Introduction to medical virology

“Viral structure and Classification”

Dr. Abdulkarim Alhetheel
Assistant Professor in Microbiology Unit
College of Medicine & KKUH
OBJECTIVES

➢ General characteristics of viruses.
➢ Structure & symmetry of viruses.
➢ Classification of viruses.
➢ Steps of virus replication.
➢ Laboratory diagnosis of viral infections.
<table>
<thead>
<tr>
<th>characteristic</th>
<th>Parasite</th>
<th>Fungi</th>
<th>Bacteria</th>
<th>Virus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Type of nucleus</strong></td>
<td>Eukaryotic</td>
<td>Eukaryotic</td>
<td>Prokaryotic</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Nucleic acid</strong></td>
<td>Both DNA &amp; RNA</td>
<td>Both DNA &amp; RNA</td>
<td>Both DNA &amp; RNA</td>
<td>DNA or RNA</td>
</tr>
<tr>
<td><strong>Ribosomes</strong></td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Mitochondria</strong></td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Replication</strong></td>
<td>Mitosis</td>
<td>Budding or mitosis</td>
<td>Binary fission</td>
<td>Special</td>
</tr>
</tbody>
</table>
Characteristics of viruses

➢ Acellular organisms
➢ Tiny particles
  • Internal core
  • Protein coat
  • Some Vs have lipoprotein mb (envelope)
➢ Obligate intracellular organisms
➢ Replicate in a manner diff from cells
  (1V → many Vs)
Size; 20-300 nm
Viral Structure

1- Viral genome

2- Capsid

3- Envelope
1-Viral genome

**DNA**
- (Deoxyribonucleic acid)
  - All DNA Vs have ds except Parvoviruses
  - Single molecule

**RNA**
- (Ribonucleic acid)
  - All RNA Vs have ss except Reoviruses
  - Single / double
  - (+) polarity
  - (-) polarity

All Vs are haploid, except retroviruses are diploid
Viral structure

2-Capsid

- a protein coat
- Subunits (capsomeres)
- Genome (NA) + capsid
  - = nucleocapsid

Function:
- Protects NA
- Facilitates its entry into cell
Symmetry based on arrangement of capsomeres

- **Cubic symmetry**
  (Icosahedral)

- **Helical symmetry**

- **Complex symmetry**
Symmetry

based on arrangement of capsomeres

- \textit{1-Cubic symmetry (Icosahedral)}

[Images of Adenovirus and Herpes virus]

Capsomer

Nucleic acid

Adenovirus

Herpes virus
Symmetry based on arrangement of capsomeres

- **2- Helical symmetry**

- **3- Complex symmetry**
  - poxviruses

**Elongated** (filoviruses)

**Pleomorphic** (influenza v.)
Viral structure

3-Envelope

Lipoprotein mb
(host lipid, virus specific protein)

➢ During viral budding

➢ Envelope is derived from cell mb
  except herpesviruses from nuclear mb

➢ Enveloped Vs are more sensitive to
  heat, dry & other factors than nonenveloped Vs

➢ Glycoprotein attaches to host cell receptor
**Viral proteins**

- **The outer viral ps**
  - Mediate attachment to specific Rs
  - Induce neutralizing Abs
  - Target of Abs

- **The internal viral ps**
  - Structural ps (capsid ps of enveloped Vs)
  - Nonstructural ps (enzymes)
    - All ssRNA Vs (-) polarity have transcriptase (RNA dependent RNA polymerase) inside virions
    - RetroVs & HBV contain reverse transcriptase
Classification of viruses

➢ Type of NA
➢ The no. of strand
➢ The polarity of viral genome
➢ The presence or absence of envelope
➢ Type of symmetry
Medically Important Viruses

DNA
- Single-stranded
  - Nonenveloped
    - Icosahedral: Parvoviridae
  - Enveloped
    - Complex: Poxviridae
    - Icosahedral: Herpesviridae, Hepadnaviridae

RNA
- Nonenveloped
  - Icosahedral: Adenoviridae, Papovaviridae
Replication

➢ Adsorption (Attachment)
➢ Penetration
➢ Uncoating
➢ Synthesis of viral components
  • mRNA
  • Viral proteins
  • NA
➢ Assembly
➢ Release

Viral growth cycle
**Adsorption**

- Attachment site;
  - glycoprotein
  - folding in the capsid proteins.
**Penetration**

1-Fusion

- **Enveloped virus**
  - Binding of a virus to a host cell membrane receptor
  - Fusion of viral envelope with the host cell membrane
  - Nucleocapsid enters the cell

2-Endocytosis

- Enveloped viruses fuse with endosome mb.
- Nonenveloped viruses lyse, or pore em.
Replication

- Adsorption (Attachment)
- Penetration
- Uncoating

Release of viral genome - cytoplasm
- nucleus
Synthesis of viral components

- mRNA
  - Viral genome transcription mRNA
  - +ssRNA acts directly

- Viral proteins
  - mRNA translation viral proteins
  - cell ribosome - enzymes
  - - structural ps

- replication of viral genome
Replication

➢ Adsorption (attachment)
➢ Penetration
➢ Uncoating
➢ Synthesis of viral components
  • mRNA
  • Viral proteins
  • NA

➢ Assembly

\[ NA + V. \text{ proteins} = \text{Virions} \]

➢ Release
Release

➢ 1-Budding  
(enveloped Vs)  
-cell mb*  
-nuclear mb  
(herpesVs)

➢ 2- Cell lysis  
or rupture of the cm  
(nonenveloped Vs)
laboratory diagnosis of viral infections

➢ Microscopic examination.
➢ Cell culture.
➢ Serological tests.
➢ Detection of viral Ag.
➢ Molecular method.
Microscopic examination

- **Light microscopy**, Histological appearance
  Ex. Inclusion bodies

- **Electron microscopy**;
  - Morphology & size of virions
  - Ex. Diagnosis of viral GE such as rota, adenoviruses.
    Diagnosis of skin lesion caused by herpes, or poxviruses.
  - It is replaced by Ag detection & molecular tests

*Owl’s eye (CMV)*
Electron micrographs

Rotavirus

Adenovirus

Herpesvirus

Poxvirus
Virus cultivation

- Laboratory animals
- Embryonated eggs
- Cell culture
## Cell culture

<table>
<thead>
<tr>
<th>Type</th>
<th>No of sub passages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary C/C</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Diploid C/C [semi continuous]</td>
<td>20 to 50</td>
</tr>
<tr>
<td>Continuous cell line</td>
<td>Indefinite</td>
</tr>
</tbody>
</table>

![Diagram of cell culture process](image-url)
Variation in Sensitivity of cell cultures to infection by viruses commonly isolated in clinical virology laboratories

<table>
<thead>
<tr>
<th>Virus</th>
<th>Cell culture&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PMK</td>
</tr>
<tr>
<td>RNA virus</td>
<td></td>
</tr>
<tr>
<td>Enterovirus</td>
<td>+++</td>
</tr>
<tr>
<td>Rhinovirus</td>
<td>+</td>
</tr>
<tr>
<td>Influenza virus</td>
<td>+++</td>
</tr>
<tr>
<td>RSV</td>
<td>++</td>
</tr>
<tr>
<td>DNA virus</td>
<td></td>
</tr>
<tr>
<td>Adenovirus</td>
<td>+</td>
</tr>
<tr>
<td>HSV</td>
<td>+</td>
</tr>
<tr>
<td>VZV</td>
<td>+</td>
</tr>
<tr>
<td>CMV</td>
<td>-</td>
</tr>
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</table>

<sup>a</sup>PMK, primary MK. Degree of sensitivity: ++++, highly sensitive; ++, moderately sensitive; +, low sensitivity; +/-, variable; -, not sensitive.
Detection of viral growth

➢ Cytopathic effects

- Uninfected cc
- Cell rounding
- Syncytium

➢ IF

➢ Other
Problems with cell culture

- Long incubation (up to 5 days)
- Sensitivity is variable
- Susceptible to bacterial contamination
- Some viruses do not grow in cell culture
  e.g. HCV
Rapid culture technique

➢ Shell Vial Assay
➢ Detect viral antigens
➢ 1-3 days
### Serological test;  
**Antigen detection:**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Virus</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasopharyngeal aspirate</td>
<td>Influenza V.</td>
<td>IF</td>
</tr>
<tr>
<td>Skin scrapings</td>
<td>HSV</td>
<td>IF</td>
</tr>
<tr>
<td>Faeces</td>
<td>Rotavirus</td>
<td>ELISA</td>
</tr>
<tr>
<td>Blood</td>
<td>HBV (HBsAg)</td>
<td>ELISA</td>
</tr>
</tbody>
</table>
Serological test;

Antibody detection;

- e.g. of techniques
- Complement fixation test (CFT)
- Immunofluorescence (IF)
- Enzyme-linked immunosorbent assay (ELISA)
Immunofluorescence; IF

- A- Direct 
  Ag detection;
  * Sample (Ag)

- B- Indirect 
  Ab detection;
  * Sample (Ab)
Fig. 3, HSV-infected epithelial cell from skin lesion (DFA)
**ELISA**

**Ab detection**

**Ag detection**

Indirect ELISA for Ab detection; coloured wells indicate reactivity
Molecular test:

- Polymerase chain reaction (PCR)
  - NA amplification technique.
  - Viral genome
- Uses:
  - Diagnosis
  - Monitoring response to treatment
Reference book and the relevant page numbers

- **Medical Microbiology and Immunology**
  By: Warren Levinson .

- **Lippincott’s Illustrated Reviews: Microbiology**
  By: Richard A.Harvey , Pamela C Champe & Bruce D. Fisher
  Pages;233-242
Thank you