M220 Lecture 5

Discuss principle differences and similarities between prokaryotic and eukaryotic cells- See chart in Ch. 4

Bacterial Structure (outside structures first, then work inward)

1. Glycocalyx—also known as extracellular polymeric substance or the slime layer. When well-organized and firmly attached it is called a capsule. It is often described as gel-like, viscous, mucilaginous and slimy. Can be up to 10 micrometers in diameter. It is made internally and excreted by the cell. Possible functions:
   a. Protective—against drying; against phagocytosis. Phagocytic immune cells such as monocytes and neutrophils cannot engulf a bacterial cell that has become too enlarged due to a capsule layer. Therefore, the capsule can contribute to causing virulence.
   b. May act as a food reservoir
   c. May be a sloppy method of waste disposal
   d. May be a combination of the above

The capsule is not essential to life. A cell can lose a capsule without an effect on growth or reproduction. However, loss of capsules may cause loss of virulence.

Colonies of capsule positive bacteria are often mucoid and shiny (smooth).

Capsules are associated with immunologic specificity. This means that specific antibodies can attach to capsular material. (Capsular material can be antigenic) The Quellung reaction is utilized to identify one of the bacterial etiologic agents of pneumonia (Streptococcus pneumoniae). Specific antibodies are used to target this organism’s capsule. This will cause swelling and make these bacteria highly recognizable under the microscope for purposes of identification.

Chemically, most capsules are polysaccharides.

*Klebsiella pneumoniae*, a Gram negative rod that can cause pneumonia and *Bacillus anthracis* a Gram positive rod that causes anthrax, are examples of bacteria that produce capsules.

2. Flagella (singular flagellum)—Whip-like appendages that provide a mechanism for motility. They are thin (below the resolution of the light microscope—approximately 0.02 micrometers wide). Can use a special flagella stain to visualize. A mordant (any additive that intensifies a staining reaction) will precipitate upon the flagella to enlarge this structure. A stain is then used for visualization under the light microscope.

Flagella in prokaryotes are simple in structure. They are made up of repeating units of a single type of protein. Flagella can be used to help classify bacteria.
   a. Atrichous flagellation—organisms without flagella
   b. Unirichous flagellation—organisms with one (usually polar) flagellum
   c. Amphitrichous (bipolar) flagellation—organisms with flagella at both ends of the cell
   d. Lophotrichous flagellation—organisms that have tufts (two or more) of flagella.
e. Peritrichous flagellation-organisms that have flagella distributed over the entire cell. Members of the genus *Proteus* display this. When grown on a plate, they sometimes become “swarmers” where they can spread out across the entire plate.

3. Axial filaments-structure for motility found in Spirochetes. They are positioned from one pole to the other within the cell. They are flexible and can contract and then spring forward. They are simple in structure like flagella.

4. Fimbriae (singular fimbria), Pili (singular pilus)- hairlike appendages that are shorter and thinner than flagella. They are used for attachment and transfer of DNA. There can be hundreds on a cell. *Neisseria gonorrhoeae* has fimbriae (pili) which it uses to attach to the urethral lining and therefore stay anchored during urination. Pili may cause bacterial cells to stick to each other. The appearance of membranes (thin films on broth surfaces), pellicles (thick, tough films on broth surfaces) and floc’s (rafts of cells in broth media) can be explained by the presence of pili. A sex pilus may attach two bacteria together (conjugation) for purposes of conveying genetic (DNA) material. Pili may serve as receptor sites for viruses.

5. Cell wall-provides bacteria with shape and protection from lysis during osmotic imbalances. Prokaryotic cell walls are more complex than the cell walls found in eukaryote cells that have cell walls (plant cell walls for example are made up of cellulose). Examine differences between Gram positive cell wall structure and Gram negative cell wall structure. Gram positive cell walls are thicker yet less complex than Gram negative cell walls. The Gram positive cell wall is almost entirely made up of peptidoglycan (small amount of peptidoglycan in Gram negative cell walls). Peptidoglycan provides for a rigid and yet permeable framework. It is a heteropolymer (the subunits consist of different materials). It consists of amino sugars (NAG and NAM) and amino acids (DAP or dianminopimelic acid is a strange amino acid found in peptidoglycan). Small amount of teichoic acid is found in Gram positive cell walls. Gram negative cell walls are thinner yet more complex in structure. They consist of a small amount of peptidoglycan and an additional layer of LPS (lipopolysaccharide) and LP (lipoprotein). The LPS component is associated with endotoxin (more later). Gram positive bacteria are sensitive to penicillin, are inhibited by crystal violet stain and are susceptible to lysozyme digestion. This is due to the large amount of peptidoglycan. Members of the genus *Mycoplasma* lack cell walls. They are pleomorphic and must exist in hyperosmotic conditions (rich lung exudates). They are free living forms of life. L-forms (named after the Lister Institute) are cells that have lost their cell walls as a result of antibiotic exposure. Protoplasts are Gram positive bacteria that have been stripped of their cell walls. Spheroplasts are Gram negative bacteria that have been partially stripped of cell wall material.