certain vaccines e.g pneumococcal vaccine

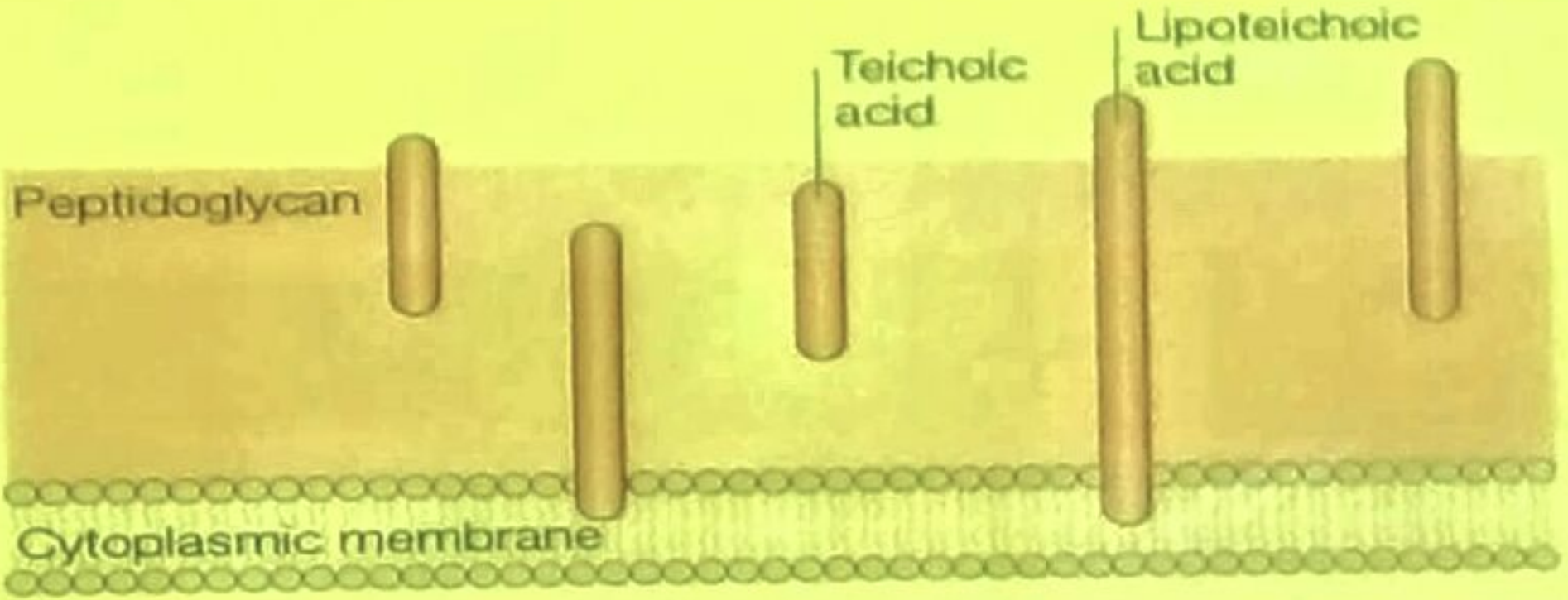
Cell wall



Cell wall

- Main component is **peptidoglycan (murein)**
- The thickness of **peptidoglycan** distinguishes gram positive from gram negative bacteria
- Overlapping N-acetyl glucosamine **(NAG) &** N-acetyl muramic acid **(NAM)**
- Present in almost all bacteria, except Mycoplasma and ureaplasma

Gram positive cell wall



Cell wall of gram positive bacteria

- **Thick peptidoglycan** layer (50-90% of cell wall material)
- Composed of;

a) Teichoic acids

- mediate attachment to mucosal membranes
- Induce septic shock in certain G+ve bacteria

Cont.

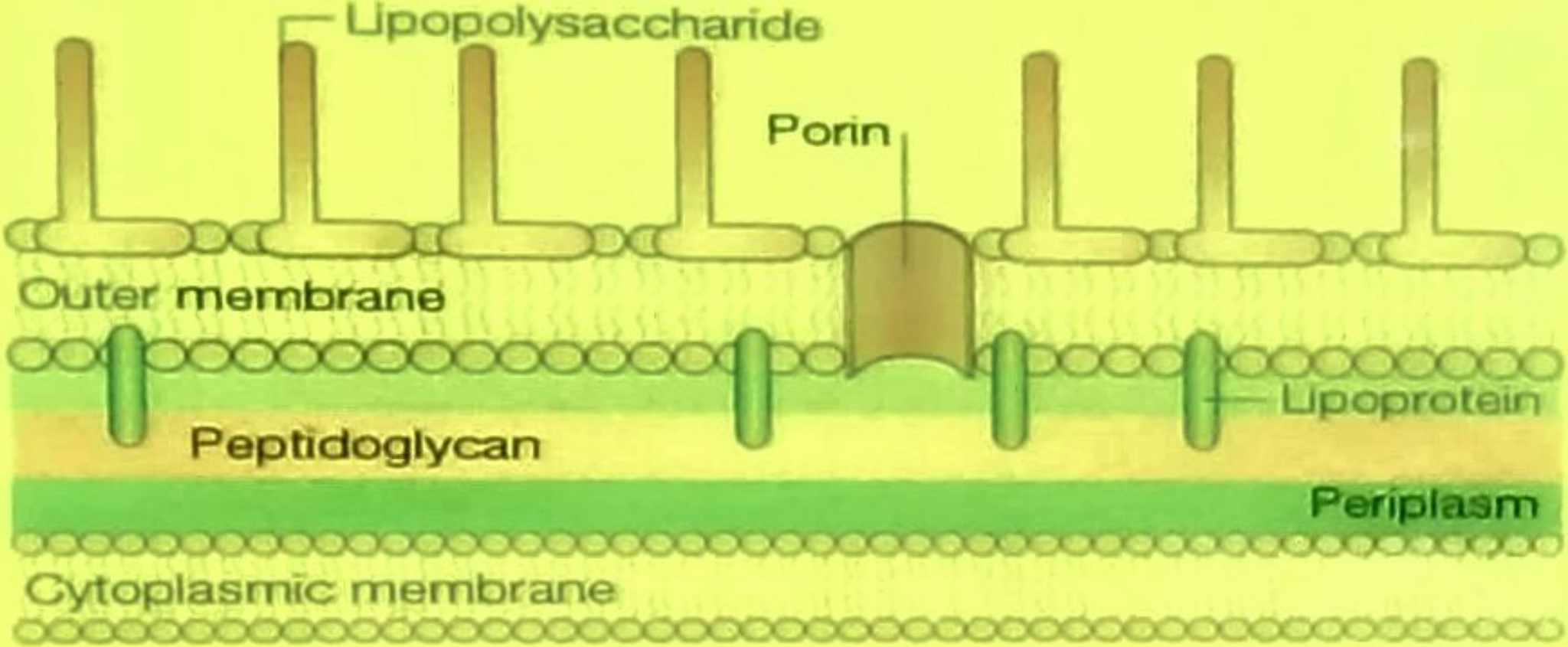
b) Lipoteichoic acid

- Anchor cell wall to cell membrane
- For epithelial cell adhesion

c) Polysaccharides and proteins

- protect peptidoglycan layer from action of agents such enzymes
- promote colonization by sticking the bacteria to the surface of host cells

Gram negative



Cell wall of Gram Negative bacteria

- **Thin peptidoglycan** layer comprising 5–10% of cell wall material.
- have an additional outer membrane.
- Have a **periplasmic space**– contains digestive enzymes and other transport proteins.
- contains **porin protein** - specifically allow transport of solutes in and out of the cell

Cont.

- G-ve cell wall contain three components

a) Lipoprotein anchors the outer membrane to peptidoglycan.

b) Outer membrane protects the cell from proteolytic enzymes.

c) Lipopolysaccharide (LPS)

- Present in almost all gram –ve bacilli
- Major component is **Lipid A**- endotoxin **(responsible for endotoxic activities – fever, hypotension, septicemia)**

Acid-fast bacteria

- The cell envelopes of Mycobacteria are more complex than other bacteria.
- Composed of **Mycolic acid** (thick waxy membranous layer outside the peptidoglycan layer)

Significance of cell wall

- Maintains cell shape
- Protects bacteria from osmotic lysis
- Determines reactivity to Gram stain
- Site of action of certain antimicrobial agents (E.g. Penicillins, Cephalosporins)
- Enhances pathogenicity

Plasma/Cytoplasmic/Cell membrane

- separates cell wall from cytoplasm
- Acts as a **semipermeable membrane**
- Composed of **lipoproteins** with small amounts of **carbohydrates**
- Generally do **not contain sterols** (except for Mycoplasma)

Plasma/Cytoplasmic/Cell membrane

Function

- active transport of molecules into the cell
- Synthesis of precursors of the cell wall
- secretes enzymes and toxins

Pili

- Hair-like projections on the surface of the cell
- Shorter and straighter than flagella
- Composed of protein – pilin
- Mostly on gram negative bacteria

Pili . . 2

- Fimbriae/ Common pili – cover the cell surface
  - For attachment

- Sex pili – longer than common pili
  - Involved in conjugation
  - Longer than fimbriae

Flagella

- Long , filamentous surface appendages
- For bacterial motility
- Composed of the protein 'flagellin'
- May serve as antigenic determinants (e.g. the H antigens of Gram-negative enteric bacteria)

Ribosomes

- They are composed of **RNA and proteins.**
- Site of protein synthesis
- Site of activity of antimicrobials that disrupt protein synthesis
- **70S** in size with 50S and 30S subunits

Nucleoid

- Area of cytoplasm in which **DNA is located**
- Bacterial DNA consists of a single, circular double-stranded DNA
- **lacks nuclear membrane** (called nucleoid)
- Contains genetic material that codes for all genetic information expressed by the cell

Plasmids

- **Extrachromosomal DNA molecules**
- Easily **passed from bacterium to bacterium** through sex pili
- Free or integrated into the chromosome
- May encode genes of antibiotic resistance and pathogenesis factors (e.g. enzymes and toxins)

Inclusion/nutrient granules

- Composed of **volutin, lipid and polysaccharide**.
- Stain characteristically with certain dyes
- **Example; Volutin granules** are seen in ***Corynebacterium*** spp

Function; Serve as storage area for nutrients and energy for cell metabolism

Mesosomes

- appear as convoluted indentations (**invaginations**) in the cytoplasmic membrane

Functions

- Are sites of respiratory enzyme activity
- Coordinate nuclear & cytoplasmic division during binary fission

Spores

- **round, oval, or elongated**
- Formed inside the parent cell (**Endospores**)
- Formed when conditions for vegetative growth are not favourable
- They exhibit **no metabolic activity**
- Resistant to heat, radiation and drying and can remain dormant for hundreds of years
- Formed by bacteria like **Clostridia, Bacillus**

Bacterial physiology

Definition

- Study of how bacteria function including such processes as nutrition, growth, reproduction and locomotion

Growth and Proliferation of bacteria

Bacterial requirements for growth

- Temperature
- Oxygen
- Nutrients
- pH
- moisture

Temperature

- Temperature – Classification
  - –Psychrophiles – low temp10-20 °C
  - –Mesophiles – 20- 40°C
  - –Thermophiles – temp. > 40°C

O_2 utilization

- **Strict (obligate) aerobes** - require O_2 for growth e.g. *Pseudomonas aeruginosa*
- **Strict (obligate) anaerobes** - grow in the absence of O_2 e.g. *Bacteroides fragilis*
- **Facultative anaerobes** – do not require O_2 for growth but grow better in its presence e.g. *Staphylococcus* species

O_2 utilization . . 2

- **Microaerophilic** – Grow well in low concentrations of oxygen and higher carbon dioxide concentrations;
  - E.g. *Neisseria meningitidis*

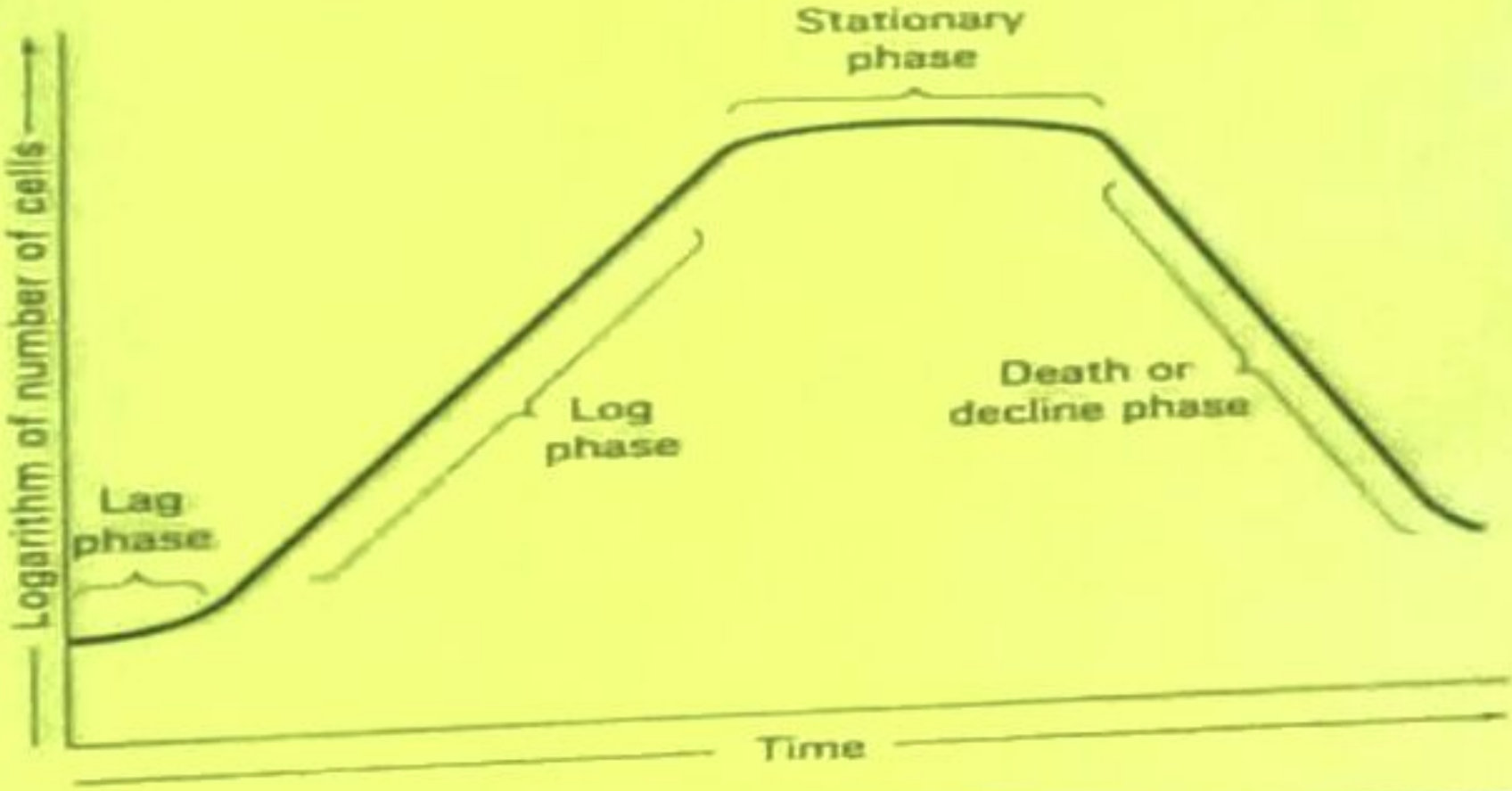
pH

- Neutrophiles (5 to 8)
- Acidophiles (below 5.5)
- Alkaliphiles (above 8.5)

Generation time

- The time required for a bacterium to give rise to 2 daughter cells under optimum conditions. Examples
  - *Escherichia coli* & other medically important bacteria – 20 mins
  - Tubercle bacilli – 20 hrs
  - Leprae bacilli – 20 days

Bacterial growth curve



Lag phase

- The bacteria are adapting to the new environment
- No cell division
- Vigorous metabolic activity
- cells may increase in size during this time, but simply do not undergo binary fission

Exponential/ Logarithmic phase

- Cells start dividing and their number increases exponentially
- Constant, maximal growth rate
- Increased rate of metabolism

Stationary phase

- the death rate equals the growth rate.
- cell division stops due to depletion of nutrients & accumulation of toxic products
- Spore formation

Decline/ Death phase

- Loss of viability—cells die due to
  - —toxic products
  - —loss of selective permeability. Fluid gets into the cells causing cell lysis