

UNIT-I

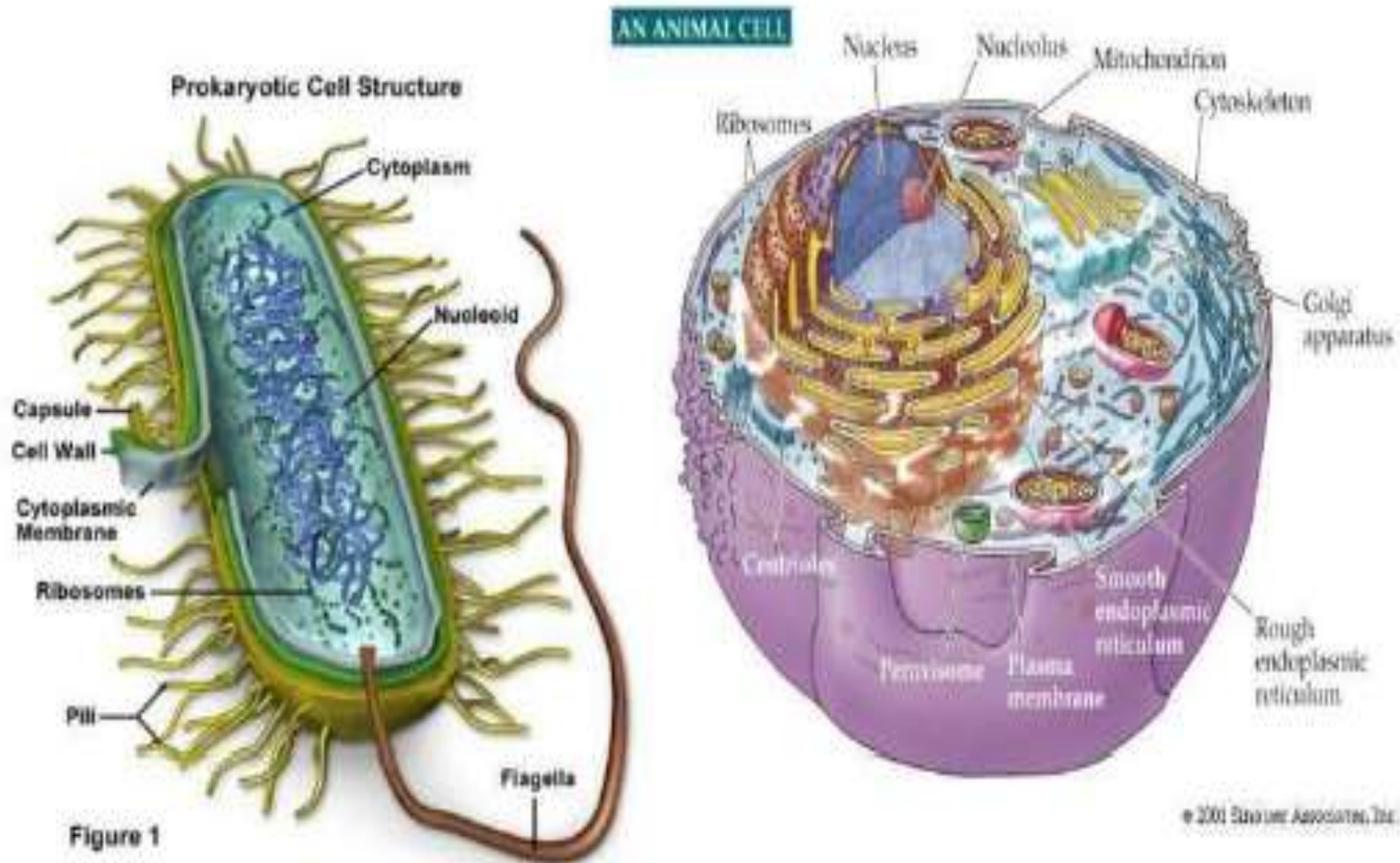
INTRODUCTION TO PROKARYOTES AND EUKARYOTES



CENTURION
UNIVERSITY
*Shaping Lives...
Empowering Communities!*

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Prokaryotic vs Eukaryotic Cells



- Theodor Schwann, Matthias Schleiden advanced the classical cell theory which states that

1. All living things are made of cells.

2. Cells are the basic building units of life.

3. New cells are created by old cells dividing into two.

- In 1855, Rudolf Virchow added another point to the theory that

4. All cells come from pre-existing cells,

- The cell theory holds true for all living things with viruses as exception. Because all cells come from existing cells, we can learn about all types of living things by learning about cells and how they function.

PROKARYOTIC CELLS

- Prokaryote is a Greek word, *pro - before and karyon - nut or kernel*. Prokaryotes are the organism with a **primordial nucleus**. They have a much simpler morphology than eukaryotic cells and **lack a true membrane bound nucleus and cell organelles like mitochondria, golgi bodies, endoplasmic reticulum, etc.** All **bacteria and archaea are prokaryotic**.
- Most prokaryotes are **unicellular, exceptions being mycobacteria** which have multicellular stages in their life cycles.

- They are **membrane bound mostly unicellular** organisms **lacking any internal membrane bound organelles.**
- Though prokaryotes lack cell organelles they have few internal structures, such as the **cytoskeletons, ribosomes.**
- Membranous organelles are known in some groups of prokaryotes, such as **vacuoles** or membrane systems devoted to photosynthesis or **chemolithotrophy.**
- In addition, some species also contain **protein-enclosed microcompartments**, which have distinct physiological roles (carboxysomes or gas vacuoles).

A prokaryotic cell will have generally following components:

- **Flagella:** It is a long, whip-like protrusion found in most prokaryotes that aids in cellular locomotion. Besides it may functions as a sensory organelle, sensitive to chemicals and temperatures outside the cell.
- **Capsule:** Found in some bacterial cells and protects the cell when it is engulfed by phagocytes and by viruses.
- Also assists in retaining moisture. Helps the cell adhere to surfaces and nutrients.
- The capsule is found most commonly among Gram-negative bacteria. Examples of gram negative bacteria are Escherichia coli, Klebsiella pneumoniae Haemophilus influenzae, Pseudomonas aeruginosa and Salmonella etc.

- **Cell wall:** Cell wall is the outermost layer of most cells that protects the bacterial cell and gives it shape. **Mycoplasma lacks cell wall.**
- Bacterial cell walls are made of **peptidoglycan** which is made from polysaccharide chains cross-linked by unusual peptides containing D-amino acids.
- **Plants and fungi cell walls** are made of **cellulose and chitin**, respectively.
- The cell wall of **of Archaea, do not contain peptidoglycan.** The cell wall is essential to the survival of many bacteria.
- **Cell membrane:** Cell membrane surrounds the cell's cytoplasm and regulates the flow of substances in and out of the cell.

Bacterial Cell Wall

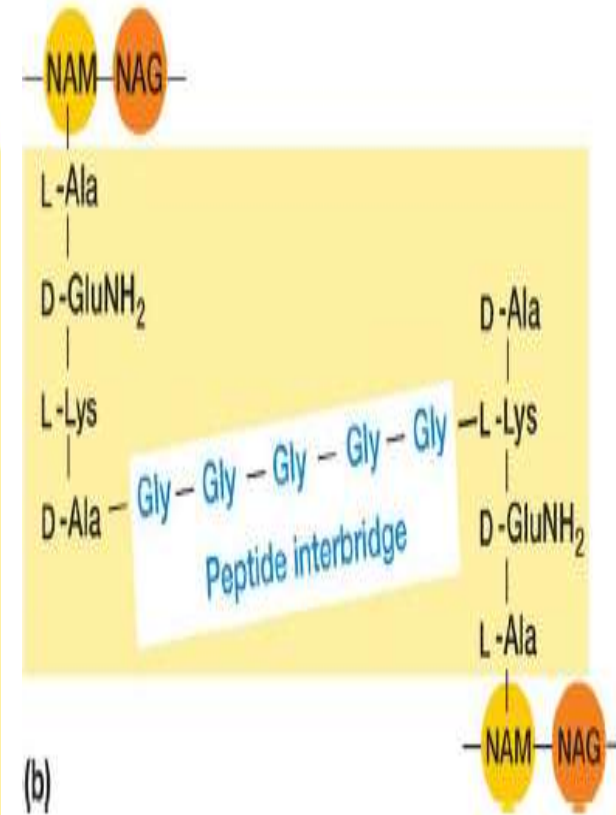
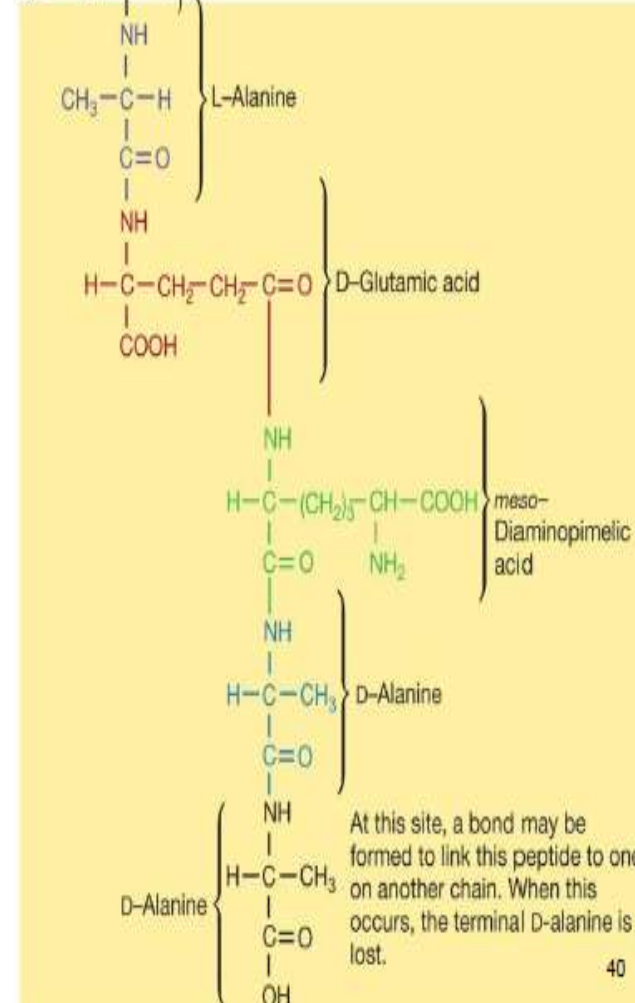
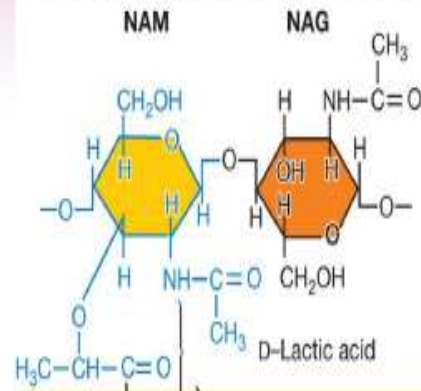
- Peptidoglycan (murein)
 - rigid structure that lies just outside the cell plasma membrane
 - two types based on Gram stain
 - Gram-positive: stain purple; thick peptidoglycan
 - Gram-negative: stain pink or red; thin peptidoglycan and outer membrane

Cell Wall Functions

- Maintains shape of the bacterium
 - almost all bacteria have one
- Helps protect cell from osmotic lysis
- Helps protect from toxic materials
- May contribute to pathogenicity

Peptidoglycan Structure

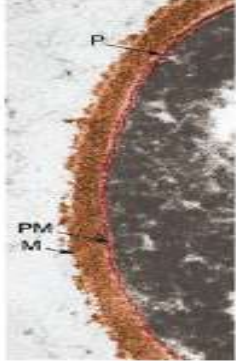
- Meshlike polymer of identical subunits forming long strands
 - two alternating sugars
 - *N*-acetylglucosamine (NAG)
 - *N*-acetylmuramic acid
 - alternating D- and L-amino acids



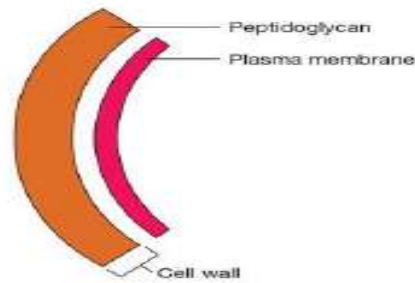
(b)

Gram-Positive Cell Walls

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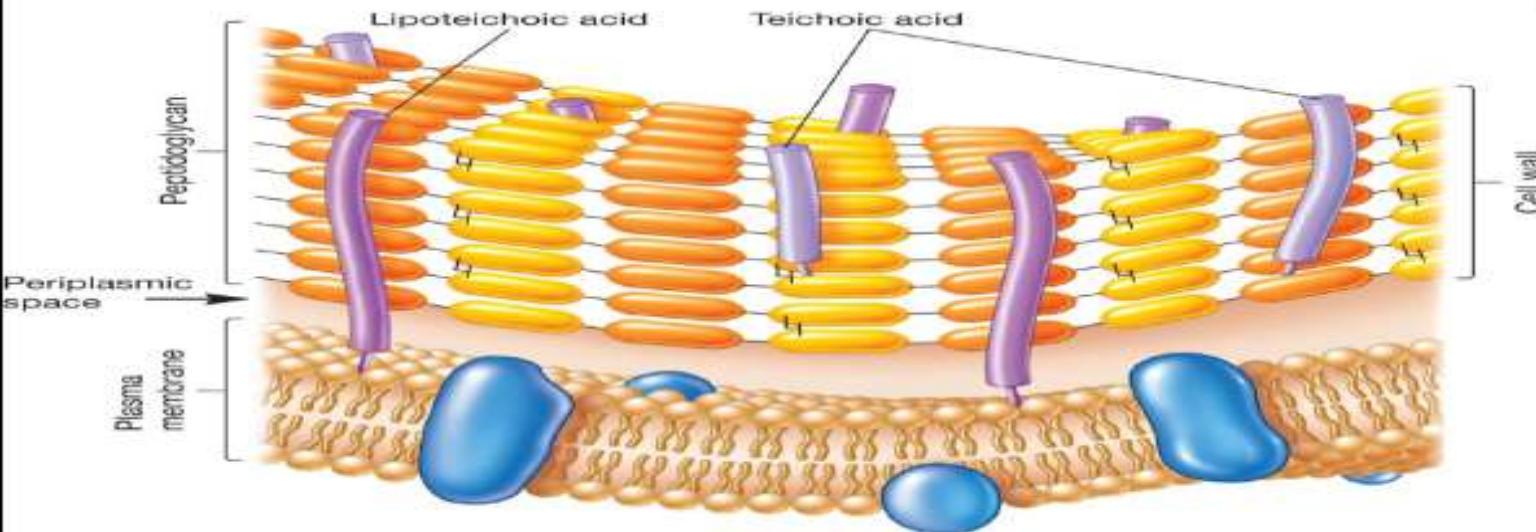


The typical Gram-positive cell envelope

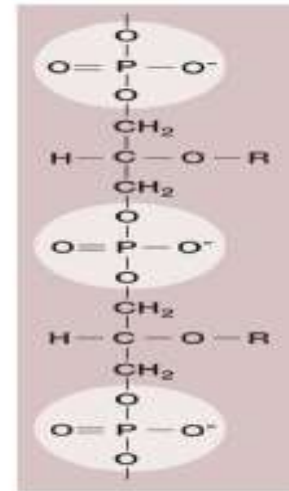


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- Composed primarily of peptidoglycan
- May also contain teichoic acids (negatively charged)
 - help maintain cell envelope
 - protect from environmental substances
 - may bind to host cells
- some gram-positive bacteria have layer of proteins on surface of peptidoglycan



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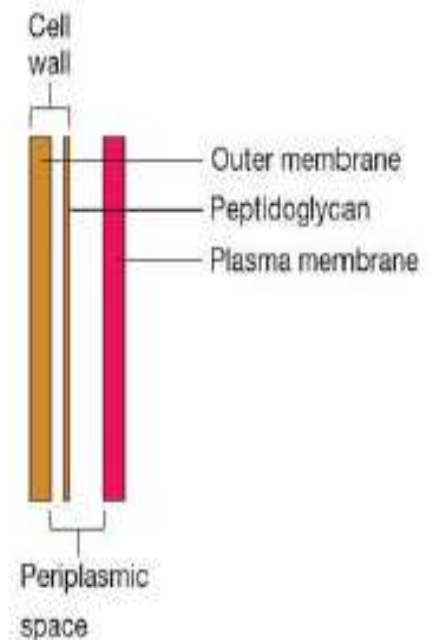
Gram-Negative Cell Walls

- More complex than Gram-positive
- Consist of a thin layer of peptidoglycan surrounded by an outer membrane
- Outer membrane composed of lipids, lipoproteins, and lipopolysaccharide (LPS)
- No teichoic acids

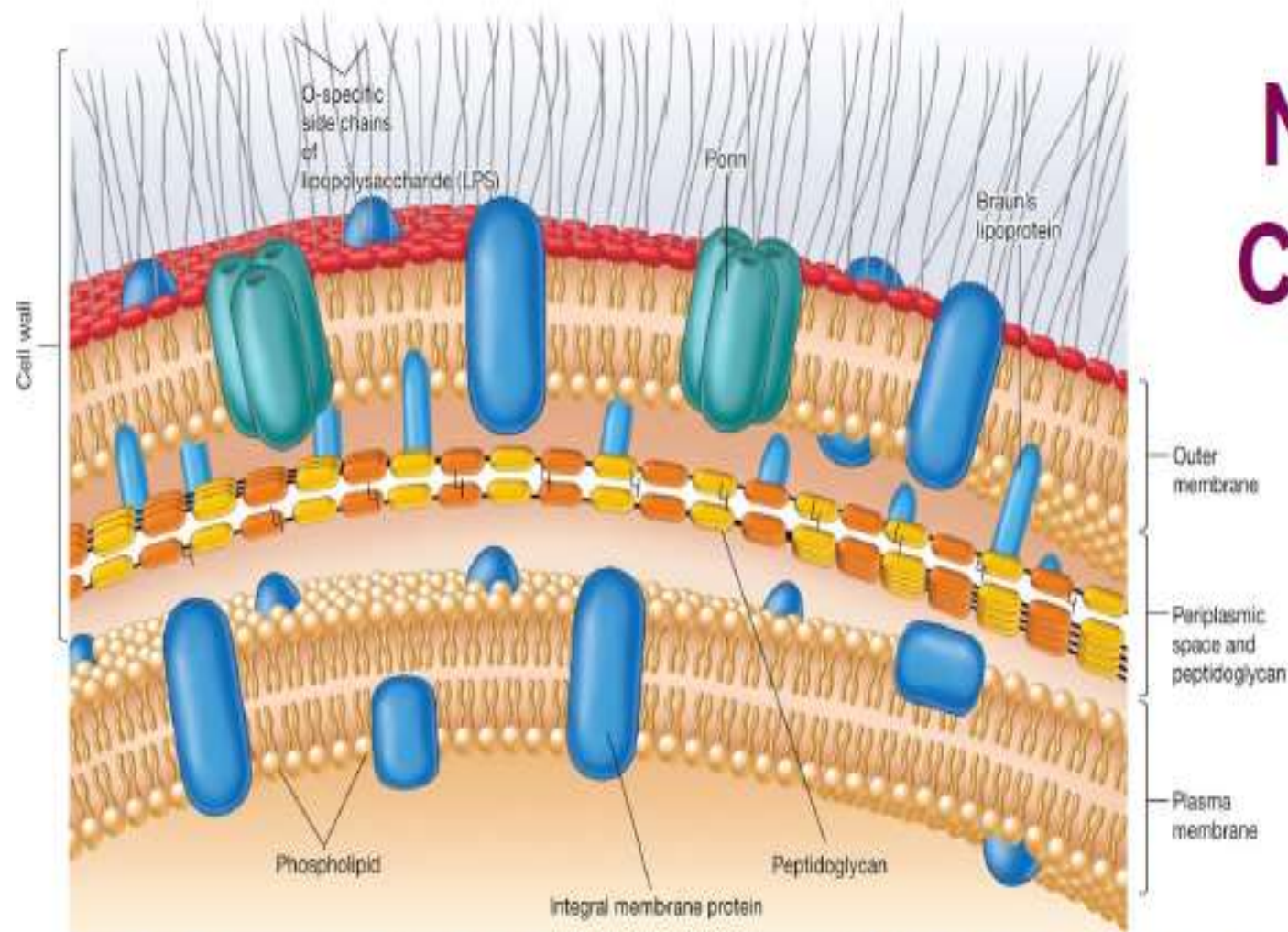
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The typical Gram-negative cell envelope



Gram-Negative Cell Walls



outer membrane lies outside the thin peptidoglycan layer

- **Cytoplasm:** The cytoplasm of a cell is a fluid in nature that fills the cell and is composed mainly of 80% water that also contains enzymes, salts, cell organelles, and various organic molecules.
- **Ribosomes:** Ribosomes are the organelles of the cell responsible for protein synthesis.
- **Nucleoid Region:** The nucleoid region is possessed by a prokaryotic bacterial cell. It is the area of the cytoplasm that contains the bacterial DNA molecule.

Pili:

- Pili are hair-like structures on the surface of the cell that help attach to other bacterial cells. Shorter
- pili called fimbriae help bacteria attach to various surfaces.
- A pilus is typically 6 to 7 nm in diameter.
- The types of pili are Conjugative pili and Type IV pili.
- Conjugative pili allow the transfer of DNA between bacteria, in the process of bacterial conjugation.
- Some pili, called type IV pili, generate motile forces.

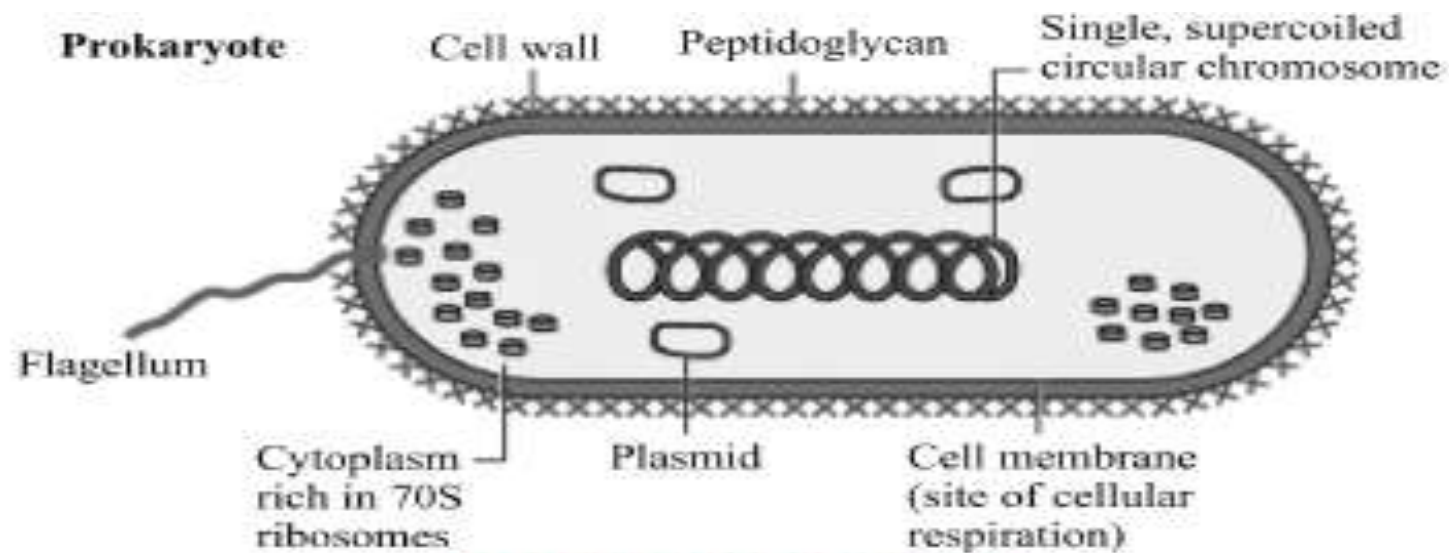


Fig. 1.1: Prokaryote Cell

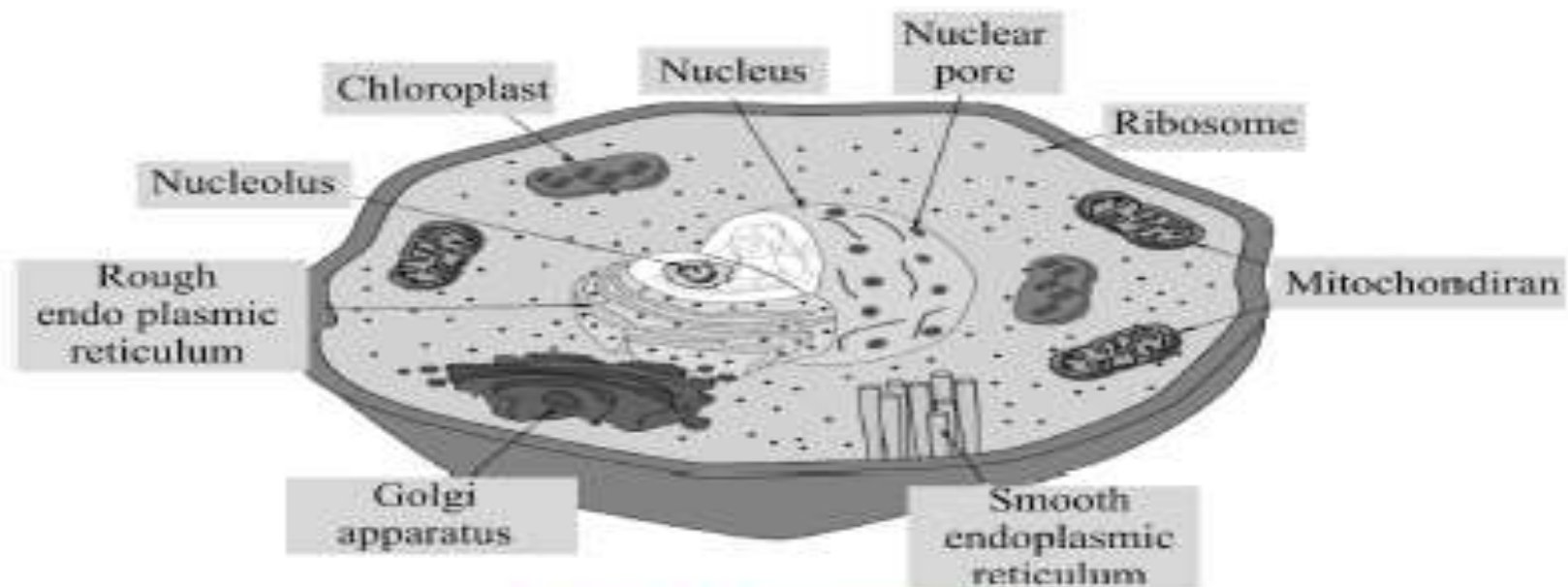


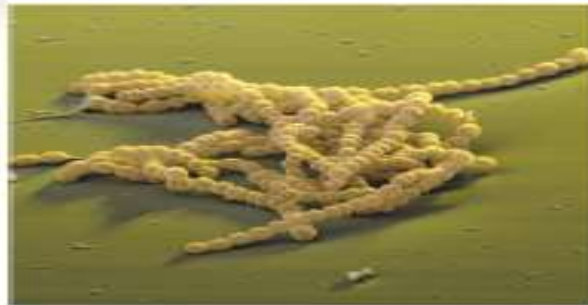
Fig. 1.2: Eukaryote Cell

Morphology of prokaryotic cells

- Cocci – spherical
- Bacilli - rod-shaped
- Spirochaete - spiral-shaped
- Vibrio - comma-shaped

Shape and Arrangement-1

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(a) *S. agalactiae*—cocci in chains



(b) *S. aureus*—cocci in clusters

Cocci (s., coccus) – spheres

– diplococci (s., diplococcus) – pairs

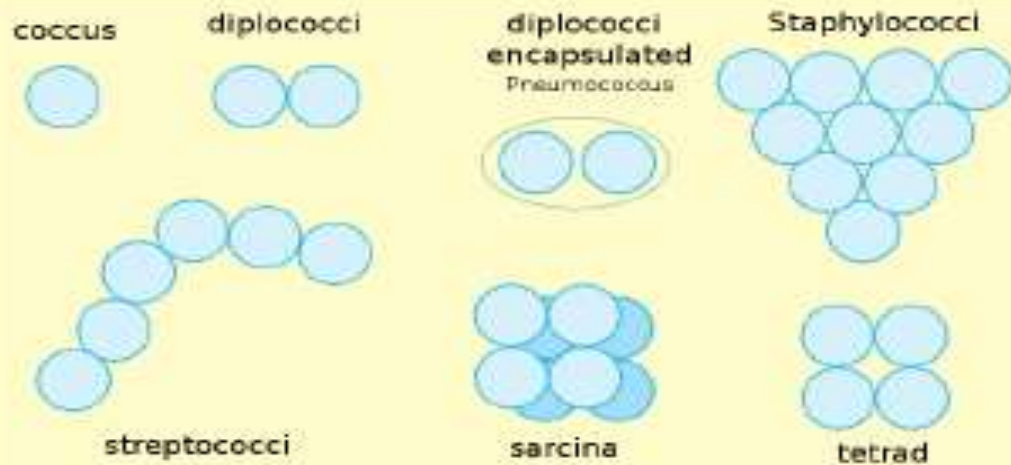
– streptococci – chains

– staphylococci – grape-like clusters

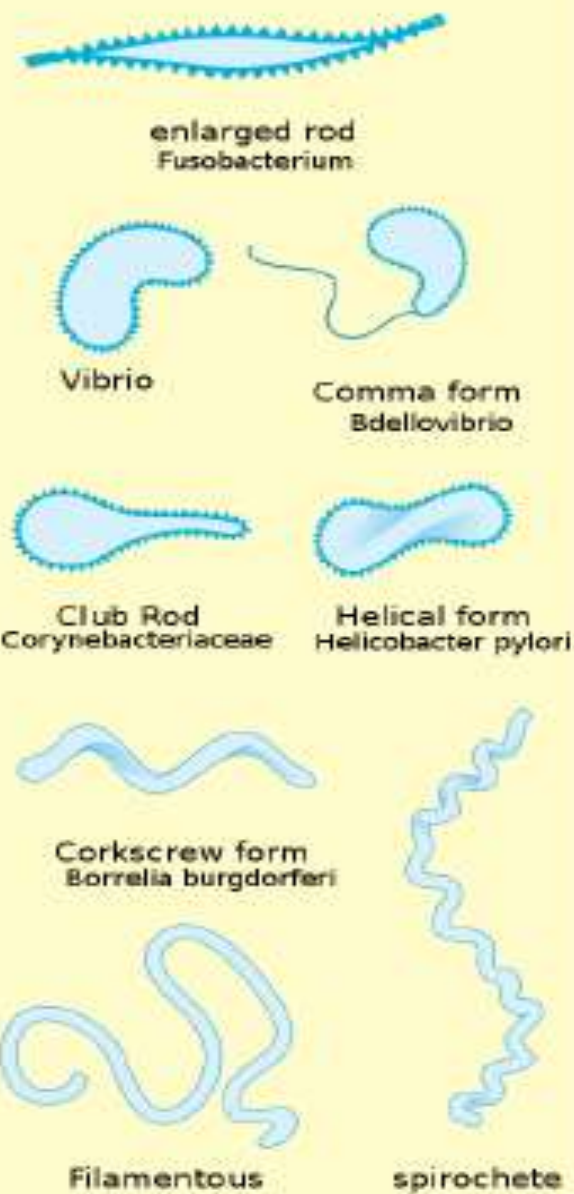
– tetrads – 4 cocci in a square

– sarcinae – cubic configuration of 8 cocci

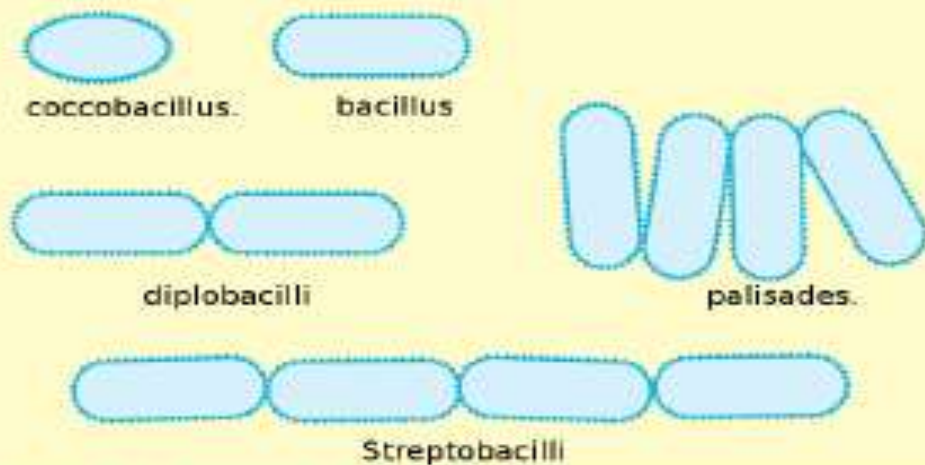
Cocci



Others



Bacilli



Budding and appendaged bacteria

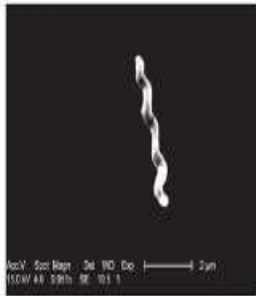


Shape and Arrangement-2

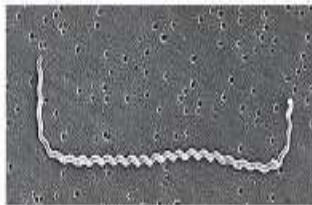
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(a) *V. cholerae*—comma-shaped vibrios



(b) *C. jejuni*—Spiral-shaped spiroillum



(c) *Leptospira interrogans*—a spirochete

a: CDC; b: CDC; c: Janice Heney Carr,

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(c) *B. megaterium*—rods in chains

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- bacilli (s., bacillus) – rods
 - coccobacilli – very short rods
- vibrios – resemble rods, comma shaped
- spirilla (s., spirillum) – rigid helices
- spirochetes – flexible helices

Shape and Arrangement-3

- mycelium – network of long, multinucleate filaments
- pleomorphic – organisms that are variable in shape

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(a) Mycetozoa



(b) Streptomyces – a filamentous bacterium



(c) *M. luteus* fruiting body

EUKARYOTIC CELLS

- Eukaryote is a Greek word, *eu - true and karyon - nut or kernel*. Eukaryotes possess a membrane enclosed nucleus and cell organelles. They are more complex morphologically and are usually larger than prokaryotes. **Algae, fungi, protozoa, higher plants and animals are eukaryotic.**
- Eukaryotic genome is **enclosed in the nucleus surrounded by the nuclear membrane**. Many membrane bound organelles dwell in their cell cytoplasm. Cell division involves separating of the genome which is in the form of tightly packed **condensed structure** known as the **chromosomes**, through movements directed by **the cytoskeleton**.

Classification:

- The eukaryotes are composed of four kingdoms:
- Kingdom Protista
- Kingdom Fungi
- Kingdom Plantae
- Kingdom Animalia

Cell features

- Eukaryotic cells are **much larger than prokaryotic cells**. Range between **10 to 100 micrometers**. They have a variety of internal membranes and structures, called **organelles**, and a **cytoskeleton composed of microtubules, microfilaments, and intermediate filaments**, which play an important role in defining the cell's organization and shape.
- Eukaryotic **DNA is divided into several linear bundles called chromosomes**, which are **separated by a microtubular spindle during nuclear division**.
- Eukaryote cells include a variety of membrane-bound structures, collectively referred to as the **endomembrane system** involved in various functions.
- **Simple compartments, called vesicles or vacuoles**, can form by budding off other membranes.

- The nucleus is surrounded by a **double membrane** (commonly referred to as a nuclear envelope), **with pores that allow material to move in and out.**
- **Various tube and sheet like extensions** of the nuclear membrane form what is called the **endoplasmic reticulum** or ER, which is involved in **protein transport** and maturation.
- It includes the **rough ER where ribosomes** are attached to synthesize proteins, which enter the interior space or lumen.
- Subsequently, they generally enter vesicles, which bud off from the smooth ER.

- In most eukaryotes, these protein-carrying vesicles are released and further modified in stacks of flattened vesicles, called **golgi bodies** or dictyosomes.
- Vesicles may be specialized for various purposes. For instance, **lysosomes contain enzymes that break down the contents of food vacuoles**, and **peroxisomes are used to break down peroxide**, which is **toxic** otherwise.
- In multicellular organisms, **hormones are often produced in vesicles**.
- In **higher plants**, most of a **cell's volume is taken up by a central vacuole**, which **primarily maintains its osmotic pressure**.

Characteristic	Prokaryotes	Eukaryotes
Size of cell	Typically 0.2-2.0 μm in diameter	Typically 10-100 μm in diameter
Nucleus	No nuclear membrane or nucleoli (nucleoid)	True nucleus, consisting of nuclear membrane & nucleoli
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria & chloroplasts
Flagella	Consist of two protein building blocks Complex;	consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple
Plasma Membrane	No carbohydrates and generally lacks sterols.	Sterols and carbohydrates that serve as receptors present
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA) arrangement	Single circular chromosome; lacks histones	Multiple linear chromosomes with histones
Cell division	Binary fission	Mitosis
Sexual reproduction	No meiosis; transfer of DNA fragments only (conjugation)	Involves Meiosis