Introduction to Virology
Learning objectives:

▷ What Is a Virus?
▷ Viral Structure.
▷ Classification of Virus.
▷ Why do we Study Viruses?
▷ How do we Detect and Measure Viruses?
1. What Is a Virus?

(The concept of virus, Historical background, Host Range, General characteristics of viruses)
Viruses are very different from the other microbial groups. They are so small (filterable) that most can be seen only with an electron microscope, and they are acellular (not cellular). Viruses can reproduce only by using the cellular machinery of other organisms (obligatory intracellular parasites) (1).
### Table 1. Viruses and Bacteria Compared

<table>
<thead>
<tr>
<th></th>
<th>Typical Bacteria</th>
<th>Rickettsias/Chlamydias</th>
<th>Viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracellular Parasite</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plasma Membrane</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Binary Fission</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Pass through Bacteriological Filters</td>
<td>No</td>
<td>No/Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Possess Both DNA and RNA</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ATP-Generating Metabolism</td>
<td>Yes</td>
<td>Yes/No</td>
<td>No</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sensitive to Antibiotics</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sensitive to Interferon</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
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</table>
One hundred years ago, researchers couldn’t imagine sub microscopic particles, so they described the infectious agent as *contagium vivum fluidum*—a contagious fluid.

(1798) Edward Jenner, introduced the term *virus* in microbiology. noticed that milk maids who infected with cowpox develop immunity against smallpox. He inoculated a boy with the vesicle fluid taken from the hand of infected maid. The boy developed sustained immunity against smallpox.

(1935) Wendell Stanley, isolated tobacco mosaic virus (TMV), making it possible for the first time to carry out chemical and structural studies on a purified virus. At about the same time, the invention of the electron microscope made it possible to see viruses.
Figure 1. Edward Jenner inoculating a boy with the vesicle fluid taken from the hand of infected maid with cowpox. The boy developed sustained immunity against smallpox.
Figure 2. Tobacco mosaic virus (TMV)
Virus Host Range

The **host range** of a virus is the spectrum of host cells the virus can infect.

Viruses are able to infect specific types of cells of only one **host species.** (host-specific)

In rare cases, viruses cross the host-species barrier, thus **expanding** their host range.
Virus Host Range

Viruses can infect:

- Invertebrates
- Vertebrates
- Plants

- Protists
- fungi
- bacteria
  (bacteriophages)
Viruses infect:

- Humans
  - Smallpox

- Other vertebrates
  - Foot and mouth disease

- Invertebrates
  - Leatherjackets infected with *Tipula* iridescent virus

- Plants
  - Delayed emergence of potato caused by tobacco rattle virus infection
  - Damaged potato (spraying) caused by tobacco rattle virus infection

- Fungi
  - Mushroom virus X

- Bacteria
  - *Escherichia coli* cell with phage T4 attached

(Virology Principles & Applications Book, p1)
Viral Size

Viral sizes are determined with the aid of electron microscopy. Different viruses vary considerably in size. Although most are quite a bit smaller than bacteria, some of the larger viruses (such as the vaccinia virus) are about the same size as some very small bacteria (such as the mycoplasmas, rickettsias, and chlamydias). Viruses range from 20 to 1000 nm in length.
**Figure 3** Virus sizes. The sizes of several viruses (teal blue) and bacteria (brown) are compared with a human red blood cell, shown below the microbes. Dimensions are given in nanometers (nm) and are either diameters or length by width.
2. Viral Structure

(General Structure Of Virus, Virus Genomes, General Morphology)
**Structure of Virus**

- **Capsid**: The capsid contains the virus’ genetic material (DNA or RNA).

- **Surface proteins**: These help the virus recognise and bind to cells in the host organism.

- **Viral envelope**: The viral envelope is made from fatty lipid molecules taken from cells in the host.

- **Virus genetic material**: (DNA or RNA) material contains the instructions for making new copies of the virus.
Bacteriophage Structure

- Genome (DNA or RNA)
- Protein Coat
- Tail Fibers
- Icosohedral Head
- Base Plate
- Tail

2D vs. 3D structural representations.
Virus Genomes

In contrast to prokaryotic and eukaryotic cells, in which DNA is always the primary genetic material (and RNA plays an auxiliary role), a virus can have either DNA or RNA but never both.

The nucleic acid of a virus can be single-stranded or double-stranded.
Virus Nucleic acid

- double-stranded DNA
- single-stranded DNA
- double-stranded RNA
- single-stranded RNA
General Morphology
(basis of their capsid architecture)

▷ Helical Viruses:
Helical viruses resemble long rods that may be rigid or flexible. The viral nucleic acid is found within a hollow, cylindrical capsid that has a helical structure.
▷ Example: Rabies and Ebola viruses

▷ Polyhedral Viruses:
Or many-sided, viruses. The capsid of most polyhedral viruses is in the shape of an icosahedron.
▷ Example: poliovirus.

▷ Complex Viruses:
One example of a complex virus is a bacteriophage.
3. Classification of Virus

(Naming of viruses, Classification of virus: ICTV, Baltimore Classification)
## Nomenclature of Viruses

Various approaches, *(do not obey the binomial nomenclature)* derived from:

<table>
<thead>
<tr>
<th>Named after the diseases</th>
<th>Name after the places where the disease first reported</th>
<th>Host and signs of disease</th>
<th>Latin and Greek words</th>
<th>Virus discovers</th>
</tr>
</thead>
<tbody>
<tr>
<td>eg. Measles virus, smallpox virus</td>
<td>eg. Newcastle disease virus, Ebola virus, Norwalk virus, Bunyaviridae</td>
<td>e.g. Tobacco mosaic virus, cauliflower mosaic virus brome mosaic virus</td>
<td>e.g. Coronaviridae – “crown” Parvoviridae – “small”</td>
<td>e.g. Epstein-Barr virus</td>
</tr>
</tbody>
</table>

How they were originally thought to be contracted:
- e.g. dengue virus (“evil spirit”), influenza virus (the “influence” of bad air)
Classification of Virus

Using International Committee on Taxonomy of Viruses (ICTV) to classify the viruses

1- Classical system
   - eg. animal, plant, bacterial virus
   - eg. naked or enveloped virus

2- Based on Genomics
   Baltimore classification

3- Based on Serology
   Classification based on Diagnostic virology
Baltimore classification
4. Why do we Study Viruses?
1- Viruses are capable of infecting all forms of life
   Vertebrates, prokaryotes, fungi, algae

2- Most abundant form of life
   Bacteriophages are extremely abundant
   Estimated $10^{31}$ tailed bacteriophages

3- Gene vectors for protein production.
   Viruses such as certain baculoviruses and adenoviruses are used as vectors to take genes into animal cells growing in culture
4- Gene vectors for treatment of genetic diseases.

Children with severe combined immunodeficiency have been successfully treated using retroviruses as vectors to introduce into their stem cells a non-mutated copy of the mutated gene responsible for the disease.

5- Excellent molecular biology tools - Sources of enzymes:

A number of enzymes used in molecular biology are virus enzymes (eg. reverse transcriptases from retroviruses and RNA polymerases from phages).
6- Anti-cancer agents:
Genetically modified strains of viruses, such as herpes simplex virus and vaccinia virus, are being investigated for treatment of cancers.

7- Pesticides.
Some insect pests are controlled with baculoviruses and myxoma virus.
4. How do we Detect and Measure Viruses?

(Isolation, Cultivation, and Identification of Viruses)
They can **not** be cultivated on artificial culture media.
The fact that viruses can’t multiply outside a living host cell complicates their detection, enumeration, and identification.

✓ Viruses must be provided with living cells instead of a fairly simple chemical medium (1).
However, viruses that use bacterial cells as a host (bacteriophages) are rather easily grown on bacterial cultures.
Methods for growing viruses in the laboratory

(1) Growing Bacteriophages
   - Solid media
     - Plaque method (detect and count viruses)
   - Liquid media

(2) Growing Animal Viruses
   - Living Animals
   - Embryonated Eggs
   - Cell Cultures

(3) Growing plant Viruses
(1) Growing Bacteriophages in the Laboratory

The Number of Plaques = Plaque-forming Units (PFU).

Figure 4. plaque method.
(2) Growing Animal Viruses

A- In Living Animals:

- Some animal viruses can be cultured only in living animals, such as mice, rabbits, and guinea pigs.
- Most experiments to study the immune system’s response to viral infections.
- Animal inoculation may be used as a diagnostic procedure for identifying and isolating a virus from a clinical specimen.
B- In Embryonated Eggs:

Viral growth is signalled by:

1. the death of the embryo.
2. embryo cell damage.
3. by the formation of typical pocks or lesions on the egg membranes.
(2) Growing Animal Viruses

B- In Embryonated Eggs:

The different sites of viral inoculation in embryonated eggs are:

1. Chorioallantoic membrane (CAM)
2. Amniotic Cavity
3. Allantoic Cavity
4. Yolk sac

Figure 5. *Inoculation of an embryonated egg.* The viruses will grow on the membrane at the inoculation site.
(2) Growing Animal Viruses

C - In Cell Cultures:

Cell cultures have replaced embryonated eggs as the preferred type of growth medium for many viruses. Cell cultures consist of cells grown in culture media in the laboratory.
C - In Cell Cultures:

Cell culture lines are started by treating a slice of animal tissue with enzymes that separate the individual cells (Figure 5). These cells are suspended in a solution that provides the osmotic pressure, nutrients, and growth factors needed for the cells to grow.

Figure 5: Cell cultures. Transformed cells can be grown indefinitely in laboratory culture.
Two main growth conditions

1. Monolayers (Adherent cultures)
2. Free-floating (Suspension cultures)
Examples of Cultureware

Flasks

Plates

Roller Bottles
Laminar Flow Hood

[Diagram showing a laminar flow hood with illustrations indicating items that are not allowed.]
Commonly Used Commercial Media

1. Dulbecco’s Modified Eagle Medium (DMEM)
2. Roswell Park Memorial Institute-1640 (RPMI)
3. Ham’s F12 Nutrient Mixture (F12)
(1) Growing plant Viruses in the Laboratory

Plant viruses = similar in morphology and nucleic acid types to animal viruses

Common crop viruses:
- Bean mosaic virus
- Wound tumor virus
  ▪ corn and sugarcane
- Potato yellow dwarf virus

Must penetrate cell wall by:
- Wounds
- Parasites
  ▪ Ex) aphids that eat sap

Result = color change, deformed/stunted growth, wilting
1) Growing plant Viruses in the Laboratory
References:

- [https://www.abmgood.com/marketing/knowledge_base/cell_culture_introduction.php#categories](https://www.abmgood.com/marketing/knowledge_base/cell_culture_introduction.php#categories)
Thanks!

Any questions?

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