VIRUS STRUCTURE

(chapter 3)
Introduction

- Virus ≠ Virion
- Genome + capsid

Virion (gene delivery system)

- Protection of the genome
- Entry into the host cell

- Lipid envelope with proteins
Virus genomes

• Nucleic acid: DNA or RNA

• Single stranded or double stranded

• Linear or circular
Genome size

<table>
<thead>
<tr>
<th>Viruses</th>
<th>Approximate genome size (kbp DNA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatitis B virus</td>
<td>3.2</td>
</tr>
<tr>
<td>Phage λ.</td>
<td>48.5</td>
</tr>
<tr>
<td>Mimivirus</td>
<td>1200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cells</th>
<th>Approximate genome size (kbp DNA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mycoplasma genitalium</td>
<td>580</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>4700</td>
</tr>
<tr>
<td>Human</td>
<td>3200000</td>
</tr>
</tbody>
</table>
Secondary and tertiary structure

- Signal for control of gene expression contained in secondary and tertiary structure
- Secondary structure → stem-loops, bulges, pseudoknot (ssRNA)
Modifications at ends of virus genomes

- Modifications at 5’ and 3’ end
- At 5’ end → cap (methylated)
- At 3’ end → poly(A)tail
Segmented genomes

• Genes in some viruses are encoded in 2 or more nucleic acid molecules

• Advantage: new gene combinations $\rightarrow$ rapid evolution

• Disadvantage: all segments must enter the cell
## Repeat sequences

<table>
<thead>
<tr>
<th>Nucleic acid</th>
<th>Type of repeat</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>XY dsDNA XY</td>
<td>DTR</td>
<td>Some herpesviruses, T phages</td>
</tr>
<tr>
<td>xy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY dsDNA yX</td>
<td>ITR</td>
<td>Adenoviruses, Tectiviruses (phages)</td>
</tr>
<tr>
<td>xy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY ssDNA yX</td>
<td>ITR</td>
<td>Some paroviruses</td>
</tr>
<tr>
<td>xy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY ssRNA(+) XY</td>
<td>DTR</td>
<td>Retroviruses</td>
</tr>
<tr>
<td>xy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY ssRNA(−) yX</td>
<td>ITR</td>
<td>Influenza viruses, Bunyaviruses</td>
</tr>
<tr>
<td>YX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Diagram:

- XY dsDNA XY
- XY ssDNA yX
- XY ssRNA(+) XY
- XY ssRNA(−) yX
- YX

Diagram shows the structure and repeats for different nucleic acids and their corresponding types of repeat.

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1. Type of repeat can be DTR or ITR.
Virus proteins

Functions of structural proteins

• protection of virus genome
• attachment of virion to the host cell
• fusion of virion envelope to a cell membrane

• enzymes (reverse transcriptase)
• transcription factors
• primers for nucleic acid replication
Capsids

Major functions of capsid are –
1. protection of virus genome otherwise susceptible to inactivation;
2. recognition and attachment to a host cell in which the virus can be replicated.

Capsid must be:
- stable to survive in extracellular environment;
- able to alter its conformation to release genome inside the host cell.

Capsid + genome it encloses = virion (for many viruses)
• Construction of capsids: many molecules of one/few species of protein that assemble in symmetrical structures, usually helical or icosahedral.

• Helical symmetry:

(a) Structure of a capsid with helical symmetry. The ssRNA coils are coated with repeated copies of a protein.
(b) Part of measles virus nucleocapsid. The complete nucleocapsid is folded and enclosed within an envelope.
• Icosahedral symmetry: capsids consist of a shell built from protein molecules arranged on scaffolding in the form of an icosahedron.
• They have less contact with the virus genome compared to helical symmetry.

Capsid constructed from sixty protein molecules. (a) Arrangement of protein molecules, with three per triangular face. (b) Virions of satellite tobacco mosaic virus.

• There is a huge range in the sizes of icosahedral capsids. The satellite tobacco mosaic virus capsid is about 17 nm in diameter, whereas the diameter of the *Paramecium bursaria Chlorella* virus 1 capsid is about ten times greater than this.
• Capsid surfaces vary in their topography; there may be canyons, hollows, ridges and/or spikes present.
• Capsids with icosahedron symmetry can have various structures: icosahedron shape, spherical, elongated etc.

Capsid constructed from two protein species.

Capsids with icosahedral symmetry. Some of the wide ranges of capsid architectures and sizes are illustrated.
• The majority of the known phages are constructed in the form of a tail attached to a head, which contains the virus genome.
• All of these phages have dsDNA genomes
• Head has icosahedral symmetry.
• HIV-1 and baculoviruses have capsids that are conical and rod shaped, respectively.

• Inside each capsid is a copy of the virus genome coated in a highly basic protein. Both of these viruses have enveloped virions.
Virion membranes

• Many viruses have a lipid membrane component.

• In most of these viruses the membrane is at the virion surface and is associated with one or more species of virus protein.

• This lipid–protein structure is known as an envelope and it encloses the nucleocapsid (nucleic acid plus capsid).

• Many animal viruses are enveloped, including all those with helical symmetry, e.g. influenza viruses, and a significant number of those with icosahedral symmetry, e.g. herpesviruses.

• Many enveloped viruses, including influenza viruses and retroviruses, have a layer of protein between the envelope and the nucleocapsid. This protein is often called a matrix protein.

• There are several viruses that have a lipid membrane within the virion rather than at the surface.
Lipid-containing viruses:
• Some viruses provide added protection to the virions whilst outside their hosts by occluding them in protein crystals.

• There are two major types of occlusion body in which baculoviruses embed their rod-shaped virions: the granuloviruses form small granular occlusion bodies, generally with a single virion in each while the nucleopolyhedroviruses form large occlusion bodies with many virions in each.
Thank you for your attention!