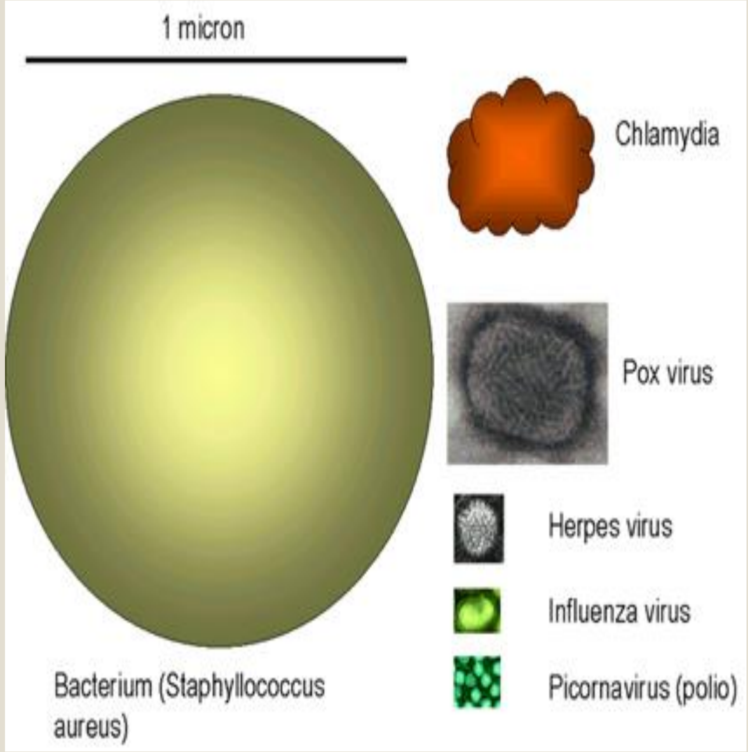
General Properties of Viruses

Lec 1: Virology

Dr. Hujaz Ismail, Microbiology and Immunology Module ,2023-2024, 1st year

Viruses

- Viruses are the smallest infectious agents (ranging from about 20 to 300 nm in diameter) and contain only one kind of nucleic acid (RNA or DNA) as their genome. The nucleic acid is encased in a protein shell, which may be surrounded by a lipid-containing membrane.



General Properties of Viruses

(1) Viruses are particles composed of an internal core containing **either DNA or RNA (but not both)** covered by a protective protein coat. Some viruses have an outer lipoprotein membrane, called an envelope, external to the coat. **Viruses do not have a nucleus, cytoplasm, mitochondria, or ribosomes.** Cells, both prokaryotic and eukaryotic, have both DNA and RNA.

Eukaryotic cells, such as fungal, protozoal, and human cells, have a nucleus, cytoplasm, mitochondria, and ribosomes. Prokaryotic cells, such as bacteria, are not divided into nucleus and cytoplasm and do not have mitochondria but do have ribosomes; therefore, they can synthesize their own proteins.

(2) **Viruses must reproduce (replicate) within cells**, because they cannot generate energy or synthesize proteins. Because they can reproduce only within cells, viruses are obligate intracellular parasites. (The only bacteria that are obligate intracellular parasites are chlamydiae and rickettsiae). They cannot synthesize sufficient energy to replicate independently.

(3) **Viruses replicate in a manner different from that of cells** (i.e., viruses do not undergo binary fission or mitosis). One virus can replicate to produce hundreds of progeny viruses, whereas one cell divides to produce only two daughter cells.

Comparison of Viruses and Cells

Property	Viruses	Cells
Type of nucleic acid	DNA or RNA but not both	DNA and RNA
Proteins	Few	Many
Lipoprotein membrane	Envelope present in some viruses	Cell membrane present in all cells
Ribosomes	Absent[1]	Present
Mitochondria	Absent	Present in eukaryotic cells but not in prokaryotic cells
Enzymes	None or few	Many
Multiplication by binary fission or mitosis	No	Yes

1 Arenaviruses have a few nonfunctional ribosomes

Classification of viruses

- Viruses are divided into related groups, or families, and, sometimes into subfamilies based on:

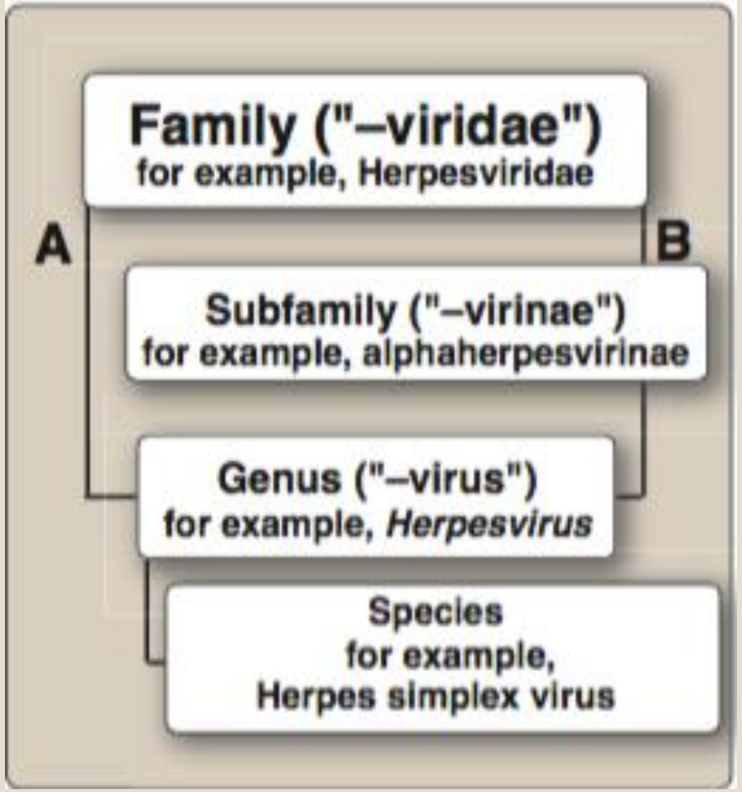
1) Type and structure of the viral nucleic acid.

2) The strategy used in its replication.

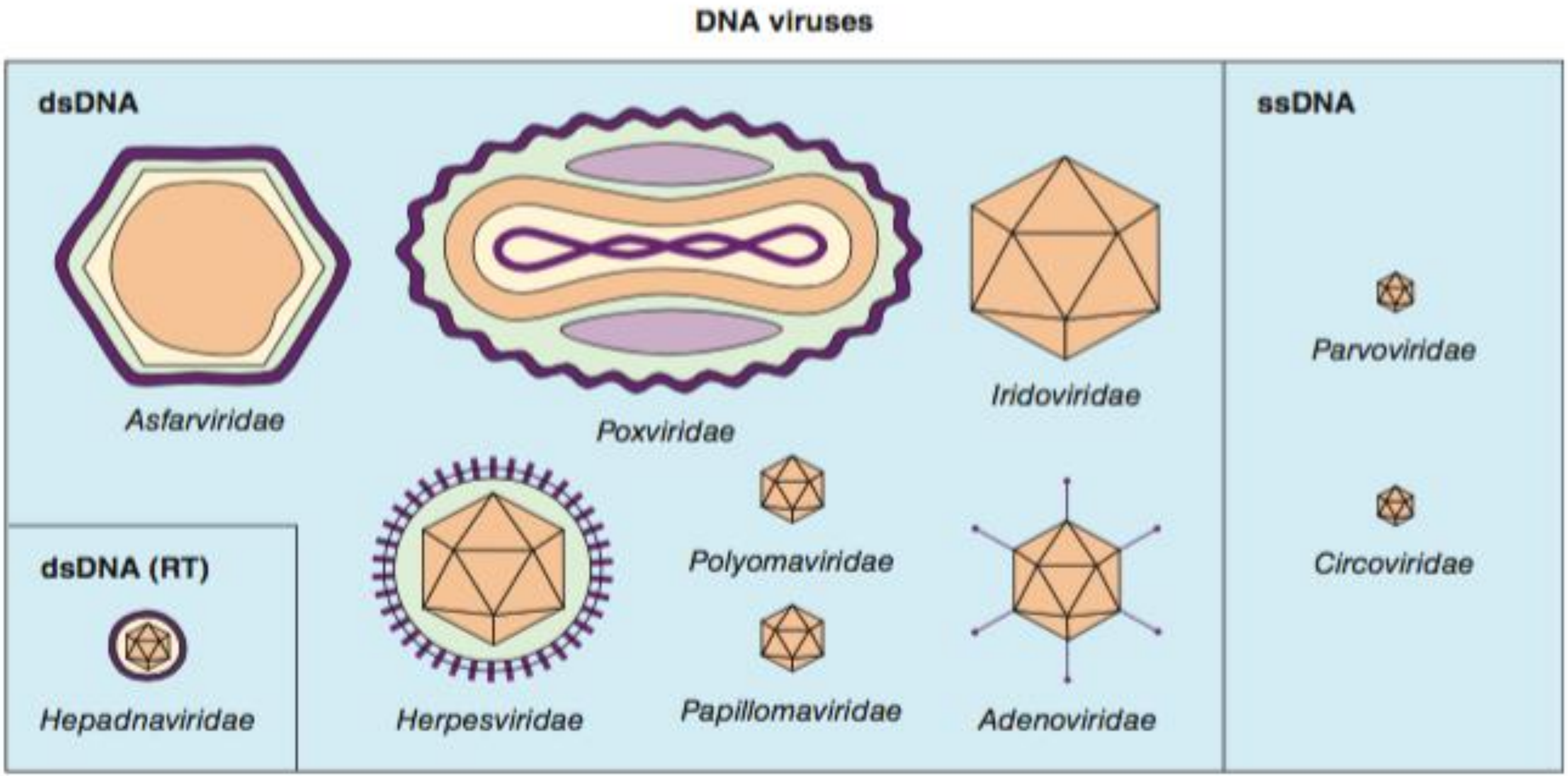
3) Type of symmetry of the virus capsid (helical versus icosahedral

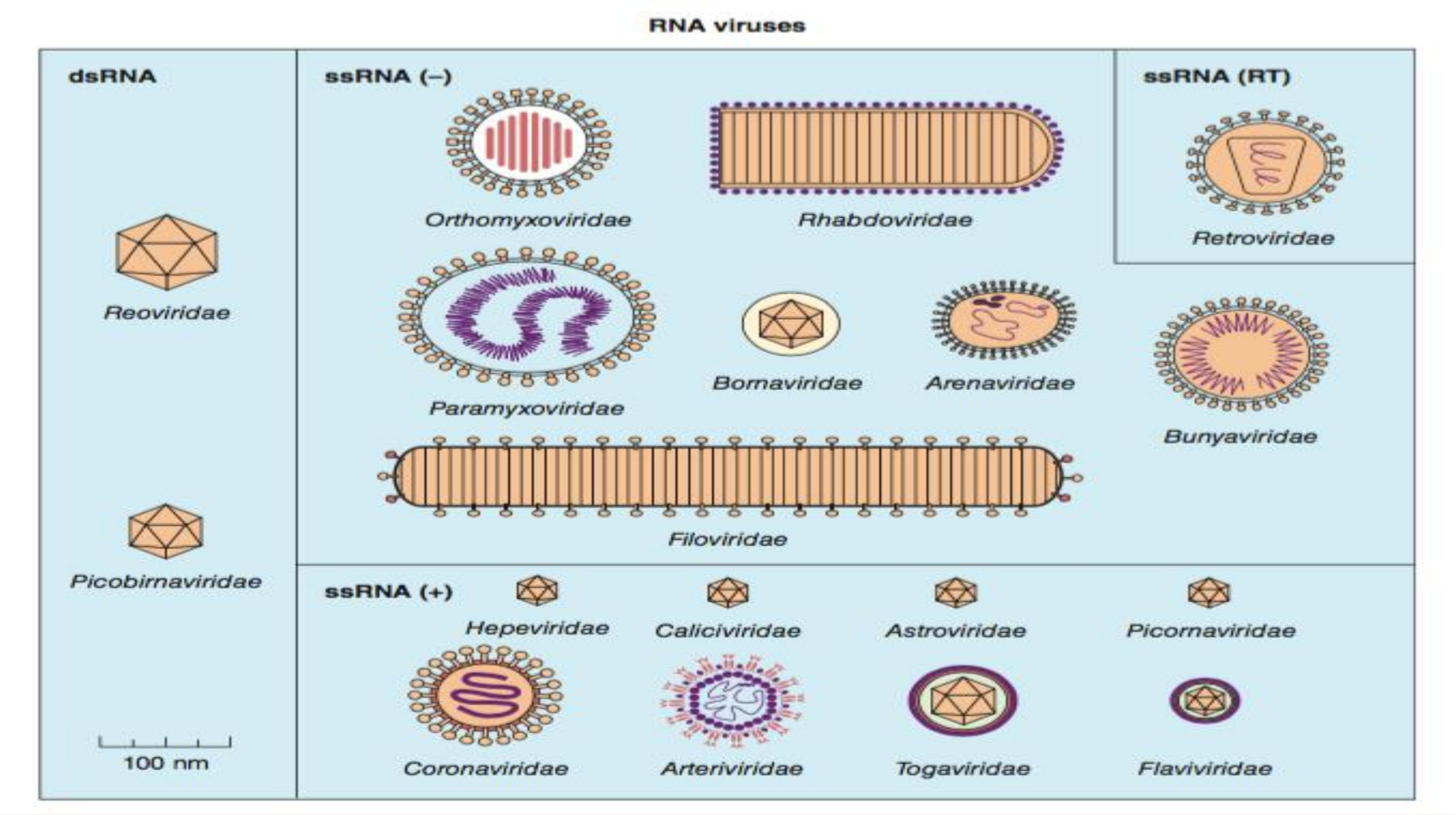
4) Presence or absence of a lipid envelope.

- Within a virus family, differences in additional specific properties, such as host range, serologic reactions, amino acid sequences of viral proteins, degree of nucleic acid homology, among others, form the basis for division into genera (singular = genus) and species.



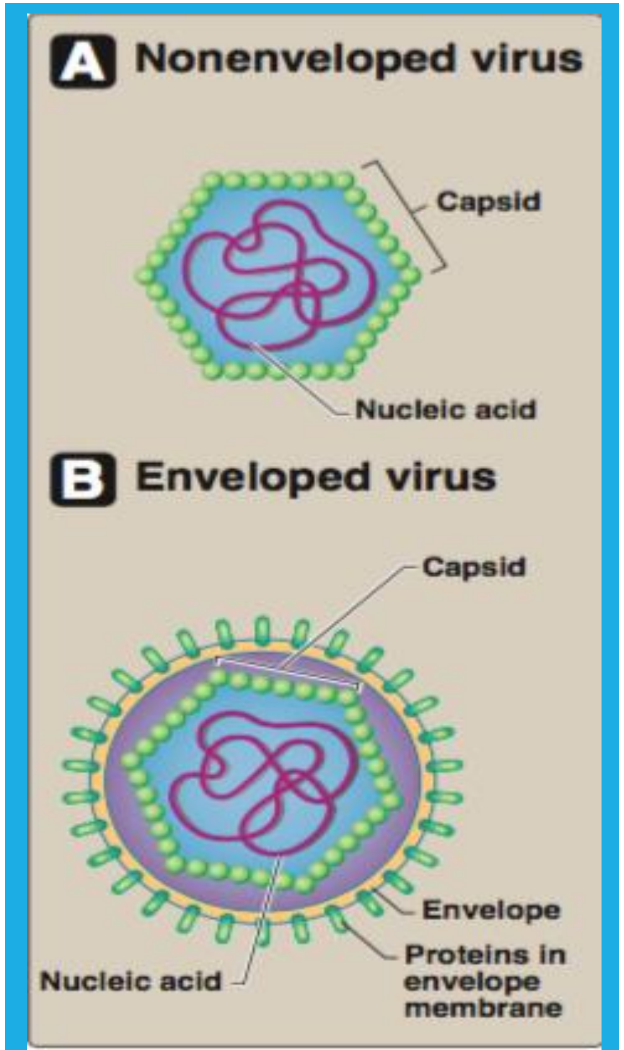
Classification of viruses:
A. No subfamilies present.
B. Subfamilies present


DNA viruses
dsDNA
Asfarviridae
Poxviridae
Iridoviridae
ssDNA
Parvoviridae
Circoviridae
dsDNA (RT)
Hepadnaviridae
Herpesviridae
Polyomaviridae
Papillomaviridae
Adenoviridae


RNA viruses
dsRNA
Reoviridae
Picobirnaviridae
100 nm
ssRNA (–)
Orthomyxoviridae
Rhabdoviridae
Paramyxoviridae
Bornaviridae
Arenaviridae
Bunyaviridae
Filoviridae
ssRNA (RT)
Retroviridae
ssRNA (+)
Hepeviridae
Caliciviridae
Astroviridae
Picornaviridae
Coronaviridae
Arteriviridae
Togaviridae
Flaviviridae

Viral Structure

- Viral Nucleic Acid (Genome)
- Viral Capsid
- Viral Lipid Envelopes
- Viral Glycoproteins



General structure:

A. non- enveloped.

B. enveloped viruses.

Genome

- Viruses contain **a single kind of nucleic acid—either DNA or RNA**—that encodes the genetic information necessary for replication of the virus. The genome may be single or double stranded, circular or linear, and segmented or non segmented.

- Single-stranded viral RNA genomes are further subdivided into those of “**positive polarity**” (that is, of messenger RNA sense, which can therefore be used as a template for protein synthesis), and those of **“negative polarity”** or are antisense (that is, complementary to messenger RNA sense, which cannot therefore be used directly as a template for protein synthesis). Viruses containing these two types of RNA genomes are commonly referred to as **positive-strand** and **negative-strand RNA viruse**s, respectively.

Capsid

- The nucleic acid is surrounded by a protein coat called a **capsid** made up of subunits called **capsomers**.

- Each capsomer, consisting of one or several proteins, can be seen in the electron microscope as a spherical particle, sometimes with a central hole.

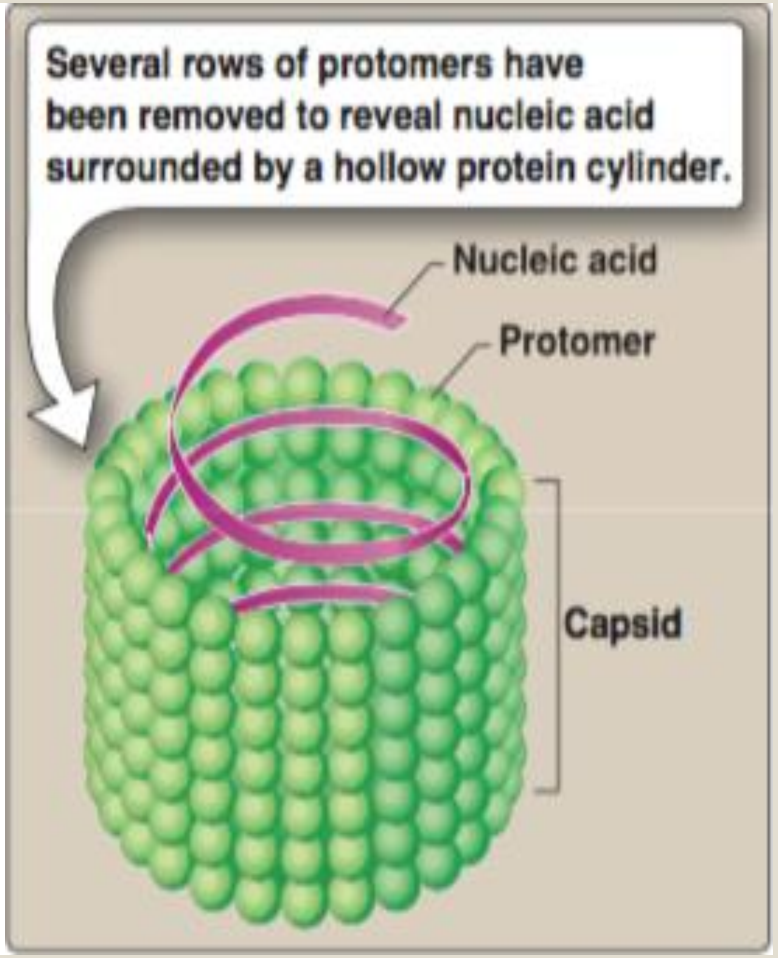
- The structure composed of the nucleic acid genome and the capsid proteins is called the **nucleocapsid.**

Capsid symmetry

- The protein shell enclosing the genome is, for most virus families, found in either of two geometric configurations: **helical (rod-shaped or coiled) or icosahedral (spherical, symmetric or cubic**).
- The capsid is constructed of multiple copies of a single polypeptide type (found in helical capsids) or a small number of different polypeptides (found in icosahedral capsids), requiring only a limited amount of genetic information to code for these structural components.
- **Some virus particles do not exhibit simple cubic or helical symmetry but are more complicated in structure (Complex Structures). For example, poxviruses are brick shaped, with ridges on the external surface and a core and lateral bodies inside**

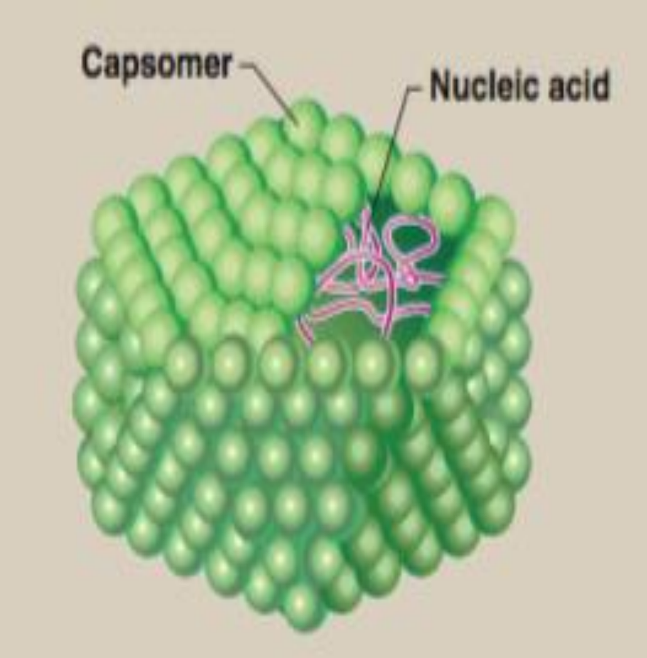
Helical Symmetry

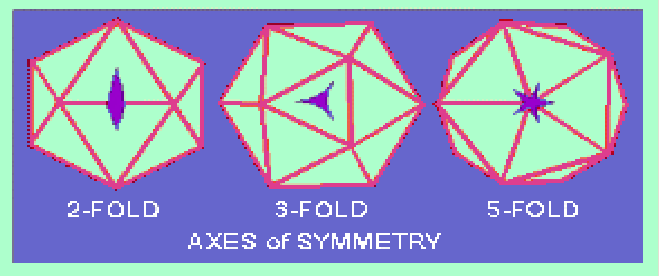
- Capsids with helical symmetry consist of repeated units of a single polypeptide species that—in association with the viral nucleic acid—self-assemble into a helical cylinder.
- Each polypeptide unit (protomer) is hydrogen-bonded to neighboring protomers. The complex of protomers and nucleic acid is called the nucleocapsid.
- Most helical viruses are enveloped



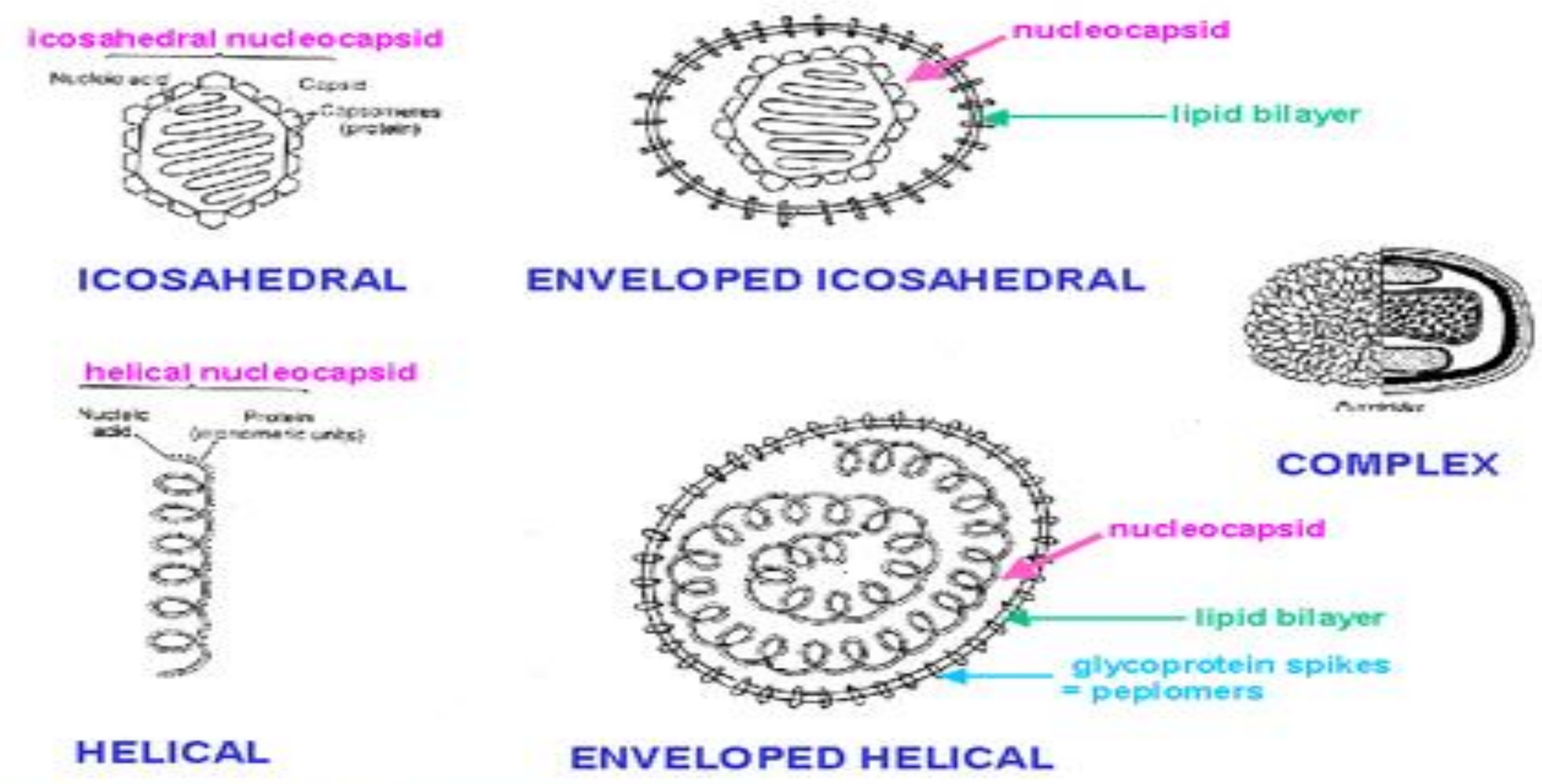
Icosahedral (Cubic Symmetry)

- Capsids with icosahedral symmetry are more complex than those with helical symmetry, in that they consist of several different polypeptides grouped into structural subassemblies called capsomers.
- These, in turn, are hydrogen-bonded to each other to form an icosahedron.
- The nucleic acid genome is located within the empty space created by the rigid, icosahedral structure.
- Have exactly 60 subunits on the surface of an icosahedron
- Have fivefold, threefold and twofold rotational symmetry





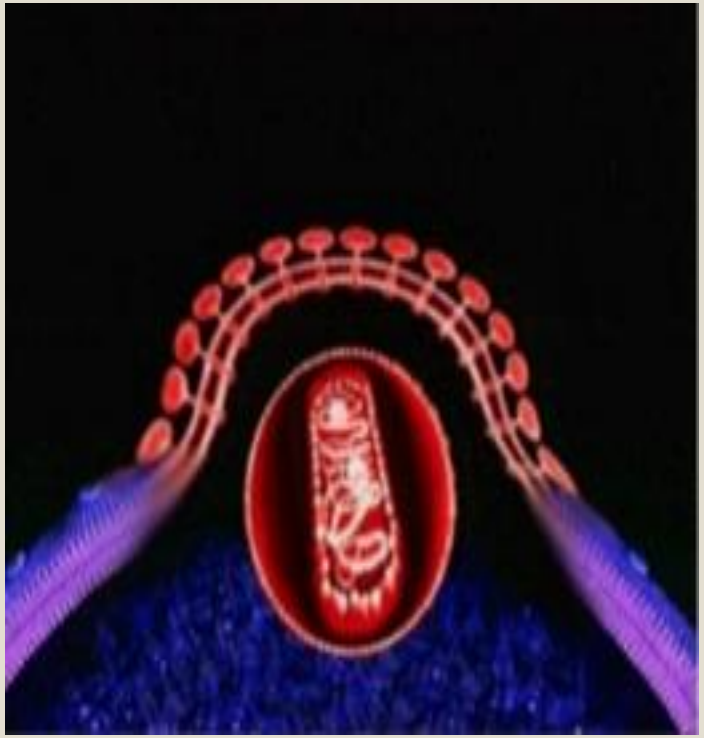
5 BASIC TYPES OF VIRAL SYMMETRY



Envelope

- The envelope is a lipoprotein membrane composed of lipid derived from the host cell membrane and protein that is virus-specific. Furthermore, there are frequently glycoproteins in the form of spike like projections on the surface, which attach to host cell receptors during the entry of the virus into the cell. Another protein, the matrix protein, mediates the interaction between the capsid proteins and the envelope.

- The viral envelope is acquired as the virus exits from the cell in a process called “budding”. The envelope of most viruses is derived from the cell’s outer membrane, with the notable exception of herpesviruses that derive their envelope from the cell’s nuclear membrane.



- In general, the presence of an envelope confers instability on the virus.
- **Enveloped viruses are more sensitive to heat, drying, detergents, and lipid solvents such as alcohol and ether than are nonenveloped (nucleocapsid) viruses, which are composed only of nucleic acid and capsid proteins.**
- All viruses transmitted by feco-oral route like **Hepatitis A** virus (HAV), poliovirus rotavirus are non-enveloped (those have to survive in environment)
- Enveloped viruses are often transmitted by direct contact as by blood, sexual contact like human immunodeficiency virus(HIV), **hepatitis B** virus (HBV), **hepatitis C virus (**HCV), rabies virus, measles, mumps, rubella viruses.

Viral Glycoproteins

- Viral envelopes contain glycoproteins. In contrast to the lipids in viral membranes, which are derived from the host cell, the envelope glycoproteins are virus encoded.
- The surface glycoproteins of an enveloped virus attach the virus particle to a target cell by interacting with a cellular receptor. They are also often involved in the membrane fusion step of infection.
- The glycoproteins are also important viral antigens. As a result of their position at the outer surface of the virion, they are frequently involved in the interaction of the virus particle with neutralizing antibody.

Atypical Virus-like Agents

- **(1) Defective viruses**
- **(2) Pseudovirions**
- **(3) Viroids**
- **(4) Prions**

Defective viruses

- **Defective** viruses are composed of viral nucleic acid and proteins but cannot replicate without a “helper” virus, which provides the missing function.

- Defective viruses usually have a mutation or a deletion of part of their genetic material.
- During the growth of most human viruses, many more defective than infectious virus particles are produced.

Pseudovirions

- **Pseudovirions** contain host cell DNA instead of viral DNA within the capsid. They are formed during infection with certain viruses when the host cell DNA is fragmented and pieces of it are incorporated within the capsid protein.
- Pseudovirions can infect cells, but they do not replicate.

Viroids

- **Viroids** consist solely of a single molecule of circular RNA without a protein coat or envelope.
- There is extensive homology between bases in the viroid RNA, leading to large double-stranded regions.
- The RNA is quite small and apparently does not code for any protein. Nevertheless, viroids replicate, but the mechanism is unclear. They cause several plant diseases but are not implicated in any human disease.

Prions

- **Prions** are infectious particles that are composed **solely of protein** (i.e , they contain no detectable nucleic acid)
- They are implicated as the cause of certain “slow” diseases called **transmissible spongiform encephalopathies**, which include such diseases as Creutzfeldt-Jakob disease in humans and scrapie in sheep.
- Because neither DNA nor RNA has been detected in prions, they are clearly different from viruses. Furthermore, electron microscopy reveals filaments rather than virus particles.

Feature	Prions	Conventional Viruses
Particle contains nucleic acid	No	Yes
Particle contains protein	Yes, encoded by cellular genes	Yes, encoded by viral genes
Inactivated rapidly by ultraviolet light or heat	No	Yes
Appearance in electron microscope	Filamentous rods (amyloid-like)	Icosahedral or helical symmetry
Infection induces antibody	No	Yes
Infection induces inflammation	No	Yes


Thank you!