Lecture 7

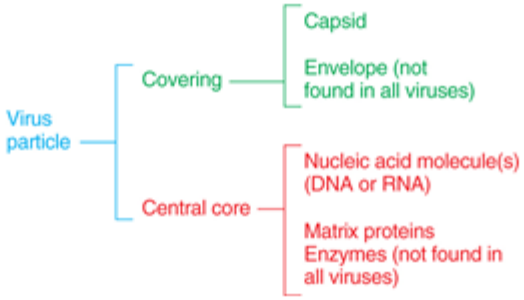
An Introduction to Viruses

TABLE 6.1 Properties of Viruses

- Obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants, and animals
- Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter)
- Not cellular in nature; structure is very compact and economical.
- Do not independently fulfill the characteristics of life
- Inactive macromolecules outside the host cell and active only inside host cells
- Basic structure consists of protein shell (capsid) surrounding nucleic acid core.
- Nucleic acid of the viral genome is either DNA or RNA but not both.
- Nucleic acid can be double-stranded DNA, single-stranded DNA, single-stranded RNA, or double-stranded RNA.
- Molecules on virus surface impart high specificity for attachment to host cell.
- Multiply by taking control of host cell's genetic material and regulating the synthesis and assembly of new viruses
- Lack enzymes for most metabolic processes
- Lack machinery for synthesizing proteins

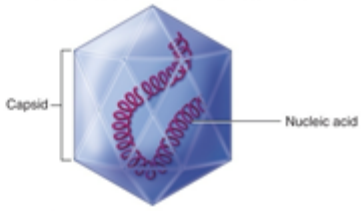
Viral Structure

- Viruses bear no resemblance to cells
  - Lack protein-synthesizing machinery
- Viruses contain only the parts needed to invade and control a host cell

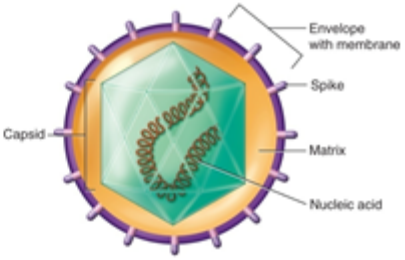


General Structure of Viruses

- **Capsids**
  - All viruses have capsids (protein coats that enclose and protect their nucleic acid)
  - The capsid together with the nucleic acid is the **nucleocapsid**
  - Some viruses have an external covering called an **envelope**; those lacking an envelope are **naked**
  - Each capsid is made of identical protein subunits called **capsomers**



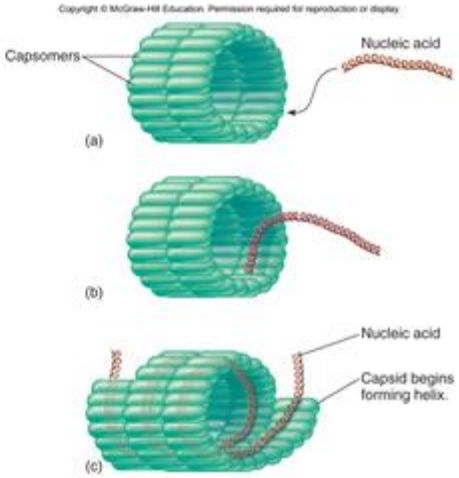
(a) **Naked Nucleocapsid Virus**



(b) **Enveloped Virus**

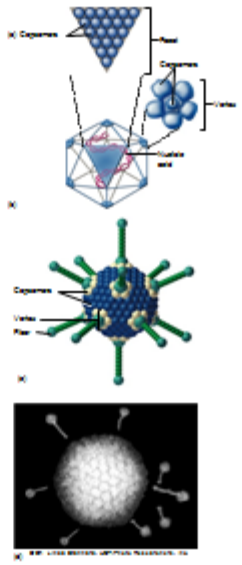
General Structure of Viruses

- Two structural capsid types:
  - **Helical** - continuous helix of capsomers forming a cylindrical nucleocapsid
  - **Icosahedral**



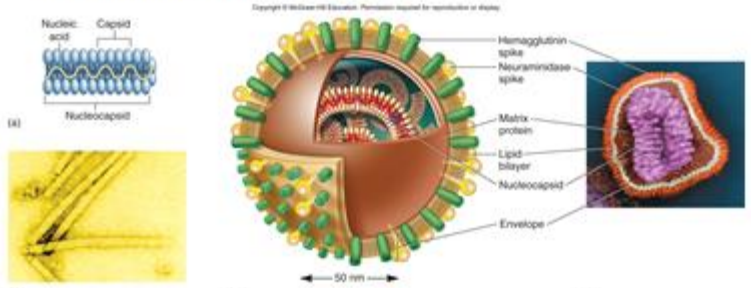
General Structure of Viruses

- Two structural capsid types:
  - **Helical** -
  - **Icosahedral** - 20-sided with 12 corners



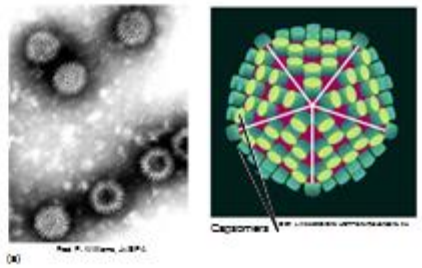
General Structure of Viruses

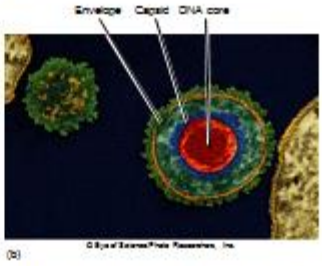
- **Viral envelope**
  - Mostly animal viruses
  - Acquired when the virus leaves the host cell
  - Exposed proteins on the outside of the envelope, called **spikes**, are essential for attachment of the virus to the host cell



Functions of Capsid/Envelope

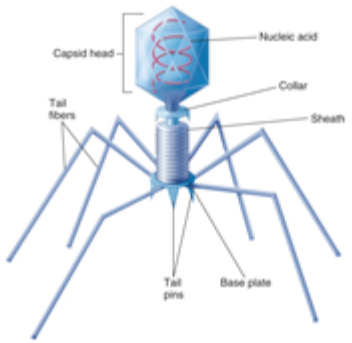
- Protects the nucleic acid when the virus is outside of the host cell
- Helps the virus bind to a cell surface and assists the penetration of the viral DNA or RNA into a suitable host cell



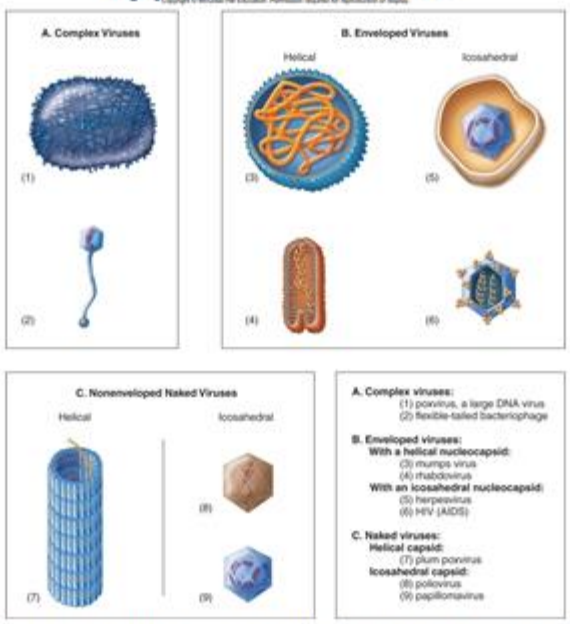


General Structure of Viruses

- **Complex** viruses: atypical viruses
  - Poxviruses lack a typical capsid and are covered by a dense layer of lipoproteins
  - Some **bacteriophages** have a polyhedral nucleocapsid along with a helical tail and attachment fibers



Types of Viruses



Nucleic Acids

- **Viral genome** – either DNA or RNA but never both
- Carries genes necessary to invade host cell and redirect cell's activity to make new viruses
- Number of genes varies for each type of virus – few to hundreds

Nucleic Acids

- DNA viruses
  - Usually double stranded (ds) but may be single stranded (ss)
  - Circular or linear
- RNA viruses
  - Usually single stranded, may be double stranded, may be segmented into separate RNA pieces
  - ssRNA genomes ready for immediate translation are **positive-sense RNA**
  - ssRNA genomes that must be converted into proper form are **negative-sense RNA**

General Structure

- Pre-formed enzymes may be present
  - Polymerases – DNA or RNA
  - Replicases – copy RNA
  - Reverse transcriptase – synthesis of DNA from RNA (AIDS virus)

How Viruses Are Classified

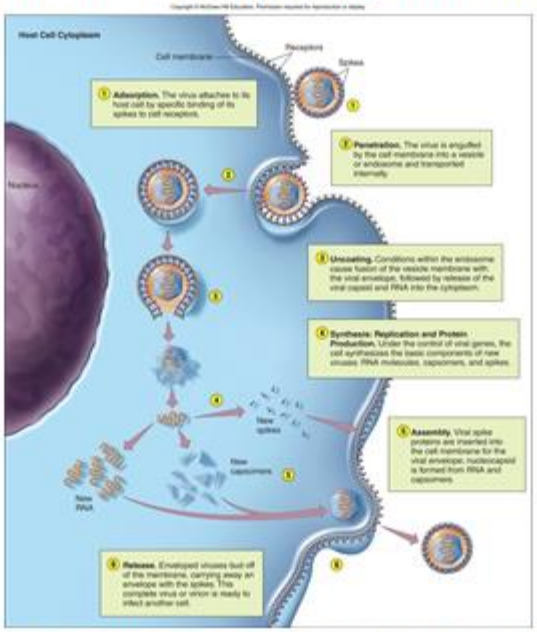
- Main criteria presently used are structure, chemical composition, and genetic makeup
- Currently recognized: 3 orders, 63 families, and 263 genera of viruses
- Family name ends in -viridae, i.e.Herpesviridae
- Genus name ends in -virus, Simplexvirus
- Herpes simplex virus I (HSV-I)

Modes of Viral Multiplication

General phases in animal virus multiplication cycle:

1. **Adsorption** – binding of virus to specific molecules on the host cell
2. **Penetration** – genome enters the host cell
3. **Uncoating** – the viral nucleic acid is released from the capsid
4. **Synthesis** – viral components are produced
5. **Assembly** – new viral particles are constructed
6. **Release** – assembled viruses are released by budding (exocytosis) or cell lysis

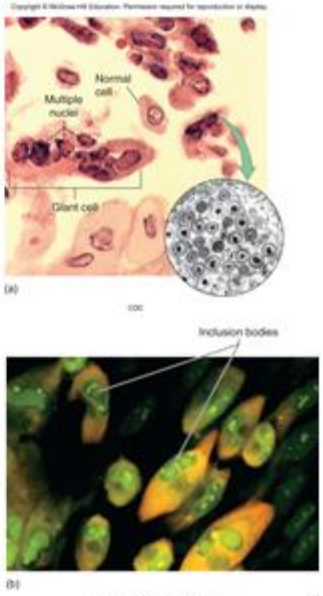
Animal Virus Multiplication



Damage to Host Cell

Cytopathic effects - virus-induced damage to cells

1. Changes in size and shape
2. Cytoplasmic inclusion bodies
3. Inclusion bodies
4. Cells fuse to form multinucleated cells
5. Cell lysis
6. Alter DNA
7. Transform cells into cancerous cells



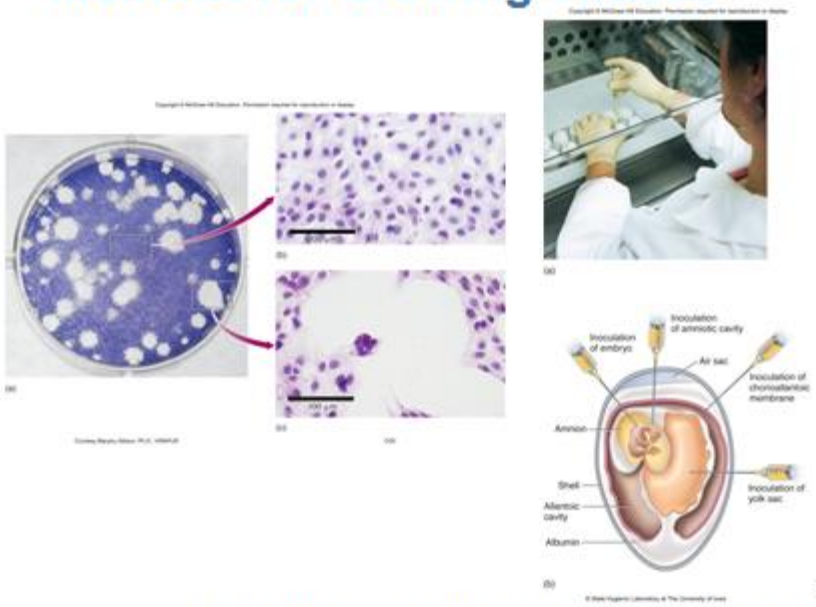
Multiplication Cycle in Bacteriophages

- **Bacteriophages** – bacterial viruses (phages)
- Most widely studied are those that infect *Escherichia coli* – complex structure, DNA
- Multiplication goes through similar stages as animal viruses
- Only the nucleic acid enters the cytoplasm - uncoating is not necessary
- Release is a result of cell lysis induced by viral enzymes and accumulation of viruses - **lytic cycle**

Techniques in Cultivating and Identifying Animal Viruses

- Obligate intracellular parasites that require appropriate cells to replicate
- Methods used:
  - Cell (tissue) cultures – cultured cells grow in sheets that support viral replication and permit observation for cytopathic effects
  - Bird embryos – incubating egg is an ideal system; virus is injected through the shell
  - Live animal inoculation – occasionally used when necessary

Methods for Growing Viruses



Medical Importance of Viruses

- Viruses are the most common cause of acute infections
- Several billion viral infections per year
- Some viruses have high mortality rates
- Possible connection of viruses to chronic afflictions of unknown cause
- Viruses are major participants in the earth's ecosystem

Detection and Treatment of Animal Viral Infections

- More difficult than other agents
- Consider overall clinical picture
- Take appropriate sample
  - Infect cell culture – look for characteristic cytopathic effects
  - Screen for parts of the virus
  - Screen for immune response to virus (antibodies)
- Antiviral drugs can cause serious side effects