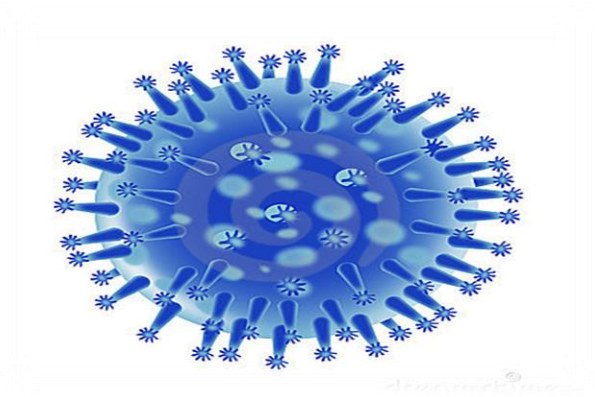
Viral Structure and Classification

2022-2023

Lecture 12



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Aims

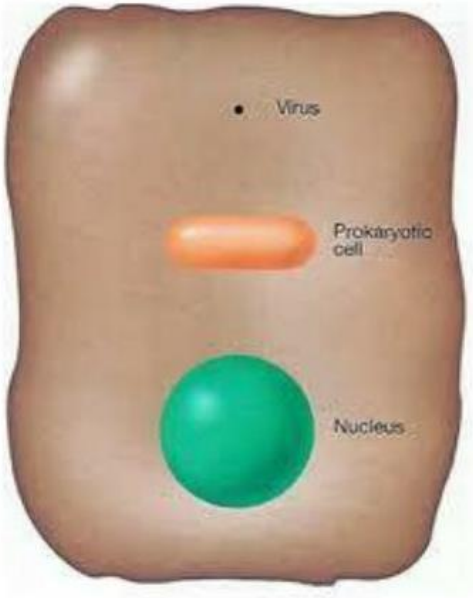
- Definitions
- Difference between bacteria & virus.
- General morphology
- Characteristics of virus
- Virus classification
- Viral structure

Introduction to Virology

- A virus is an obligate intracellular parasite containing genetic material surrounded by protein.
- In latin means poison
- Virus particles can only be observed by an **electron microscope**
- Their size ranges from 10 nm - 250 nm

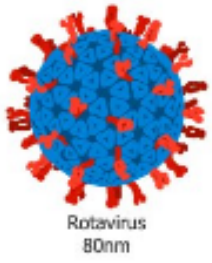
Common Characteristics of Viruses

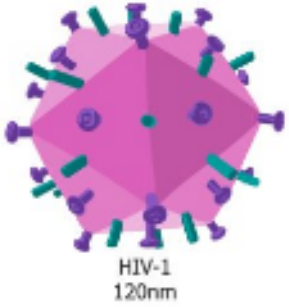
Viruses share several common characteristics:

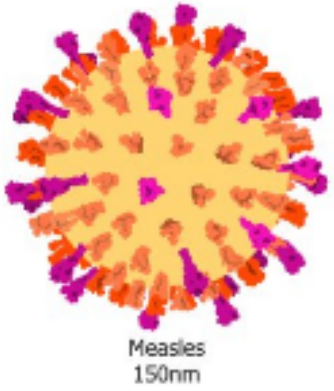


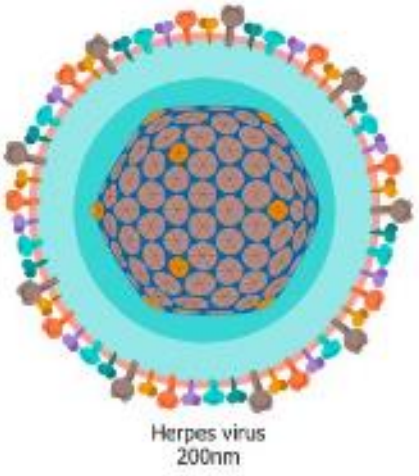
1. Viruses are Small in Size:

- Their size ranges from 10 nm - 250 nm
- Most bacteria are typically 2000–3000nm.
- Average human cells are 10–30µm (microns) in diameter, which means that they are generally 100 to 1000 times larger than the viruses that are infecting them.

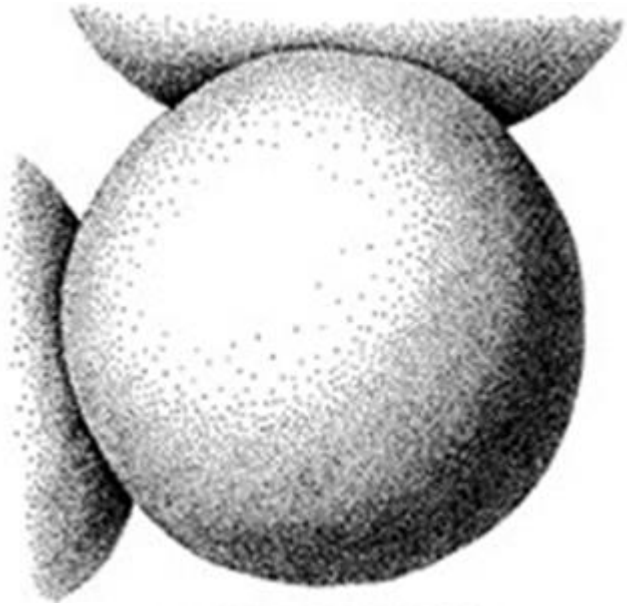








Viruses are Ultramicroscopic



STAPHYLOCOCCUS

POX VIRUS

HERPES VIRUS

INFLUENZA VIRUS

POLIO VIRUS

Common Characteristics of Viruses

2. Viruses are obligate intracellular parasites:

- Meaning that they are completely dependent upon the internal environment of the cell to create new infectious virus particles, or virions.
- viruses use the cell's energy and machinery to create and assemble new virions.

3. The genetic material of viruses:

- All living cells, whether human, animal, plant, or bacterial, have double-stranded DNA (dsDNA).
- Viruses have genomes that are composed of DNA or RNA (but not both).
- The viral genome is dsDNA, ssDNA, dsRNA, or ssRNA,

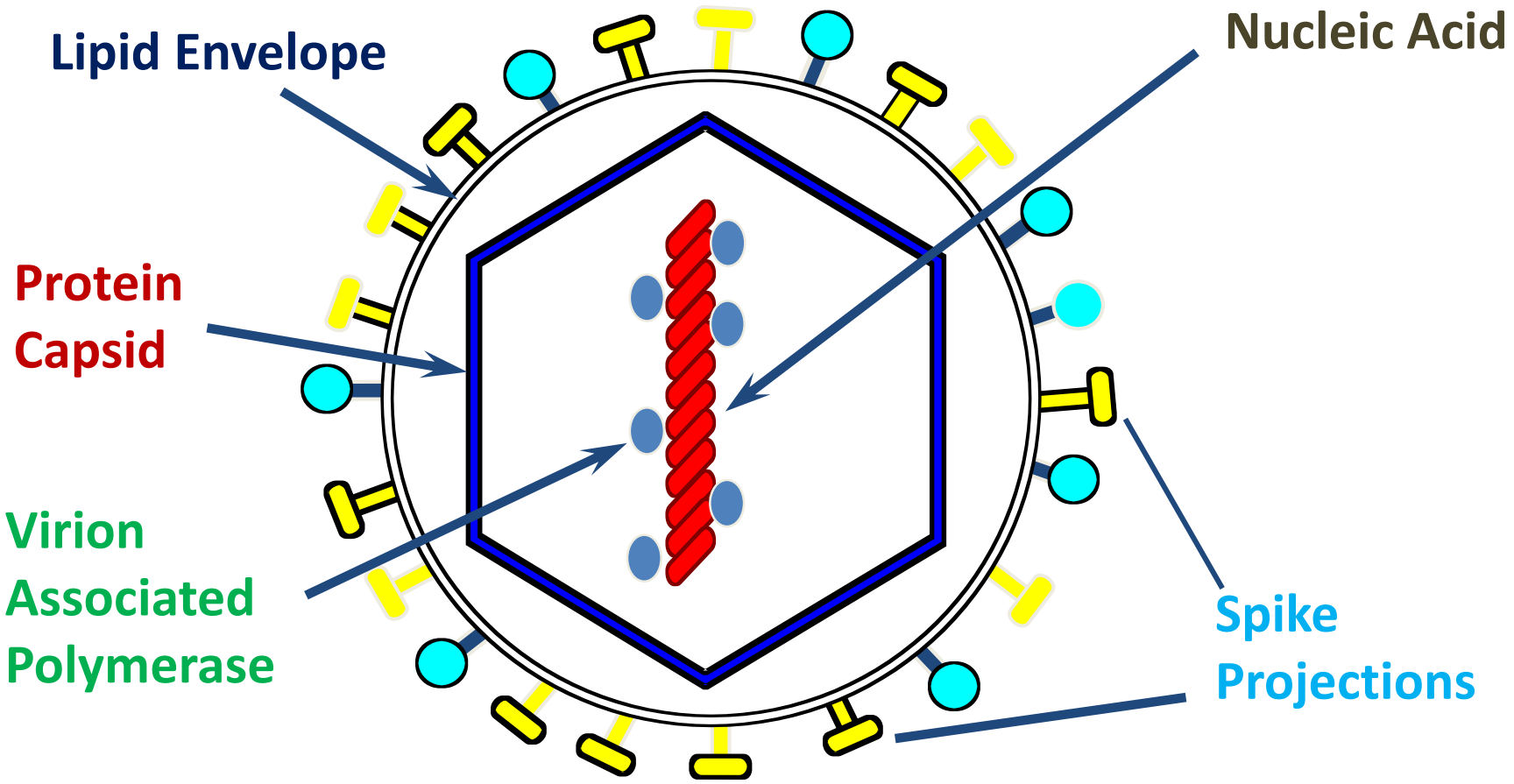
VIRUS CLASSIFICATION

A. Based on Envelope →
- Non- enveloped viruses
- Enveloped viruses

B. Based on capsid Shape →
- Polyhedral viruses
- Helical Viruses
- Complex viruses

C. Based on the type of nucleic acid genome and replication strategy of the virus.

STRUCTURE OF VIRUSES



Viral structure – some terminology

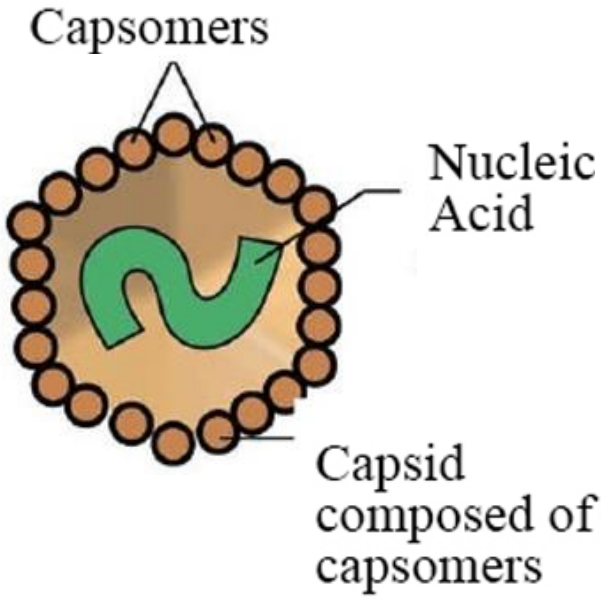
Viral structural components include:-

- **Capsid**: The protein shell directly surrounding viral nucleic acid (coat, shell). Composed of capsomeres.
- **Genome**: Nucleic acid of the virus (RNA or DNA).
- **Nucleocapsid**: capsid + genome .
- **Envelope**: The lipid bilayer and associated glycoproteins that surround some viruses. Viruses are of two types:
  - Enveloped
  - Non-enveloped

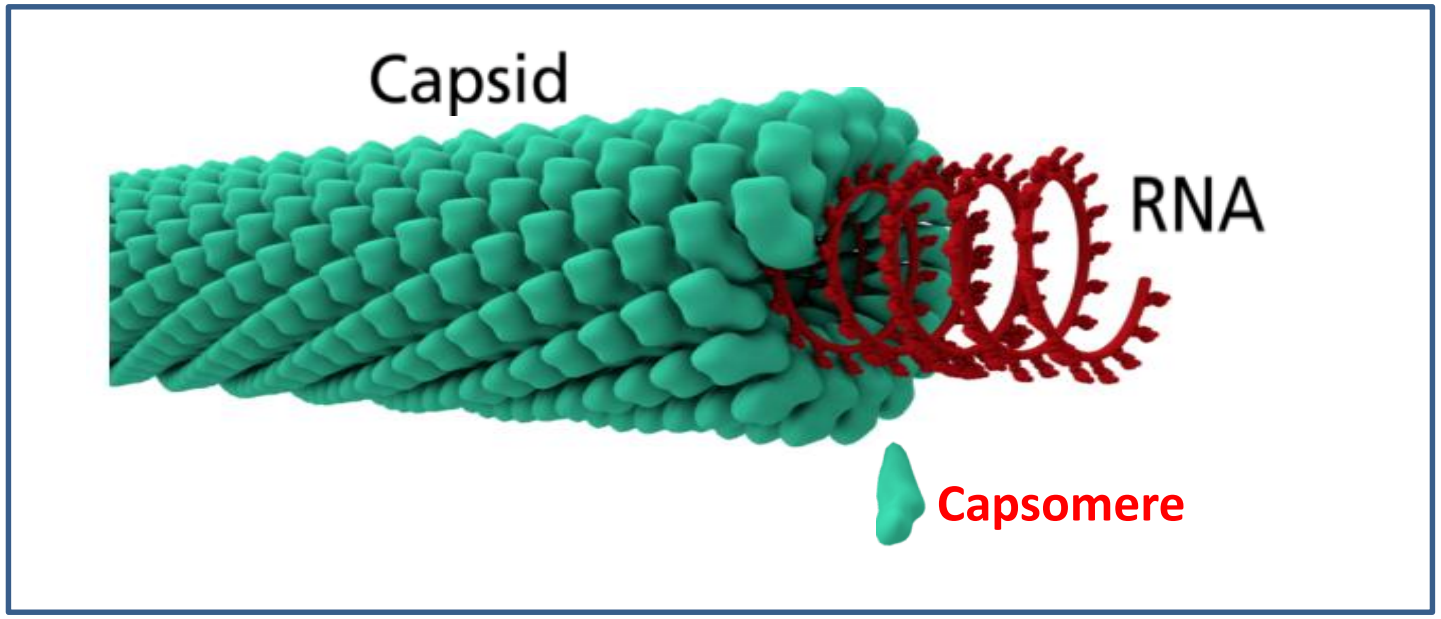
All these components form the entire infectious virus particle called the **Virion**

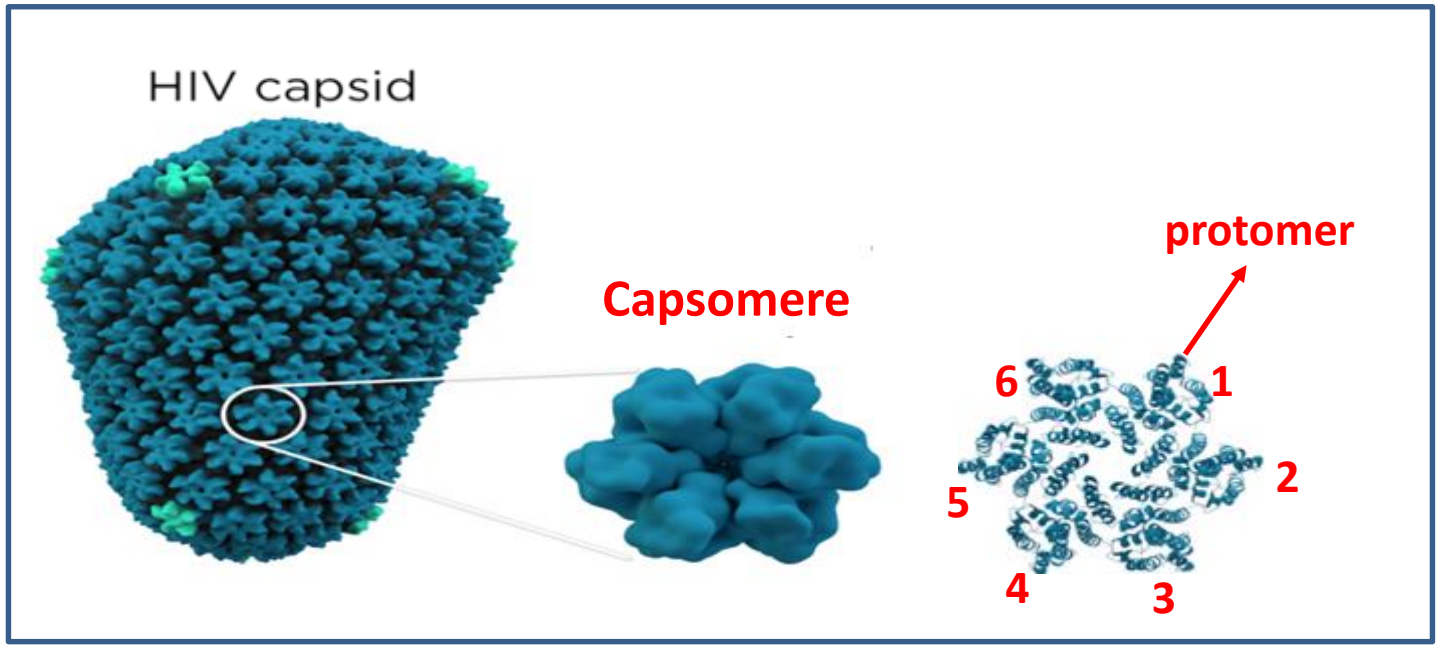
STRUCTURE OF VIRUSES

- The nucleic acid of the virus that is released from the host cell must be protected from the extracellular environment (degrading enzymes, physical stresses, ultraviolet).
- This is done by surrounding its nucleic acid with a protein shell, called the **capsid**, from the Latin **capsa**, meaning "box."
- **Capsid** is made up from a repeated units called capsomeres (capso: capsid, mere: part or segment)
- **Each capsomere** is composed of one type or more of proteins called **protomers**



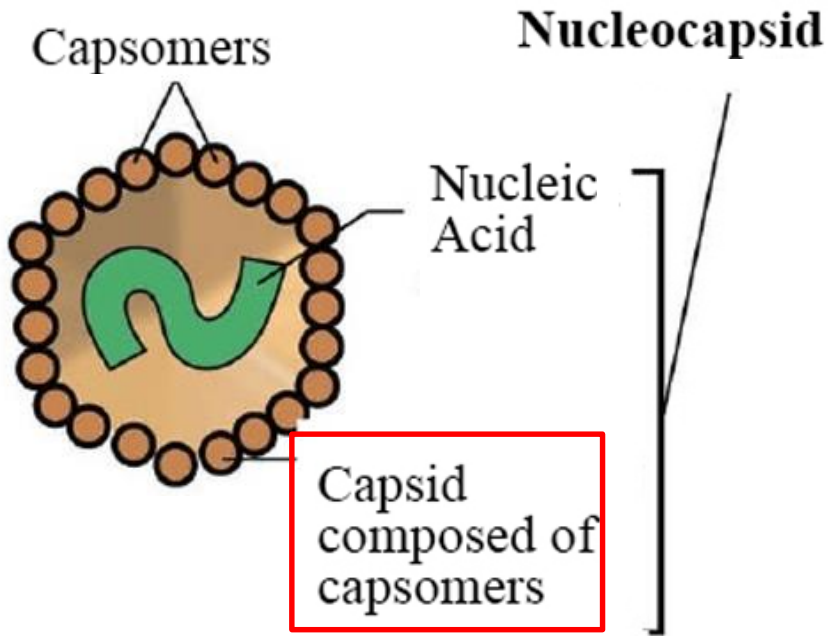
Capsid Capsomere protomer

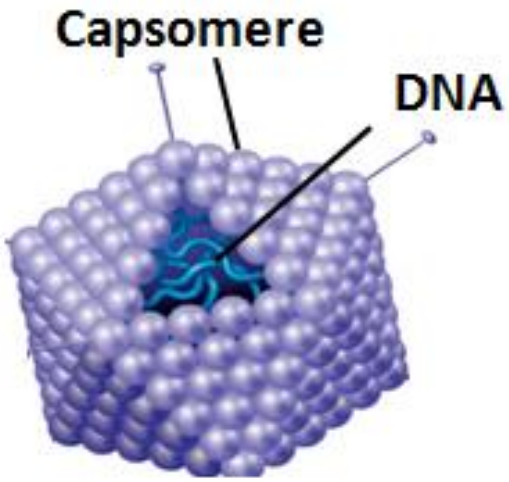




STRUCTURE OF VIRUSES

- Together, the nucleic acid and the capsid form the nucleocapsid of the virion.
- The viral genome and the capsomers will assemble spontaneously, primarily held together by electrostatic and hydrophobic forces.
- The capsid has attachment proteins that facilitate the docking of the virus to the plasma membrane of the host cell, the first step in gaining entry into a cell.
- This type of viruses called nonenveloped or naked viruses.





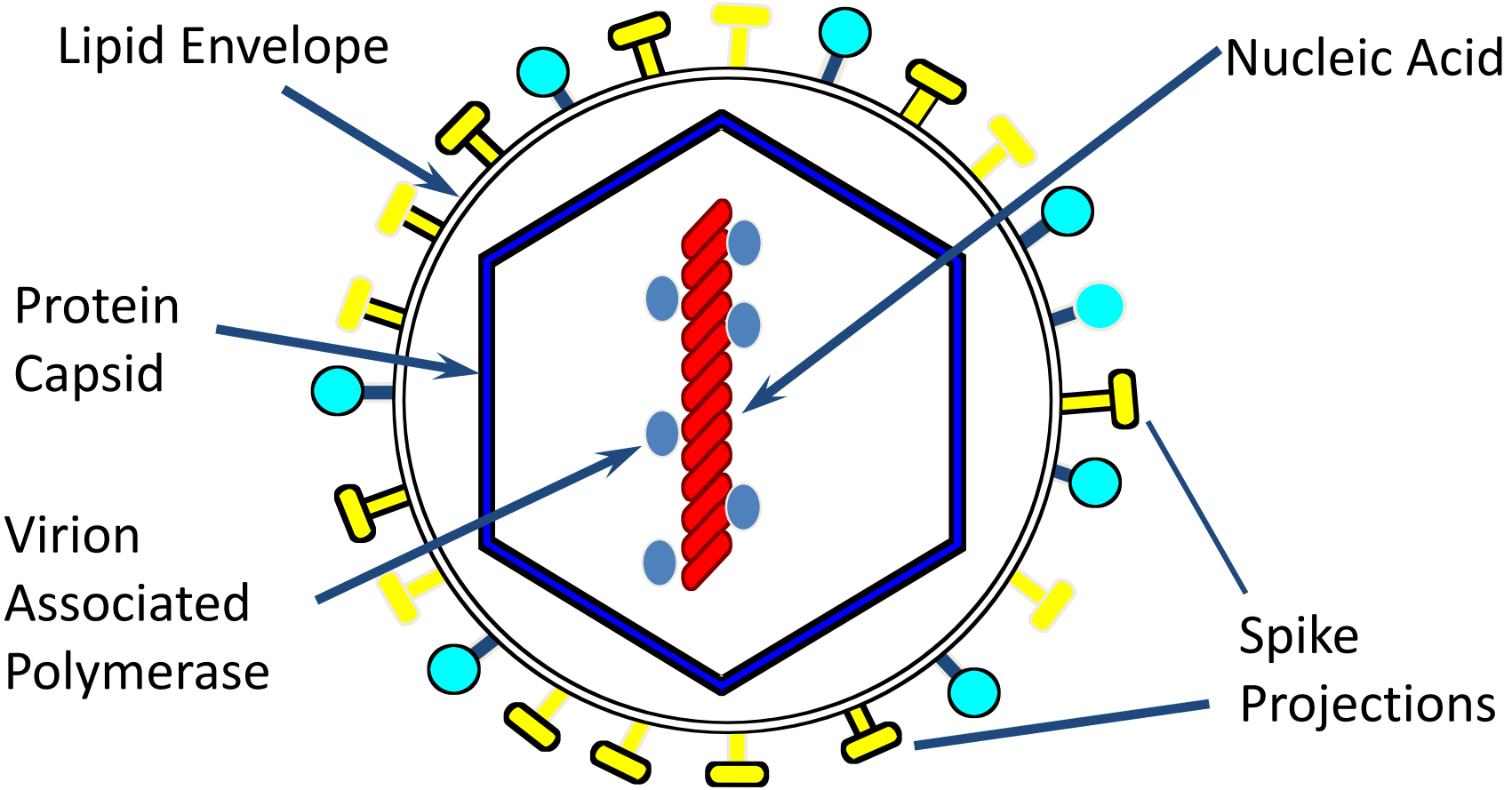
STRUCTURE OF VIRUSES

The importance of building the capsid from one type of proteins:

1. Reduces the need for genetic information.
2. Promotes self assembly.

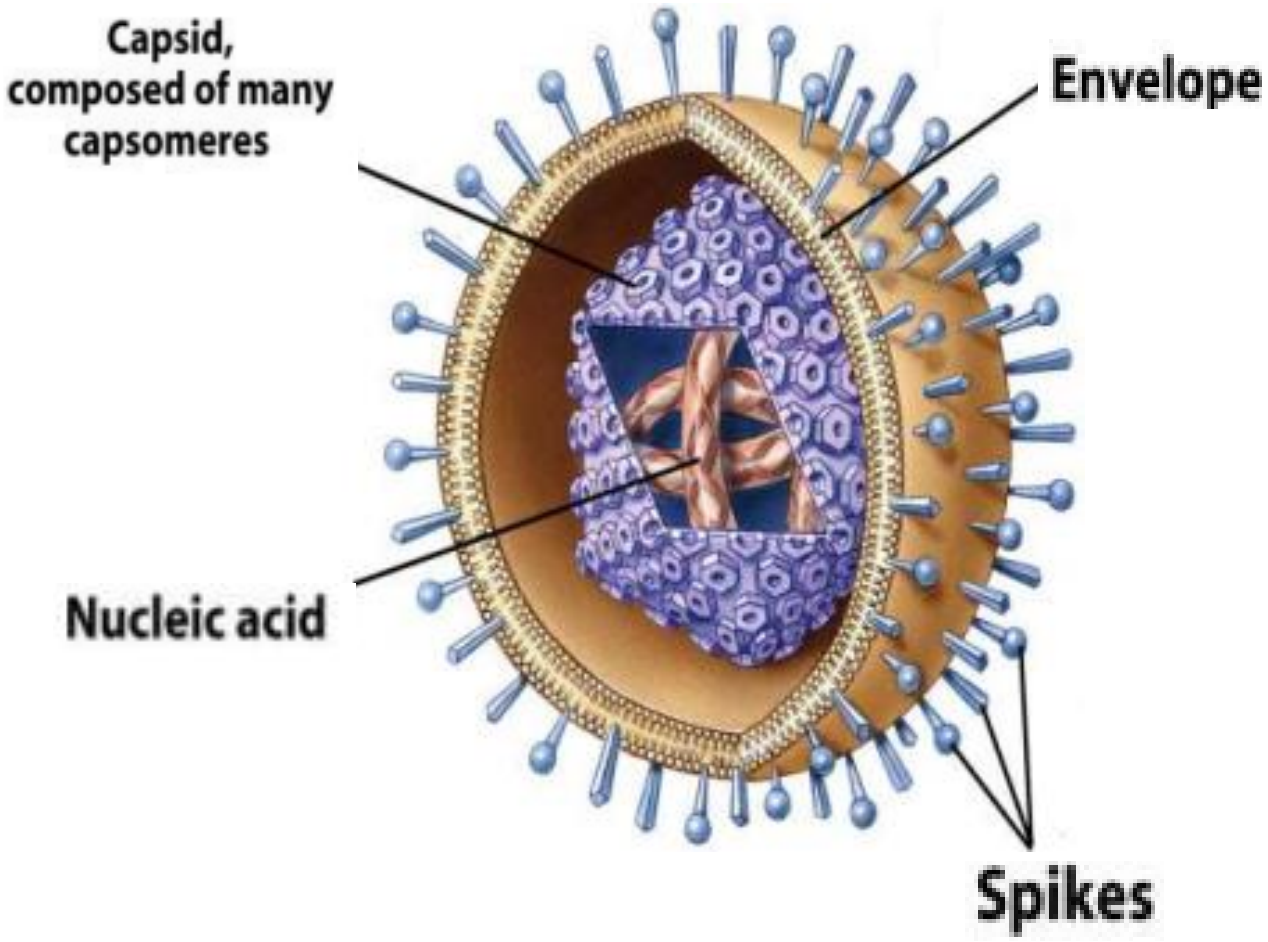
STRUCTURE OF VIRUSES

Enveloped viruses



STRUCTURE OF VIRUSES

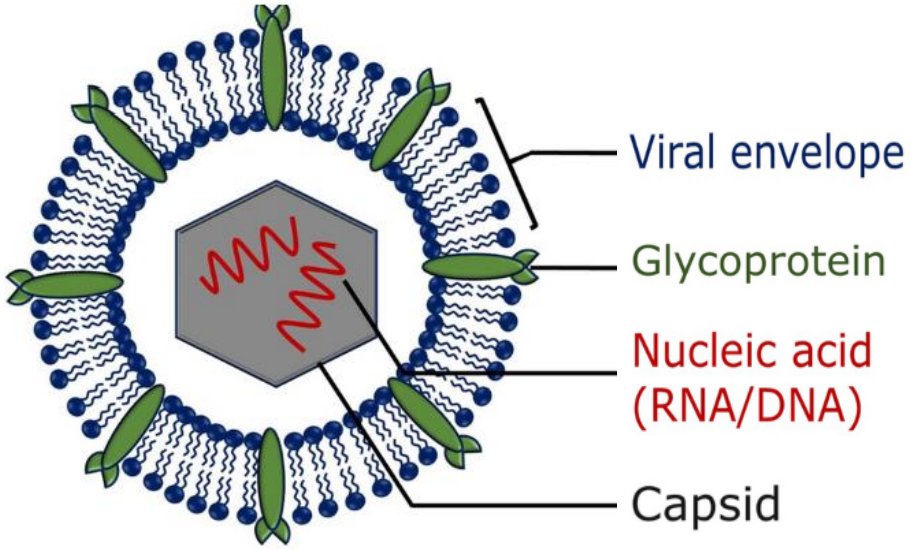
Enveloped viruses



STRUCTURE OF VIRUSES

Enveloped viruses

- Most viruses also have an envelope surrounding the capsid.
- The envelope is a lipid membrane that is derived from one of the cell's membranes, most often the plasma membrane, endoplasmic reticulum, Golgi complex, or even the nuclear membrane.
- Enveloped viruses are more sensitive to heat , drying , detergents, and lipid solvents such as alcohol and ether than are nonenveloped viruses, which are composed only of nucleic acid and capsid proteins.



STRUCTURE OF VIRUSES

Enveloped viruses

The clinical correlation

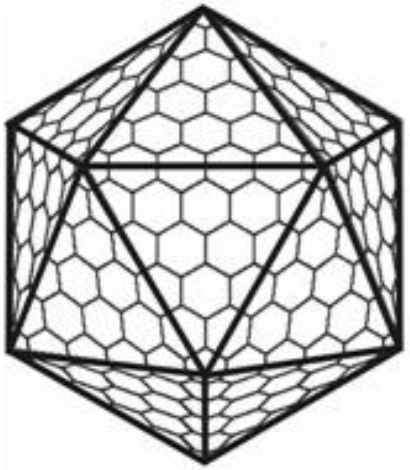
- Virtually all viruses that are transmitted **by the fecal– oral route** (those that have to survive in the environment) **do not have an envelope**, that is, they are naked nucleocapsid viruses. These include viruses such as hepatitis A virus, poliovirus, Coxsackie virus, echovirus, Norwalk virus, and rotavirus.
- In contrast, **enveloped** viruses are most often **transmitted by direct contact**, such as by blood or by sexual transmission. Examples of these include HIV, herpes simplex virus type 2, and HBV and HCV. Other enveloped viruses are transmitted directly by insect bite (e.g., yellow fever virus and West Nile virus) or by animal bite (e.g., rabies virus).
- **Many other enveloped** viruses are transmitted **from person to person in respiratory aerosol droplets**, such as influenza virus, measles virus, rubella virus, respiratory syncytial virus, and varicella-zoster virus. If the droplets do not infect directly, they can dry out in the environment, and these enveloped viruses are rapidly inactivated.

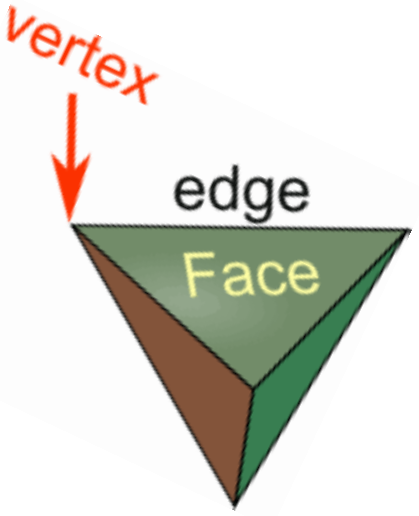
VIRUS CLASSIFICATION

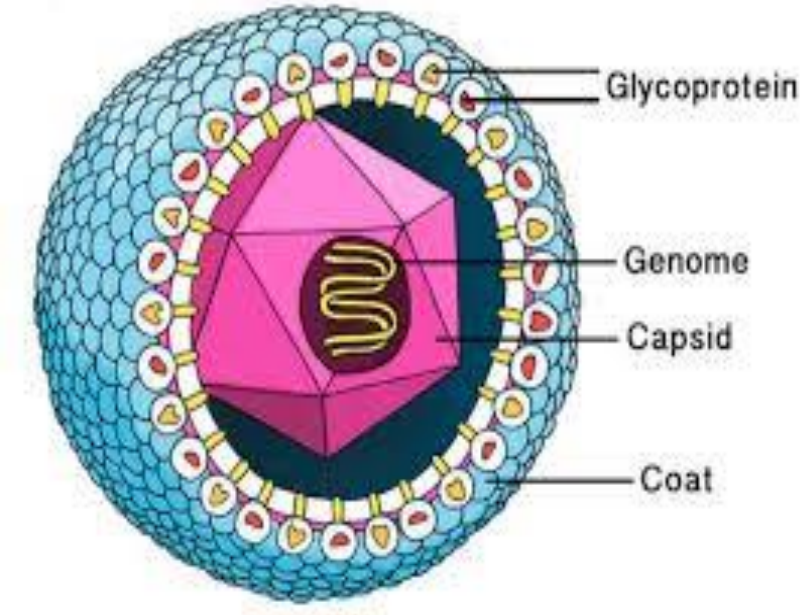
Based on capsid Shape

Polyhedral viruses

- In this arrangement, the nucleic acids are arranged inside a shell, which is in the shape of an icosahedron.
- From Ancient Greek (eíkosi) 'twenty' and (hédra) ' seat'.
- Icosahedron is a geometrical figure with 12 vertices (corners) and 20 identical facets (faces) and 30 edges.





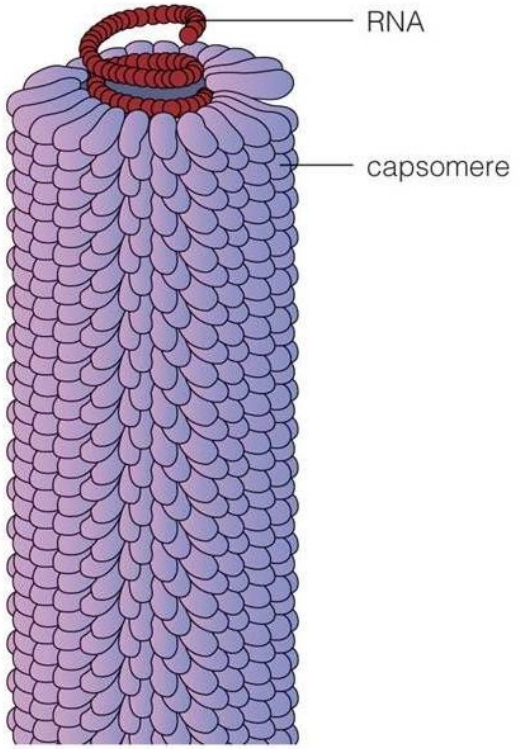


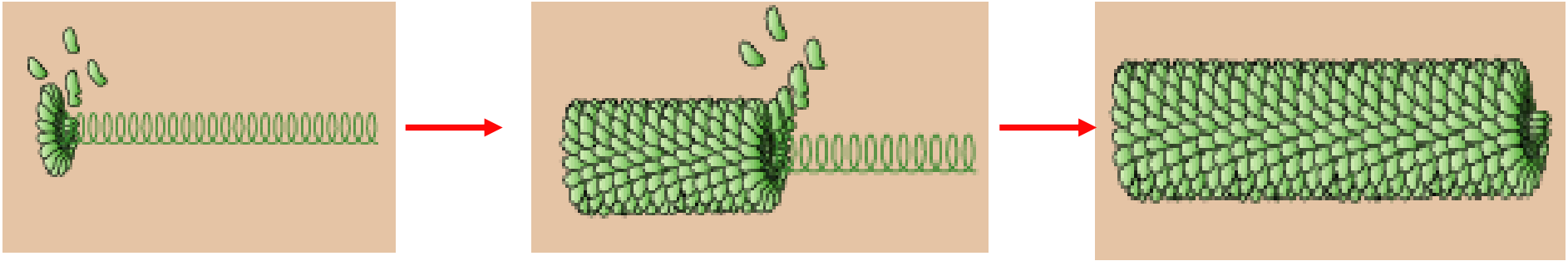
VIRUS CLASSIFICATION

Based on capsid Shape

Helical Viruses

- The nucleic acid and capsomeres are helically coiled together.
- The length of the helical viral nucleocapsid is determined by the length of the nucleic acid.
- In this symmetry the identical protein subunits are arranged in a circular form.



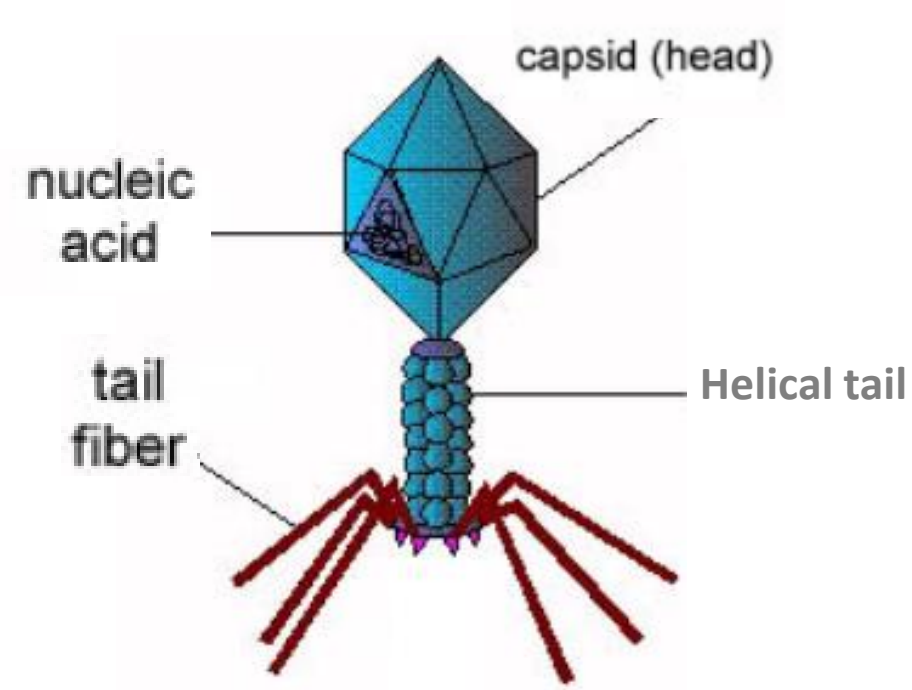


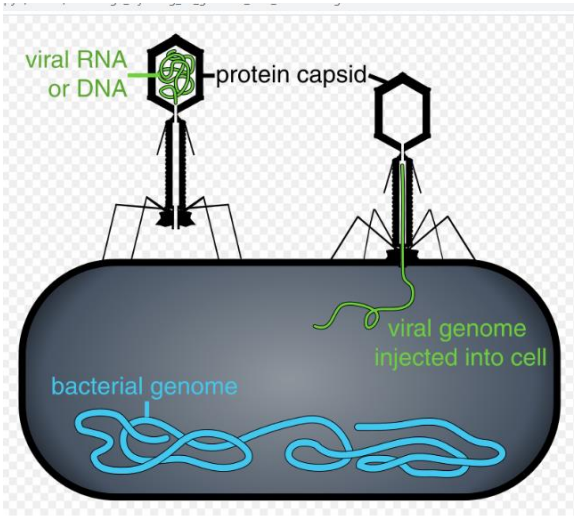
VIRUS CLASSIFICATION

Based on capsid Shape

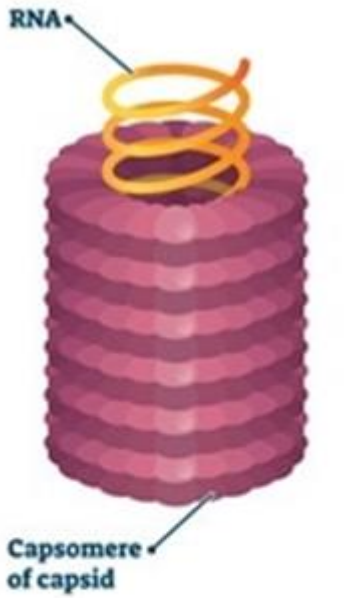
Complex viruses

- It is also referred as undefined symmetry.
- This arrangement does not fit into either helical or polyhedral symmetries.
- It has the feature of both polyhedral and helical symmetries.
- Capsid (head): polyhedral
- Head contains the nucleic acid.
- The tail is helical.
- The tail fibers - involved in the binding of the phage to the bacterial cell.



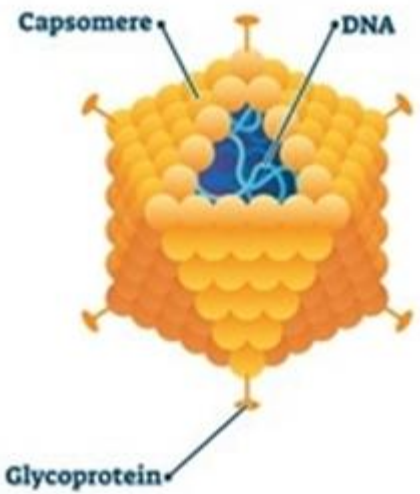


VIRUS CLASSIFICATION



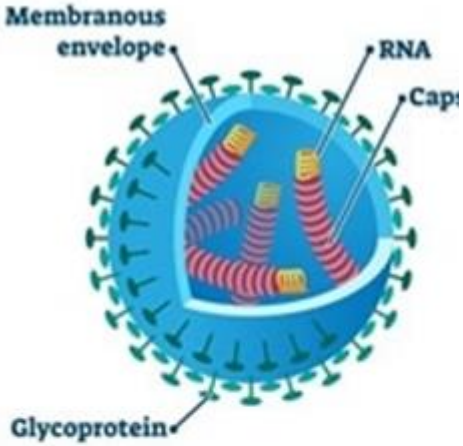
HELICAL

Tobacco Mosaic Virus



POLYHEDRAL

Adenovirus



SPHERICAL

Influenza Virus

COMPLEX

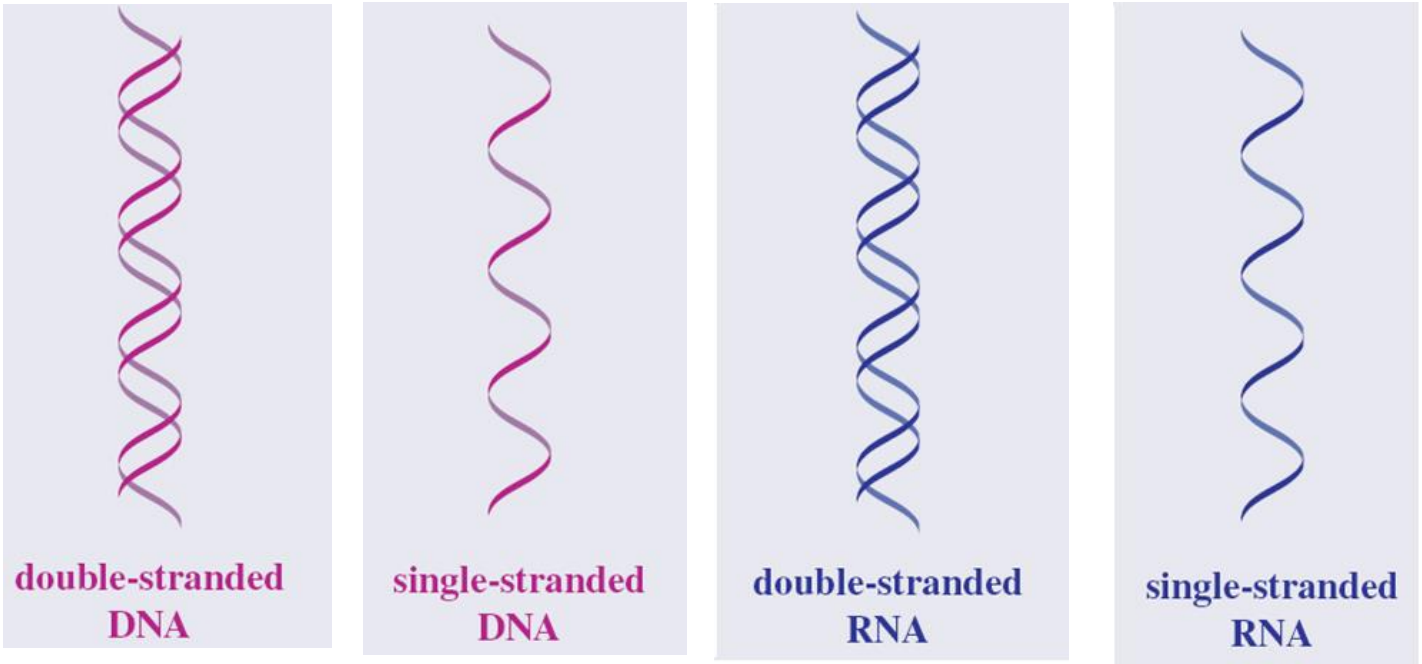
Bacteriophage

STRUCTURE OF VIRUSES

Classification based on the type of nucleic acid genome:

The viral genome is either:

- dsDNA
- ssDNA
- dsRNA
- ssRNA



STRUCTURE OF VIRUSES

The important functions of viral proteins

- The surface proteins of the virus, whether they are the capsid proteins or the envelope glycoproteins, are the principal antigens against which the host mounts its immune response to viruses.
- Mediate the attachment of the virus to specific receptors on the host cell surface.
- They induce neutralizing antibodies that inhibit the virus from entering the cell and replicating
- They activate cytotoxic T cells to kill virus-infected cells.

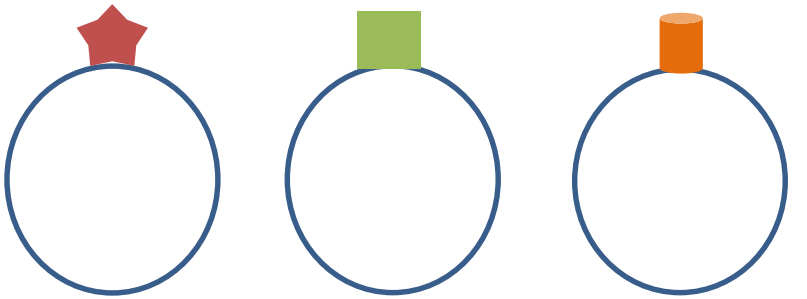
STRUCTURE OF VIRUSES

Serotypes ! (Antigenic Determinants)

- The term “serotype” is used to describe a subcategory of a virus based on its surface antigens.
- For example, measles virus has one serotype, polioviruses have three serotypes , and rhinoviruses have over 100 serotypes.
- This is because all measles viruses have only one antigenic determinant on its surface protein that induces neutralizing antibody capable of preventing infection.
- In contrast, polioviruses have three different antigenic determinants on its surface proteins.

STRUCTURE OF VIRUSES

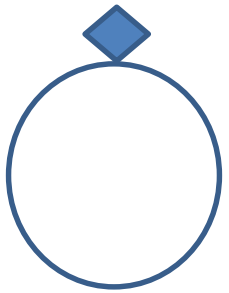
Serotypes ! (Antigenic Determinants)



poliovirus type 1 poliovirus type 2 poliovirus type 3

Serotype 1 Serotype 2 Serotype 3

Three different types of Antibodies
(Three serum types)



Measles virus

One serotypes

One type of Antibody
(One serum type)

STRUCTURE OF VIRUSES

Medical implications related to serotypes

- person can be immune (have antibodies) to poliovirus type 1 and still get the disease ,poliomyelitis caused by poliovirus types 2 or 3.
- The other implication is the polio vaccine must contain all three serotypes in order to be completely protective.

Thank you