

Shree H.N.Shukla College of Science

Subject: Microbiology

Paper-101 [Sem-1] Fundamental of Microbiology

Unit-3: Morphology and Classification of Bacteria

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INTRODUCTION

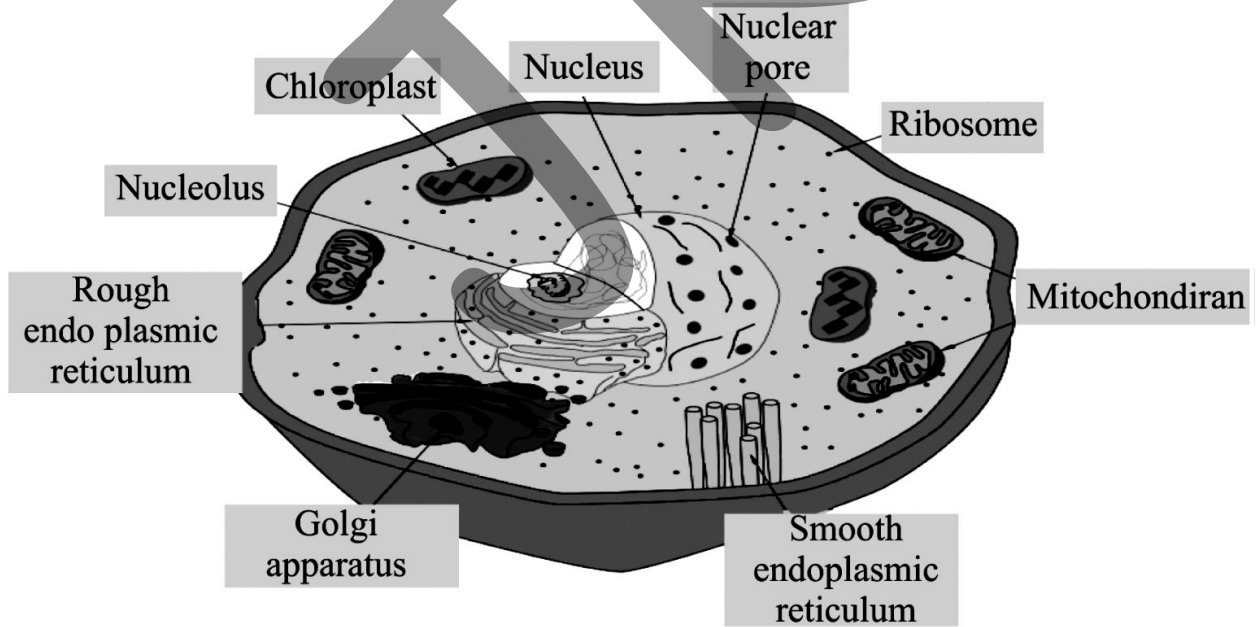
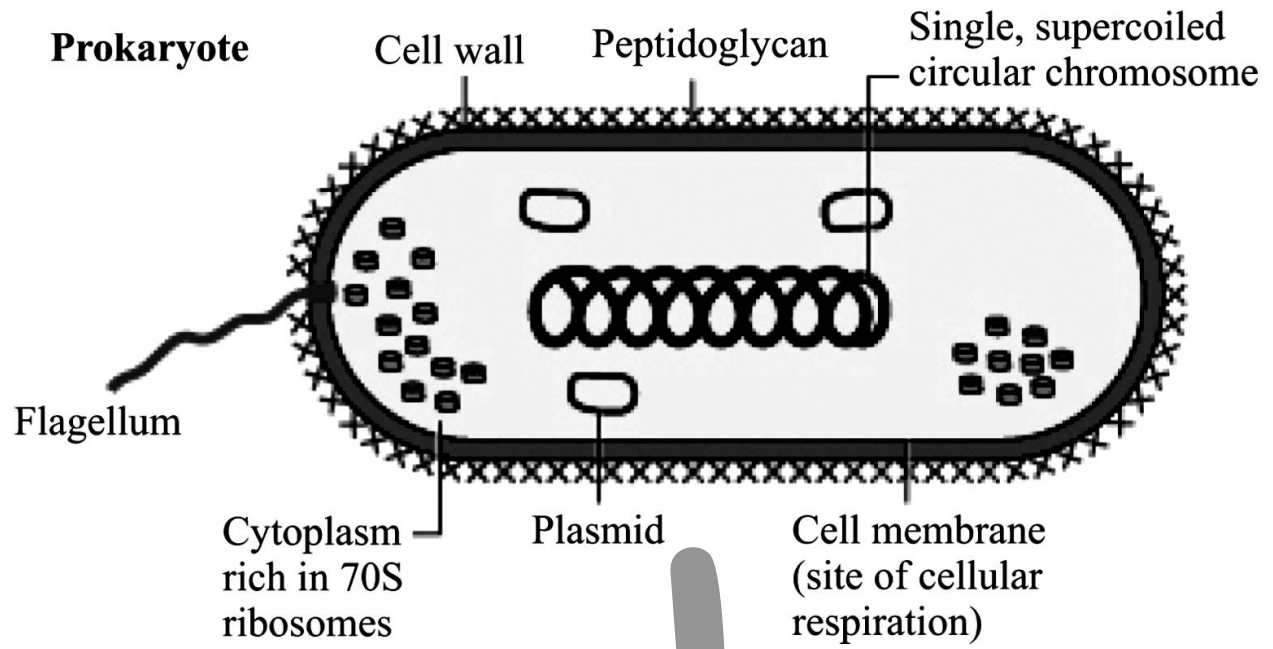
Microorganisms are a heterogeneous group of several distinct classes of living beings. Based on the difference in cellular organization and biochemistry, the kingdom protista has been divided into two groups namely prokaryotes and eukaryotes. Bacteria and blue-green algae are prokaryotes, while fungi, other algae, slime moulds and protozoa are eukaryotes. Bacteria are prokaryotic microorganisms that do not contain chlorophyll. They are unicellular and do not show true branching, except in higher bacteria like actinomycetales

OBJECTIVES

- After reading this lesson, you will be able to:
- describe the structure of Prokaryotic and Eukaryotic cell
- explain the size of bacteria
- classify bacteria based on the shape and arrangements
- describe the structure of bacterial cell wall
- describe the phases of Growth curve
- explain the factors affecting the growth of bacteria

PROKARYOTES

- The prokaryotic cells have the following characteristics such as No organelles, all the action takes place in the cytosol or cytoplasmic membrane
- Most bacteria possess peptidoglycan, a unique polymer that makes its synthesis a good target for antibiotics
- Protein synthesis takes place in the cytosol with structurally different ribosome's



Difference between	Prokaryotes	Eukaryotes
Character	Absent. No nuclear	Present with nuclear
Nucleus	envelope	envelope and nucleolus
Membrane-bound	Absent	Present. Includes
organelles	Single coiled chromosome	mitochondria, chloroplasts
Chromosome (DNA)	in cytoplasm 'nucleoid'	(plants), lysosomes
	region in association with	Multiple linear
	'histone-like' proteins.	chromosomes with histone
	Eubacteria have a cell wall	No cell wall in animal
	of peptidoglycan Archaea	cellsPlant cell walls =
Cell wall	have cell walls of	celluloseFungal cell walls
Mitotic division	pseudomurein	chitin
Ribosomes	Absent	Present
Flagella	70S. Free in cytoplasm	80S. Both free in
Cytoplasmic membrane	when present consist of	cytoplasm
lipids	protein flagellin	and attached to rough
	Eubacteria= Fatty acids	E.R.70S in mitochondria
	joined to glycerol by ester	and chloroplasts
	linkageArchaea=	consist of 9+2
	Hydrocarbons joined to	arrangement

Mitochondria	glycerol by ether linkage	of microtubules
Lysosomes	Absent	Fatty acids joined to
Golgi apparatus	Absent	glycerol by ester linkage
Endoplasmic Reticulum	Absent	Present
	Absent	Present
		Present

BACTERIA

The major characteristics of Bacteria are based on their size, shape and arrangements

Size

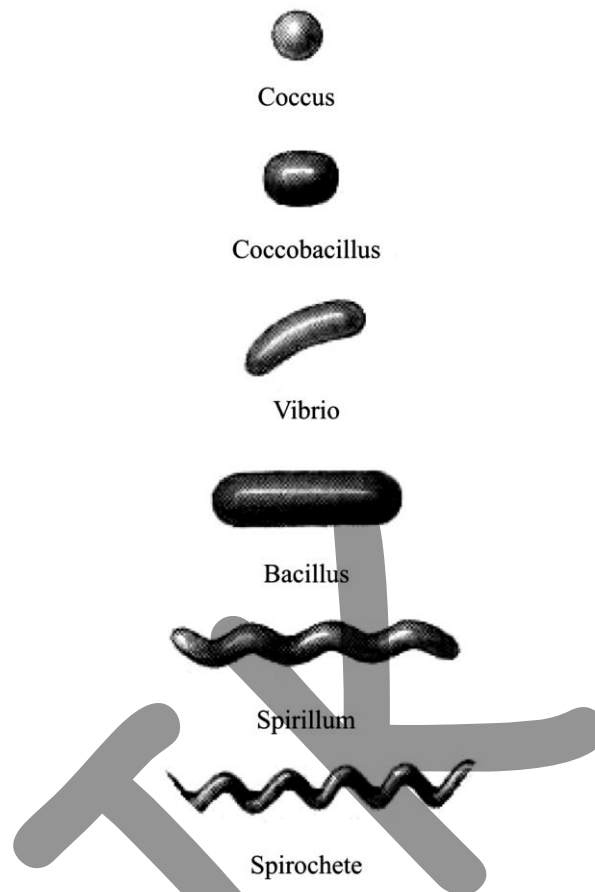
The unit of measurement used in bacteriology is the micron (micrometer) The limit of resolution with the unaided eye is about 200 microns. Bacteria are smaller which can be visualized only under magnification. Bacteria of medical importance generally measure 0.2 – 1.5 μm in diameter and about 3-5 μm in length.

SHAPE OF THE BACTERIA

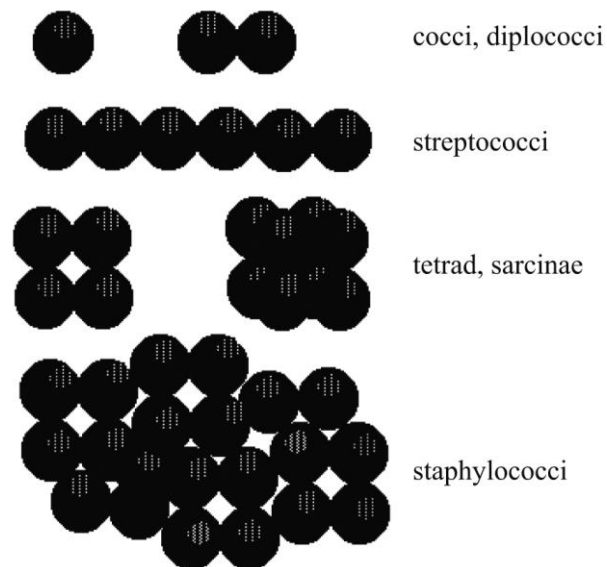
Depending on their shape, bacteria are classified into several varieties

1. Cocci (from kokkos meaning berry) are spherical or oval cells
2. Bacilli (from baculus meaning rod) are rod shaped cells
3. Vibrios are comma shaped curved rods and derive their name from their characteristics vibratory motility.
4. Spirilla are rigid spiral forms.
5. Spirochetes (from speira meaning coil and chaite meaning hair) are flexuous
6. spiral forms Actinomycetes are branching filamentous bacteria, so called because of a fancied resemblance to the radiating rays of the sun when seen in tissue lesions (from actis meaning ray and mykes meaning fungus)

7. Mycoplasmas are bacteria that are cell wall deficient and hence do not possess a stable morphology. They occur as round or oval bodies and as interlacing filaments.



Bacteria sometime show characteristic cellular arrangement or grouping. According to the plane of cellular division, cocci may be arranged in pairs (diplococci), chains (streptococci), groups of four (tetrads) or eight (sarcina), or grape like clusters (staphylococci).



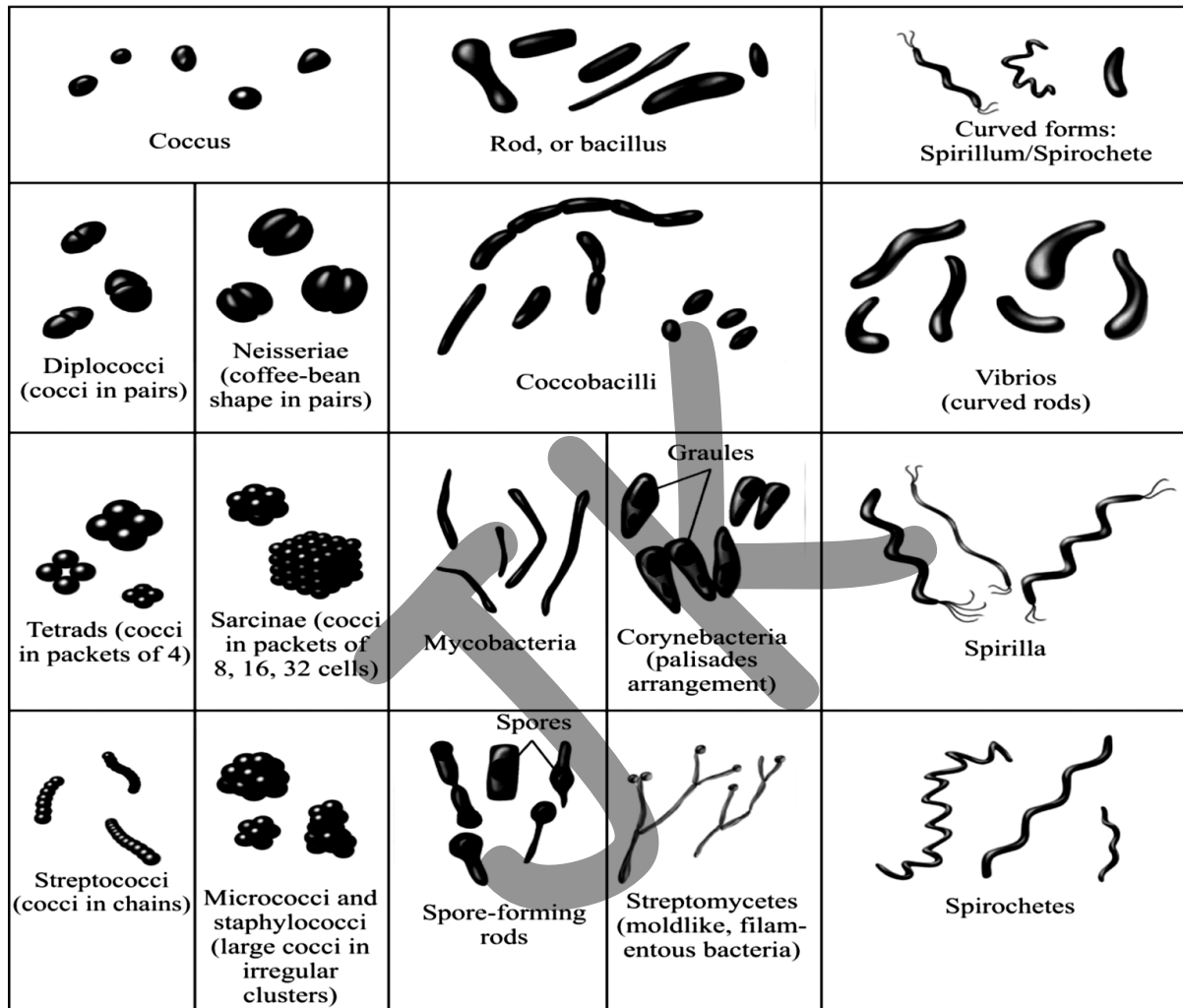
BACTERIAL STRUCTURE

The outer layer or cell envelope consists of two components, a rigid cell wall and beneath it a cytoplasmic or plasma membrane. The cell envelope encloses the protoplasm, comprising the cytoplasm, cytoplasmic inclusions such as ribosomes and mesosomes, granules, vacuoles and the nuclear body.

Cell wall

Beneath the external structures is the cell wall. It is very rigid & gives shape to the cell. Its main function is to prevent the cell from expanding & eventually bursting due to water uptake. Cell Wall constitutes a significant portion of the dry weight of the cell and it is essential for bacterial growth & division. The cell wall cannot be seen by direct light microscopy and does not stain with simple stains. It may be demonstrated by microdissection, reaction with specific antibodies, mechanical rupture of the cell, differential staining procedures or by electron microscopy.

Chemically the cell wall is composed of peptidoglycan. Mucopolysaccharide (peptidoglycan or murein) formed by N acetyl glucosamine & N acetyl muramic acid alternating in chains, cross linked by peptide chains. Embedded in it are polyalcohol called Teichoic acids. Some are linked to Lipids & called Lipoteichoic acid. Lipoteichoic acid link peptidoglycan to cytoplasmic membrane and the peptidoglycan gives rigidity.



The functions of Teichoic acid are

- gives negative charge
- major antigenic determinant
- transport ions
- anchoring
- external permeability barrier

Outer Membrane

Outer membrane is found only in Gram-negative bacteria, it functions as an initial barrier to the environment and is composed of lipopolysaccharide (LPS) and phospholipids

Lipopolysaccharide (LPS)

The LPS present on the cell walls of Gram-negative bacteria account for their endotoxic activity and antigen specificity.

A bacterium is referred as a protoplast when it is without cell wall. Cell wall may be lost due to the action of lysozyme enzyme, which destroys peptidoglycan.

This cell is easily lysed and it is metabolically active but unable to reproduce.

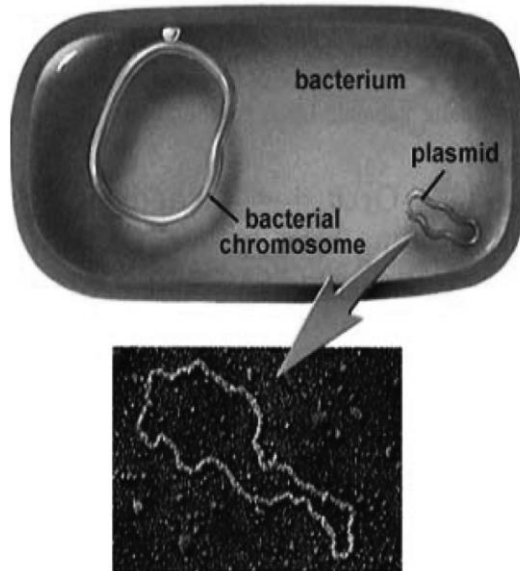
A bacterium with a damaged cell wall is referred as spheroplasts. It is caused by the action of toxic chemical or an antibiotic, they show a variety of forms and they are able to change into their normal form when the toxic agent is removed, i.e. when grown on a culture media.

Cytoplasmic membrane

Cytoplasmic membrane is present immediately beneath the cell wall, found in both Gram positive & negative bacteria and it is a thin layer lining the inner surface of cell wall and separating it from cytoplasm. It acts as a semipermeable membrane controlling the flow of metabolites to and from the protoplasm.

Cytoplasm

The cytoplasm is a Colloidal system containing a variety of organic and inorganic solutes containing 80% Water and 20% Salts, Proteins. They are rich in ribosomes, DNA & fluid. DNA is circular and haploid. They are highly coiled with intermixed polyamines & support proteins. Plasmids are extra circular DNA.



Ribosomes

They are the centers of protein synthesis. They are slightly smaller than the ribosomes of eukaryotic cells

Mesosomes

They are vesicular, convoluted tubules formed by invagination of plasma membrane into the cytoplasm. They are principal sites of respiratory enzymes and help with cell reproduction

Cytoplasmic Inclusions

The Inclusion bodies are aggregates of polymers produced when there is excess of nutrients in the environment and they are the storage reserve for granules phosphates and other substances. Volutin granules are polymetaphosphates which are reserves of energy and phosphate for cell metabolism and they are also known as metachromatic granules.

Nucleus

The Nucleus is not distinct and has no nuclear membrane or nucleolus and the genetic material consist of DNA. The cytoplasmic carriers of genetic information

are termed plasmids or episomes.

Capsule

Capsule is the outer most layer of the bacteria (extra cellular). It is a condensed well defined layer closely surrounding the cell. They are usually polysaccharide and if polysaccharide envelops the whole bacterium it is capsule and their production depends on growth conditions. They are secreted by the cell into the external environment and are highly impermeable. When it forms a loose mesh work of fibrils extending outward from the cell they are described as glycocalyx and when masses of polymer that formed appear to be totally detached from the cell and if the cells are seen entrapped in it are described as slime layer.




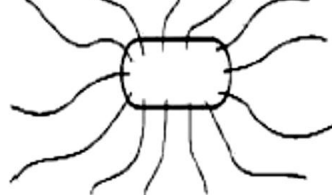
The Capsule protects against complement and is antiphagocytic. The Slime layer & glycocalyx helps in adherence of bacteria either to themselves forming colonial masses or to surfaces in their environment and they resist phagocytosis and desiccation of bacteria.

Flagella

Flagella are long hair like helical filaments extending from cytoplasmic membrane to exterior of the cell. Flagellin is highly antigenic and functions in cell motility. The location of the flagella depends on bacterial species as polar situated at one or both ends which swims in back and forth fashion and lateral at along the sides.

The parts of flagella are the filament, hook and the basal body. Filament is external to cell wall and is connected to the hook at cell surface, the hook & basal body are embedded in the cell envelope. Hook & filament is composed of protein subunits called as flagellin. Flagellin is synthesized within the cell and passes through the hollow centre of flagella. The arrangement of flagella may be described as

- (i) Monotrichous – single flagella on one side
- (ii) Lophotrichous – tuft of flagella on one side
- (iii) Amphitrichous – single or tuft on both sides
- (iv) Peritrichous – surrounded by lateral flagella

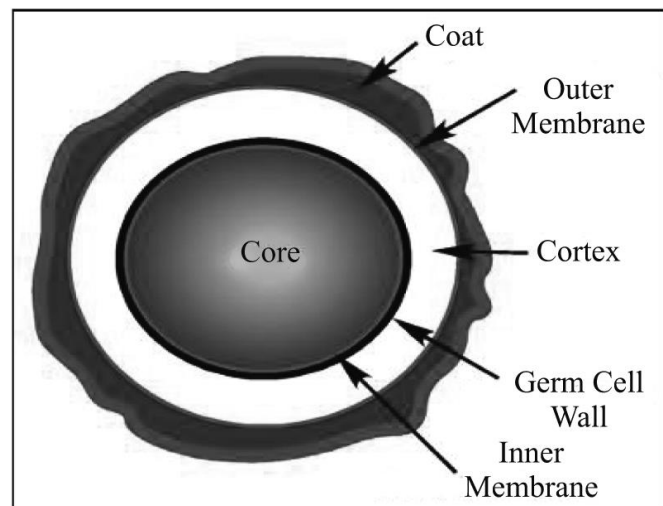
Structure	Flagella Type	Example
	Monotrichous	Vibrio cholerae
	Lophotrichous	Bartonella bacilliformis
	Amphitrichous	Spirillum serpens
	Peritrichous	Escherichia coli

Pili / Fimbriae

Hair-like proteinaceous structures that extend from the cell membrane to external environment are pili which are otherwise known as fimbriae. They are thinner, shorter and more numerous than flagella and they do not function in motility. The fimbriae is composed of a subunit called pilin. There are two types of pili namely Non-sex pili (Common pili) eg. fimbriae or type IV and the sex pili. The fimbriae are antigenic and mediate their adhesion which inhibits phagocytosis. The sex pili help in conjugation.

Spore

Some bacteria have the ability to form highly resistant resting stage called spores, which helps them to overcome adverse environmental conditions that are unfavorable for vegetative growth of cell. They are not a reproductive form and not a storage granule. These spores are resistant to bactericidal agents and adverse physical conditions. Each spore can give rise to only one endospore which plays a role in heat resistance. Spores consist of three layers namely core, cortex and spore coat.



Characteristics of Bacteria Cell Structures

Structure	Functions(s)	Predominant chemical composition
Flagella	Swimming movement	Protein
Pili		
Sex pilus	Stabilizes mating bacteria during DNA transfer by conjugation	Protein
Common pili or fimbriae	Attachment to surfaces; protection against phagotrophic engulfment	Protein
Capsules (includes “slime layers” and glycocalyx)	Attachment to surfaces; protection against phagocytic engulfment, occasionally killing or digestion; protection against desiccation	Usually polysaccharide; occasionally polypeptide
Cell wall		
Gram-positive bacteria	confers rigidity and shape on cells	Peptidoglycan (murein) complexed with teichoic acids
Gram-negative bacteria	confers rigidity and shape; outer membrane is permeability barrier; associated LPS and proteins have various functions	Peptidoglycan (murein) surrounded by phospholipid protein-lipopolysaccharide “outer membrane”
Plasma membrane	Permeability barrier; transport of solutes; energy generation; location of numerous enzyme systems	Phospholipid and protein
Ribosomes	Sites of translation (protein synthesis)	RNA and protein
Inclusions	Often reserves of nutrients; additional specialized functions	Highly variable; carbohydrate, lipid, protein or inorganic
Chromosome	Genetic material of cell	DNA
Plasmid	Extrachromosomal genetic material	DNA