Microbial cell structure
A major biologic division separate the eukaryotes organisms containing a membrane bound nucleus from prokaryotic organisms in which DNA is not physically separated from the cytoplasm (Primitive cells).
Eukaryotic are termed protists which include algae, protozoa, fungi and slime molds. They are large in size (true cells).
Prokaryotic include bacteria mycoplasma, chlamydia and rickettsia.
Eukaryotes and prokaryotes are organisms because they contain all of enzymes required for the replication and posses the biologic equipment necessary for the production of metabolic energy so they are distinguished form viruses which depends upon host cells for there necessary functions.

Optical method:
Are methods for observation and study of microorganisms:
1. The light microscope: the resolving power of light microscope (L.M.) is about half the wave length of the light being used. Microscopes employ a 90-power objective lens x10 power ocular lens that magnifying the specimen 900 times.
2. The electron microscope: have a high resolving power that is used to observe the detailed structures of prok. and eukar cells. This is due to the fact that electrons have a much shorter wave length than the photons of white light.

EM is of two types:
a. Transmission electron M. (TEM)
b. Scanning electron M. (SEM).
3. Dark field illumination: There is a special condenser is used that both blocks direct light rays and reflects it off a mirror on the side of the condenser at an oblique angle. Its used for observing organisms (such as spirochetes) which is less than 0.2μm in diameter and therefore cannot be observed with direct light.
4. Phase phase microscopes used for examination of internal structures in transparent living cells using a special optical systems.
5. Autoradiography: is used to reveal the position of the radio active label cells that have incorporated radio active atoms such as in cases in following the replication of DNA.

**Prokaryotic**

The prokaryotic cells simpler than the eukaryotic cell at every level, with one exception: the cell envelope is more complex.

**Bacterial cell organelles**

**The Nucleoid:**

1. It’s equivalent to the eukaryotic nucleus can be seen in L.M. it is Feulgen-positive indicating the presence of DNA. A histone-like proteins exist in bacteria DNA similar to histone protein that bind to eukaryotic DNA by ionic interactions.
2. The nuclear membrane and the mitotic apparatus present in eukaryotic cells are absent in prokaryotes.

3. The nuclear region is filled with DNA fibrils the nucleoid of bacterial cells consist of a single continuous circular folded molecules of haploid chromosome.
4. The number of copies of these chromosomes in a cell depend on the stage in the cell cycle.
5. However bacteria have a linear chromosome as in Borrelia Bugdorferi.
6. A small amounts of RNA are present in nucleoid of most bacteria.
7. Bacterial DNA is associated at one point with an invagination of the cytoplasmic membrane called a mesosome this attachment plays a role in the separation of the two sister chromosomes following replication.
8. a. On the other hand the nucleus of eukaryotic cell is bounded by a membrane continuous with the endoplasm reticulum. The nuclear membrane exhibits the selection permeability between nucleus and cytoplasm.
   c. Eukaryotic chromosome contain linear DNA arrange in double helix in the nucleus.
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Lecture 2

Cytoplasmic structures:
1. Prokaryotic cells lack the endoplasmic reticulum and the self-reproducing plastid as mitochondria, golgi apparatus, and chloroplasts that present in eukaryotes.
2. The electron transport enzyme for respiration is localized in the cytoplasmic membrane instead of mitochondria.
3. The photosynthetic pigment of photosynthetic bacteria is localized in membrane arrangement vesicles underlying the cell membrane.  
4. Bacteria often store reserve material in the form of insoluble granules. When the source of nitrogen, sulfur, or phosphorus is limited or when the pH is low, excess carbon in the medium is converted to various polymers of glucose such as starch and glycogen. These granules are then used as a carbon source when protein nucleic acid synthesis is resumed. Similarly, certain bacteria oxidize the sulfide form H₂S producing intracellular granules of polyphosphate as reserves of inorganic phosphate granules are termed volutine granules or metachromic granules that are present in corynebacteria.
5. Microtubular structures which are characteristic of eukaryotes are generally absent in prokaryotes.
6. Certain groups of bacteria contain protein-bounded vesicles in their cytoplasm.

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The Cell Envelope

The layers that surround prokaryotic cells are referred collectively the cell envelopes. The bacteria are differentiated to gram-positive and gram-negative bacteria according to the difference in their cell envelope.
The G+ve envelope is relatively simple consisting of two-three layers:
1. The cytoplasmic membrane.
2. A thick peptidoglycan layer.
3. In some bacteria an outer layer called capsule
The G-ve envelope is highly complex multilayer structure:
1. Cytoplasmic membrane (inner membrane in G-ve-).
2. Single planar sheet of peptidoglycan.
3. Complex layer called outer membrane.
4. An outer most membrane capsule may be present.
   • The space between inner and outer membrane is called periplasmic space.

The cytoplasmic membrane
Structure:
The cell membrane is a typical “unite membrane” composed of phospholipid and proteins.
The membrane of prokaryotic differ from those of eukaryotic by the absence of sterols. Convoluted invaginations of cell membrane (C.M.) specialized structures are called “mesosomes”.
   There are two types of mesosomes:

   1. Septal mesosomes that function in the formation of cross walls during cell division. The bacteria chromosome (DNA) is attached to septal mesosomes.
2. Laterla mesosomes.

Function of Cytoplasmic Membrane:
1. Selective permeability and transport of solutes: the C.M. forms a hydrophobic barrier impermeable to most hydrophilic molecules. Several transport systems are exist that enable the cell to transport nutrients into and waste product out of the cell. These transport systems work against a concentration gradient and increase the conc. of nutrients inside the cell a function that requires energy.
   There are 4 general transport mechanisms involved in membrane transport:
   a. Facilitated diffusion.
   b. Binding protein-dependent transport.
   c. Group translocation.
   d. Chemiosmotic driven transport.
2. Electron transport and oxidative phosphorylation. The cytochrome and other enzymes of the respiratory chain are located in the cell membrane in prokaryotes is a functional analog of the mitochondrial membrane in eukaryotic cells.
3. Excretion of hydrolytic exoenzymes that degrade the organic polymers to subunits small enough to penetrate the cell membrane. All organisms that use macromolecular organic polymers (as proteins, polysaccharides and lipids) as a source of nutrients excrete hydrolytic enzymes.

4. Biosynthetic functions: cell membrane is the site of the carrier lipids and enzymes used in cell wall synthesis also it carry some proteins of the DNA replication complex.
5. Chemotactic systems: organs of locomotion of bacteria as flagella bind to specific receptors in cell membrane.

**The cell Wall Functions:**
1. The osmotic pressure of bacteria is sufficient to burst the cell unless the presence of the strong cell wall that composed of peptidoglycan (murein) (or it's called mucoprotein).
2. Bacteria are classified to G+ve or G-ve according to their response to the differential stains method called Gram’s stains. The difference reside on the cell wall differences.
3. Cell wall plays an essential role in cell division as well as its own biosynthesis.
4. Cell wall is the site of antigenic determinates of the cell surface as the lipopolysaccharide of G-ve cell wall that represents the endotoxin activity of such bacteria.
5. Cell wall that selectively permeable.

**Structure:** The basal structure of cell wall is the peptidoglycan layer.
1. The peptidoglycan layer: it is a complex polymer consist of three parts:
   a. A backbone composed of alternating N-acetyl glucosamine and N-acetyl muramic acid.
   b. A set of identical tetrapeptide side chains attached to N-acetyl muramic acid.
2. Special components of G+ve cell wall contain a thick layer of peptidoglycan and teichoic acid and teichuronic acid that account for 50%
of cell wall weight. In addition some G+ve wall may contain polysaccharide. There are 2 types of teichoic acid:
a. Wall teichoic acid that linked to peptidoglycans.
b. Membrane teichoic acid that linked to membrane glycolipid. Teichoic acid constitute the surface antigens of G+ve bact.

3. Special components of G-ve cell wall: three component lie outside a single planner sheet of peptidoglycan layer, these component are:
a. Lipoprotein: that cross link the outer membrane and peptidoglycan layer and stabilize them together.
b. Outer membrane: it’s a bilayered structure: and inner leaflet resembles in composition the cell membrane. While the phospholipids of the outer leaflet are replaced by lipopolysaccharides molecules. Thus this bilayer differ from the bilayer of cell membrane. The outer membrane protect the cell from hydrophobic as well as hydrophilic molecules. The outer membrane has special channels called porins that permit the passive diffusion of low molecular weight hydrophilic compounds as sugars and amino acid also large antibiotic molecules penetrate the outer membrane slowly that makes G-ve bacteria much resistant to antibiotics.

c. Lipopolysaccharide: it consist of complex lipid called lipid A to which is attached a polysaccharides molecules that LPS is extremely toxic to animals has been called endotoxin of G-ve. It’s firmly bound to the cell surface and is released only when the cells are lysed. When LPS is split into lipid A and polyssacharide all of toxicity is associated with the former. (lipid A). The polysaccharide on the other hand represents a major surface antigen of bacteria called O-antigen.
d. The periplasmic space: the space between the inner and the outer membrane called the periplasmic space which contain the murein layer (peptidoglycan) and a gel like solution of proteins. The periplasmic proteins include binding proteins for amino acids, vitamins, sugars hydrolytic enzymes and detoxifying enzymes that inactivate certain antibiotics.

Cell wall growth:
As the protoplast increase in mass, the cell wall is elongated by the intercalation of newly synthesized sub-units into the various wall layers.

Protoplasts, spheroplasts and L-Forms:
Removal of bacterial wall may be accomplished by hydrolysis with lysozymes or blocking peptidoglycan biosynthesis with an antibiotic such as penicillin. In osmotically protective media such treatment librate protoplast from G+ve bacteria and spheroplast from G-ve bacteria (retain
outer membrane and entrapped peptidoglycans). If such cells are able to grow and divide they are called L-forms. L-forms are produced with penicillin treatment rather than lysozyme since they need the presence of residual peptidoglycan. Some L-Form can revert the normal form upon removal of inducing stimulus. Thus they are able to resynthesize a normal cell wall from the residual peptidoglycan some bacteria produce L-Forms spontaneously. L-Forms produce chronic infection in the host since they persist in protective regions in the body. Since L-Forms do not possess a cell wall so L-Forms infections are resistant to antibiotic as penicillin that act on the cell wall of bacteria.
Dividing Bact. cell

Protein $\rightarrow$ Lipid $\rightarrow$ Membrane

Folded polypeptide embedded in phospholipid

Cytoplasmic membro.

(UNITED MEMBRO. MODEL)
N. acetyl glucosamine
N. acetyl muramic acid
tetrapeptide chain
peptide bridge
Structure of bacterial cell wall (peptidoglycan layer) or mucopeptide layer

Gram-negative cell envelope
L. alanine
D. glutamate
Diaminopimelate
N-acetyl muramic acid