The Bacteria

Lecture #9 – Dr. Gary Mumaugh

Subjects Covered

- Bacteria: the Good, the Bad and the Ugly
- Bacteria: Classifications
- Bacteria: Role in the Global Ecosystem
- Pathogenic Bacteria

Bacteriology

- The study of bacteria
- We should appreciate the resourcefulness of the organism that is able to manifest itself in both beneficial and harmful ways
    - Escherichia coli linked to tainted spinach and other agricultural food products
    - The actinomycetes - produce useful antibiotics such as streptomycin and nocardicin while others live symbiotically inside of animals and humans or elsewhere on the body or the roots of certain plants where they convert nitrogen into a worthwhile form
- Additional positive usages of bacteria include:
    - adding culture to yogurt and sour to sourdough bread
    - breaking down dead organic matter
    - constituting the base of the food web in the majority of habitats
- Bacteria are seen to be of such great importance due to (both negatively and positively) their flexibility, capacity for rapid growth and reproduction, and extraordinary age - in existence for approximately 3.5 billion years
- By definition, bacteria are microscopic, unicellular organisms
- They tend to be found in coccus (spherical) or rod-shaped form
- Traditionally, the term 'bacteria' was applied to all microscopic, single-celled prokaryotes
- Present day, these evolutionary domains have been renamed now as: Bacteria and Archaea.
- Bacteria can be found in every habitat and environment on earth. For this reason, they are known as 'ubiquitous' organisms throughout the world.
- The quantity of bacteria that exist is staggering
    - Within a single gram of soil, there are literally ten billion bacterial cells
    - Bacteria also play a beneficial role in the environment and sustainable arena
- They perpetuate the cycle of nutrients throughout the environment, such as the channeling of nitrogen from the atmosphere
- Pathogenic bacteria does play a significant role in the establishment of many physiological infectious diseases, i.e., cholera gonorrhea, and tuberculosis
- Non-pathogenic bacteria is a contributor to treatment protocols the likes of antibodies and purification procedures for industrial operations

Bacteria: Classifications

The majority of bacteria may be grouped into one of three categories:

- **Aerobic** bacteria -- Thrive in the presence of oxygen and needs oxygen for continued growth and existence
- **Anaerobic** bacteria -- Cannot tolerate gaseous oxygen. Examples of these include those which live in deep underwater sediments, or those with the ability to cause bacterial food poisoning.
- **Facultative anaerobes** -- Prefer growing in the presence of oxygen, in the absence of it, they still have the ability to exist.

Bacteria: How They Obtain Energy

- Heterotrophs
    - Derive energy from breaking down complex organic compounds they take in from the environment
        - Found in decaying material along with those that depend upon fermentation or respiration for energy refueling purposes
- Autotrophs
    - Fueled by light energy, these bacteria affix to carbon dioxide in an effort to make their own food source
        - this may be fueled by light energy or by oxidation of nitrogen, sulfur, or other elements

Bacteria: Role in the Global Ecosystem

- Bacteria as we stated earlier does play a beneficial role in the on-going ebb and flow of the ecosystem
    - Both on land and in water, continuous activities are heavily dependent upon the activities of bacteria
    - The steady cycling of nutrients (carbon, nitrogen, and sulfur) is accomplished via bacteria's non-stop movement
- One of the most significant roles bacteria plays is that of decomposition
    - This is the process by which organisms at their time of death have a shut-off supply of carbon
    - Carbon dioxide plays a pivotal role in the process of photosynthesis (necessary in the continued life cycle of plants)
    - Without a supply of carbon dioxide, there would be no photosynthesis and, hence, no food for plants
- By releasing these chemical nutrients of carbon dioxide back in to the environment, bacteria is able to help sustain the existence of all living things.
- Another pivotal role of bacteria is that it also cycles nitrogen back into the environment
    - Indispensable chemical for plants, they are accustomed to deriving it from the soil (as they cannot acquire it from the atmosphere) and, thus, being depend upon it for the maintenance of their health and growth

Bacteria: Role in the Global Ecosystem - continued

- Plants derive nitrogen via what is known as nitrogen fixation via such bacteria as: *Rhizobium*, *Cyanobacteria*, *Anabaena*, *Nostoc*, and *Spirulina*
- As part of their basic metabolism, these forms of bacteria are able to convert gaseous nitrogen into nitrates (or nitrites)
    - The resulting products are thereby released into the environment.

Bacteria Organelles

- The DNA of Bacteria, which lacks the membrane-bound nuclei of eukaryotes, forms a bundle known as a nucleoid
- There exists no membrane around the center and the DNA is not bound to proteins as it is within eukaryotes
- In contrast with eukaryote DNA, which is organized into linear pieces; the chromosomes of bacterial DNA form loops
- Bacteria contain plasmid **(**small loops of DNA) which can be transmitted from one cell to another, either in the course of sex (yes, bacteria do have distinct sexual affinities) or via viruses
- Differing from eukaryotes, bacteria do not contain membrane-bound organelles
- The purpose of the membrane is to increase the potential surface area on which photosynthesis can take place
- In all groups of bacteria (except one-Mollicutes which includes such pathogens as mycoplasmas), the cell membrane is surrounded by a cell wall
- Because the composition and structure of the cell wall vary among species, it is an important character for identifying and classifying bacteria

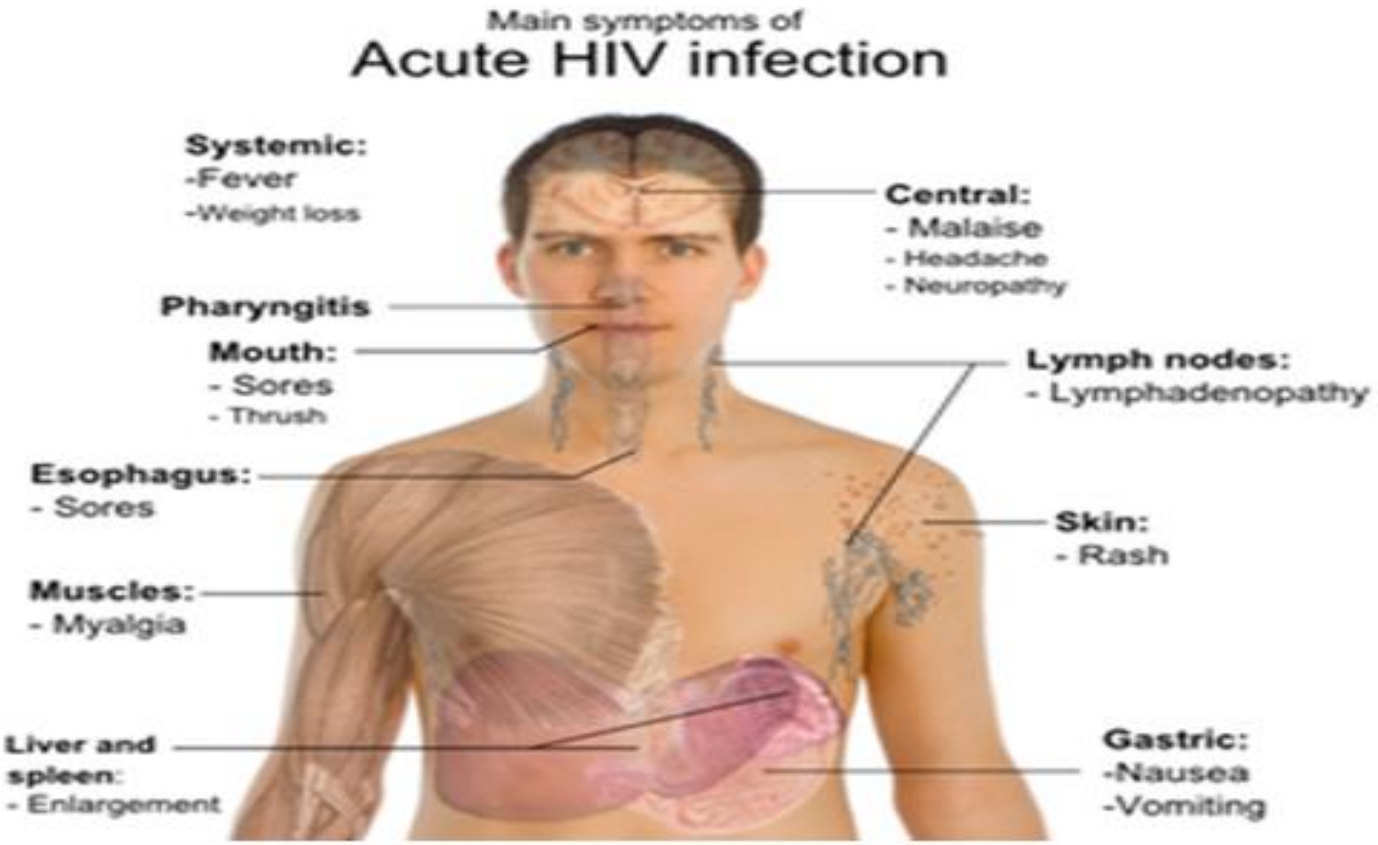
Pathogenic Bacteriology

Clinically significant bacteria

- Propensity to cause disease, i.e., how likely are they to cause disease
- Opportunistic pathogens – only cause disease in immunocompromised hosts
    - An organism that exists harmlessly as part of the normal human body environment and does not become a health threat until the body's immune system fails

Opportunistic Pathogens

- AIDs patients
- Transplant patients on immunosupressive drugs
- Cancer patients undergoing chemotherapy
- Patients who are already ill
- Opportunistic pathogens are often organisms that are typically normal flora.
    - *Staphylococcus epidermidis* and intravenous catheters
    - Given the right circumstances any organism can be invasive and lethal



Clinically significant bacteria

- Frank pathogens are always associated with disease
  - *Neisseria gonorrhoeae*
  - *Shigella species*
- Facultative pathogens fall between the two extremes (opportunistic and frank) and the majority of organisms that cause disease fall into this group
  - *Staphylococcus aureus*
  - *E. coli*

Methicillin-Resistant *Staphlococcus aureus* (MRSA)

- Typically associated with nosocomial infections
- Increasing incidence of hospitalized patients
- Chronically ill patients with multiple courses of treatment
- Typically multidrug resistant
- The bacteria can cause infection when they enter the body through a cut, sore, catheter, or breathing tube
  - The infection can be minor and local (for example, a pimple), or more serious (involving the heart, lung, blood, or bone).
- Serious staph infections are more common in people with weak immune systems
- This includes patients in hospitals and long-term care facilities and those receiving kidney dialysis

Clinically Significant Bacteria

- Various factors involved in the host-parasite interaction determine whether an organism will cause disease in the host:
    - Virulence factors of the bacteria including:
        - Capsules
        - Pili
        - IgA protease production
        - Iron capturing ability
        - Production of coagulase
        - Production of toxins
        - Ability to survive inside phagocytic cells
    - Degree of resistance of the host
        - Age
        - Gender
        - Physical health
        - Mental health
        - Antibiotic therapy that disrupts the normal balance between the host and normal flora
- From the organisms point of view, the most successful pathogen is NOT the one that inflicts the most extensive damage on the host, but rather the one that can establish a balanced pathogenicity with the host
- Parasites that kill the host will eventually lead to their own extinction

Clinically Significant Bacteria

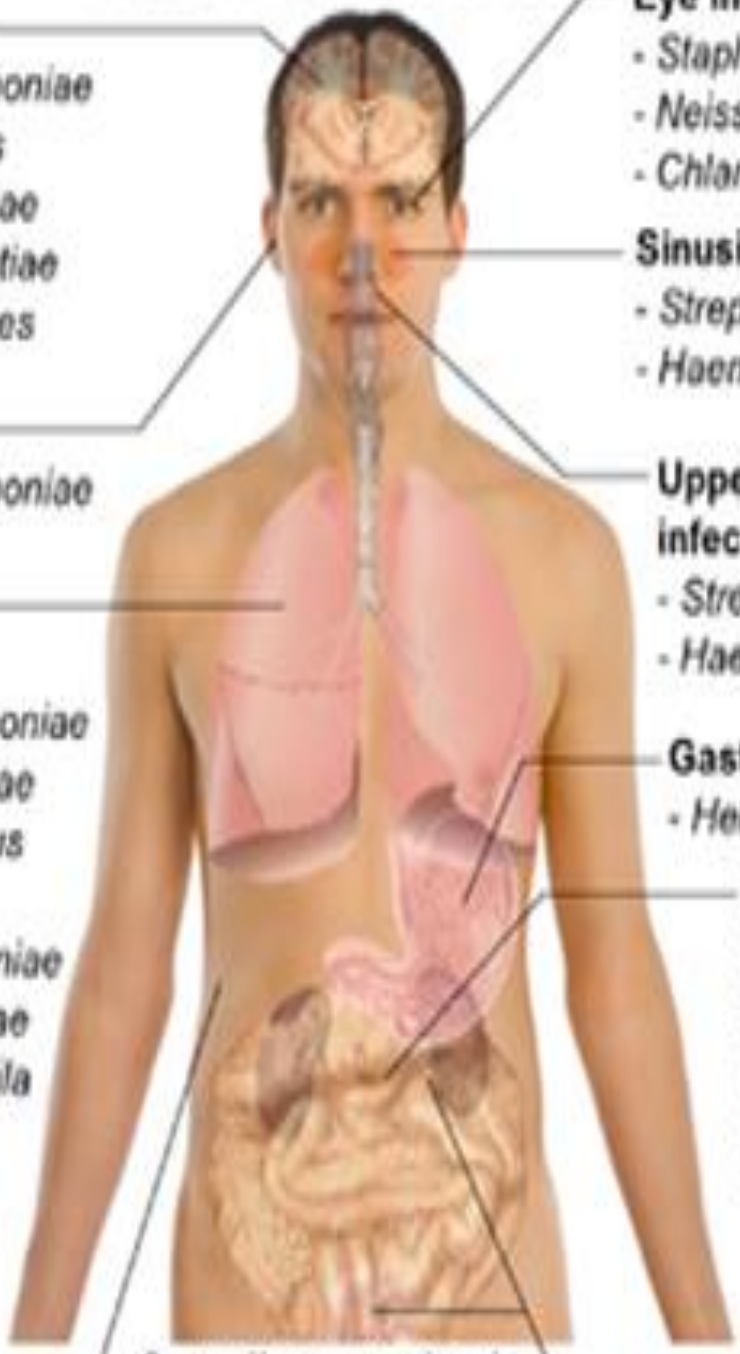
- Severe human infections - often from zoonotic organisms
    - No balanced pathogenicity
    - Humans irrelevant for organism's survival - Humans simply serve as accidental hosts.
        - Bubonic plaque
        - Anthrax
        - Leptospirosis
- Based on your knowledge of normal flora and the propensity of organisms to cause disease, you may be asked to determine the likelihood that a clinical isolate is causing disease.
- Things to consider are:
    - Site from which the organism was isolated (*E. coli* in G.I. tract versus the urinary tract)
    - Relative numbers of organism isolated
    - Age of patient

Pathogenicity vs. Virulence

- What is the difference between pathogenicity and virulence?
    - Pathogenicity is the potential to cause disease and is applied to groups or species of organisms
    - Virulence is the degree of pathogenicity within a group or species and is measurable

Overview of

Bacterial infections



Bacterial meningitis
- *Streptococcus pneumoniae*
- *Neisseria meningitidis*
- *Haemophilus influenzae*
- *Streptococcus agalactiae*
- *Listeria monocytogenes*

Otitis media
- *Streptococcus pneumoniae*

Pneumonia

Community-acquired:
- *Streptococcus pneumoniae*
- *Haemophilus influenzae*
- *Staphylococcus aureus*

Atypical:
- *Mycoplasma pneumoniae*
- *Chlamydia pneumoniae*
- *Legionella pneumophila*

Tuberculosis
- *Mycobacterium tuberculosis*

Skin infections
- *Staphylococcus aureus*
- *Streptococcus pyogenes*
- *Pseudomonas aeruginosa*

Eye infections
- *Staphylococcus aureus*
- *Neisseria gonorrhoeae*
- *Chlamydia trachomatis*

Sinusitis
- *Streptococcus pneumoniae*
- *Haemophilus influenzae*

Upper respiratory tract infection
- *Streptococcus pyogenes*
- *Haemophilus influenzae*

Gastritis
- *Helicobacter pylori*

Food poisoning
- *Campylobacter jejuni*
- *Salmonella*
- *Shigella*
- *Clostridium*
- *Staphylococcus aureus*
- *Escherichia coli*

Sexually transmitted diseases
- *Chlamydia trachomatis*
- *Neisseria gonorrhoeae*
- *Treponema pallidum*
- *Ureaplasma urealyticum*
- *Haemophilus ducreyi*

Urinary tract infections
- *Escherichia coli*
- *Other Enterobacteriaceae*
- *Staphylococcus saprophyticus*
- *Pseudomonas aeruginosa*