Viruses, viroids, and prions

Chapter 13
BIO 220

Characteristics of viruses

- Very, very small (filterable)
- Obligatory intracellular parasite
- They have no ribosomes, so must use host cell machinery to translate viral mRNA into viral proteins
- Do not store or generate ATP, so energy is derived from the host cell
- Parasitize host cell for building materials like amino acids, lipids, and nucleotides
- Without the host cell, viruses can not carry out “life”-sustaining processes

**TABLE 13.1 Viruses and Bacteria Compared**

<table>
<thead>
<tr>
<th></th>
<th>Bacteria</th>
<th>Typical Bacteria</th>
<th>Rickettsias/Chlamydias</th>
<th>Viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracellular Parasite</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plasma Membrane</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Binary Fission</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Pass through Bactiologic Filters</td>
<td>No</td>
<td>No</td>
<td>Yes/No</td>
<td>Yes</td>
</tr>
<tr>
<td>Possess Both DNA and RNA</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ATP-Generating Metabolism</td>
<td>Yes</td>
<td>Yes/No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sensitive to Antibiotics</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sensitive to Interferon</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Host range of virus

• Spectrum of cells virus can invade
• Most viruses can only infect specific types of cells of only one host species
• Range determined by
  – Virus must be able to interact with specific receptor sites on host cell surface
  – Availability within the specific host of cellular factors necessary for viral multiplication

Viral structure

• Viruses are composed of a nucleic acid surrounded by a protein coat called a capsid
• Some viruses have a lipid/protein/CHO envelope surrounding the capsid
• A virion is a complete, fully developed, infectious viral particle located outside a host cell

Nucleic acids

• Virus can have DNA or RNA
• Nucleic acid can be ds or ss
• Nucleic acid may be a few thousand nucleotides up to 250,000 nucleotides
• Nucleic acid may be circular or linear
• For some viruses, the percentage of nucleic acid in relation to protein is about 1% (influenza), can be up to 50% (certain bacteriophages)
**Capsid**

- This is the protein coat covering the viral nucleic acid
- Protein subunits of capsid are called capsomeres
- Functions:
  - Protection
  - Contains attachment sites
  - Proteins allow viral penetration of host cell

![Capsid Diagram](image.png)
Envelopes

- **Nonenveloped** viruses lack an envelope
- Some viral capsids are covered by envelopes which may be made of lipids, proteins, and CHOs
  - May be a result of extrusion from host cell
  - Viral nucleic acid codes for envelope proteins, other components derived from the host cell
- Some envelopes may be covered in spikes (CHO/protein complexes)

Spikes

- May be means of attachment to host cells
- May be used as a means of identification

**Fig. 13.3**

Influenza

- HA spikes (hemagglutinin spikes)
  - Binds sialic acid on host cell membranes
  - Bind to erythrocytes and form cross bridges, resulting in agglutination
  - Targeted by antibodies against the influenza virus
- NA spikes (neuraminidase spikes)
  - Enable virus to be released from host cell
  - Required for viral replication
  - Target of drugs like Tamiflu
- Spikes can be used for identification of subtypes

Influenza classification

- **A** – infects humans and several types of animals (i.e. birds, horses, swine)
- **B** – humans
- **C** – humans, swine, dogs
- Influenza pandemics are caused by Type A viruses, which are classified into subtypes based on the HA and NA spikes
- HA (17 versions), NA (10 versions)
Viruses are tricky

- Some viruses have evolved mechanisms for evading antibodies (that were produced in response to that particular virus)
  - Viral genes, including those determining viral surface proteins, are susceptible to mutation
  - The progeny of mutant viruses therefore have altered surface proteins, which are not recognized by the antibodies

### Influenza A Pandemics During the Past 100 Years

<table>
<thead>
<tr>
<th>Year(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918–19</td>
<td>H1N1 caused up to 50 million deaths worldwide. Virus has avian flu-like genes.</td>
</tr>
<tr>
<td>1968–69</td>
<td>H3N2 caused about 34,000 deaths in the United States. This virus contained genes from a human influenza virus and an avian influenza virus.</td>
</tr>
<tr>
<td>2009–10</td>
<td>H1N1 caused at least 14,000 deaths worldwide. A vaccine was available in developed and developing countries 3 months after the first cases.</td>
</tr>
</tbody>
</table>

### Viral morphology

Based on capsid architecture

- Helical (rabies, Ebola)
- Polyhedral (adenovirus, poliovirus)
- Enveloped (influenza)
- Complex
  - Bacteriophages

### Classification of viruses

- Way people imagined they were contracted
- Scientists that discovered them
- Based on disease they produce
- Animal/tissue affinity
- Host range or specificity
- Morphological characteristics
  - Type of nucleic acid/enveloped or naked/capsid size/capsid architecture
How can we grow viruses in the lab to study them?

For animal viruses . . .
- Grow virus in live animals
- Chicken embryos
- Cell/tissue culture

Bacteriophages
- Much easier to grow in lab

Viral multiplication
- The virion nucleic acid contains only a few genes for viral replication
  - Genes for viral structural components
  - Genes for enzymes used in viral life cycle (i.e. replicating viral nucleic acid)
  - Some virions contain a few preformed enzymes
  - Genes are only transcribed and proteins made if virus is in host cell
- Most everything else is supplied by host cell

Viral one-step growth curve
**Bacteriophage multiplication**

- The lytic cycle (T-even bacteriophage)
  - Ends with the lysis and death of host cell

- The lysogenic cycle (Bacteriophage $\lambda$)
  - Host cell lives

**Phage lysozyme**

- Degradation host DNA
- Viral mRNA transcribed/translated
- Phage components synthesized

**Consequences of lysogeny**

- Lysogenic cells immune to reinfection by the same phage
- Phage conversion – host cell may exhibit new properties, i.e. toxin production
- Specialized transduction is possible
  - When a prophage is excised from its host chromosome, it can take with it a bit of the adjacent DNA from the bacterial chromosome
### Table 13.3 Bacteriophage and Animal Viral Multiplication Compared

<table>
<thead>
<tr>
<th>Stage</th>
<th>Bacteriophages</th>
<th>Animal Viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment</td>
<td>Tail fibers attach to cell wall protein</td>
<td>Attachment sites are plasma membrane proteins and lipoproteins.</td>
</tr>
<tr>
<td>Infection</td>
<td>Viral DNA enters host cell</td>
<td>Capillaries by osmosis and membrane fusion.</td>
</tr>
<tr>
<td>Replication</td>
<td>Not required</td>
<td>Detached extracellular enveloped virus.</td>
</tr>
<tr>
<td>Lysis</td>
<td>Induces lysis of host cell</td>
<td>In nucleus DNA invades on prophage (pro-virus).</td>
</tr>
<tr>
<td>Entry into host cell</td>
<td>Lytic DNA enters infected cell</td>
<td>Replicates DNA in the nucleus.</td>
</tr>
<tr>
<td>Host cell lysis</td>
<td>Developed lysis but not necessarily of enveloped plasma membrane.</td>
<td></td>
</tr>
</tbody>
</table>