Paper: Cell Biology

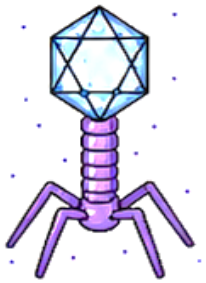
(COURSE: MAJOR & MINOR)

Topic: Virus

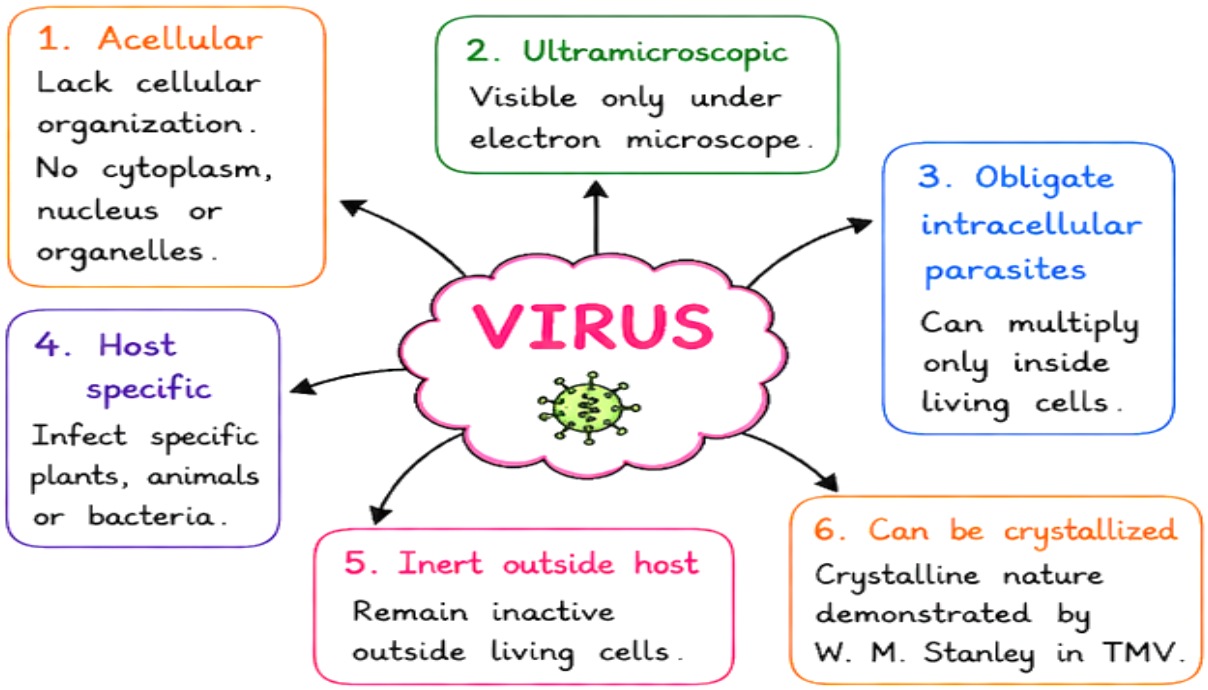
INTRODUCTION TO VIRUS

DEFINITION :

Viruses are acellular, infectious agents that contain either DNA or RNA as genetic material and can replicate only inside living host cells (obligate intracellular parasites).



CHARACTERISTICS OF VIRUSES



DISCOVERY OF VIRUSES

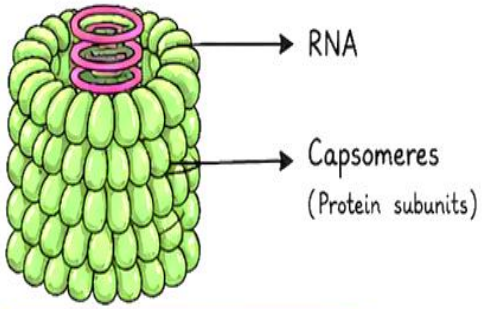
1. D. I. Ivanowsky (1892)
Showed that the infectious agent of tobacco mosaic disease can pass through bacterial filter.

2. M. W. Beijerinck (1898)
Coined the term "contagium vivum fluidum" & named it "virus" (means poison).

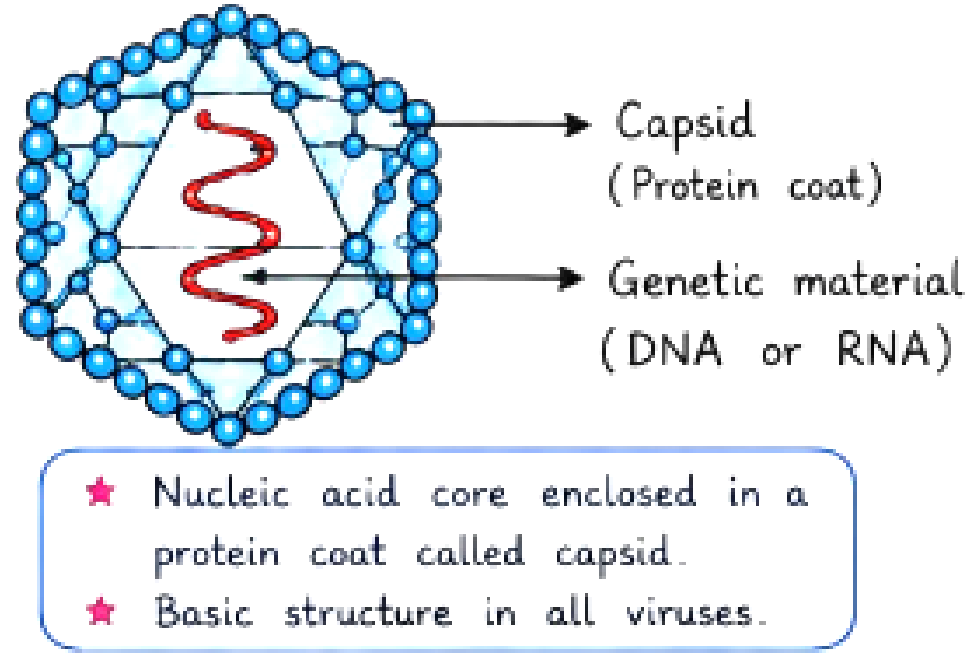
3. W. M. Stanley (1935)
Crystallized Tobacco Mosaic Virus (TMV) – the first virus to be crystallized.

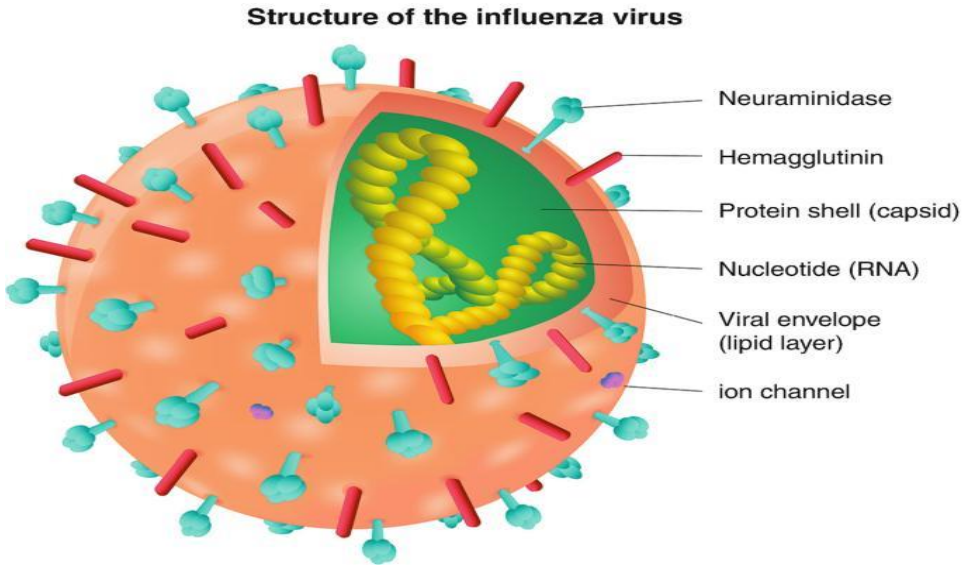
TMV CRYSTALLIZATION

TOBACCO MOSAIC VIRUS (TMV)



- Rod shaped
- Simple helical symmetry
- Infects plants (e.g., tobacco)





A typical virus is made up of

1. Genetic material

The genetic material may be **DNA** or **RNA**

A virus generally contains either DNA or RNA as its genome, not both as its genomic material.

2. Capsid

The capsid is the protein coat surrounding the viral genetic material which:

- Protects the nucleic acid.
- Gives shape to the virus.
- Helps in delivery of the viral genome into the host cell.

The capsid is made up of smaller protein units called capsomeres.

3. Envelope

Some viruses possess an additional outer lipid envelope.

The envelope is generally derived from the **host-cell membrane** during viral release.

It may contain viral glycoprotein spikes.

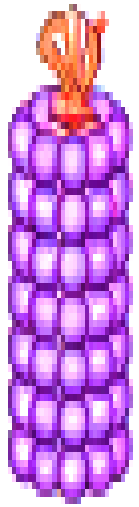
Influenza virus, HIV, herpesvirus and coronavirus are examples of enveloped viruses.

VIRAL STRUCTURE - CAPSID SYMMETRY

Symmetry of Capsid

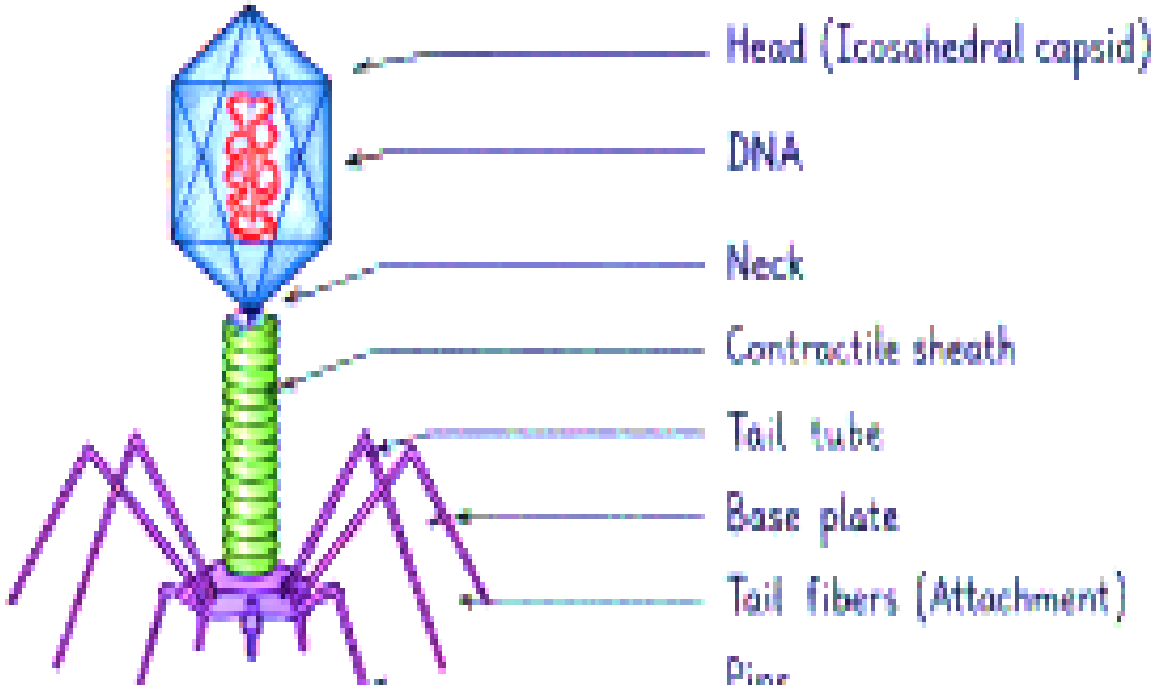
(i) Icosahedral

(ii) Helical



(iii) Complex

Structure of Bacteriophage (T4)



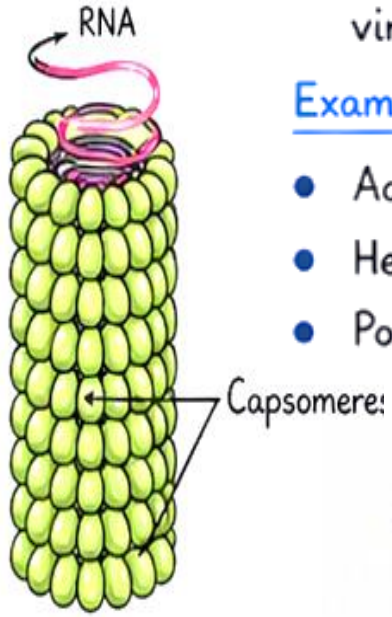
VIRAL STRUCTURE - CAPSID SYMMETRY & ENVELOPE

1. CAPSID SYMMETRY

Capsid (protein coat) shows definite symmetry. Mainly two types.

A) Helical Symmetry

- ★ Capsomeres arranged in helical manner around nucleic acid.
- ★ Rod or filament shaped viruses.



Examples :

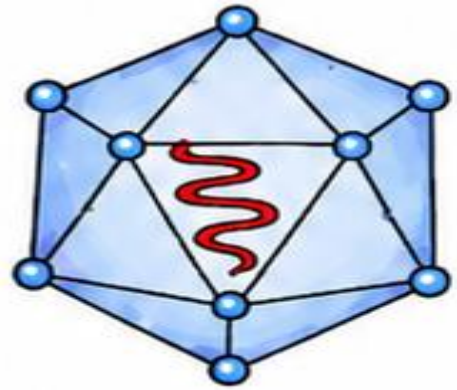
- TMV
- Rabies virus
- Tobacco necrosis virus

B) Icosahedral Symmetry

- ★ Capsomeres arranged in twenty triangular facets.
- ★ Spherical or polyhedral viruses.

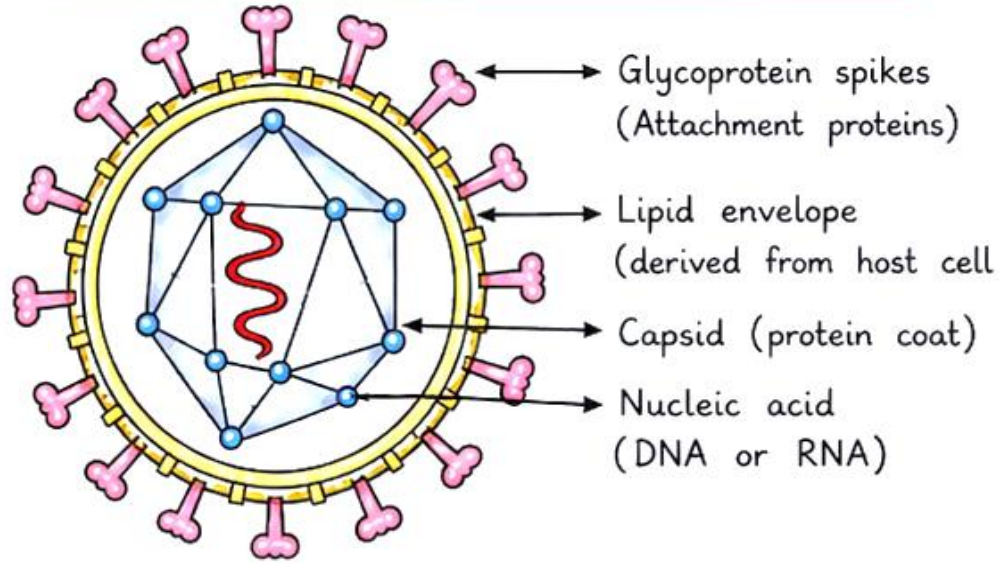
Examples :

- Adenovirus
- Herpes virus
- Polio virus



2. ENVELOPE (SUPER CAPSID) AND SPIKES

- ★ Some viruses possess an outer lipoprotein envelope derived from host cell membrane.
- ★ Envelope contains viral glycoprotein spikes.
- ★ Helps in attachment and entry into host cell.
- ★ Enveloped viruses are generally more labile.



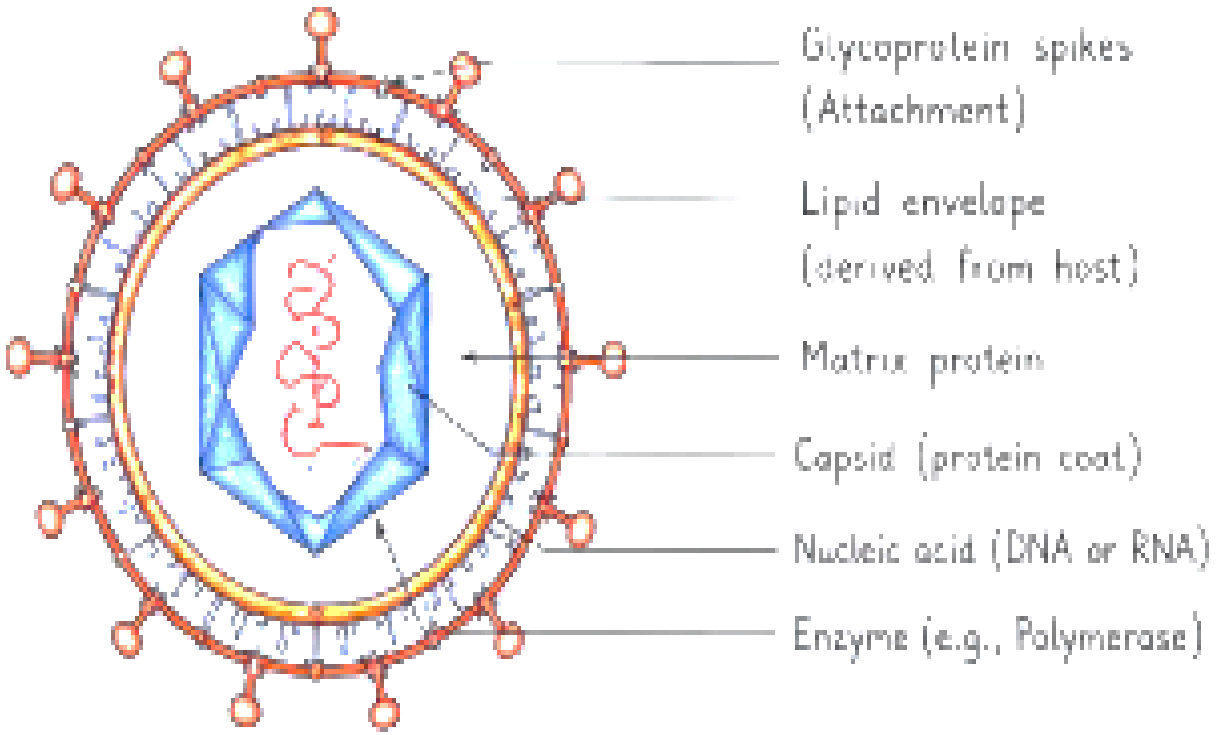
Examples of enveloped viruses :

- Influenza virus
- HIV
- Herpes virus
- Hepatitis B virus

VIRAL STRUCTURE

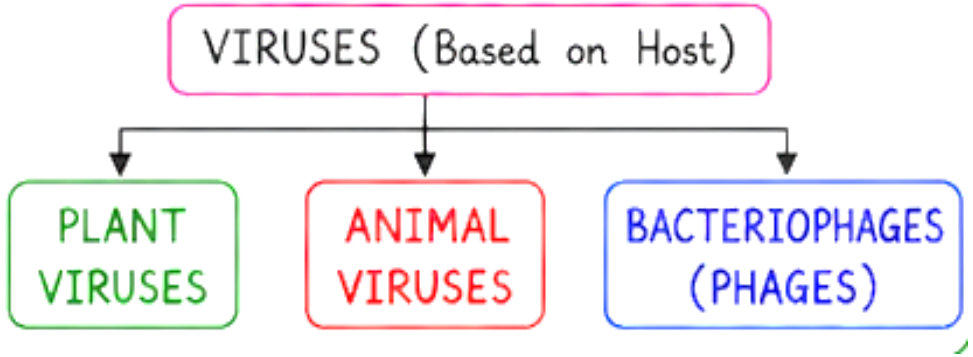
- Viruses are acellular, obligate intracellular parasites.
- Genome is either DNA or RNA (never both).
- Genome is enclosed in a protein coat called capsid.
- Capsid + Nucleic acid = Nucleocapsid
- Some viruses possess an outer lipid envelope derived from host cell membrane.
- Viruses lack ribosomes and independent metabolism.
- Size: 20 – 300 nm (visible under electron microscope only).

. Structure of a Typical Enveloped Virus



TYPES OF VIRUSES (BASED ON HOST)

Viruses infect a wide range of hosts. Based on the type of host infected, viruses are grouped into three major categories.



- Plant viruses – generally RNA viruses.
- Animal viruses – DNA or RNA.
- Bacteriophages – mostly DNA viruses.
- All viruses are obligate intracellular parasites.

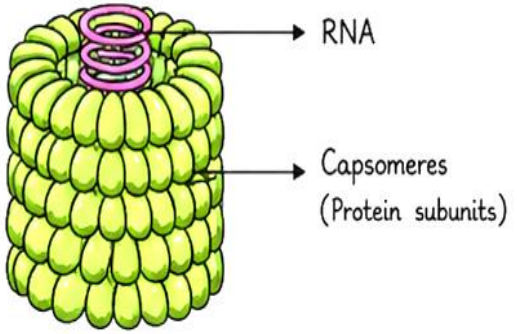
1. PLANT VIRUSES

- Infect plants.
- Mostly contain RNA as genetic material.
- Usually transmitted mechanically or by vectors (insects, fungi, nematodes).

EXAMPLES

- Tobacco Mosaic Virus (TMV)
- Potato Virus X (PVX)

EXAMPLE : TMV (Tobacco Mosaic Virus)



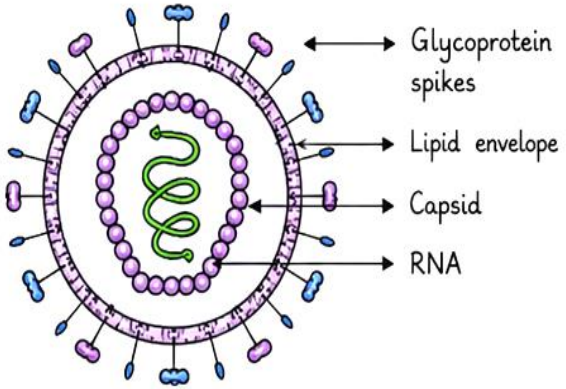
2. ANIMAL VIRUSES

- Infect animals including humans.
- Contain either DNA or RNA.
- Many are transmitted by vectors, direct contact, droplets etc.
- Cause a variety of diseases.

EXAMPLES

- Rabies Virus
- Influenza Virus
- Herpes Virus
- HIV (Human Immunodeficiency Virus)

EXAMPLE : Influenza Virus



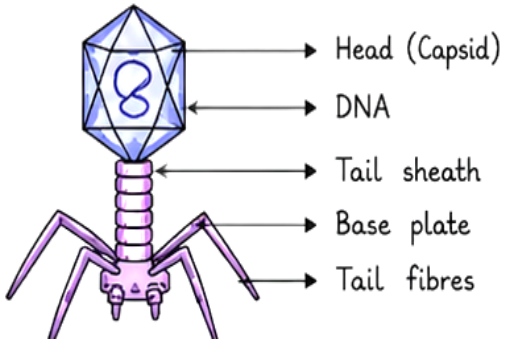
3. BACTERIOPHAGES (PHAGES)

- Infect bacteria.
- Usually contain DNA.
- Common in nature.
- Used in research and biotechnology (Genetic engineering, phage therapy).

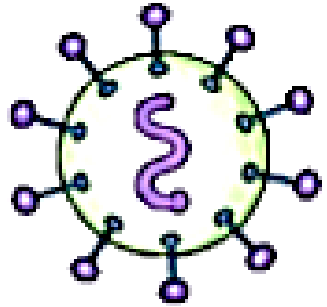
EXAMPLES

- T2 Phage
- Lambda (λ) Phage

EXAMPLE : T2 BACTERIOPHAGE



DNA VIRUSES AND RNA VIRUSES



Viruses contain either DNA or RNA as their genetic material. They never contain both.

A. DNA VIRUSES

- Contain DNA as genetic material
- Usually double stranded (dsDNA).
- More genetically stable.
- Replication occurs mostly in nucleus.
- Examples :
  - Adenovirus
  - Herpes virus
  - Pox virus
  - Hepadnavirus (Hepatitis B virus)
  - Bacteriophages (e.g., λ phage)

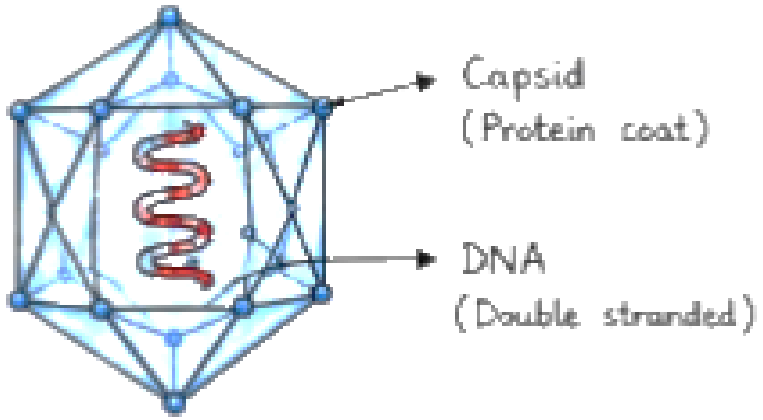
B. RNA VIRUSES

- Contain RNA as genetic material.
- Mostly single stranded (ssRNA).
- High mutation rate; genetically less stable.
- Replication occurs in cytoplasm
- Examples :
  - Tobacco Mosaic Virus (TMV)
  - Influenza virus
  - Rabies virus
  - Coronavirus
  - HIV (Retrovirus)

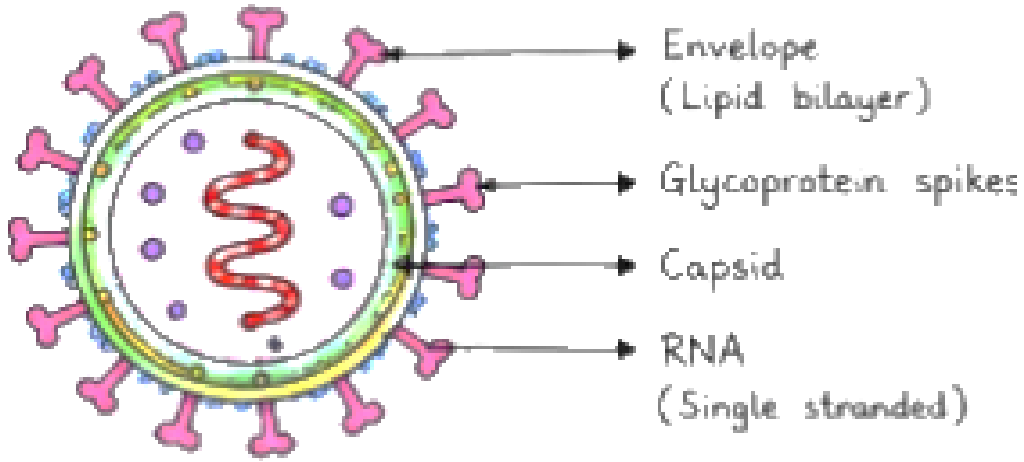
COMPARISON BETWEEN DNA VIRUSES AND RNA VIRUSES

Feature	DNA Viruses	RNA Viruses
1. Genetic material	DNA (never RNA)	RNA (never DNA)
2. Strandedness	Mostly double stranded	Mostly single stranded
3. Genetic stability	More stable	Less stable (high mutation rate)
4. Site of replication	Nucleus (mostly)	Cytoplasm
5. Enveloped / Naked	Both enveloped and naked	Both enveloped and naked
6. Examples	Adenovirus, Herpes virus, Pox virus, λ phage	TMV, Influenza virus, Rabies virus, HIV, Corona virus

GENERAL STRUCTURE OF A DNA VIRUS



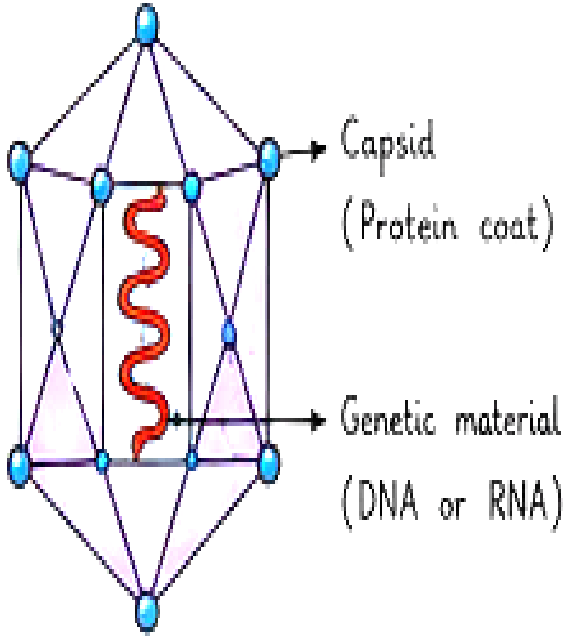
GENERAL STRUCTURE OF AN RNA VIRUS



Based on the presence or absence of a lipid envelope around the capsid, viruses are of two types :

1. NAKED VIRUSES

- Capsid is present.
- No lipid envelope.
- More resistant to heat, drying, and chemicals.
- Usually non-enveloped viruses.
- Released by lysis of host cell.



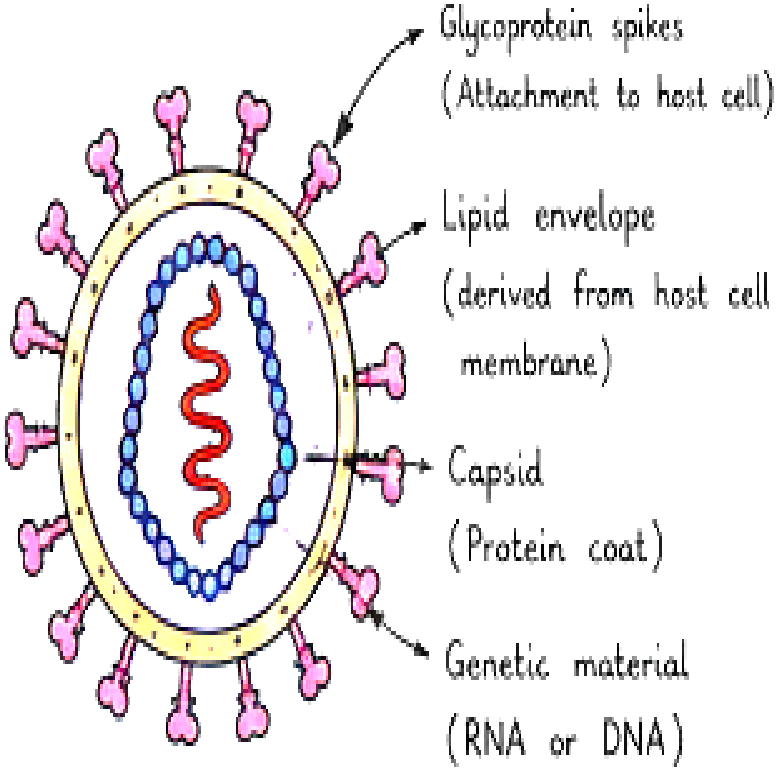
No envelope or spikes present.

Examples :

- Poliovirus
- Adenovirus

2. ENVELOPED VIRUSES

- Capsid is surrounded by a lipid envelope derived from host cell membrane.
- Envelope has glycoprotein spikes.
- Less resistant to heat, drying and chemicals.
- Released by budding from host cell membrane.



Envelope with spikes present

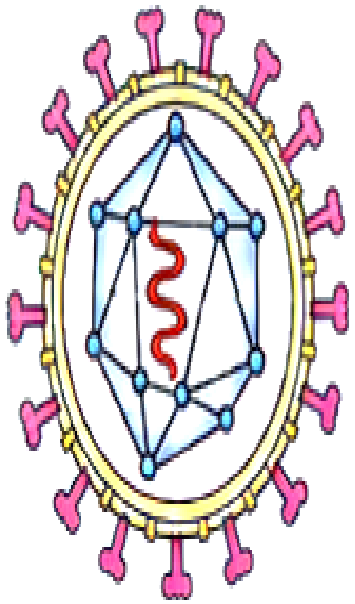
Examples :

- HIV
- Influenza virus

ENVELOPED VS NON-ENVELOPED VIRUSES

Feature	Enveloped Viruses	Non-enveloped Viruses
Outer covering	Present (lipoprotein envelope)	Absent
Origin	Derived from host cell membrane	No host membrane
Spikes	Present (glycoprotein spikes)	Absent
Stability	Less stable, sensitive to heat, detergents, drying	More stable, resistant to heat, detergents, drying
Examples	Influenza, HIV, Herpes, Hepatitis B	TMV, Adenovirus, Polio virus

Enveloped virus

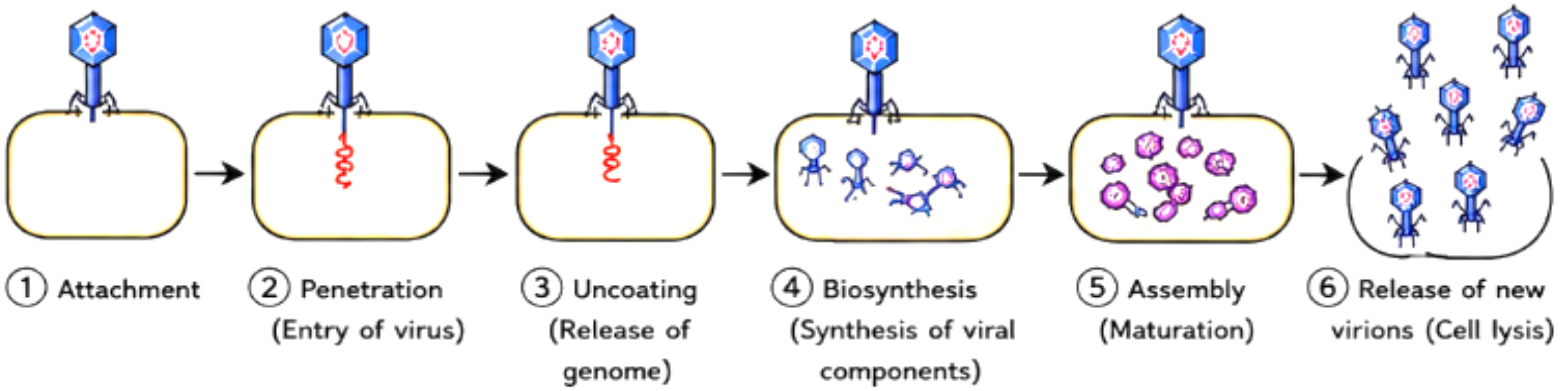


Non-enveloped virus

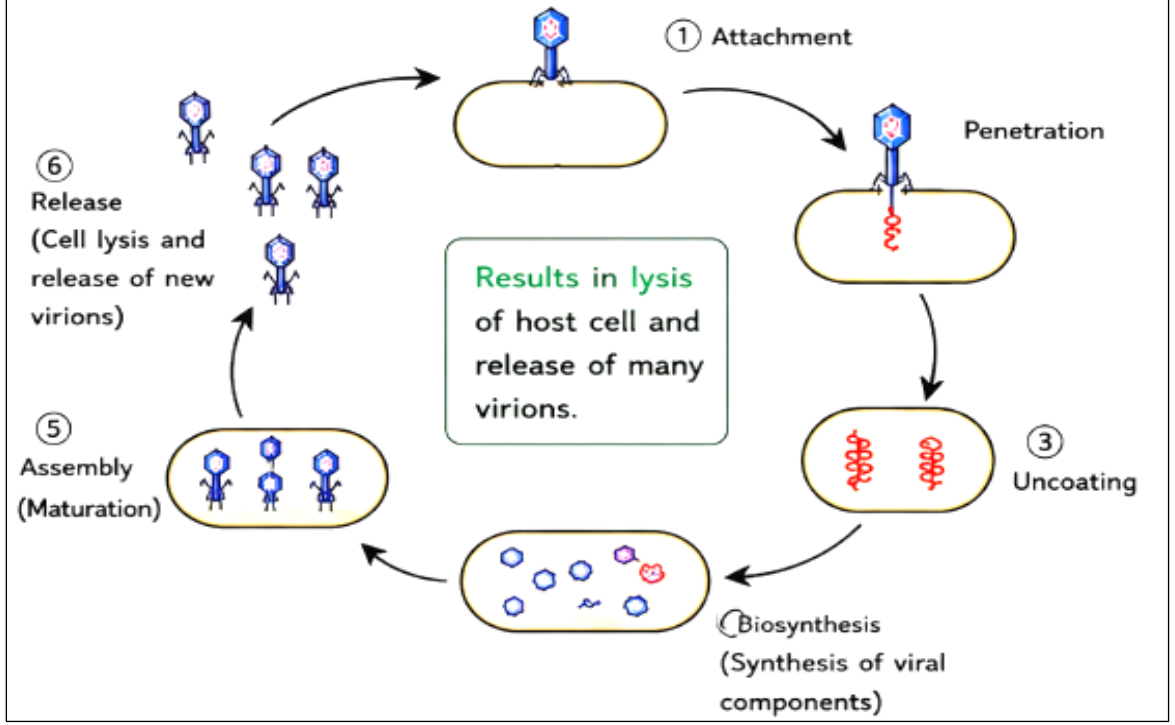
REPLICATION OF VIRUSES

- Viruses replicate only inside living host cells by using host machinery.
- General steps: Attachment → Penetration → Uncoating → Biosynthesis → Assembly → Release
- Two types of replication cycle:
  (i) Lytic cycle (ii) Lysogenic cycle
- Replication strategies vary among DNA and RNA viruses.

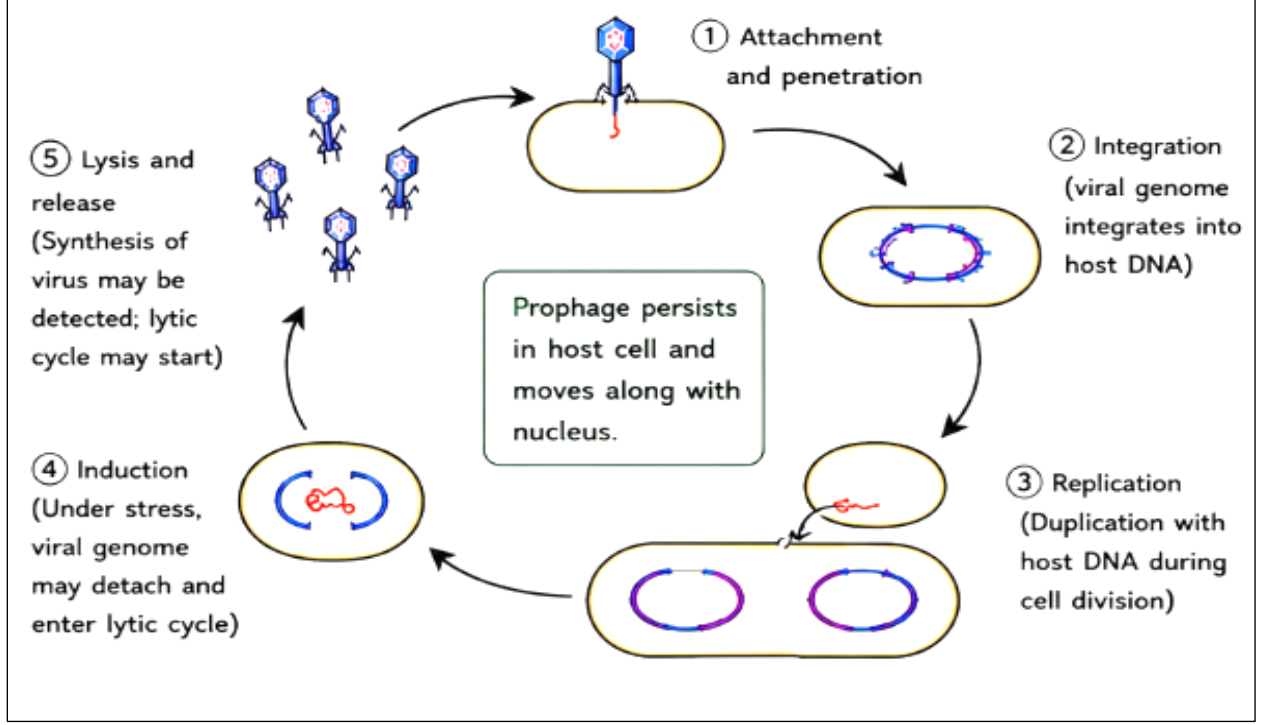
GENERAL STEPS IN VIRAL REPLICATION (LYTIC CYCLE)



. LYTIC CYCLE (Productive Cycle)



LYSOGENIC CYCLE (Non–productive Cycle)



Bacteriophage (Phage)

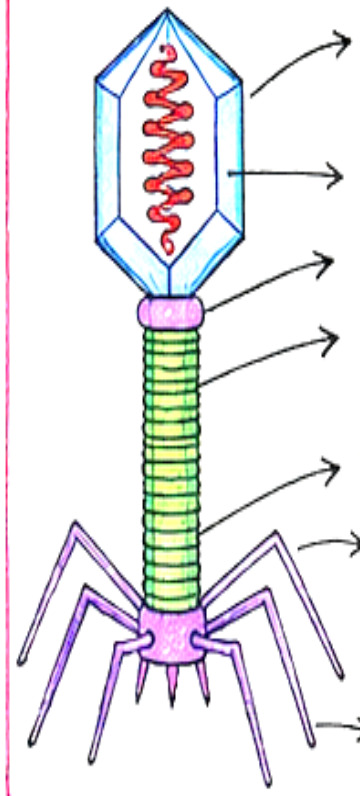
Viruses That Infect Bacteria

Bacteriophages are viruses that specifically infect bacteria. They are the most abundant biological entities on Earth.

1. Introduction

- Discovered by Twort (1915) and independently by d'Herelle (1917).
- Obligate parasites – replicate only inside bacterial cells.
- Highly specific – infect particular bacterial species or strains.
- Play important roles in bacterial genetics, evolution, biotechnology and medicine.

2. Structure (Typical: T4 Phage)



- Head (Capsid) – Icosahedral, protein coat
- Nucleic acid (DNA)
- Collar
- Tail sheath – Contractile sheath
- Base plate
- Tail fibres – For attachment to bacterial cell
- Tail pins (spikes) – For penetration

Functions

- Head – Protects genetic material.
- DNA – Genetic information for replication.
- Tail fibres – Recognize and bind to bacterial receptors.
- Tail sheath – Injects DNA into host cell.

3. Classification

Based on nucleic acid :

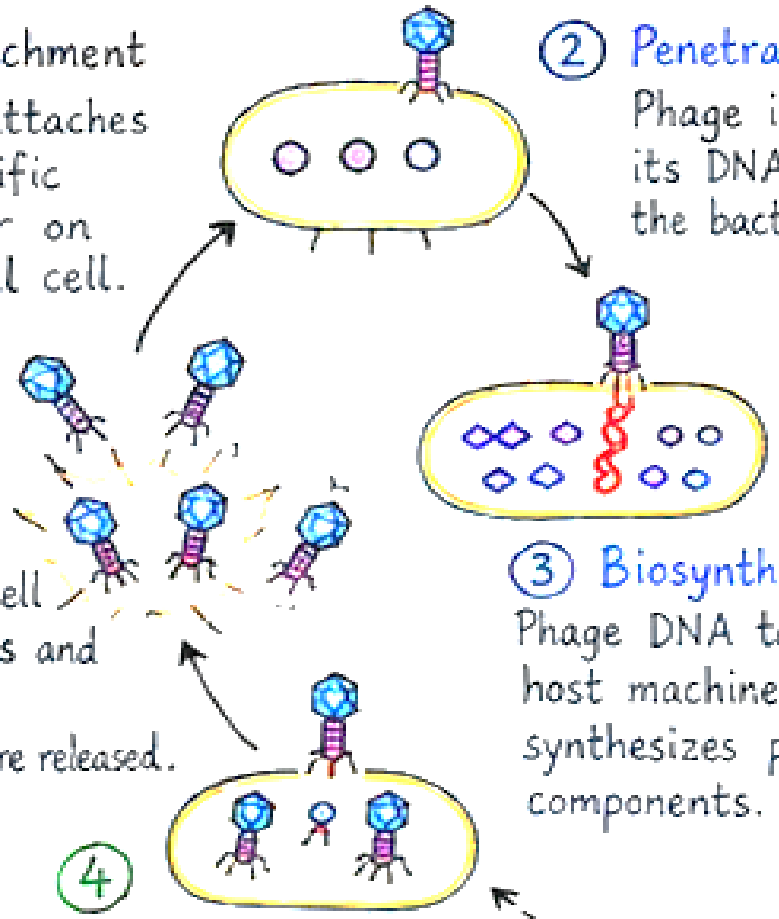
- DNA phages (e.g., T2, T4, λ)
- RNA phages (e.g., MS2, Qβ)

Based on morphology (Baltimore system):

- Icosahedral (e.g., T2)
- Helical (e.g., M13)
- Complex (e.g., T4)
- Filamentous (e.g., M13)

4. Life Cycle of Bacteriophage

A. Lytic Cycle



1 Attachment
Phage attaches to specific receptor on bacterial cell.

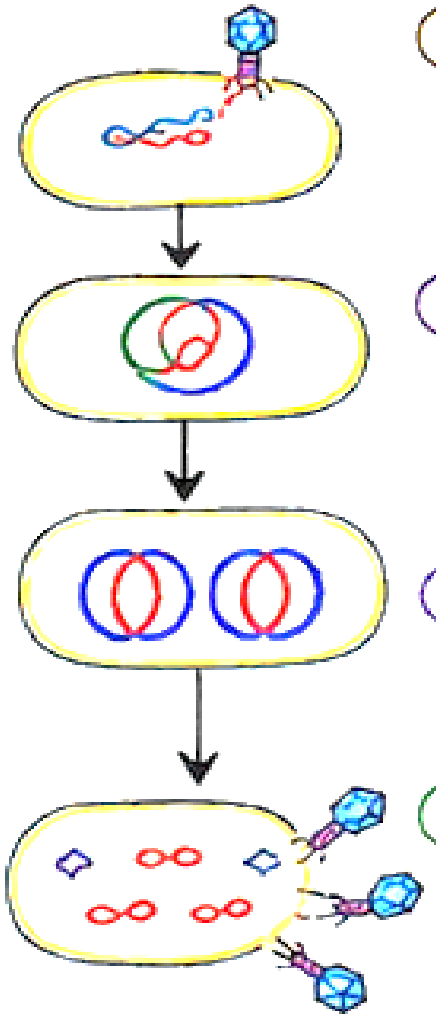
2 Penetration
Phage injects its DNA into the bacterial cell.

3 Biosynthesis
Phage DNA takes over host machinery and synthesizes phage components.

4 Assembly
New phage particles are assembled.

5 Lysis
Bacterial cell wall breaks and new phage particles are released.

B. Lysogenic Cycle



1 Attachment & Penetration
Phage DNA enters bacterial cell.

2 Integration
Phage DNA integrates into host genome as prophage.

3 Replication
Prophage replicates along with host DNA.

4 Induction
Under stress (UV, chemicals), prophage excises and enters lytic cycle.

5. Applications

Phage therapy – Treats bacterial infections, especially antibiotic-resistant strains.

- Molecular Biology – Vectors for cloning, gene transfer, libraries.

- Food Industry – Control of bacterial contamination in fermented foods.

- Bacterial Typing – Phage typing used in epidemiology.

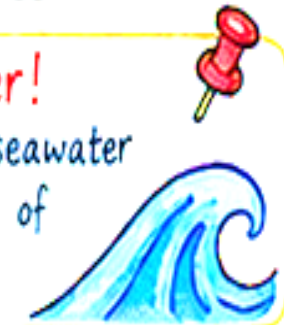
- Biocontrol – Used to control harmful bacteria in agriculture and aquaculture.

6. Significance

- Regulate bacterial populations in nature.
- Drive evolution via horizontal gene transfer.
- Important in biotechnology, genetic engineering and synthetic biology.

Remember!

Every drop of seawater contains millions of bacteriophages!



7. Examples of Bacteriophages

Phage	Type	Host	Nucleic Acid
T4	Complex	E. coli	dsDNA
T2	Icosahedral	E. coli	dsDNA
λ (Lambda)	Icosahedral	E. coli	dsDNA
M13	Filamentous	E. coli	ssDNA
MS2	Icosahedral	E. coli	ssRNA

Virion

A complete, mature, infectious virus particle outside a host cell.