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BACTERIA



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Morphology and Fine Structure

- Bacterial cells are characterized by their size, shape, structure and arrangement
- Cells are very small, approximately 0.5 to 1.0 μm in diameter with a rigid cell wall
- Individual cells are spherical (cocci), rod (bacillus) like, or helical (spirilla) or pleomorphic
- Some (*Streptomyces* species) form long branched multinucleate filaments called hyphae



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External Structures

- **Flagella** are hair like, helical appendages that protrude through the cell wall and are responsible for motility
- Flagellum is composed of three parts: basal body, hook, and a helical filament
- Most motile bacteria are capable of directed swimming towards or away from chemical compounds referred to as chemotaxis



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External Structures

- **Pili** (fimbriae) are hollow, nonhelical, filamentous appendages that are thinner and shorter than flagella
 - F pilus serves as entry point of genetic material
 - Also aid in entry of several human pathogens
- **Capsule** is a viscous substance forming a covering envelope around the cell wall
 - Protect the cell from drying by binding water
 - Block attachment of bacteriophages
 - Inhibit the engulfment of pathogenic bacteria by WBC



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Cell Wall

- **Cell Wall** – is a rigid structure that gives shape to the cell and function is to prevent the cell from expanding
 - Walls of Gram-negative bacteria are more complex with an outer membrane
 - Composed of peptidoglycan (more in Gram-positive than Gram-negative)
 - Beneath the cell wall is the cytoplasmic membrane - serves as hydrophobic barrier to penetration by most water-soluble molecules



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Cytoplasmic Membrane

- **Cytoplasmic membrane** contains various enzymes involved in respiration, and in synthesis of capsule and cell wall components
- Is an important functional structure and damage to it can result in death of the cell
- **Protoplast** – portion of a bacterial cell consisting of the cytoplasmic membrane and the cell material bounded by it
- Invaginations of the cytoplasmic membrane form vesicles termed mesosomes



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Cytoplasm

- Cell material bounded by the cytoplasmic membrane is divided into cytoplasmic area rich in RNA bodies known as ribosomes
 - Chromatinic area rich in DNA
 - Fluid portion with dissolved substances
 - Absence of endoplasmic reticulum
 - Sedimentation coefficient of procaryotes is 70 Svedberg units composed of 50S and 30S subunit
 - Concentrated deposits known as metachromatic granules are detected in the cytoplasm



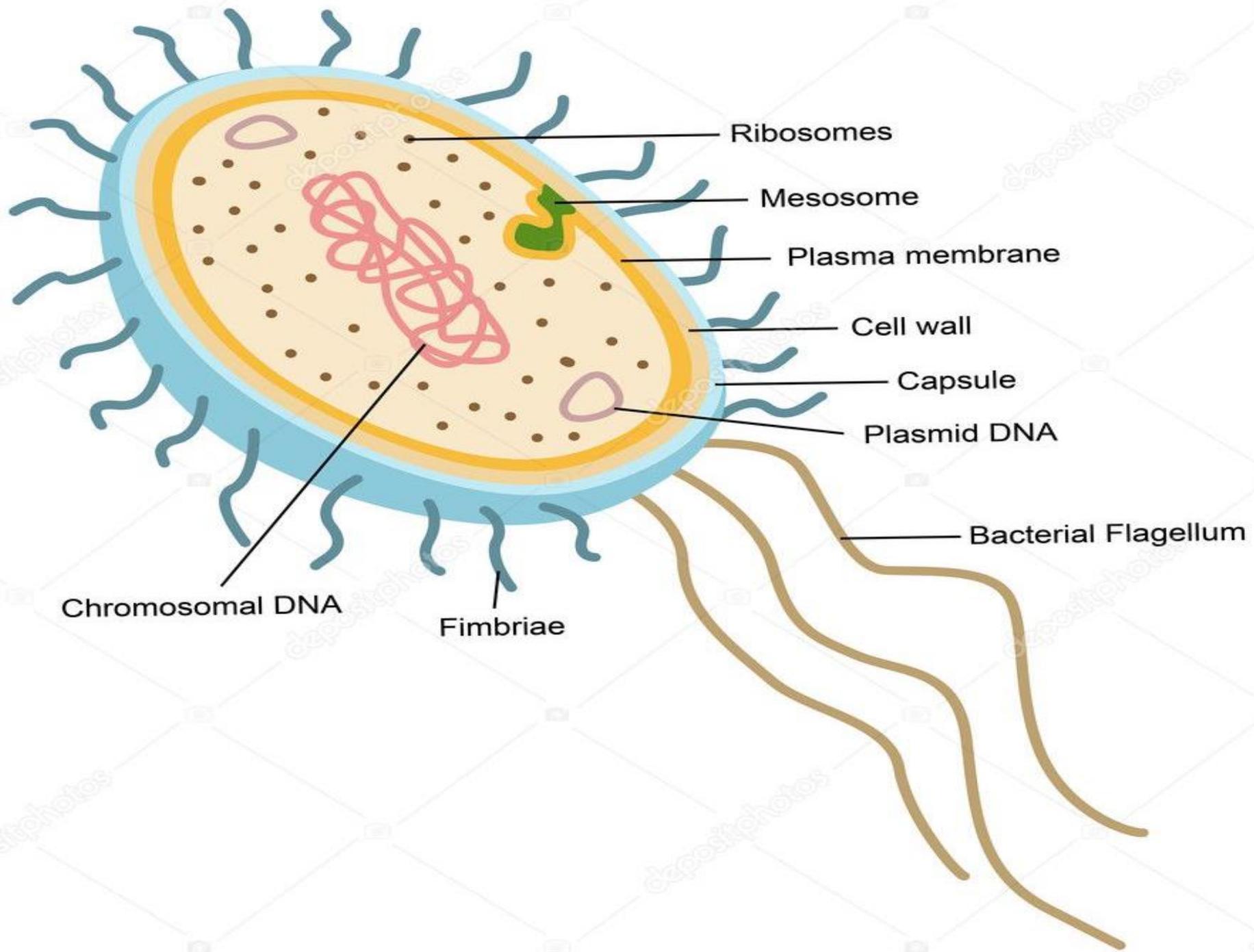
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Nuclear Material and Spores

- An area near the center of the cell that is regarded as a nuclear structure and the DNA (nucleoid) is confined to this area
 - Consists of a single, circular DNA in which all the genes are linked
- Certain species produce spores either within the cell (endospores - *Clostridium*) or external to the cell (exospores - *Methylosinus*)
- Actinomycetes form branching hyphae in which spores develop (sporangiospores in sporangium)
- Cysts are dormant, thick walled forms that develop by differentiation of a vegetative cell - *Azotobacter*

STRUCTURE OF A BACTERIAL CELL





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Nutritional Requirements

- Carbon for synthesizing cell components
- Nitrogen, sometimes atmospheric nitrogen, while others thrive on nitrates, nitrites, ammonium salts/amino acids
- Require at least small amounts of CO₂
- Metal ions such as K⁺, Ca⁺², Mg⁺², and Fe⁺² are required for normal growth
- Sulphur is needed for synthesis of certain amino acids
- Phosphorus is required in the form of phosphate - essential component of nucleic acids, phospholipids



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Nutritional Requirements

- Vitamins or vitamin like compounds that function either as coenzymes or as building blocks for coenzymes and some synthesize from other compounds in the medium
- Water is essential and all nutrients must be in aqueous solution before they enter the cell and water being a chemical reactant is required for many hydrolytic reactions



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Nutritional Classification of Bacteria

- **Phototrophs** – Utilize light as energy source
- **Chemotrophs**– rely on chemical compounds rather than light for energy (cannot carry out photosynthesis)
- **Lithotrophs** – use reduced inorganic compounds as electron donors
- **Organotrophs** – use organic compounds as electron donors



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Nutritional Classification of Bacteria

- **Photolithotrophs** – use inorganic compounds such as H_2S source of electrons (photolithotrophs – *Chromatium okeinii*), while some use organic compounds such as fatty acids and alcohols as electron donors (photoorganotrophs - *Rhodospirillum*)
- Use inorganic compounds as source of electrons (**chemolithotrophs - *Nitrosomans***) and others use organic compounds such as glucose (**chemoorganotrophs – *Pseudomonas pseudoflora***)



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Nutritional Classification of Bacteria

- **Autotrophic** - synthesize all their food from inorganic substances such as CO_2 , H_2O , H_2S)
 - **Photoautotrophs** – capture the energy of sunlight and transform into chemical energy where CO_2 is reduced to carbohydrates, has chlorophyll pigment in the cell and its main function is to capture sunlight – *Cyanobacteria*
 - **Chemoautotrophs** – oxidize certain inorganic substances with the help of atmospheric oxygen



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Nutritional Classification of Bacteria

- **Heterotrophic** – obtain food from organic substances, living or dead (pathogenic bacteria)
 - **Photoheterotrophs** – utilize light energy but cannot use CO_2 as their sole source of carbon
 - **Chemoheterotrophs** – obtain both carbon and energy from organic compounds
 - **Saprophytic** – obtain food from the dead and organic decaying matter (*Bacillus mucoides*, *B. ramosus*)



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Nutritional Classification of Bacteria

- **Parasitic bacteria** – obtain their nutrition from the tissues of the hosts on which they grow and some may cause serious diseases (pathogens – *Bacillus anthracis*, *B. tuberculosis*, *B. tetani*)
- **Symbiotic bacteria** – live in close association with other organisms (symbiosis) and are considered beneficial – *B. azotobacter*, *Clostridium*, *Rhizobium* – fix atmospheric nitrogen into nitrogenous compounds that are utilized by plants)



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Cultivation of Bacteria

- **Bacteriological media** – chemically defined media needed for the cultivation
- Complex raw materials such as peptones, meat and yeast extract support growth of heterotrophic bacteria
- Agar/broth is included as a non-nutritive solidifying/liquid agent
- Yeast extract provide B vitamins and other growth promoting substances
- Supplements such as bovine rumen fluid, animal blood, extracts of animal or plant tissues may be required for the cultivation of certain fastidious heterotrophs



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Cultivation of Bacteria

- **Selective Media** – provide nutrients that enhance the growth of a particular type of bacterium and may inhibit other types of organisms that may be present
- **Differential Media** – supplements/reagents added to the culture media may allow differentiation of various kinds of bacteria (blood agar media)



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Cultivation of Bacteria

- **Non-selective media** – media that supports growth of majority of the organisms
- **Solid and semisolid media** – solid/semisolid media is used for cultivation of bacteria and has agar (1.5 – 2%) and solid media is used for isolating bacteria and for determining the characteristics of colonies
 - Silica gel is sometimes used as an inorganic solidifying agent for autotrophic bacteria



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Preparation of Media

- Media are prepared by compounding the required individual ingredients, or by adding a dehydrated product to water
- After adjusting the pH, agar is added and the medium is boiled to dissolve the agar
- Media is dispensed in tubes, sterilized by autoclaving and dispensed in agar plates



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Food Borne Pathogens

- Bacteria

- Gram Positive

- *Staphylococcus aureus* spp
- *Bacillus cereus*
Campylobacter spp
- *B. anthracis*
- *Clostridium botulinum*
- *C. perfringens*
enterocolitica
- *Listeria monocytogenes*

- Gram Negative

Salmonella

Escherichia coli O157:H7

Brucella spp

Yersinia



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Food Borne Pathogens

- Viruses – *Hepatitis, Rotavirus*
- Prions – New variant of CJD (Creutzfeldt Jakob disease)
- Tape worms – *Taenia* spp
- Round worms – *Trichinella* spp
- Protozoa – *Toxoplasma* spp, *Sarcocystis* spp