Medical Virology

Introduction to Basics

Dr. Mushtak T. S. Al-Ouqaili
History Virology

- Smallpox was endemic in China in the past. In response, the practice of variolation was developed. Recognizing that survivors of smallpox outbreaks were protected from subsequent infection, variolation involved inhalation of the dried crusts from smallpox lesions like snuff, or in later modifications, inoculation of the pus from a lesion into a scratch on the forearm of a child.
Virus infections are Universal ......
Introduction to Virology

• A virus is an obligate intracellular parasite containing genetic material surrounded by protein

• Virus particles can only be observed by an electron microscope
General Properties of Viruses
General Properties

- Obligate intracellular parasites
- Contain only one type of nucleic acid, either DNA or RNA
- Do not possess cellular organization
- Lacks enzymes necessary for protein & NA synthesis
- Depends on host cell machinery for replication
- Causes a large no. of human diseases ranging from minor ailments like common cold to terrifying diseases such as rabies, HIV etc.
General Properties

- Morphology – size, structure, shape, chemical properties, resistance
- Replication
- Hemagglutination
- Cultivation
- Viral assay
- Viral infections: virus-host interactions
Morphology - Size

- Much smaller than bacteria
- "Filterable agents" – can pass through filters that can hold back bacteria
- Vary widely in size:
  - Largest – poxvirus (300nm)
  - Smallest – parvovirus (20nm)
- Virion – extracellular infectious virus particle
Human DNA viruses

- Parvovirus
- Papovavirus
- Adenovirus
- Herpesvirus
- Poxvirus

Human RNA viruses

- Picornavirus
- Reovirus
- Togavirus
- Coronavirus
- Orthomyxovirus
- Rhabdovirus
- Paramyxovirus

Bacteriophage MS2
Bacteriophage M13
Tobacco mosaic virus
Bacteriophage T2
Chlamydia

Escherichia coli (6 μm long)
Morphology - Structure of Virus

- Nucleic acid
- Capsid
- Envelope
- Peplomer

Size in nanometers
Morphology – Structure & Shape of a virus

- Nucleic acid & capsid with or without envelope.

- **Capsid** – the protein coat surrounding the nucleic acid core. It
  - protects nucleic acid from inactivation
  - helps to introduce viral genome into host cell

- **Capsomers** - the repeating protein subunits that make up the capsid

- **Protomers** – the polypeptide chains which make up the capsomers
1. Protomers

2. Capsomers

3. Pro-Capsid

4. Mature Capsid
Morphology – Structure & Shape of a virus: Capsid

- Capsomers – symmetrically arranged to form an impenetrable shell (capsid) around the nucleic acid core.

- This symmetry is of two types:
  - Icosahedral (cubical)
  - Helical
Morphology – Structure & Shape of a virus: Capsid

- **Icosahedron** – a polygon with 12 corners (vertices) & 20 sides (facets)
  - Side – equilateral triangle
  - Two types of capsomers form the capsid
  - Pentagonal capsomers form the vertices
  - Hexagonal capsomers form the sides.

- **Helical** – the capsomers & nucleic acid are wound together to form a helical or spiral tube.

- The overall shape of virus is quite variable, but mostly they are **spherical**.
Morphology – Structure & Shape of a Virus: Envelope

- May or may not be present
- Derived from the host cell membrane
- Lipoprotein in nature – lipid is of host cell origin while protein is from virus.
- Protein subunits seen as projecting spikes on the surface of envelope – called Peplomer.
- A virus may have more than one type of peplomer e.g. influenza virus.
- Confers chemical, antigenic & biological properties.
- Susceptible to lipid solvents
Comparison of naked and enveloped virus, two basic types of virus particles.

**Caption:** Many enveloped viruses are so because they become covered with host cytoplasmic membrane as they are released from the cell.
**Resistance**

- Very heat labile but stable at low temperatures
  - Inactivated within seconds at 56°C.
  - Can be kept frozen at -70°C for long term storage.

- Inactivated by sunlight, UV rays & ionising radiations.

- More resistant than bacteria to chemical disinfectants.

- Most active **antiviral agents** (virucidal) – oxidising agents like hydrogen peroxide, potassium permangnate, hypochlorites
Pathways for Viral Entry into Host Cell

Surface
Fusion

Fusion in
Endosome

Lysis of
Endosome

Receptor-Mediated Endocytosis
Viral Properties

- Viruses are inert (nucleoprotein) filterable Agents
- Viruses are obligate intracellular parasites
- Viruses cannot make energy or proteins independent of a host cell
- Viral genome are RNA or DNA but not both.
- Viruses have a naked capsid or envelope with attached proteins
- Viruses do not have the genetic capability to multiply by division.
- Viruses are non-living entities
Viruses are Ultramicroscopic
The size of viruses
VIRAL STRUCTURE – SOME TERMINOLOGY

- virus particle = virion
- protein which coats the genome = capsid
- capsid usually symmetrical
- capsid + genome = nucleocapsid
- may have an envelope
5 Characteristics of Life

- 1. Cells
- 2. Grow and maintain their structure by taking up chemicals and energy from the environment
- 3. Respond to their external environment
- 4. Reproduce and pass on their organization to their offspring
- 5. Evolve and Adapt to their environment
Viruses are:

- 1. Acellular
- 2. Obligate intracellular parasites
- 3. No ATP generating system
- 4. No Ribosomes or means of Protein Synthesis
Typical Virus 2 Parts

- 1. Nucleic Acid
  - DNA or RNA (But never both)
- 2. Capsid (Coat Protein)

- Some Viruses:
  - A. Envelope
  - B. Enzymes
**Host range**

- Spectrum of host cells that a virus can infect

- Some viruses only infect:
  - plants
  - invertebrates
  - protists
  - fungi
  - bacteria (Bacteriophages)
Host range

- Most viruses have a narrow host range

- Polio virus - nerve cells
- Adenovirus - cells in upper Respiratory Tract
Host range is determined by Viruses' ability to interact with its host cell.

- Binding Sites match Receptor Sites
- Binding Sites - on viral capsid or envelope
- Receptor Sites - on host cell membrane
Viral Size

20 nm to 1,000 nm

.02 u to 1 u
**Viral Structure**

- 1. Nucleic Acid
- 2. Capsid (Coat Protein)

- **Nucleic Acid**
  - DNA or RNA (But never both)
    - ssDNA
    - ds DNA
    - ss RNA
    - ds RNA
Viral Structure

- **Capsid** (Coat Protein)
  - protects viral genome from host endonucleases
  - capsomeres
  - Binding Sites

- **Envelope**
  - derived from the host cell
  - Binding Sites
Viral Morphology

1. Helical

(a) A helical virus
Viral Morphology

2. Polyhedral

(a) A polyhedral virus

Icosahedral
Viral Morphology

3. Enveloped

A. Enveloped Helical
B. Enveloped Polyhedral
Viral Morphology

4. Complex
Viral Classification

- 1. Nucleic Acid
- 2. Morphology
- 3. Strategy for replication
Virion

- The complete infectious unit of virus particle
- Structurally mature, extracellular virus particles.
Virion

- Viral core
- Capsid
- Envelope
Virion Structure

Lipid Envelope

Nucleic Acid

Protein

Capsid

Spike

Projections

Virion

Associated

Polymerase
Distinguishing characteristics of viruses

• Obligate intracellular parasites
• Extreme genetic simplicity
• Contain DNA or RNA
• Replication involves disassembly and reassembly
• Replicate by "one-step growth"
How are viruses named?

• Based on:
  - the disease they cause
    - poliovirus, rabies virus
  - the type of disease
    - murine leukemia virus
  - geographic locations
    - Sendai virus, Coxsackie virus
  - their discovers
    - Epstein-Barr virus
  - how they were originally thought to be contracted
    - dengue virus ("evil spirit"), influenza virus (the "influence" of bad air)
  - combinations of the above
    - Rous Sarcoma virus
Virus particle = virion
5 BASIC TYPES OF VIRAL STRUCTURE

ICOSAHEDRAL

- Icosahedral nucleocapsid
  - Nucleic acid
  - Capsid
  - Capsomers (protein)

ENVELOPED ICOSAHEDRAL

- Nucleocapsid
  - Lipid bilayer

HELICAL

- Helical nucleocapsid
  - Nucleic acid
  - Protein (monomeric units)

ENVELOPED HELICAL

- Nucleocapsid
  - Lipid bilayer
  - Glycoprotein spikes = peplomers
Icosahedral

- Adeno-associated Virus (AAV)
  - Adenovirus
  - B19
  - Coxsackievirus - A
  - Coxsackievirus - B
  - Cytomegalovirus (CMV)
  - Eastern Equine Encephalitis Virus (EEEV)
  - Echovirus
  - Epstein-Barr Virus (EBV)
  - Hepatitis A Virus (HAV)
  - Hepatitis B Virus (HBV)
  - Hepatitis C Virus (HCV)
  - Hepatitis Delta Virus (HDV)
  - Hepatitis E Virus (HEV)
- Herpes Simplex Virus 1 (HHV1)
- Herpes Simplex Virus 2 (HHV2)
- Human Immunodeficiency Virus (HIV)
- Human T-lymphotrophic Virus (HTLV)
- Norwalk Virus
- Papilloma Virus (HPV)
- Polio virus
- Rhinovirus
- Rubella Virus
- Saint Louis Encephalitis Virus
- Variella-Zoster Virus (HHV3)
- Western Equine Encephalitis Virus (WEEV)
- Yellow Fever Virus
Viral Replication

Stages in virus replication begin when virions infect cells

Attachment/Adsorption

Penetration

Uncoating

Biosynthesis

Maturation & Assembly

Release
Eclipse phase – from the stage of penetration till the appearance of mature daughter virions, the virions cannot be detected inside the host cell.

http://www.liquidjigsaw.com(animation/anim5.htm#)