VIRAL STRUCTURE AND CLASSIFICATION

Course: Medical Virology

Course Code: MA 423

Semester: Summer Term

2024-2025

Outline

- Structure of viruses
- Classification of viruses

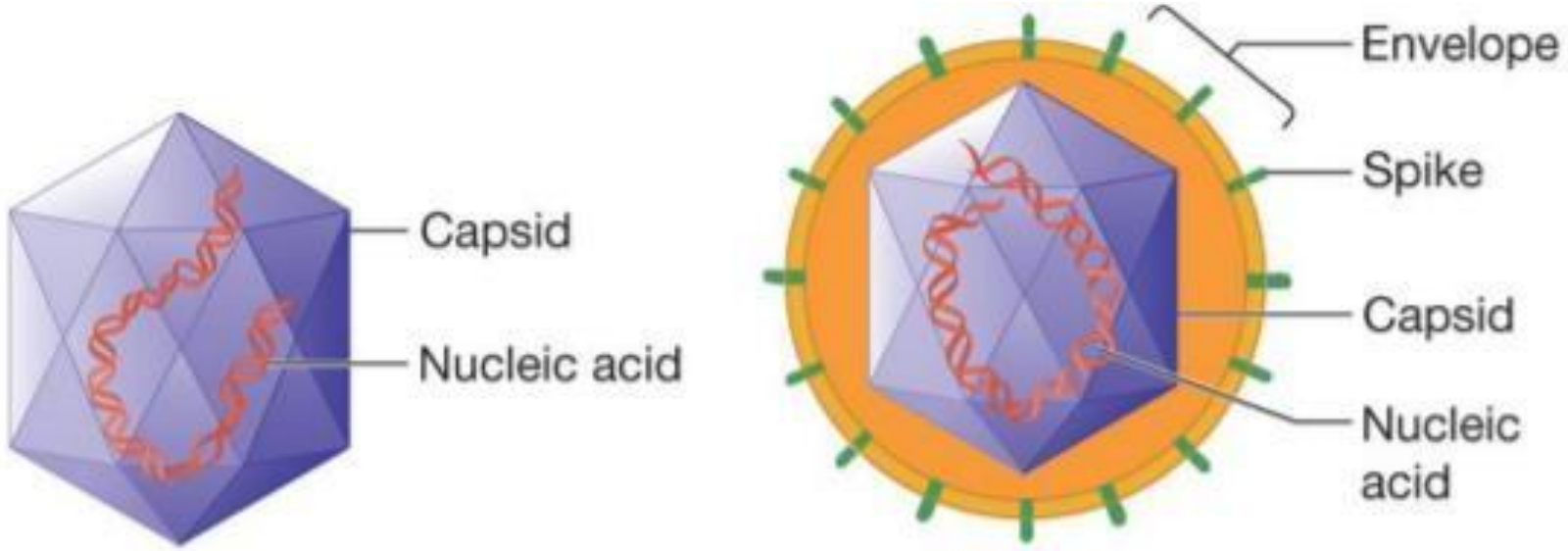
Objectives

- To learn about nucleocapsid
- To get knowledge about viral envelope and spike
- To get information about classification of viruses based on

1. Genetic material
2. Capsid structure
3. Envelope presence
4. Host range

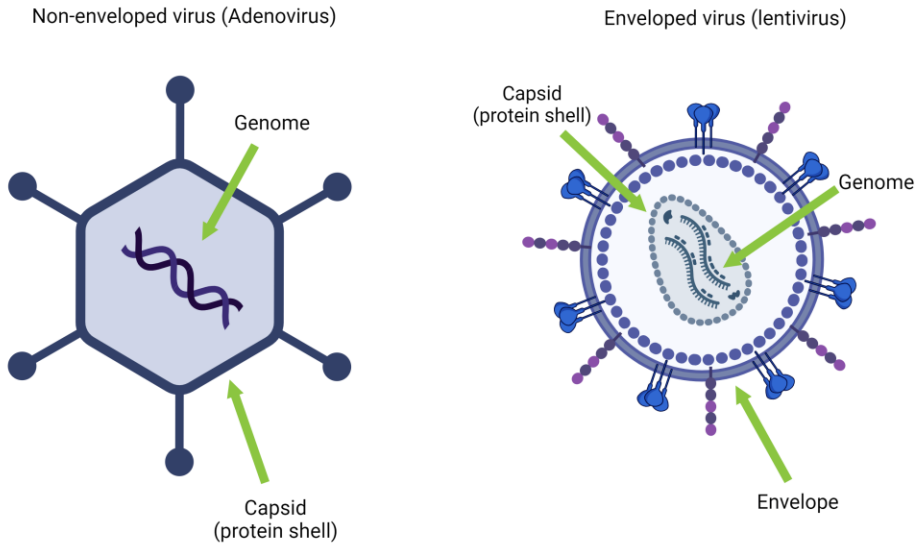
Viral structure

- A virus consists of **genetic material (either DNA or RNA)** enclosed in a protein coat.
- This protein coat is called the **capsid**.
- Some viruses also have an outer lipid **envelope** derived from the host cell's membrane.



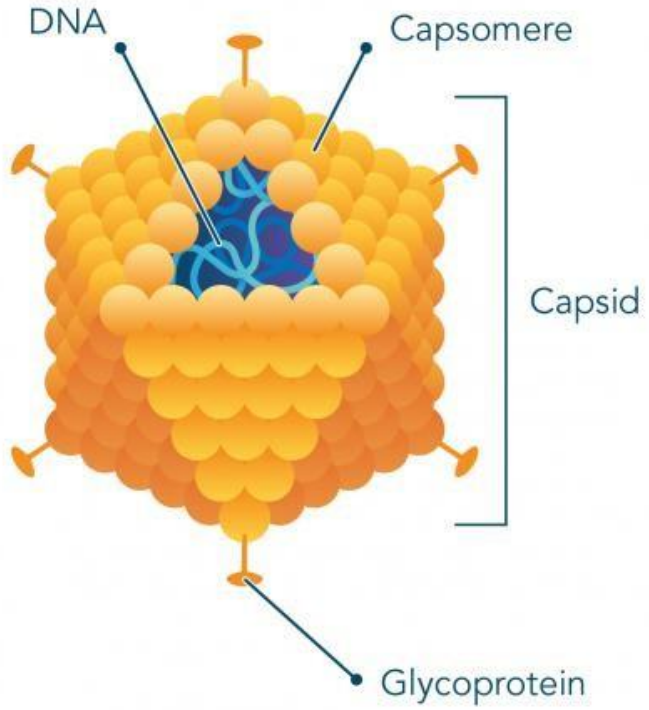
Viral genome

- Viral genome is either DNA or RNA
- Viral genome characteristics are used as one criterion for **viral classification**.
- Viral-specific enzymes, other proteins within the virion (virus), or both may be associated with the genome.



Viral capsid

- **A capsid** is a protein coat or shell that surrounds the genetic material of a virus.
- Capsid is composed of structural units called **capsomers**, which are aggregates of viral-specific polypeptides.

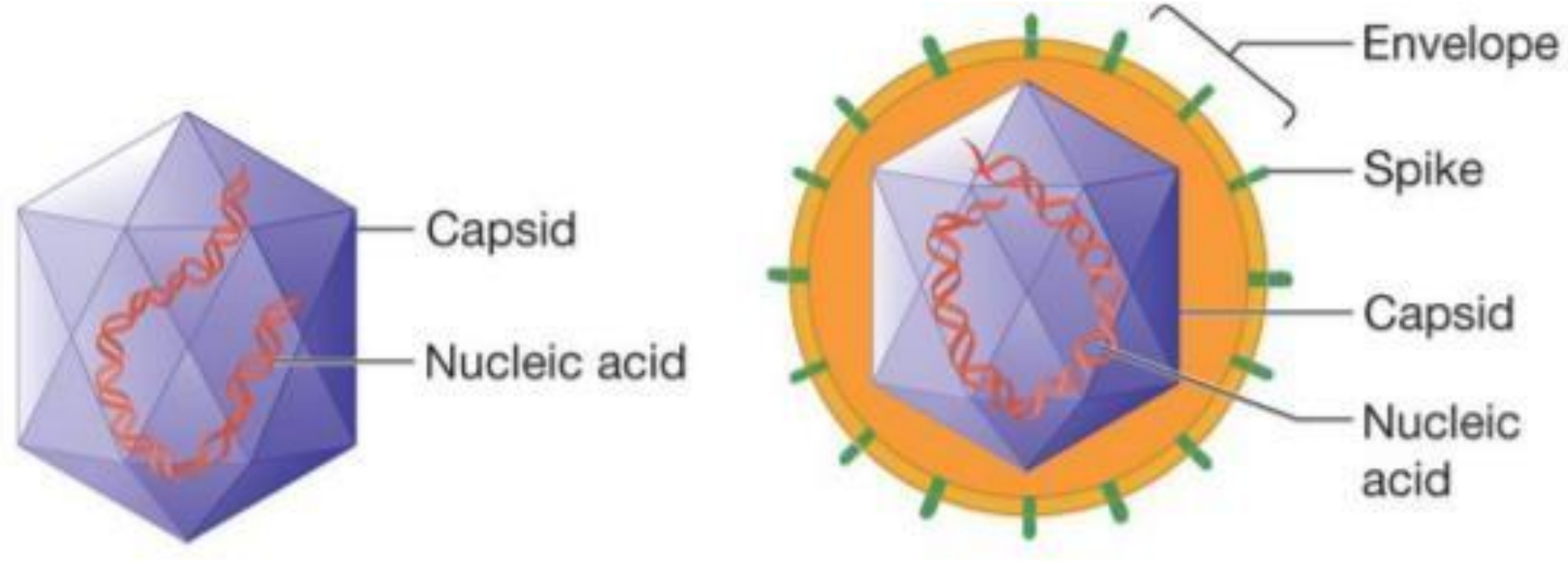


Function of capsid:

1. protect the nucleic acid.
2. Attachment of particle virus with host.
3. Transport of viral nucleic acid from one cell to another

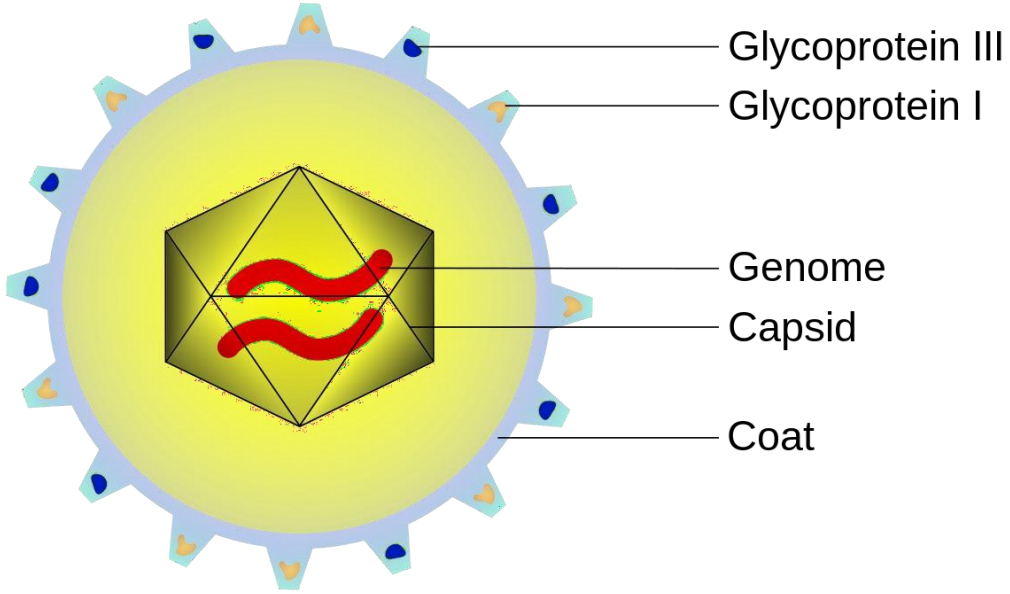
Nucleocapsid

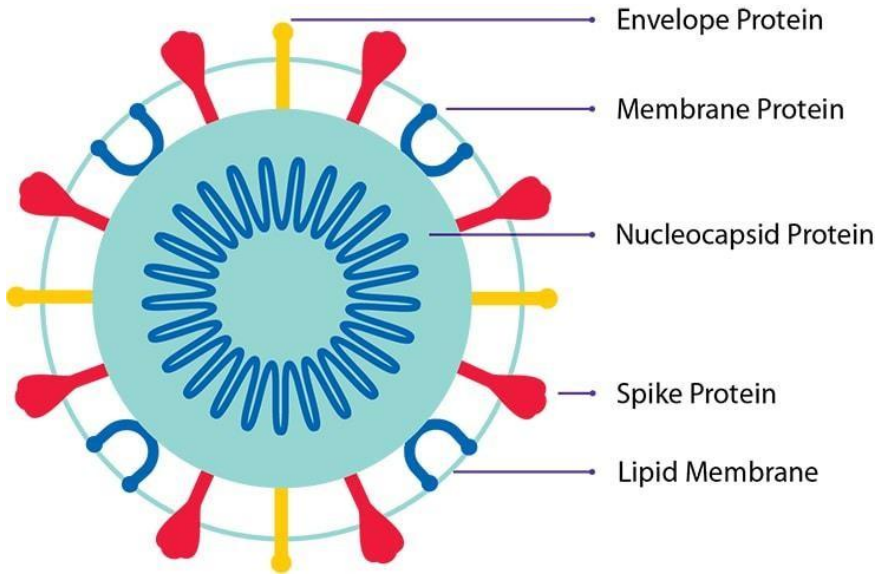
- All virions contain a **nucleocapsid** which is composed of **nucleic acid (DNA or RNA)** and **a protein coat (capsid)**
- some viruses consist only of a nucleocapsid, others have additional components (Envelopes).



Viral envelope

- Many viruses are bound by an outer, flexible, membranous layer called the **viral envelope** that surrounds the nucleocapsid of enveloped viruses and is composed of **viral specific glycoproteins** and **host-cell-derived lipids** and **lipoproteins**.
- Animal virus envelopes (**lipids and carbohydrates**) usually arise from host cell plasma or nuclear membranes.
- **Envelope proteins**, which are virally encoded, may project from the envelope surface as **spikes**.





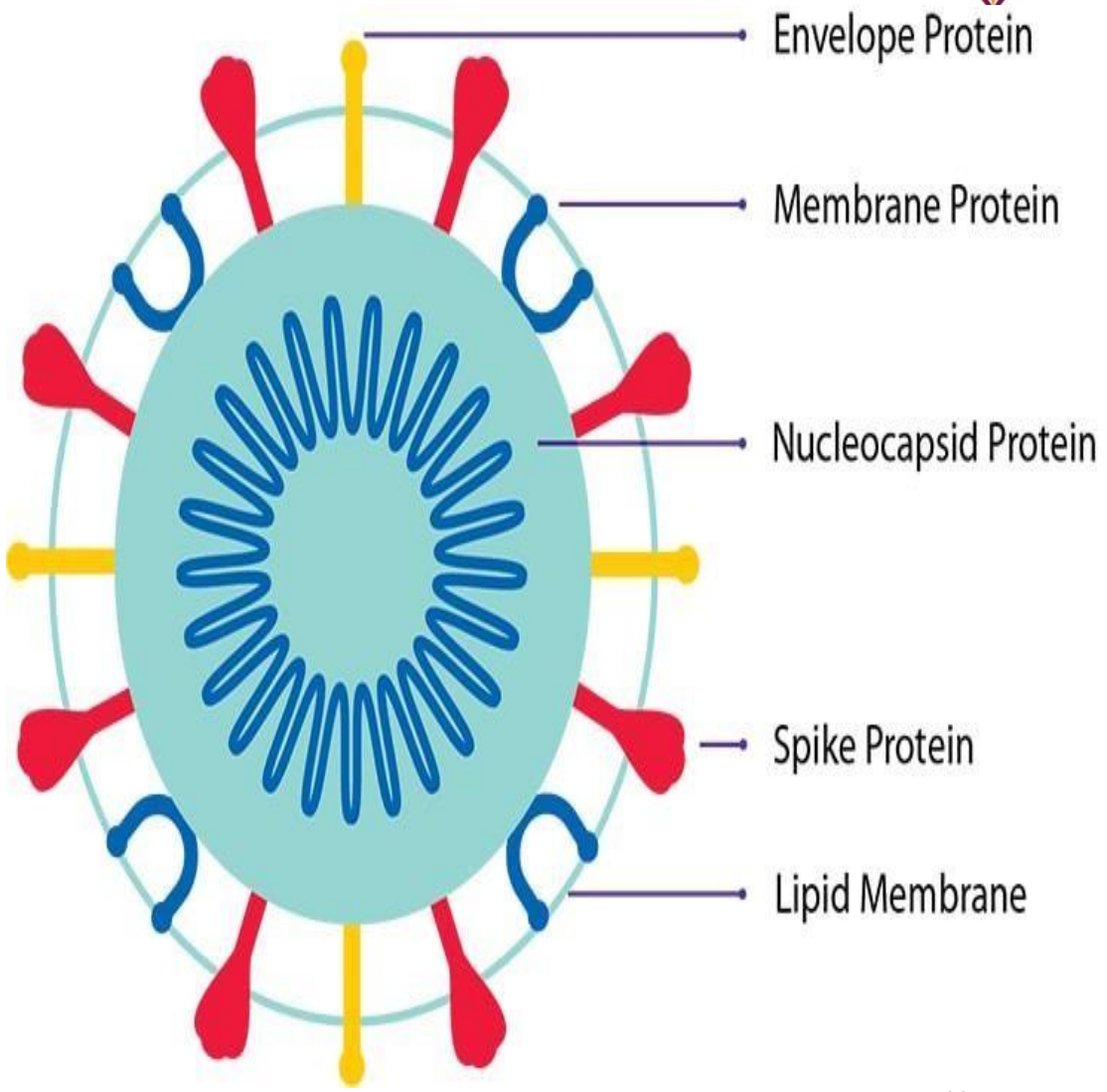
Importance of viral envelope proteins

1. Envelope contains molecules that are necessary for enveloped viruses to initiate infection.
2. May have enzymatic or other activity.
3. Act as a stimulus for antibody production.
4. Serve as antigens in serologic tests; therefore, they have role in identification

Viral spike

simply spike protein, **is** a specialized **protein** on the surface of certain viruses, particularly enveloped viruses.

It plays a crucial role in the virus's ability to infect host cells. The spike protein is responsible for attaching to specific receptors on the surface of host cells, facilitating the virus's entry into the cell.



Classification of viruses

- **Virus classification** is the process of naming viruses and placing them into a taxonomic system similar to the classification systems used for cellular organisms. Therefore, classification identifies and groups viruses according to their similarities in order to describe the diversity of viruses.

Classification of viruses

Viruses are classified based on several key characteristics, which help researchers and scientists understand their diversity and evolutionary relationships.

The main characteristics used to classify viruses include:

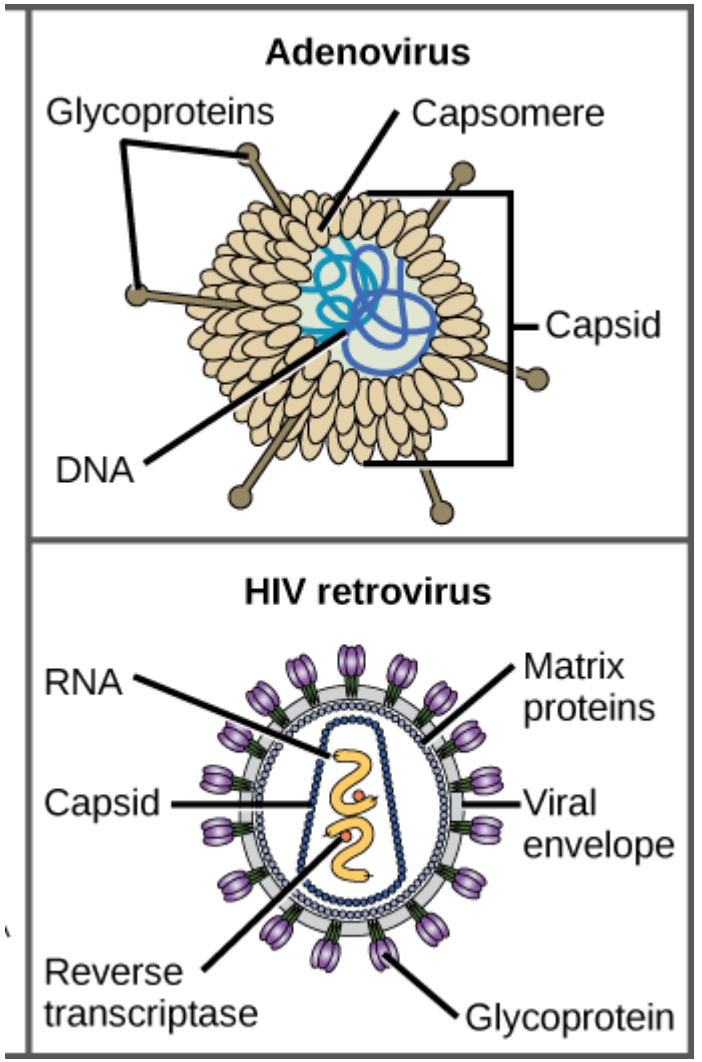
1. **Genetic material (Nucleic acid)**
2. **Capsid structure**
3. **Envelope presence**
4. **Host range**

Classification of viruses based on genetic material

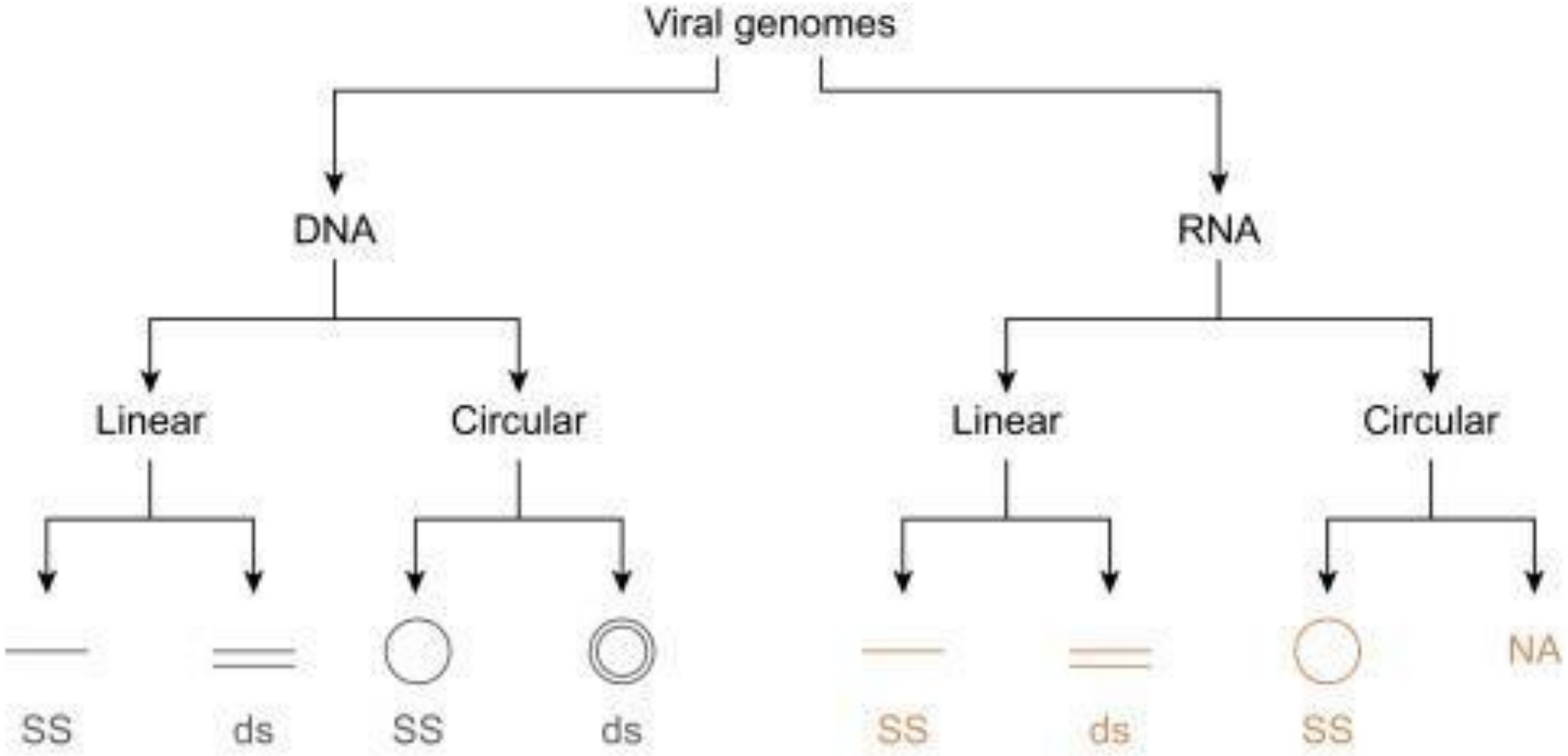
Genetic material (Nucleic acid): This is one of the fundamental criteria for classification:

1. **DNA Viruses:** These viruses have a DNA genome. DNA viruses can be further classified based on the nature of their genome (single-stranded or double-stranded) and linear or circular configuration.

2. **RNA Viruses**: These viruses have an RNA genome. Like DNA viruses, RNA viruses can be classified based on similar criteria



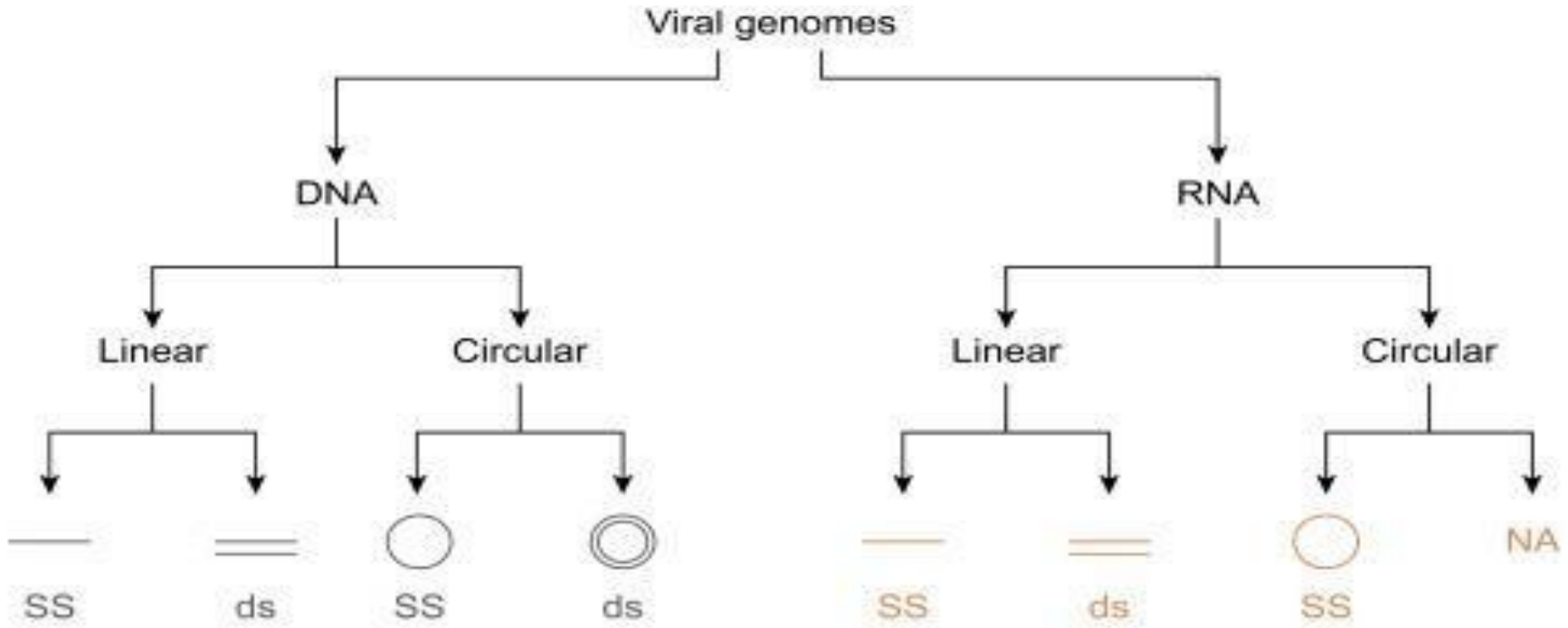
Classification of viruses based on genetic material



Classification of viruses based on capsid structure

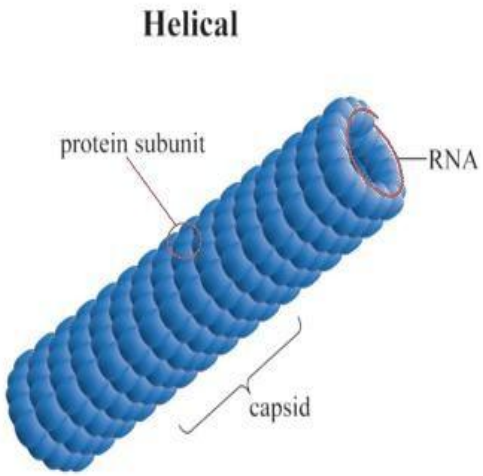
Capsid Structure: The **capsid** is the protein coat that surrounds the viral genetic material. Capsid structure is an important classification criterion:

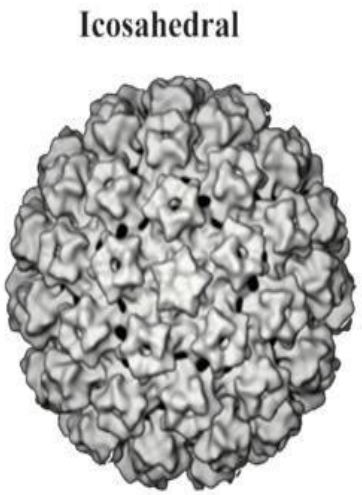
1. **Helical**
2. **Icosahedral**
3. **Complex**

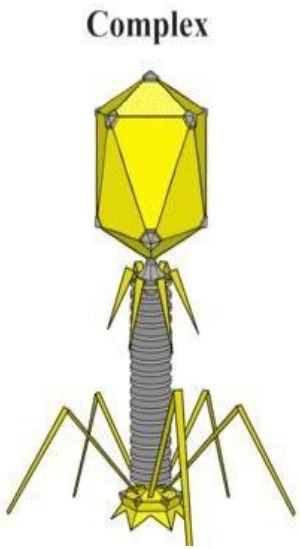


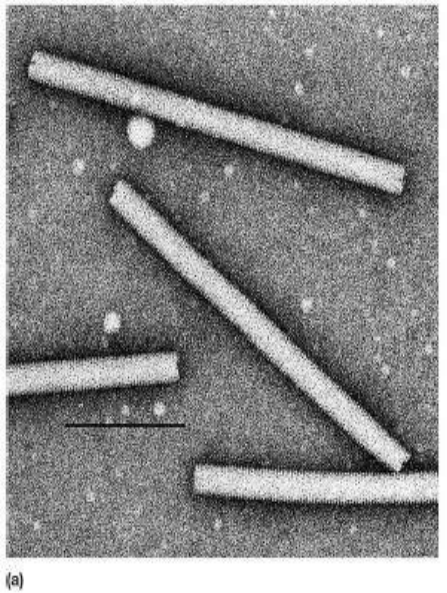
Helical capsids

- Shaped like hollow tubes with protein walls



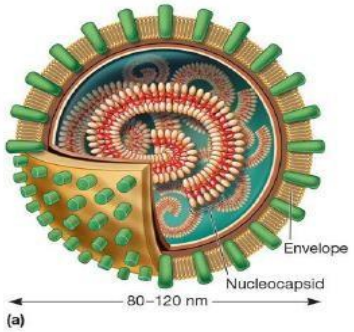


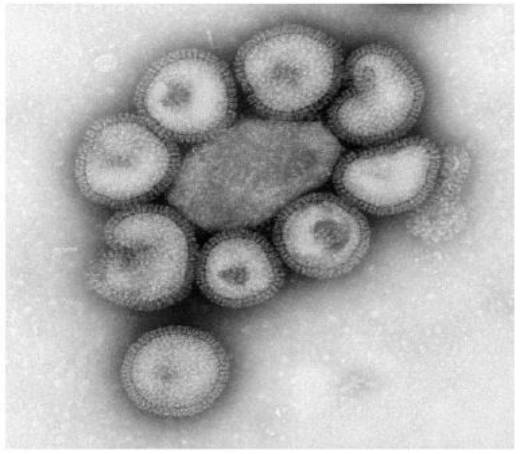


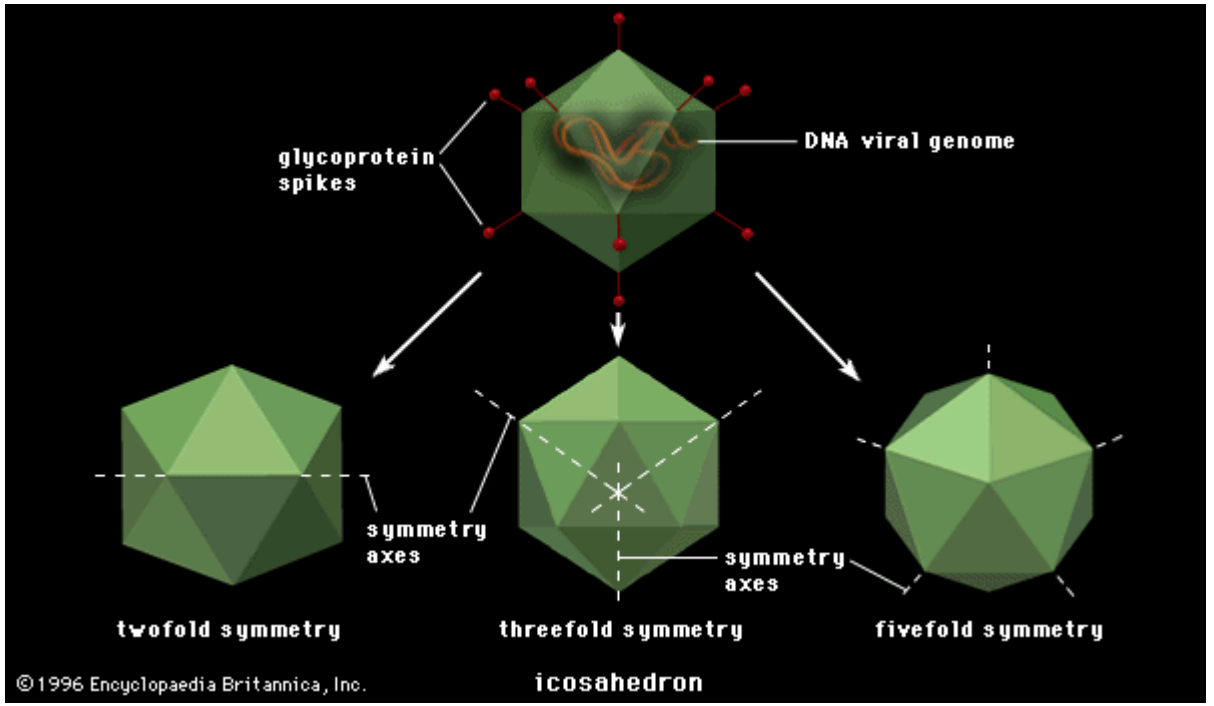


Icosahedral capsids

- An icosahedron is a regular polyhedron with 20 equilateral faces

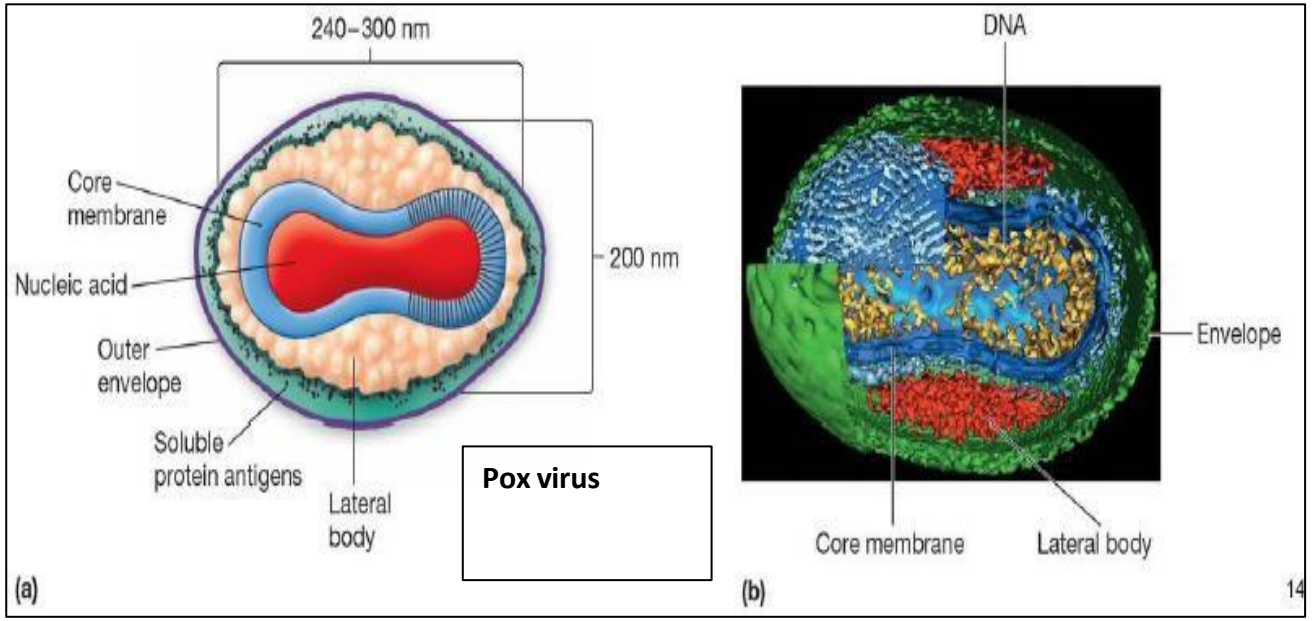


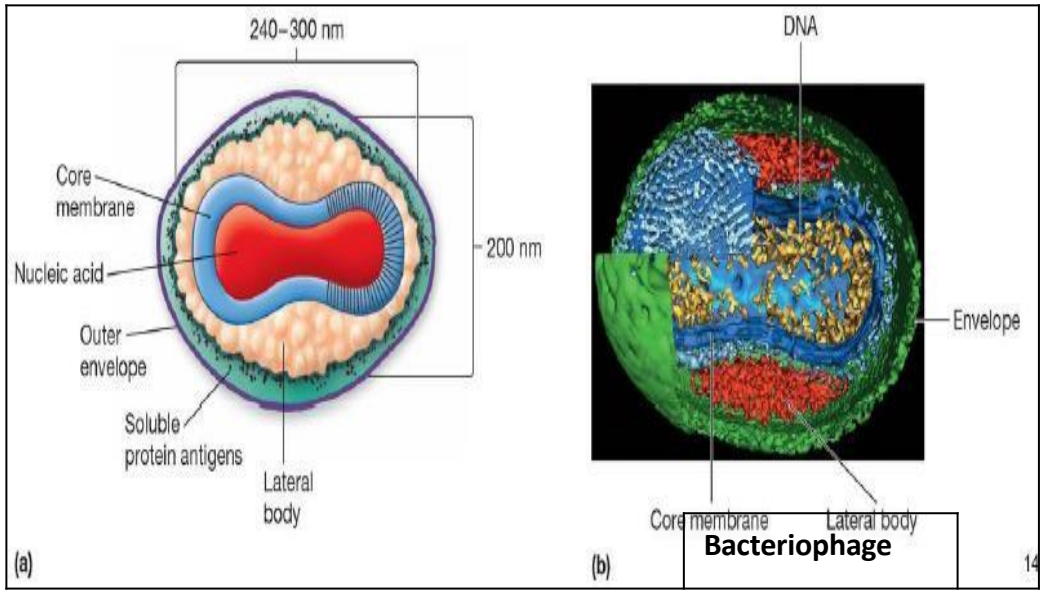




Capsids of complex symmetry

- Viruses with a combination of icosahedral and helical features
- Example: **Bacteriophages** have binal symmetry, head resembles icosahedral, and tail is helical.

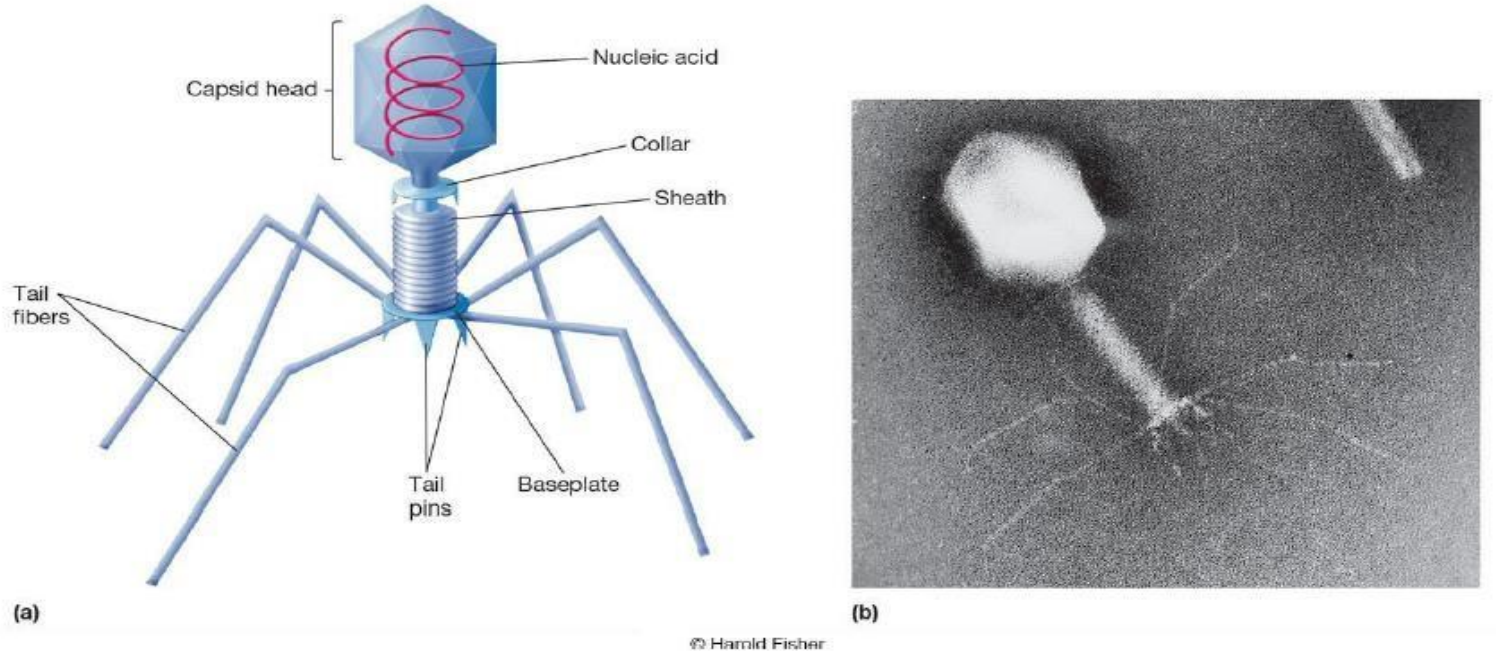




Classification of viruses based on the presence of envelope

Envelope is a lipid membrane derived from the host cell's membrane. Viruses can be classified based on the presence or absence of envelope into

1. **Non enveloped (naked) viruses**
2. **Enveloped virus**



Classification of viruses based on host range

Host Range: Viruses can infect specific host organisms, and this specificity is an important classification criterion. Viral host range can be classified as:

1. **Specific:** Some viruses target a particular species, organ, or cell type.
2. **Broad:** Others can infect a wide range of hosts or cell types.

What is tropism?

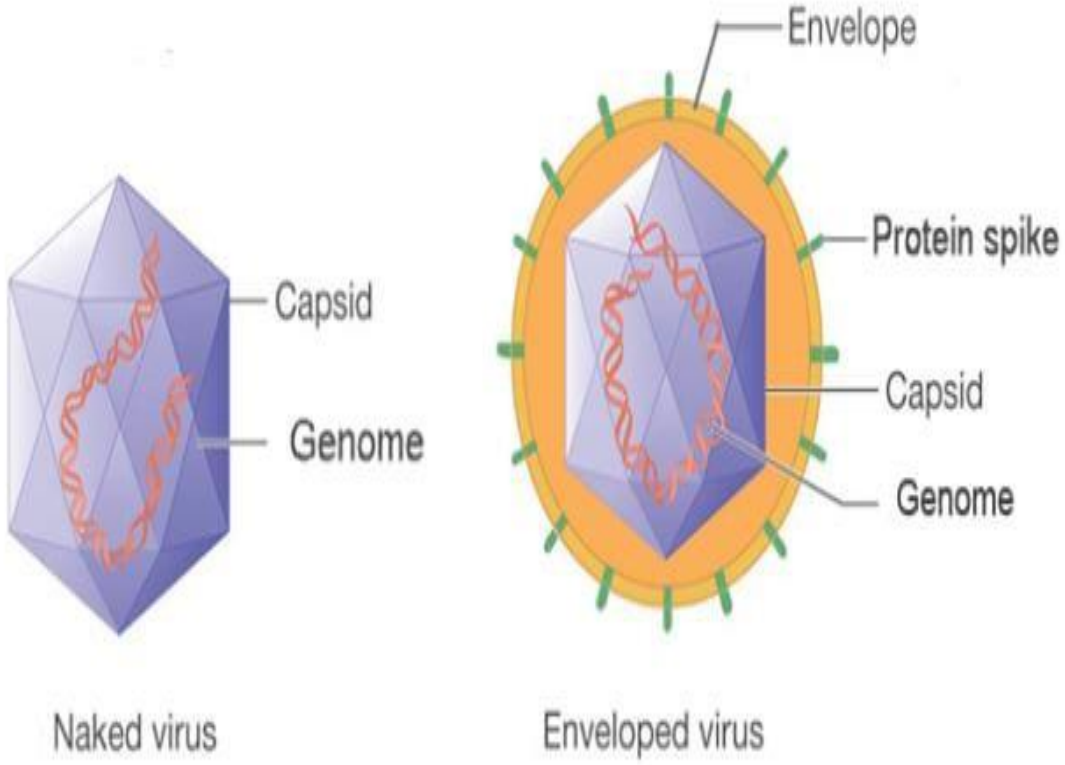
Tropism: The capability of a virus to infect a distinct group of cells in the host. For many viruses, tropism is determined by the availability of virus receptors on the surface of a host cell.

Baltimore classification

According to the Baltimore classification, viruses are divided into seven groups (classes) based on the way of synthesizing their mRNAs:

1. dsDNA viruses "double strand DNA".
2. ssDNA viruses "single strand DNA".
3. dsRNA viruses "double strand RNA".
4. (+) sense ssRNA viruses (codes directly for protein).
5. (-) sense ssRNA viruses.
6. RNA reverse transcribing viruses.
7. DNA reverse transcribing viruses.

Overall, **DNA viruses** are in **groups I and II**, **RNA viruses** are in **groups III, IV, and V**, and **reverse transcribing viruses** are in groups **VI and VII**.



Baltimore classification

The following characteristics are considered in the Baltimore classification:

1. Whether the genome is composed of DNA or RNA
2. Genome strandedness (either single- or double-stranded)
3. For single-stranded genome, whether it is positive or negative sense

Reference

- Koonin, E. V., et al. (2021). "The Baltimore Classification of Viruses 50 Years Later: How Does It Stand in the Light of Virus Evolution?" Microbiol Mol Biol Rev **85**(3): e0005321.
- Lefkowitz, E. J., et al. (2018). "Virus taxonomy: the database of the International Committee on Taxonomy of Viruses (ICTV)." Nucleic Acids Res **46**(D1): D708-d717.
- Simmonds, P. and P. Aiewsakun (2018). "Virus classification - where do you draw the line?" Arch Virol **163**(8): 2037-2046.
- John Carter, Venetia Saunders - Virology Principles and Applications-Wiley (2007).