Viruses - a major section of the course. The word virus came from the word that meant poison. Viruses were observed as filterable, and would pass through the clay or porcelain filters used in the past. Since the filtrate that came through these filters was clear, the early thinking was that this was a chemical poison. In 1892, Dimitri Ivanowski a Russian bacteriologist injected healthy tobacco plants with filtered fluid. These plants soon showed signs of tobacco mosaic disease. Yellow fever was the first human disease associated with a filterable agent. These filterable “poisons” are now known to be particulate infectious agents. We refer to them as particles since they are not alive and therefore not cells. They were first observed as particles in the early 1940’s using electron microscopy. Viruses are obligate intracellular particles that can attack all forms of life. We refer to a virus as a virion when it is a complete and infectious particle. Viruses alternate between two states an intracellular state and an extracellular state. When intracellular they are capable of replication, a process which involves making copies of their nucleic acids, protein coats (capsid), additional components and then assembling the parts into a complete virus-more later. When extracellular, viruses are metabolically inert (inactive or quiet).

Viral Structure

1. Nucleic acids-viral genes are made of either DNA or RNA. Theses nucleic acids are either single stranded or double stranded. Some viruses have as little as 1% nucleic acid content relative to their protein content, while others have as much as 50% nucleic acid content relative to their protein content. Most bacteriophages possess double stranded DNA as their nucleic acid. Most plant viruses are RNA containing viruses. With respect to animal viruses, some possess DNA as their nucleic acid, while others possess RNA as their nucleic acid. Herpes simplex type 1 virus is an example of a DNA virus that is double stranded. The polio virus is an example of a single stranded RNA virus. The number of genes in a virus can vary tremendously depending upon the particular virus. A group known as the poxviruses possess double stranded DNA as their nucleic acid. These pox viruses which include the smallpox virus and the cowpox virus have as many as 400 genes. At the other end of the spectrum, the adenosatellite virus, also called adeno-associated virus (AAV) has only 7 genes. This virus is a single stranded DNA virus that is so small it cannot code for everything that it needs. For this AAV to replicate it must co-infect a host cell with another virus known as the adenovirus (double stranded DNA virus which is 3X as large).

2. Capsid (protein coat)-the capsid covers and protects the nucleic acid. This protein coat of a virus is made up of subunits called capsomeres.

3. Envelope-some viruses possess a layer outside of the capsid called an envelope. The envelope consists of a combination of lipids, carbohydrates and proteins. If a virus leaves the host cell after replication by the process of extrusion (rather than by lysis), the envelope may be made up largely of the host cell plasma membrane. The envelope may help the virus when it comes to surviving host defenses. The host immune system may not recognize the virus as foreign when it is surrounded by a structure that is at least in part made up of the host cell membrane. Additional protein components of the envelope are determined by the viral genes. Non-
enveloped viruses are called "naked". Some viruses pick up their envelope from the nuclear membrane.

4. Spikes (formerly called peplomers)-some viral envelopes are covered with spikes. These are carbohydrate-protein complexes that project from the surface of the envelope. The influenza virus (single stranded RNA virus) contains these spikes. The spikes are used to categorize and identify the "flu" virus. HA spikes are hemagglutinin spikes. These spikes will bind to erythrocytes and form cross bridges, resulting in agglutination. The HA spikes are commonly targeted by antibodies that attack the influenza virus. Furthermore these spikes are important when serological tests are used to identify the various "flu" viruses. The NA spikes are neuraminidase spikes they help the virus separate and exit from the host cell following replication. They are also used in viral identification. There are 16 subtypes of HA and 9 of NA. The Spanish influenza of 1918 was type H1N1. The 2009 pandemic was a new strain of H1N1. H5N1 most commonly refers to the bird (avian) "flu" that has been problematic in recent years.

5. Viral enzymes-viral enzymes are limited. The viral enzymes that are present are mostly involved with the entrance and exit to and from the host cell. Viral enzymes are typically not involved with such activities as energy production. The enzyme lysozyme is found on the tail structures of the T-even bacteriophage. This enzyme breaks down the cell wall of the host bacterial cell to facilitate viral penetration.

Viral Size-using EM, viral size varies. The viruses range in length from approximately 20 to 1000 nm. The smallest of viral particles is considerably smaller than bacteria. The largest may be close in size to the smallest bacteria (mycoplasmas, rickettsias and chlamydias).

Viral Morphology-3 major morphologies based upon capsid architecture.

1. Helical-capsid winds around in a helical spiral structure. The nucleic acid is found within this hollow and cylindrical capsid structure. Examples include the tobacco mosaic virus which is a helical single stranded RNA virus and the influenza virus which is an enveloped helical single stranded RNA virus.

2. Polyhedral-this geometrically formed capsid looks like a soccer ball. The polyhedral viruses contain many sides and most are 20 sided and are called icosahedrons. The icosahedral viruses contain 20 triangular sided faces. The adenovirus is an example of an icosahedron. The herpes simplex virus is an example of a polyhedral (icosahedral) virus that is also enveloped.

3. Complex-viruses that have a complex structure fall into this category. Most of these viruses are bacterial viruses (bacteriophages). The poxviruses which are animal viruses also fall into this category as they do not possess capsids that are readily identified.

Viral Classification Schemes

1. Classified based upon the disease that they produce.
   a. meningitis virus   b. pneumonia virus   c. hepatitis virus