Introduction to **Virology**

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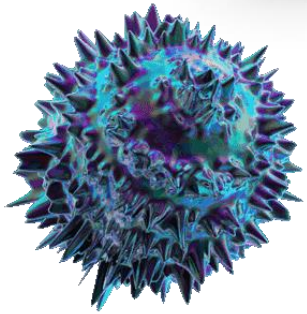
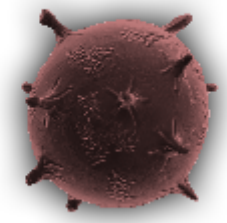
Learning objectives:

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

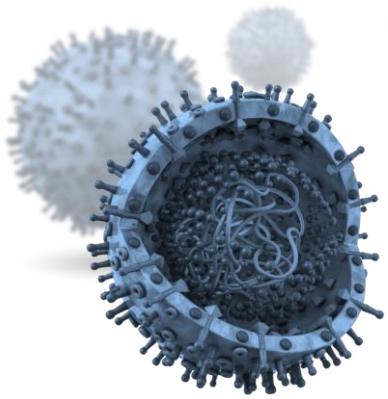




1.

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** (1).

	Bacteria		
	Typical Bacteria	Rickettsias/ Chlamydias	Viruses
Intracellular Parasite	No	Yes	Yes
Plasma Membrane	Yes	Yes	No
Binary Fission	Yes	Yes	No
Pass through Bacteriological Filters	No	No/Yes	Yes
Possess Both DNA and RNA	Yes	Yes	No
ATP-Generating Metabolism	Yes	Yes/No	No
Ribosomes	Yes	Yes	No
Sensitive to Antibiotics	Yes	Yes	No
Sensitive to Interferon	No	No	Yes

Historical background

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.

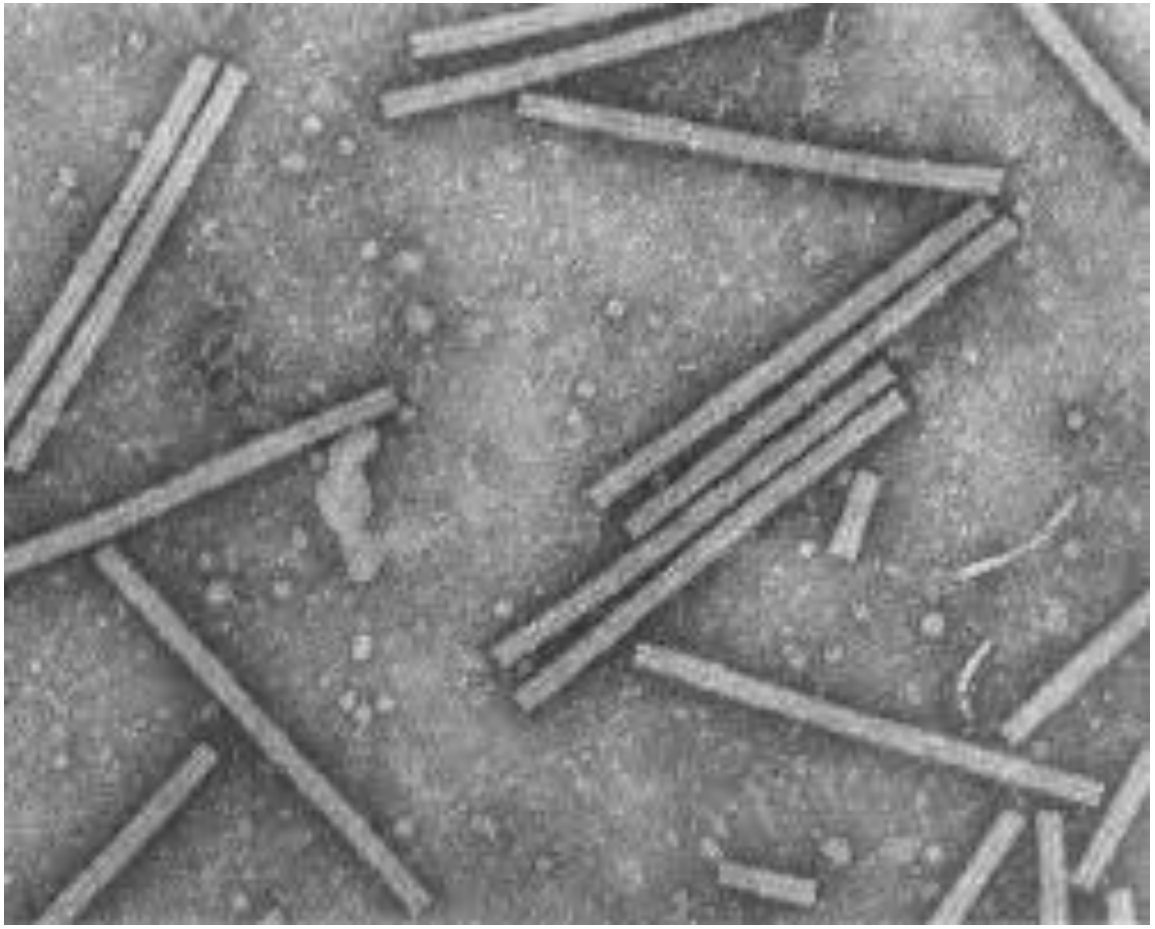


Figure 2. Tobacco mosaic virus (TMV)

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
  - Human
  - Other vertebrates
- Plants
- Protists
- fungi
- bacteria

(**bacteriophages**)

Viruses infect:

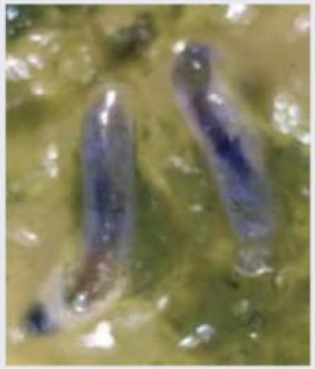
- **Humans**

Smallpox [1]

- **Other vertebrates**

Foot and mouth disease [2]

- **Invertebrates**



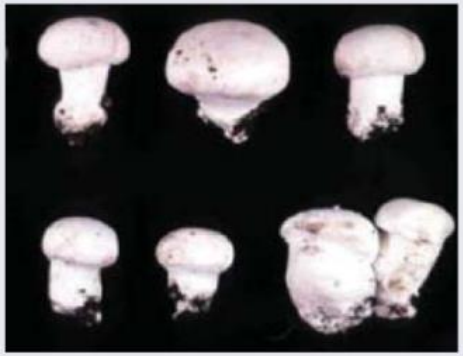
Leatherjackets infected with *Tipula* iridescent virus

- **Plants**

Delayed emergence of potato caused by tobacco rattle virus infection [3]

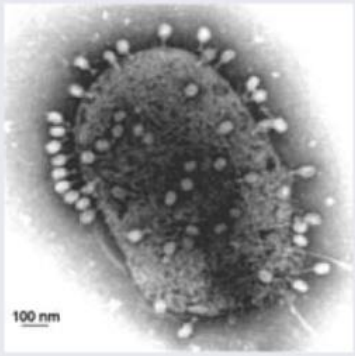
Damaged potato (spraing) caused by tobacco rattle virus infection [3]

- **Fungi**



Mushroom virus X [4]

- **Bacteria**



Escherichia coli cell with phage T4 attached [5]

(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.

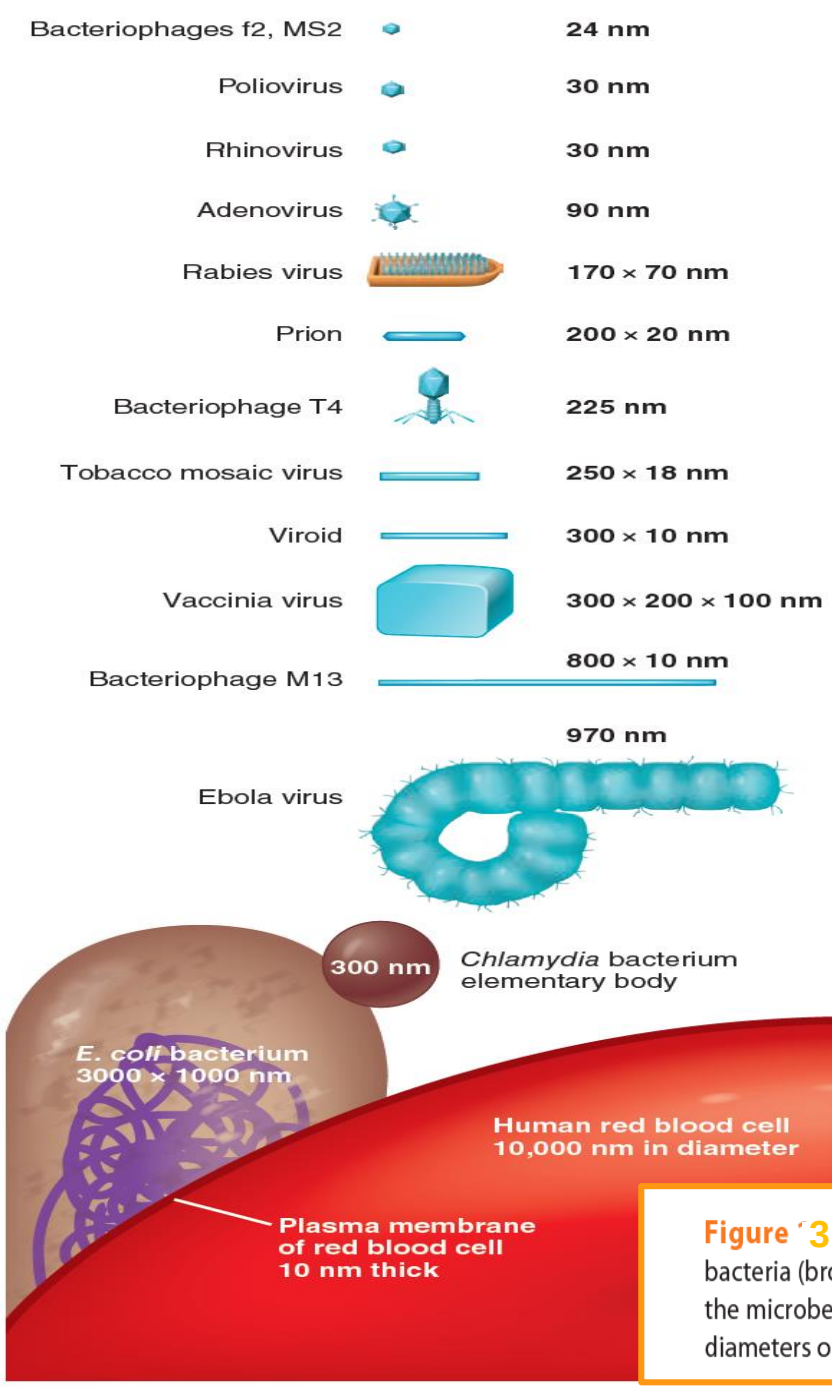


Figure 3 **Virus sizes.** The sizes of several viruses (teal blue) and bacteria (brown) are compared with a human red blood cell, shown below the microbes. Dimensions are given in nanometers (nm) and are either diameters or length by width.

2.

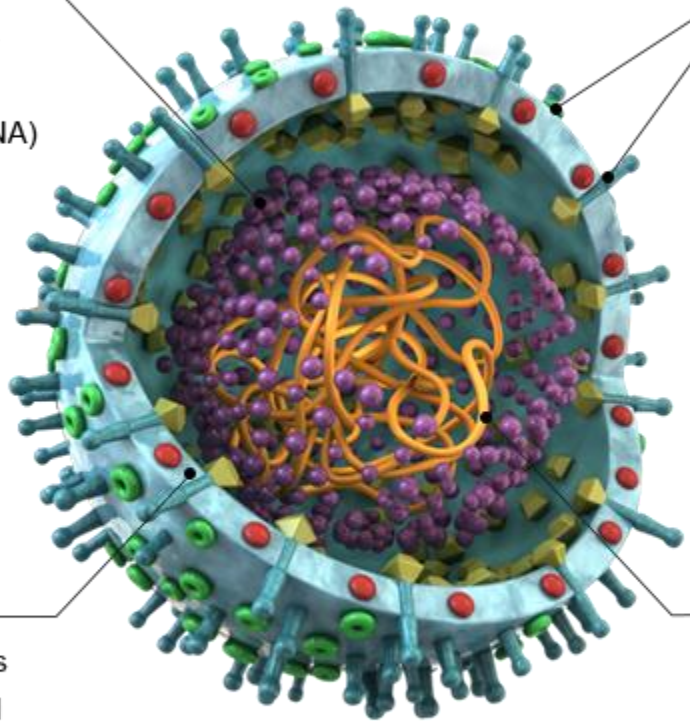
Viral Structure

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

Structure of Virus

Capsid
The capsid contains the vius'genetic material (DNA or RNA)

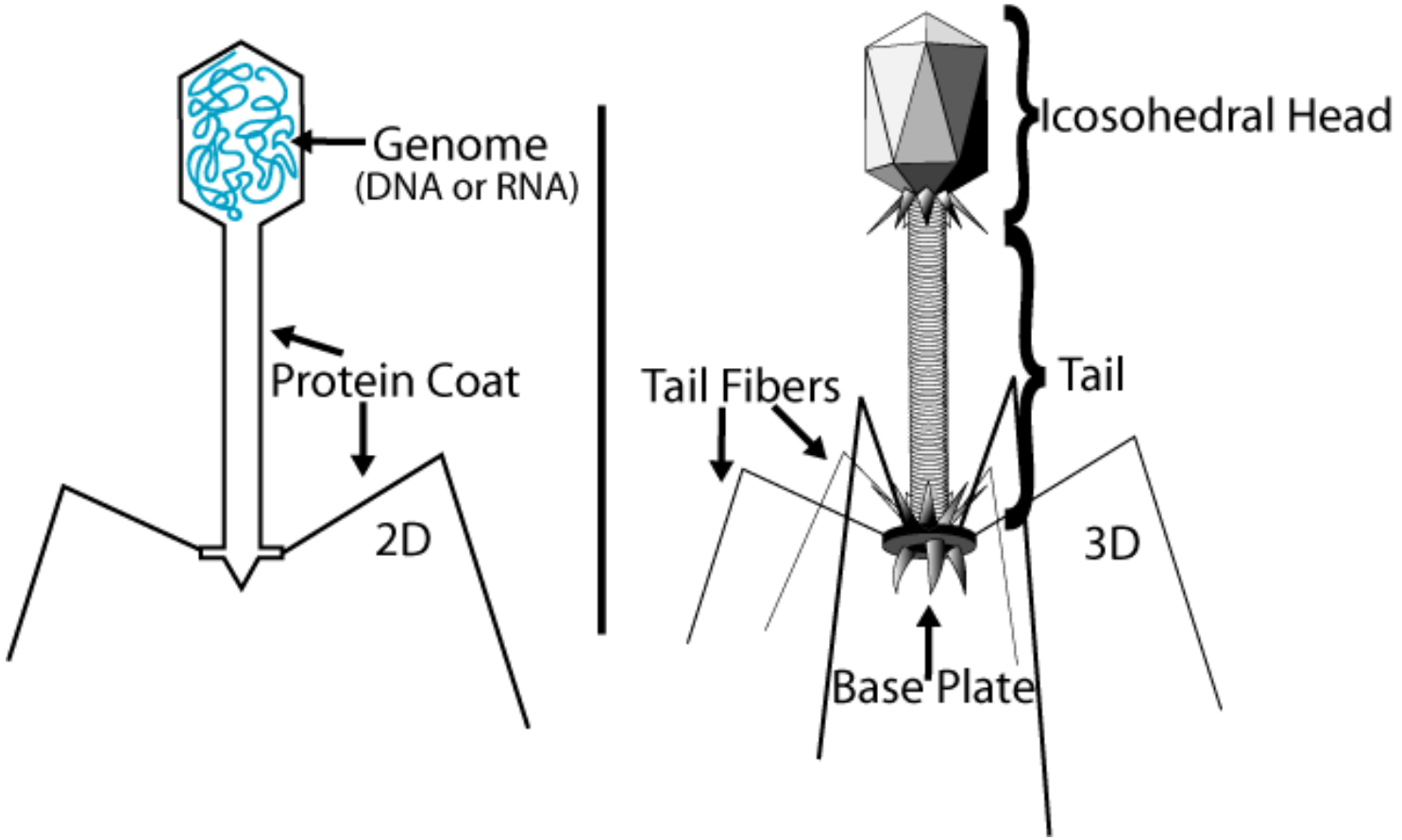
Surface proteins
These help the virus recognise and bind to cells in the host organism



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



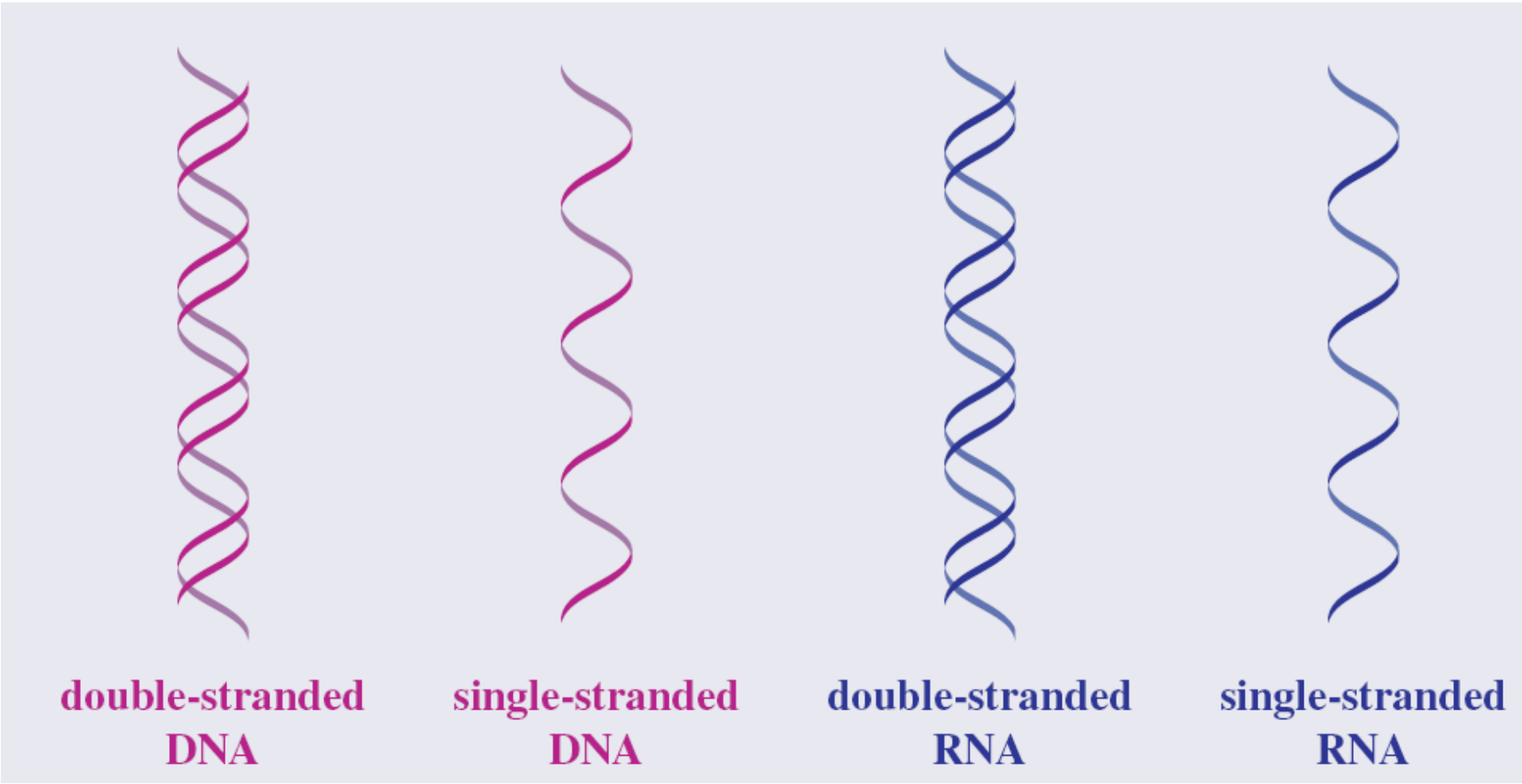
Virus Genomes

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
- double-stranded.

Virus Nucleic acid



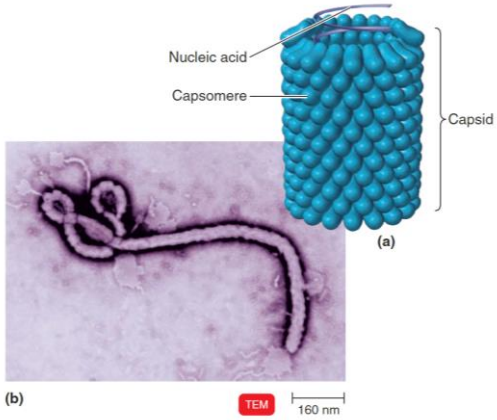
General Morphology

(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

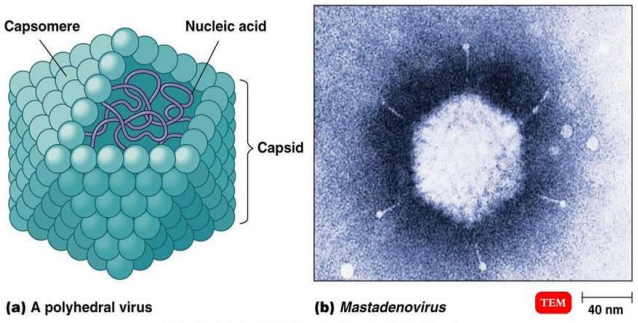
▷ Example: **Rabies** and **Ebola** viruses



▷ Polyhedral Viruses:

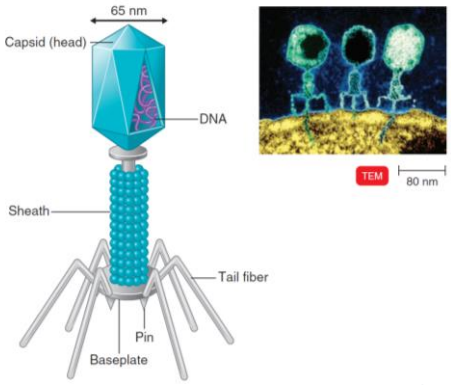
Or many-sided, viruses. The capsid of most polyhedral viruses is in the shape of an *icosahedron*

▷ Example: **poliovirus.**



▷ Complex Viruses:

One example of a complex virus is a **bacteriophage.**



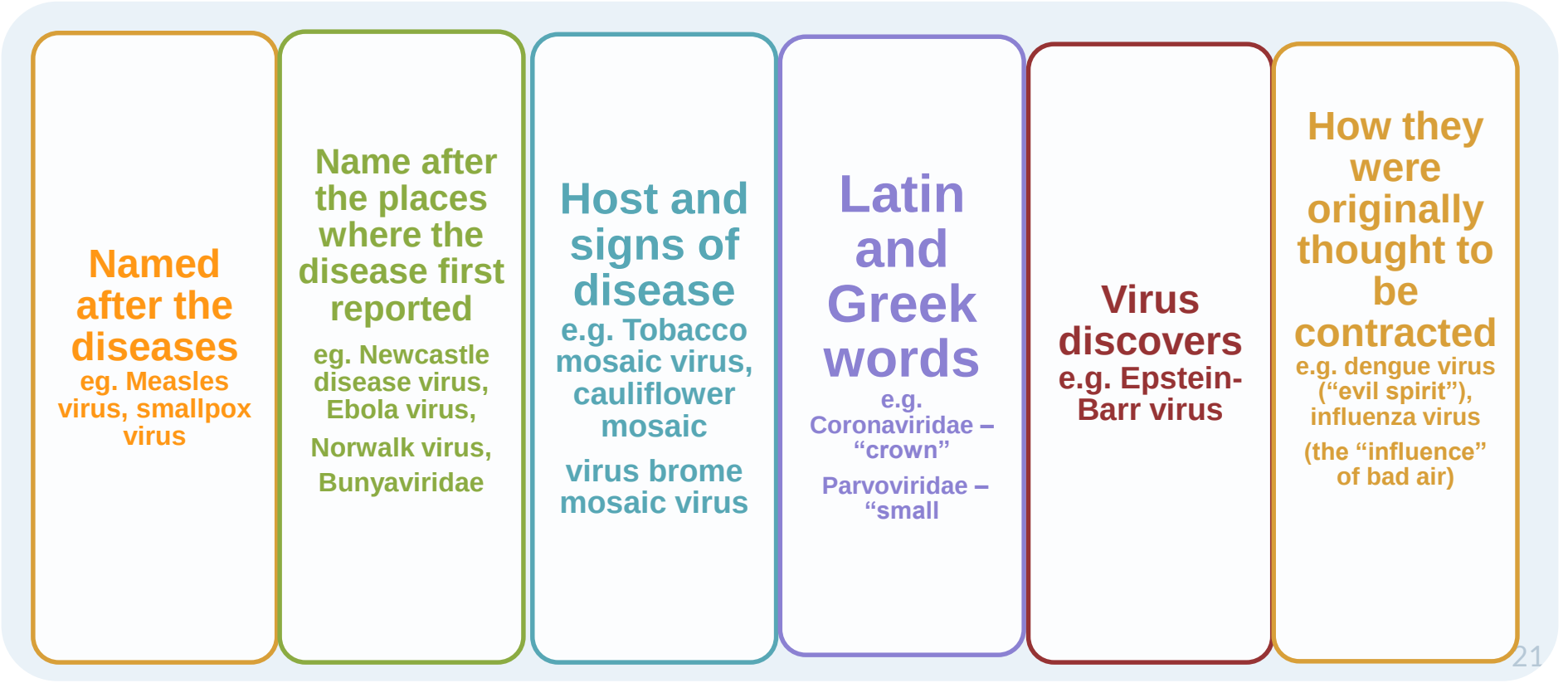
3.

Classification of Virus

(Naming of viruses, Classification of virus: ICTV, Baltimore Classification)

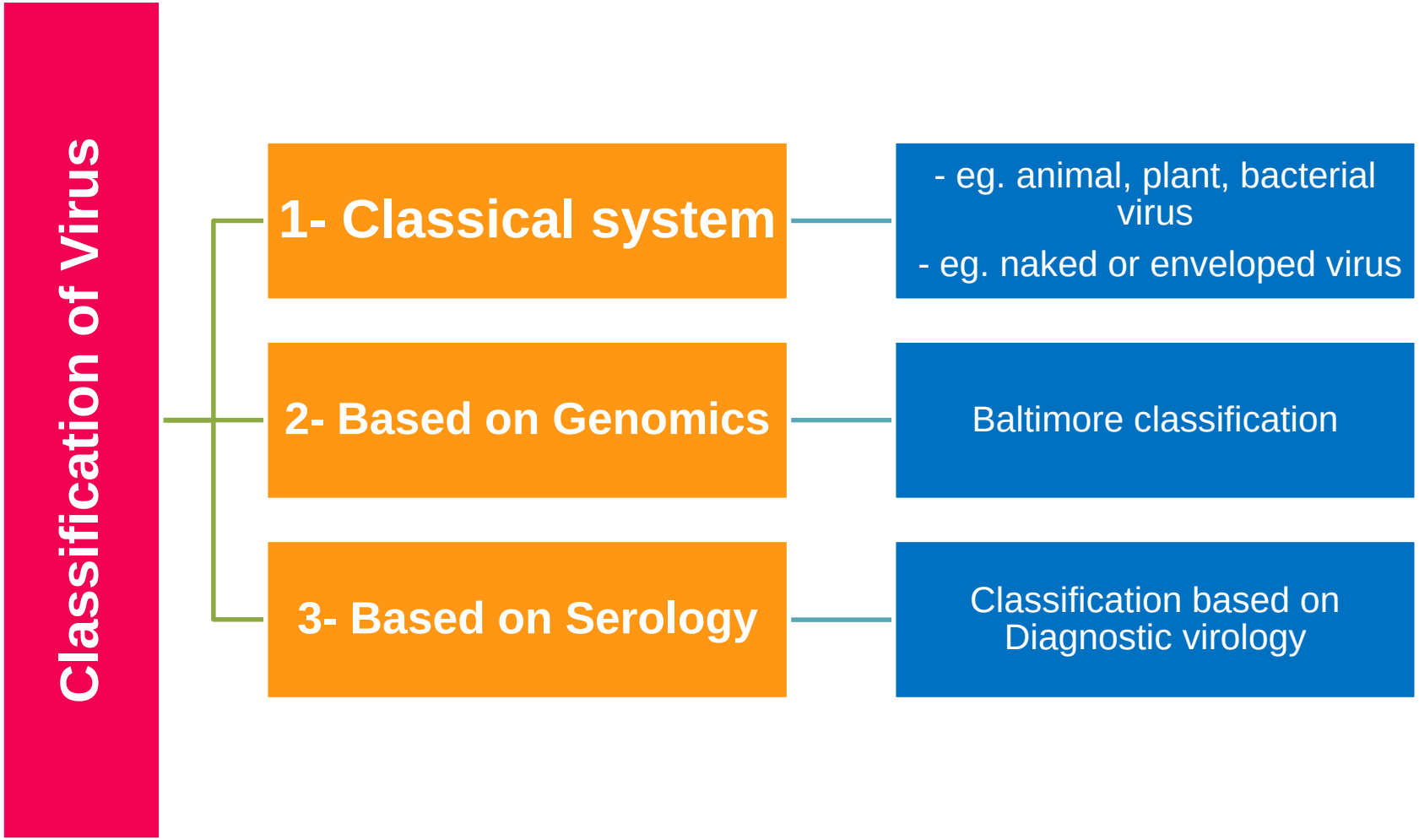
Nomenclature of Viruses

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

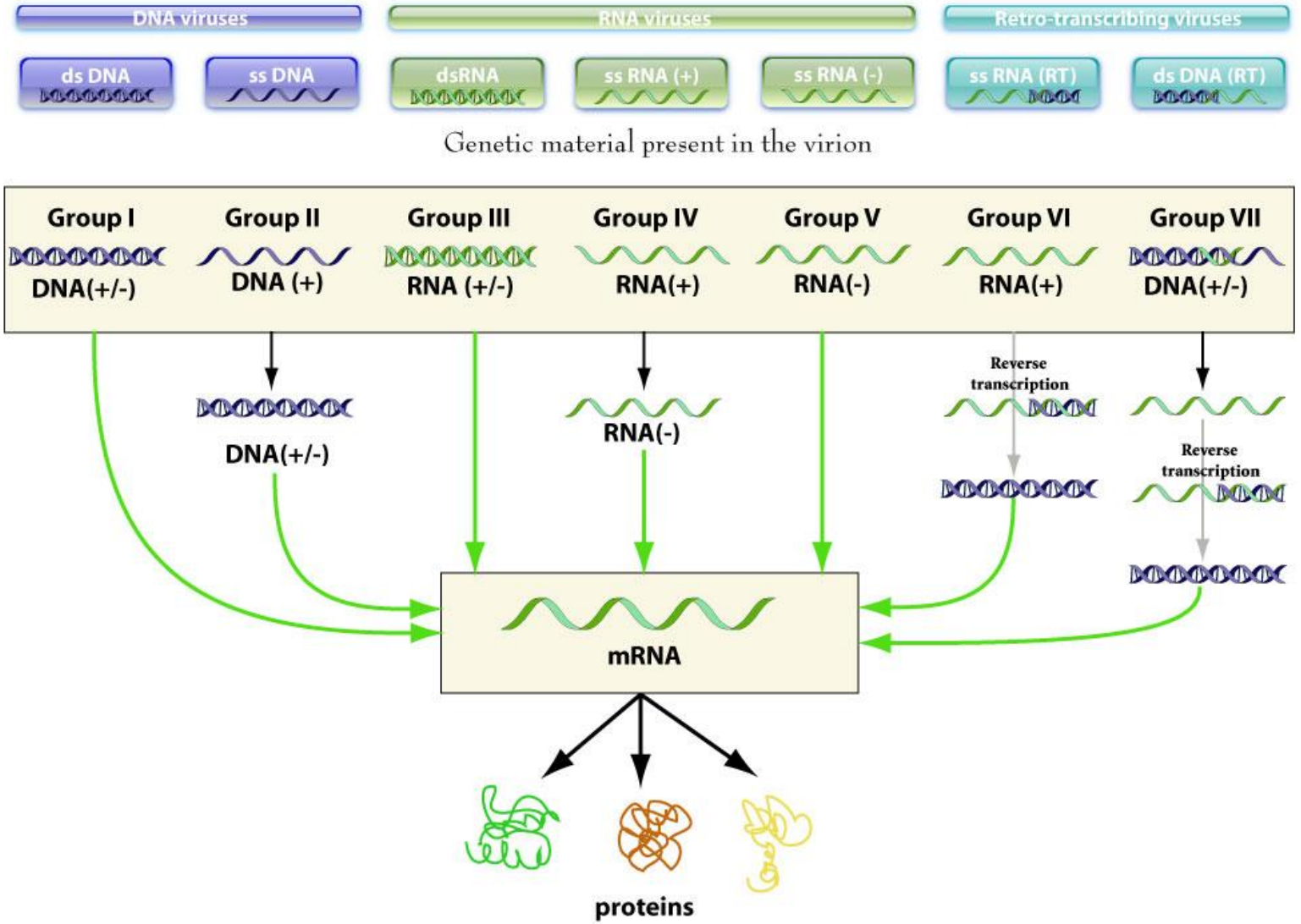


Classification of Virus

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



Baltimore classification



4.

Why do we Study Viruses?

Reasons for studying 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

Reasons for studying viruses

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)

Reasons for studying viruses

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.

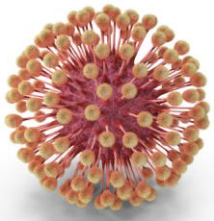
Some insect pests are controlled with baculoviruses and myxoma virus.

4.

How do we Detect and Measure Viruses?

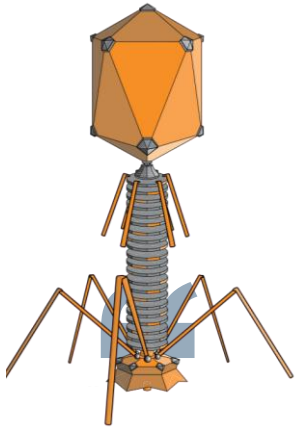
(Isolation, Cultivation, and Identification of Viruses)

They can **not** be cultivated on artificial culture media.

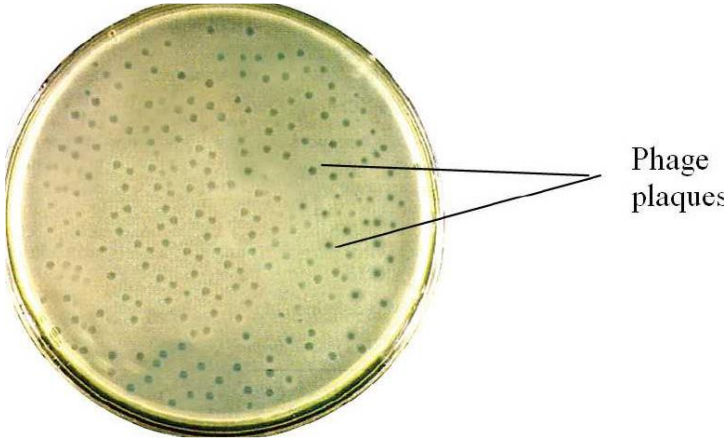


The fact that viruses **can't** multiply outside a living host cell complicates their detection, enumeration, and identification.

- ✓ 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.**



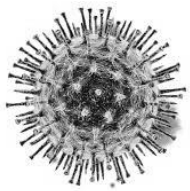
Methods for growing viruses in the laboratory

(1) Growing Bacteriophages

solid media → *plaque method* (*detect and count viruses*)

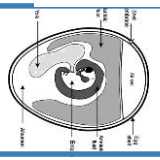
liquid media

(2) Growing Animal Viruses



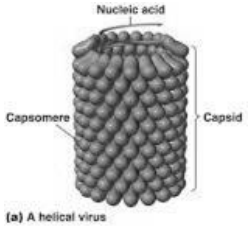
Living Animals →

Embryonated Eggs →



Cell Cultures →

(3) Growing plant Viruses



→

(1) Growing Bacteriophages in the Laboratory

The Number of Plaques

=

Plaque-forming Units (PFU).

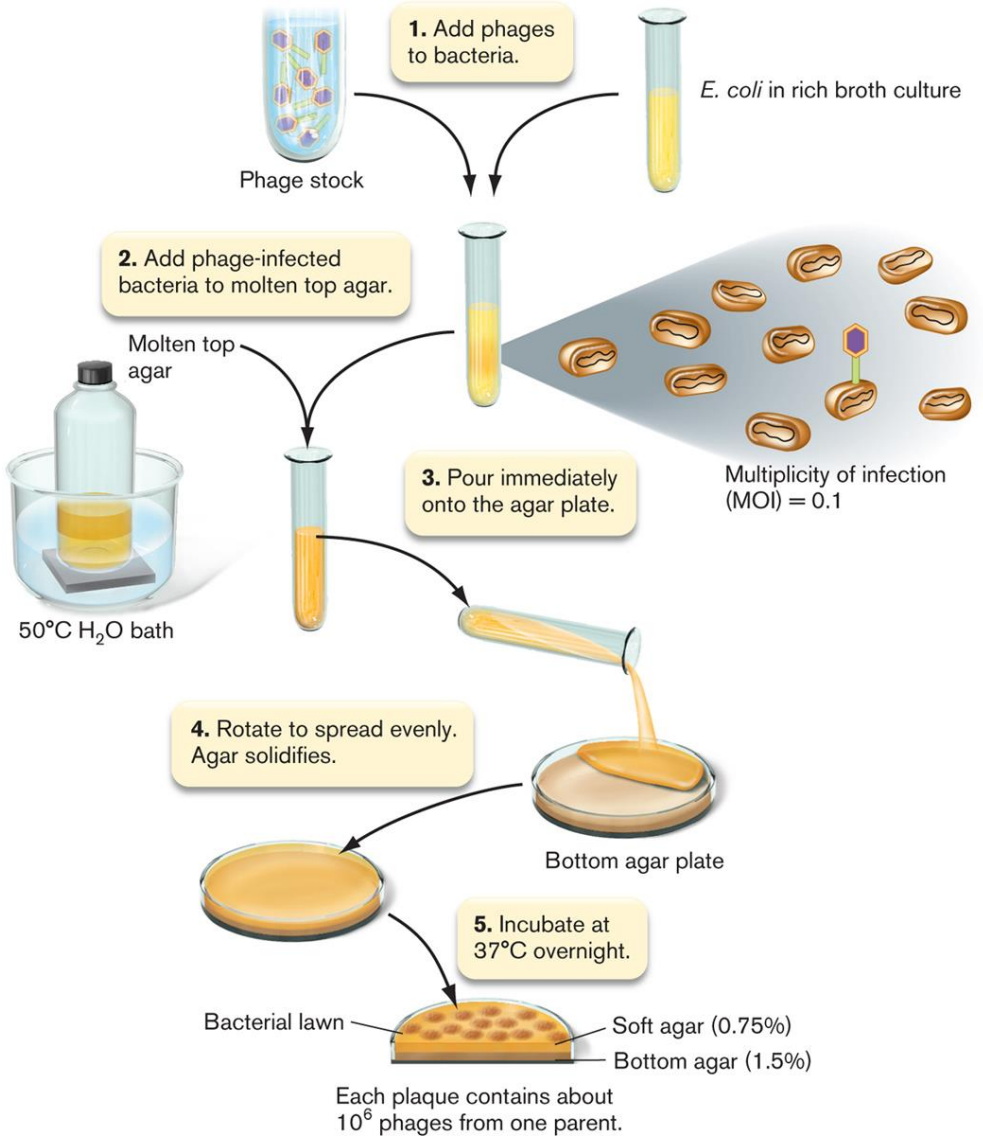
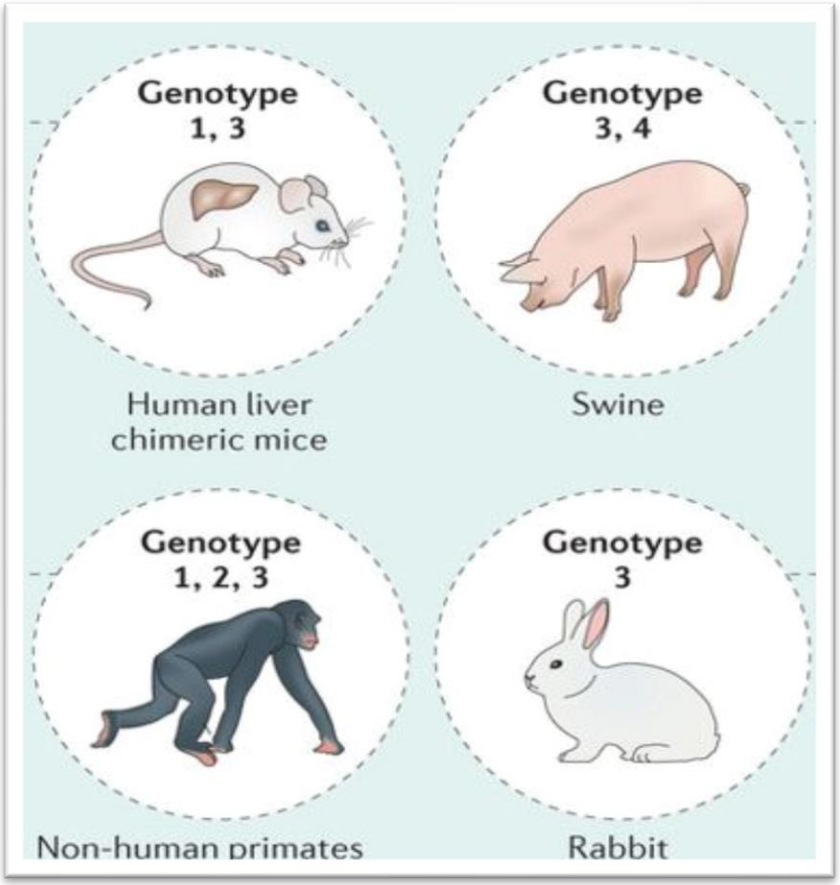


Figure 4. *plaque method.*

(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.



(2)Growing Animal Viruses

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.

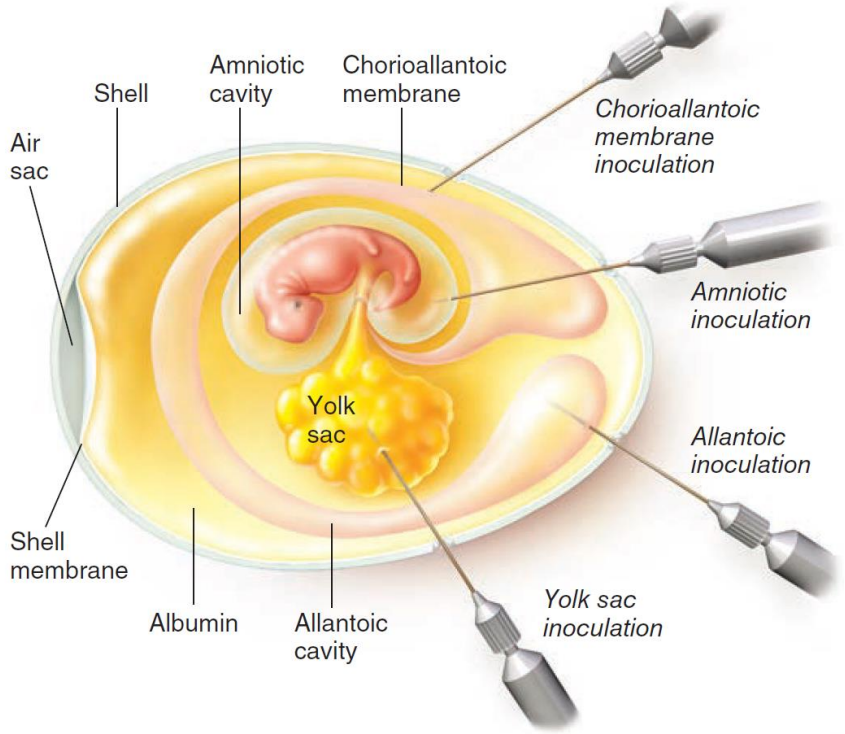


Figure 5. Inoculation of an embryonated egg. The viruses will grow on the membrane at the inoculation site.

(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

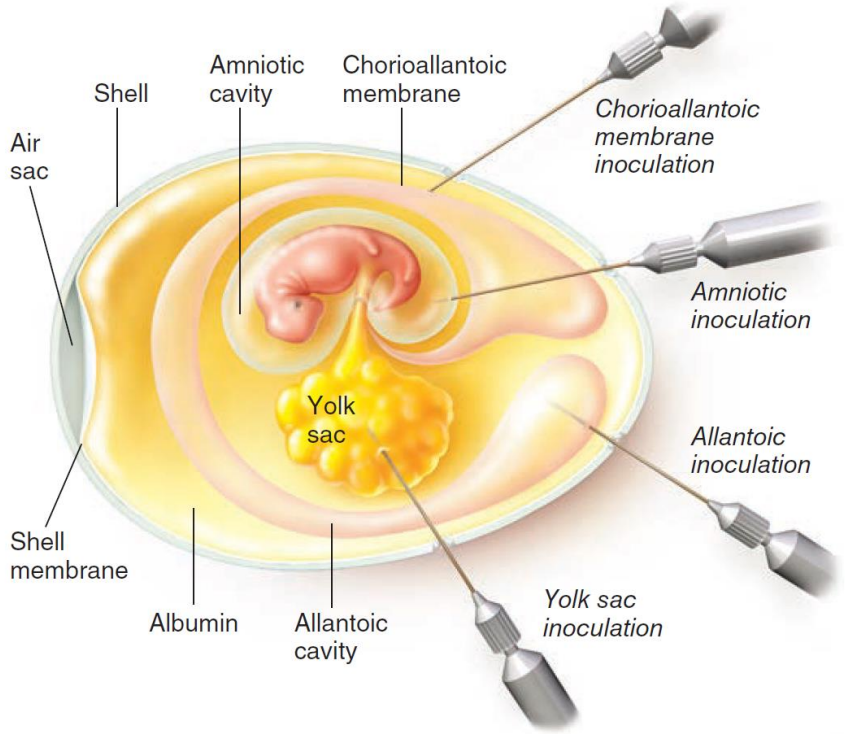
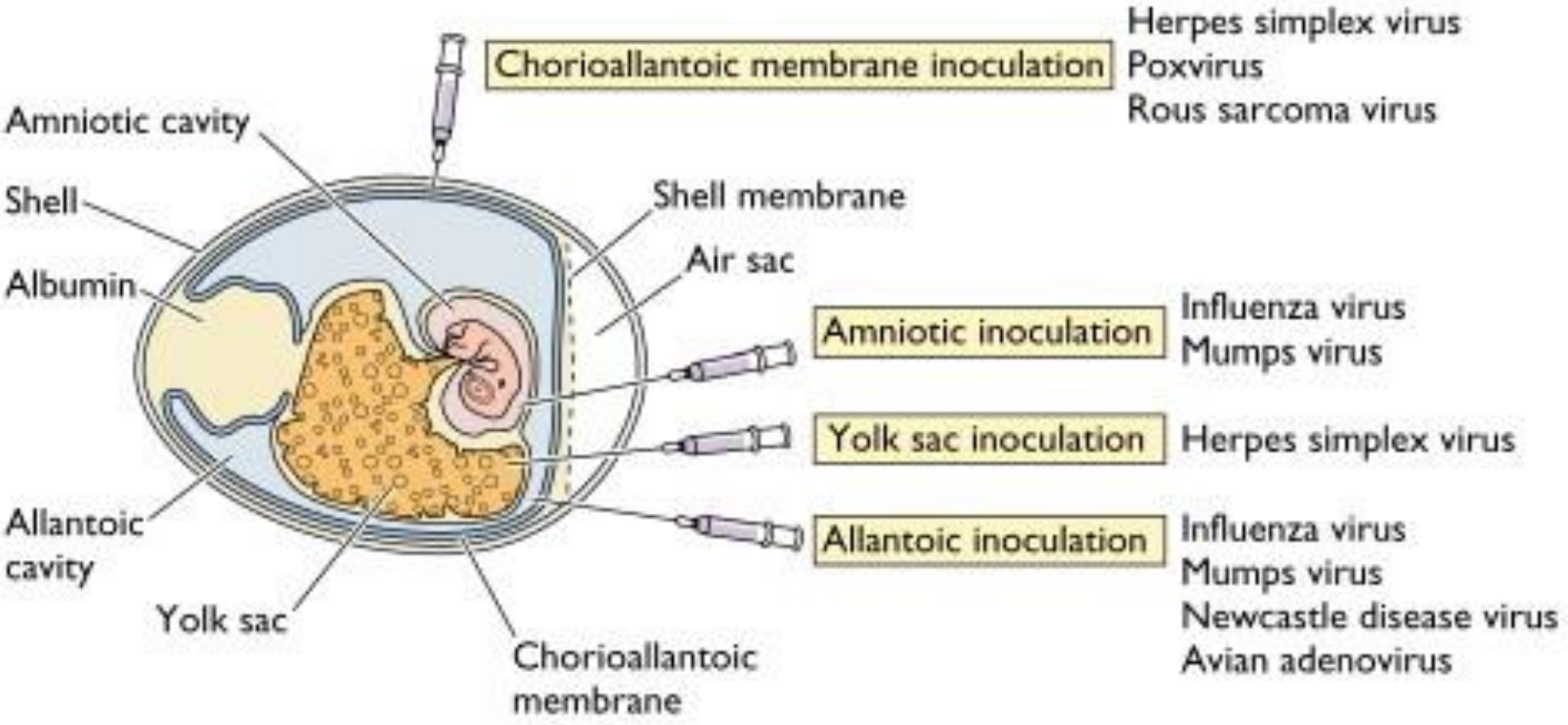


Figure 5. Inoculation of an embryonated egg. The viruses will grow on the membrane at the inoculation site.


Chorioallantoic membrane inoculation
Herpes simplex virus
Poxvirus
Rous sarcoma virus
Amniotic cavity
Shell
Albumin
Shell membrane
Air sac
Amniotic inoculation
Influenza virus
Mumps virus
Yolk sac inoculation
Herpes simplex virus
Allantoic cavity
Allantoic inoculation
Influenza virus
Mumps virus
Newcastle disease virus
Avian adenovirus
Yolk sac
Chorioallantoic membrane

(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.**

(2)Growing Animal Viruses

C - In Cell Cultures:

Cell culture lines are started by treating a slice of animal tissue with enzymes that separate the individual cells (**Figure5**). These cells are suspended in a solution that provides the osmotic pressure, nutrients, and growth factors needed for the cells to grow.

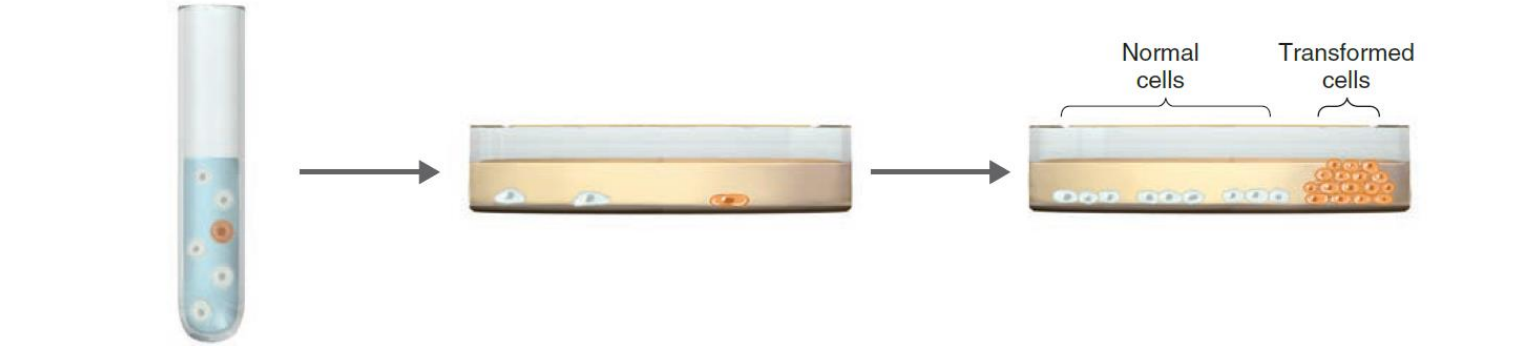
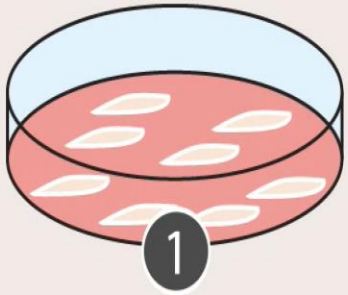
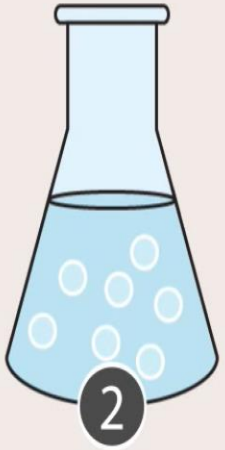


Figure 5 **Cell cultures.** Transformed cells can be grown indefinitely in laboratory culture.

Two main growth conditions



Monolayers
(Adherent cultures)



Free-floating
(Suspension cultures)

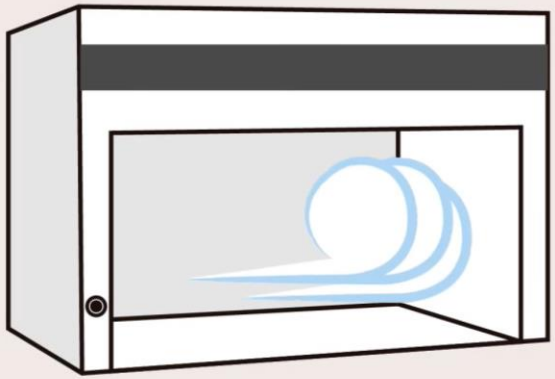
Examples of Cultureware

Flasks

Plates

Roller Bottles

Laminar Flow Hood



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

Tobacco mosaic virus

Cauliflower mosaic virus

Barley yellow dwarf

Bud blight

Sugarcane mosaic virus

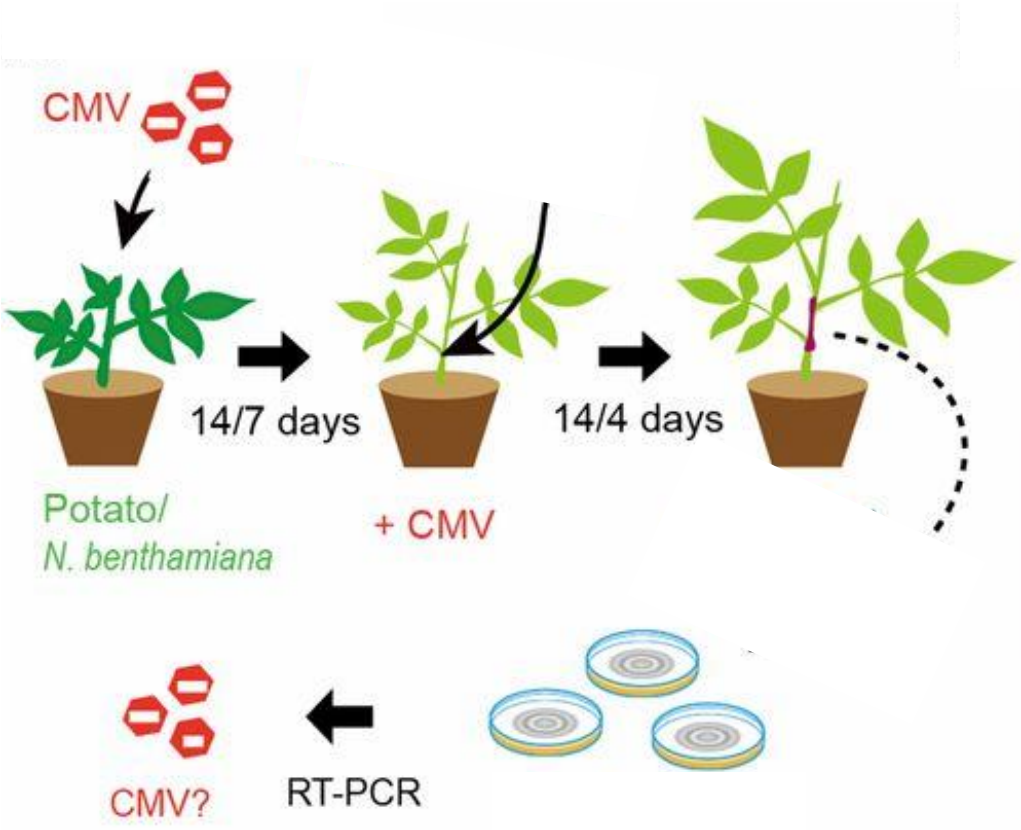
Lettuce mosaic virus

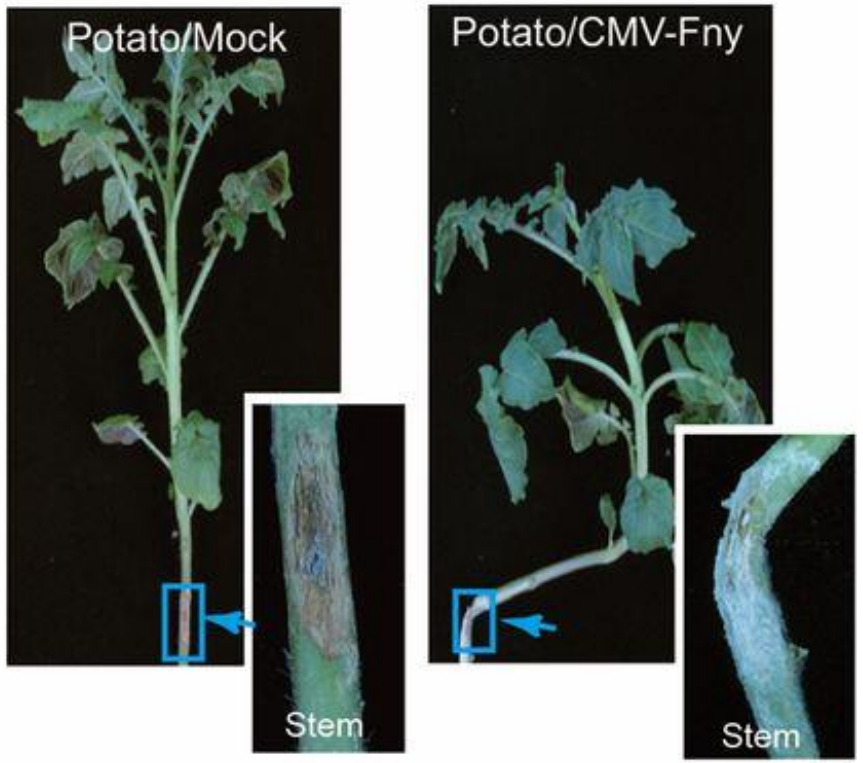
Maize mosaic virus

Peanut stunt virus

Leaf curl virus

(1) Growing plant Viruses in the Laboratory





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- Madigan, M.T., Martinko, J.M. and Parker, J., 1997. *Brock biology of microorganisms* (Vol. 11). Upper Saddle River, NJ: Prentice hall.
- https://www.abmgood.com/marketing/knowledge_base/cell_culture_introduction.php#categories

Thanks!

Any questions?

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