CLASSIFICATION OF VIRUSES
Disclosures

Relevant relationships with commercial entities:
- Speaker Honorarium: Merck, Pfizer
- Research Funding: Qvella, bioMerieux
- Advisory Board: Merck, Roche

Potential for conflicts of interest within this presentation – none

Steps taken to review and mitigate potential bias – N/A
LEARNING OBJECTIVES

This lecture is designed to meet the following end-of-week learning objective:

1. Describe the classification of viruses
MODULE OBJECTIVES

By the end of this module, you should be able to:

1. List classes of viruses that are clinically relevant
2. Describe how viruses are identified in the laboratory
VIRUS PROPERTIES

• The term virus is Latin for ‘poison’
• Most abundant biologic entities on Earth; outnumber all others put together
• Virus is defined as a nucleoprotein complex which infects cells and uses their metabolic processes to replicate
VIRUS PROPERTIES

• Metabolically inert - no metabolic activity outside host cell; must enter host cell to replicate (‘Obligate intracellular molecular parasites’)

• Can infect all types of life forms, but most are highly species-specific
VIRUS PROPERTIES

Virus: general term for any aspect of the infectious agent and includes:
- The infectious or inactivated virus particle
- Viral nucleic acid and protein in the infected cell

Virion: the physical particle in the extra-cellular phase which is able to spread to new host cells; complete intact virus particle

Viroid: a short stretch of circular, single-stranded RNA without a protein coat; RNA does not code for any protein; mostly plant pathogens; Hepatitis D virus is similar to viroids
VIRUS CLASSIFICATION

• Historically based on:
  Size: “filterable agents”
  Host preference: Plant, insect, animal, human
  Target organ: respiratory, hepatic, enteric, etc.
  Vector: arboviruses

• Overlapping, inconsistent
VIRUS CLASSIFICATION

Currently based on:

• Type of symmetry of the virus capsid
• Presence or absence of a lipid envelope
• Type and structure of the viral nucleic acid
• Strategy used in replication
5 BASIC TYPES OF VIRAL SYMMETRY

- **ICOSAHEDRAL**
- **ENVELOPED ICOSAHEDRAL**
- **HELICAL**
- **ENVELOPED HELICAL**
- **COMPLEX**

Adapted from Schaefer et al., Mechanisms of Microbial Disease
VIRUS STRUCTURE

Virus particles exhibit 3 types of capsid symmetry:

Helical / tubular - most helical viruses possess an outer envelope (e.g., measles); All known animal viruses with helical structure have RNA genomes

Icosahedral - isometric or cubic; may (e.g., herpes) or may not (e.g., adenovirus) possess an outer envelope

Complex - does not conform to either of above (e.g., vaccinia)
VIRUS STRUCTURE

Viral Nucleic Acid:

DNA or RNA (most common), but not both:

• single- or double-stranded
• intact or fragmented
• linear or circular
• encodes very few proteins
ADENOVIRUS

(NON-ENVELOPED CUBIC VIRUS)
HERPESVIRIDAE

(ENVELOPED CUBIC VIRUS)
VIRUS CLASSIFICATION

Nucleic acid:
- DNA
- RNA

Envelope:
- Yes
- No

Symmetry:
- Cubic (Icosahedral)
- Helical (Cylindrical)
VIRUS CLASSIFICATION

• Viruses with similar structural, genomic & replication properties are grouped into families (suffix: viridae) [e.g., Herpesviridae]

• Families subdivided into genera (suffix: virus) [e.g., Herpes simplex virus, Cytomegalovirus, Varicella zoster virus]

• Subtypes based on nucleotide sequence and antigenic reactivities [e.g., Herpes simplex virus type 1, Herpes simplex virus type 2]
<table>
<thead>
<tr>
<th>Family</th>
<th>Viruses</th>
<th>Type of Nucleic Acid</th>
<th>Envelope</th>
<th>Capsid Symmetry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picornaviridae</td>
<td>Enteroviruses, polio, hep. A</td>
<td>ss (+) RNA</td>
<td>No</td>
<td>I</td>
</tr>
<tr>
<td>Caliciviridae</td>
<td>Norwalk virus</td>
<td>ss (+) RNA</td>
<td>No</td>
<td>I</td>
</tr>
<tr>
<td>Togaviridae</td>
<td>Rubella</td>
<td>ss (+) RNA</td>
<td>Yes</td>
<td>I</td>
</tr>
<tr>
<td>Rhabodovirida</td>
<td>Rabies</td>
<td>ss (+) RNA</td>
<td>Yes</td>
<td>H</td>
</tr>
<tr>
<td>Paramyxovirida</td>
<td>Parainfluenza, RSV, measles, mumps</td>
<td>ss (-) RNA</td>
<td>Yes</td>
<td>H</td>
</tr>
<tr>
<td>Orthomyxovirida</td>
<td>Influenza</td>
<td>ss (-) RNA</td>
<td>Yes</td>
<td>H</td>
</tr>
<tr>
<td>Retroviridae</td>
<td>HIV 1, 2, HTL I, II</td>
<td>ss (+) RNA</td>
<td>Yes</td>
<td>I</td>
</tr>
<tr>
<td>Hepadnavirida</td>
<td>Hepatitis B</td>
<td>ds DNA</td>
<td>Yes</td>
<td>Unknown</td>
</tr>
<tr>
<td>Parvoviridae</td>
<td>Parovirus B-19</td>
<td>ss (+) or (-) DNA</td>
<td>No</td>
<td>I</td>
</tr>
<tr>
<td>Adenoviridae</td>
<td>Adenovirus</td>
<td>ds DNA</td>
<td>No</td>
<td>I</td>
</tr>
<tr>
<td>Herpesviridae</td>
<td>HSV, CMV, EBV, VZV, HHV6</td>
<td>ds DNA</td>
<td>Yes</td>
<td>I</td>
</tr>
</tbody>
</table>

I = Icosahedral, H = Helical
VIRUS CLASSIFICATION
(COMMON CLINICALLY RELEVANT VIRUSES)

DNA
Hepatitis B
Human Papilloma Virus
Parvovirus B19
Adenovirus
Herpesviridae
Polyomaviruses

RNA
Influenza
RSV
Parainfluenza
Hepatitis A, C, D, E
Enteroviruses
Encephalitis viruses
Measles, Mumps, Rubella
Norwalk, Rotavirus
Virtually all others
LABORATORY DETECTION OF VIRUSES

Three approaches:

- Virus isolation (culture)
- Direct detection
- Serology (antibody/antigen)
LABORATORY DETECTION OF VIRUSES

Culture:

- Definitive diagnosis – isolation of virus always indicates that patient is infected
- Limitations:
  - Not all viruses are culturable in the lab
  - May take days to weeks for virus to grow
  - Biohazard level
LABORATORY DETECTION OF VIRUSES

Direct detection:

- Rapid: minutes to several hours
- Methods:
  - Microscopy – light, electron, fluorescent
  - Molecular techniques – e.g., polymerase chain reaction (PCR) for detection of viral RNA or DNA
  - Protein (antigen) detection
LABORATORY DETECTION OF VIRUSES

Serology:

• Detection of antibodies or antigen in blood (and few other body fluids such as CSF)
• Not available for all viruses
• Used to:
  • determine immunity (IgG)
  • latent infection (IgG)
  • active infection (IgG)
  • recent (acute) infection (IgM)
TYPICAL SEROLOGIC PROFILE FOLLOWING VIRAL INFECTION

**NB:** during reinfection, IgM may be absent or present at a low level transiently
VIRUS CLASSIFICATION: SUMMARY

Many ways to classify viruses - most common is based on 3 features:

1. Capsid shape/symmetry
2. Presence or absence of an envelope
3. Nucleic acid type

Understanding virus classification:

1. Helps in laboratory diagnosis
2. Aids the development and selection of anti-viral treatment
3. Provides insight into virus stability and survival within the host and in the environment
MODULE OBJECTIVES

By now, you should be able to:

1. List classes of viruses that are clinically relevant
2. Describe how viruses are identified in the laboratory