Virology

General properties of viruses

Objectives:
1-Describe the structure of viruses.
2-Specify the functions of viral proteins & envelope.
3-List the reaction of viruses to physical & chemical agents.
4-Discuss the principles of classification of viruses.

Comparison between viruses and bacteria

<table>
<thead>
<tr>
<th>No.</th>
<th>Property</th>
<th>Viruses</th>
<th>Bacteria</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Size</td>
<td>20-300 nm</td>
<td>1000 nm</td>
</tr>
<tr>
<td>2</td>
<td>Genome (type of nucleic acid)</td>
<td>DNA or RNA but not both</td>
<td>DNA and RNA</td>
</tr>
<tr>
<td>3</td>
<td>Cell wall</td>
<td>Envelope present in some viruses</td>
<td>Cell wall</td>
</tr>
<tr>
<td>4</td>
<td>Ribosomes</td>
<td>No ribosomes</td>
<td>Ribosomes</td>
</tr>
<tr>
<td>5</td>
<td>Multiplication by binary fission</td>
<td>_</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Sensitivity to antibiotics</td>
<td>_</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Growth in culture media</td>
<td>Grow only in living host cell</td>
<td>Grow in culture media</td>
</tr>
</tbody>
</table>
**What are viruses?**

1. They are small size (20-300 nm in diameter) retaining infectivity after passage through filters able to hold back bacteria.
2. They are totally dependent upon a living cell, either eukaryotic or prokaryotic, for replication and existence. Viruses are obligate intracellular parasites.
3. They possess only one species of nucleic acid, either DNA or RNA.
4. They have a component - a receptor binding protein for attaching to cells.

**The structure of viruses:**

1. **Viral nucleic acid:**
   
The viral nucleic acid is located internally and can be either single- or double- stranded RNA or DNA. The nucleic acid can be either linear or circular. The DNA is always a single molecule, the RNA can exist either as a single molecule or in several pieces (segmented).
   
   - Some RNA viruses are positive polarity and others are negative polarity.
   - Positive polarity is defined as an RNA with same base sequence as the mRNA.
   - Negative polarity has a base sequence that is complementary to the mRNA.
2. **Capsid:**

The protein shell, or coat, that encloses the nucleic acid genome and mediates the attachment of the virus to specific receptors on the host cell surface. This interaction of the viral proteins with the cell receptor is the major determinant of species & organ specificity. The capsid proteins protect the genome from degradation by nucleases.

3. **Capsomeres:**

Morphologic units seen in electron microscope. Each capsomere, consisting of one or several proteins. The structure composed of nucleic acid + capsid proteins is called (nucleocapsid).

4. **Viral envelope:**

The envelope is a lipoprotein membrane composed of lipid derived from the host cell membrane and protein that is virus-specific.

Furthermore, there are frequently glycoproteins in form of spike-like projections on the surface, which attach to host cell receptors.

**Matrix protein** mediates the interaction between the capsid proteins and envelope. **Viruses also have internal proteins, some of which are DNA or RNA polymerases, others do not**
The presence of an envelope confers instability on the virus.

Enveloped viruses → NA + capsid + envelope

The whole virus particle is called **virion**.

Outer viral proteins are also important antigens that induce neutralizing antibody & activate cytotoxic T cell to kill virus - infected cells.

**Types of symmetry of virus particles:**

1. **Icosahedral symmetry**

   Composed of 12 vertices, has 20 faces (each an equilateral triangle) with the approximate outline of a sphere.

   e.g. Herpesviruses, Adenoviruses
2. **Helical symmetry**

In which the capsomeres are arranged in a hollow coil that appears rod-shaped. The helix can be either rigid or flexible.

e.g. Influenza viruses

3. **Complex structures**

e.g. Poxviruses
Reaction to physical and chemical agents:

1. **Heat and cold**
   Viral infectivity is generally destroyed by heating at 50-60°C for 30 minutes, hours at 20°C, days at 4°C. Viruses can be preserved at -90°C or -196°C (liquid nitrogens).

2. **PH**
   Viruses can be preserved at physiological PH (7.3).

3. **Ether susceptibility:**
   Ether susceptibility can be used to distinguish viruses that possess an envelope from those that do not.

4. **Detergents:**
   Nonionic detergents solubilize lipid constituents of viral membranes. The viral proteins in the envelope are released. Anionic detergents also solubilize viral envelopes; in addition, they disrupt capsids into separated polypeptides.

5. **Salts**
   Many viruses can be stabilized by salt in concentrations of 1 mol/L. e.g. MgCl₂, MgSO₄, Na₂SO₄.

6. **Radiation**
   Ultraviolet, X-ray, and high-energy particles inactivate viruses.

7. **Formaldehyde**
   Destroys viral infectivity by reacting with nucleic acid.

8. **Antibiotics**
   Antibacterial antibiotics have no effect on viruses.
Classification of viruses

1. Virion morphology, including size, shape, type of symmetry, presence or absence of envelope.
2. Virus genome properties, including type of nucleic acid (DNA or RNA), size of genome, strandedness (single or double), whether linear or circular, positive or negative sense (polarity), segments (number, size).
3. Physicochemical properties of the virion, including PH stability, thermal stability, and susceptibility to physical and chemical agents, especially ether and detergents.
4. Virus protein properties, including number, size and functional activities of structural and non-structural proteins, amino acid sequences, and special functional activities (transcriptase, reverse transcriptase, neuraminidase, fusion activities).
5. Genome organization and replication, including gene order, strategy of replication (patterns of transcription, translation), and cellular sites (accumulation of proteins, virion assembly, virion release).
6. Antigenic properties
7. Biological properties, including natural host range, mode of transmission, vector relationships, pathogenicity, tissue tropisms, and pathology.

Universal system of virus taxonomy:

Families – on the basis of virion morphology, genome structure and strategies of replication.

Virus family names have the suffix – viridae.

Genera – based on physicochemical or serological differences.

Genus names carry the suffix – virus.
Families of Animal Viruses That Contain Members Able to Infect Humans

<table>
<thead>
<tr>
<th>Nucleic Acid Core</th>
<th>Capsid Symmetry</th>
<th>Virion: Enveloped or Naked</th>
<th>Ether Sensitivity</th>
<th>Number of Capsomeres</th>
<th>Virus Particle Size (nm)*</th>
<th>Size of Nucleic Acid in Virion (kb/kbp)</th>
<th>Physical Type of Nucleic Acidb</th>
<th>Virus Family</th>
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<tr>
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<td>Icosahedral</td>
<td>Naked</td>
<td>Resistant</td>
<td>32</td>
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<td>5.6</td>
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<td>72</td>
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<td>180</td>
<td>40–48</td>
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<td>162</td>
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<td>125–240</td>
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<td>8.5–10.5</td>
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<td></td>
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<td>16–20</td>
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</table>

Jawetz, Medical Microbiology 25th edition /2010

Summary

1-Viruses range in size from (20-300nm).

2-The genome of viruses either DNA or RNA single – stranded or double – stranded, linear or circular.

3-All viruses have protein coat called capsid. The capsid is composed of repeating subunits called capsomeres. Some viruses are naked while others possess envelope.
4- The capsomeres give the virus a symmetric appearance. Some have spherical (Icosahedral) symmetry, whereas others have helical symmetry.

5- Viral surface proteins mediate attachment to host cell receptors.

6- The viral envelope is acquired as the virus exits from the cell. Enveloped viruses are more sensitive to heat, detergent, & lipid solvents.

7- The surface proteins are the targets of antibody.

8- The classification of viruses based on virion morphology, & virus genome properties.