STRUCTURE OF VIRUSES:

Defective Viruses

Defective viruses are those virus particles whose genome lacks a specific gene or genes due to either mutation or deletion.

As a result, defective viruses are not capable of undergoing a productive life cycle in cells.

However, if the cell infected with the defective virus is co-infected with a "helper virus", the gene product lacking in the defective one is complemented by the helper and defective virus can replicate.

Interestingly, for some viruses, during infection a greater quantity of defective virions is produced than infectious virions (as much as 100:1).

The production of defective particles is a characteristic of some virus species and is believed to moderate the severity of the infection/disease in *vivo*.

Pseudovirions

Pseudovirions may be produced during viral replication when the host genome is fragmented.
As a result of this process, host DNA fragments are incorporated into the capsid instead of viral DNA. Thus, pseudovirions possess the viral capsid to which antibodies may bind and facilitate attachment and penetration into a host cell, but they cannot replicate once they have gained access to a host cell, as they have none of the essential viral genes for the process.

Prions

Prions are proteinaceous infectious particles associated with transmissible spongiform encephalopathies (TSE) of humans and animals.

TSEs include the Creutzfeldt-Jacob disease of humans, scrapie of sheep and
bovine spongiform encephalopathy.

At postmortem, the brain has large vacuoles in the cortex and cerebellum regions an thus prion diseases are called "spongiform encephalopathies". Closer examination of brain tissue reveals the accumulation of prion-protein associated fibrils and amyloid plaques.

These diseases are characterized by loss of motor control, dementia, paralysis, wasting and eventually death.

Viroids

Viroids are naked, low-molecular weight nucleic acids that are extremely resistant to heat, ultraviolet, and ionizing radiation. These particles are composed exclusively of a single piece of circular, single stranded RNA that has some double-stranded regions. Viroids mainly cause plant diseases, such as potato spindle tuber disease.

Virusoids

Virusoids (also called satellite RNAs) are similar to viroids in that they are naked, low-molecular weight nucleic acids that are extremely resistant to heat and ultraviolet and ionizing radiation. However, they depend on a helper virus for replication. Virusoids replicate in cytoplasm via a RNA dependent RNA polymerase.

Viruses are extremely small particles comprises of just proteins and nucleic acid.

The largest viruses are about 300nm in size, whereas the smallest known viruses are about 20nm. Viruses are comprised of two important components a protein **capsid** covering the **nucleic acid**.

Some viruses also possess a lipid **envelope** but the envelope is not a virus- mediated structure

Outer coat or capsid: The outer structure of virus is referred as capsid. It is made up of proteins. It is a protein shell that encloses the nucleic acid. It is built of **structure units**, which are the smallest functional equivalent building units of the **capsid.**

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Capsomeres are morphological units seen on the surface of particles and represent clusters of structural units.

Capsomeres are also referred as the basic structural subunit of capsid.

The capsid together with its enclosed nucleic acid is called the nucleocapsid.

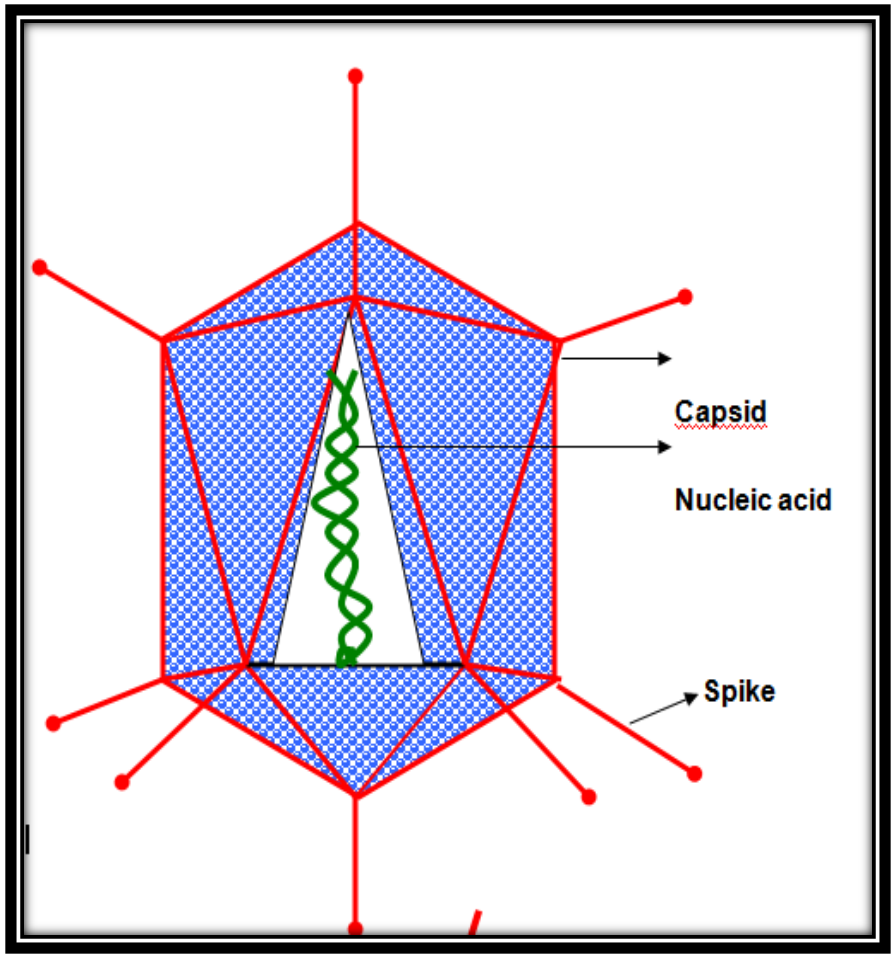
The nucleocapsid may be enclosed in an envelope, which may contain material of host cell as well as viral origin.

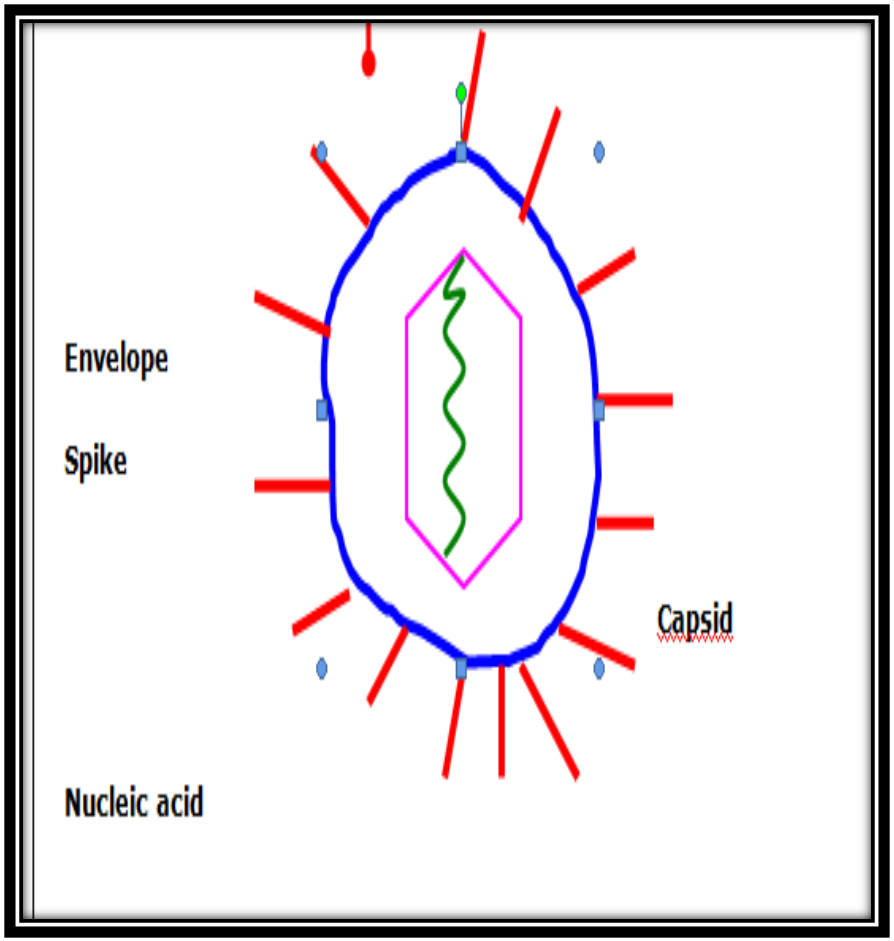
Function of the capsid of virus particle

To protect the fragile nucleic acid genome from physical, chemical and enzymatic damages.

The protein subunits in a virus capsid are multiply redundant, i.e. present in many copies per particle.

The viral nucleocapsid have the following three different morphological forms, which is also referred as symmetry. There are basic symmetries – cubical and helical .


Capsid
Nucleic acid
Spike

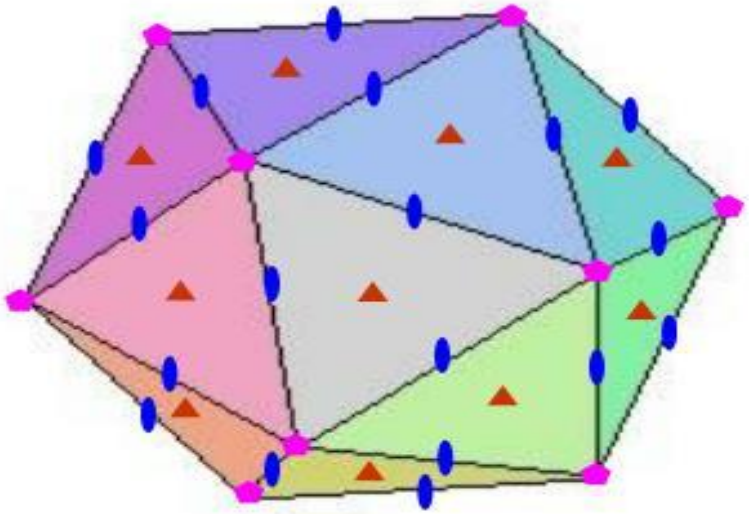

Envelope
Spike
Capsid
Nucleic acid

Icosahedral / Cubical symmetry Caplur & Klung

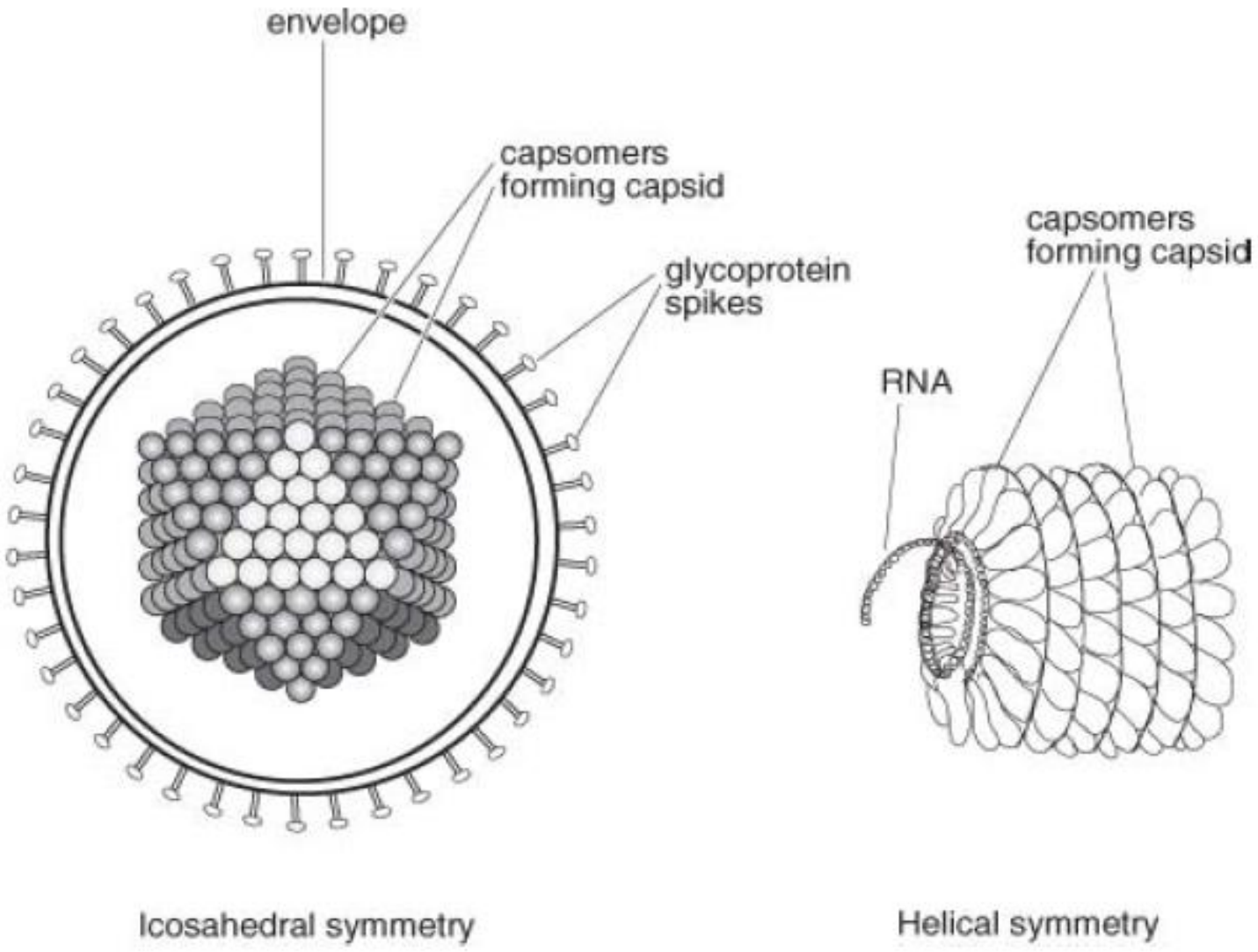
- In this arrangement, the nucleic acids are arranged inside a shell, which is in the shape of an icosahedran.
- Icosahedran is a geometrical figure with 12 vertices (corners) and 20 identical facets (faces) and 30 edges.
- Each facet is an equilateral triangle. There are six 5-fold axes of symmetry passing through the vertices,
- Ten 3-fold axes extending through each face and
- Fifteen 2-fold axes passing through the edges of an icosahedron.
- Icosahedral symmetry requires definite numbers of structure units to complete a shell. A virus with icosahedral symmetry (5:3:2 symmetry) requires a multiple of 60 subunits to cover the surface completely.

Icosahedral Symmetry

- 5, 3, 2 fold axes
  - 6 five fold axes
  - 10 three fold axes
  - 15 two fold axes
- 60 fold symmetry in total

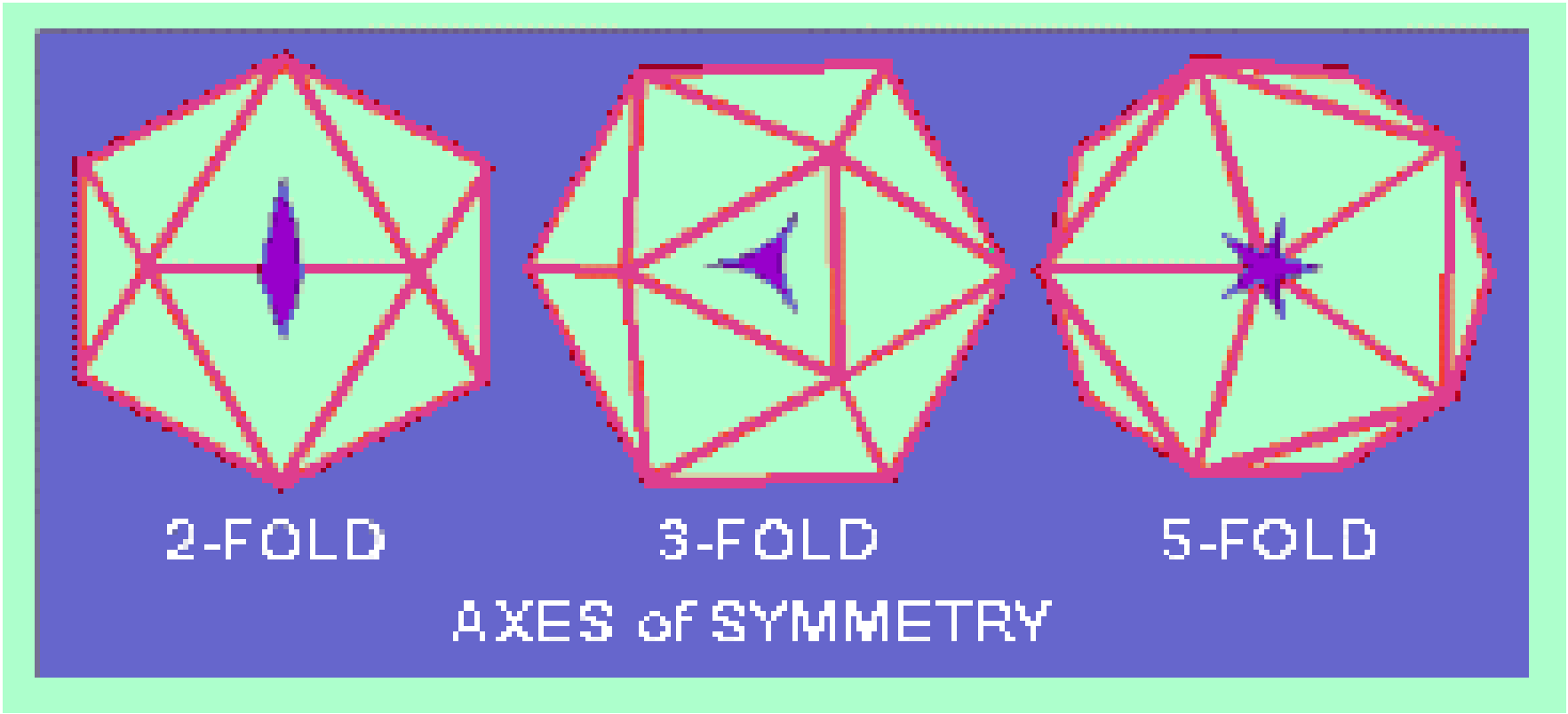


12 vertices (corners) and 20 identical facets (faces) and 30 edges.



Icosahedral symmetry

Helical symmetry


2-FOLD
3-FOLD
5-FOLD
AXES of SYMMETRY

Helical symmetry:

- 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 the form of a circle to form a disc shaped appearance.
- The cylinder or helical structure is formed as a result of stacking of multiple discs, with the virus genome coated by the protein shell or contained in the hollow centre of the cylinder.

Complex symmetry:

- **It is also referred as undefined symmetry. This arrangement does not fit into either helical or cubical symmetries. It has the feature of both cubical and helical symmetries.**

Eg. Pox Virus

VIRAL NUCLEIC ACID:

- **The genetic material of viruses are made up of only one type of nucleic acid ie. either DNA or RNA but never composed of both.**
- **The nucleic acid both DNA and RNA may be present either as single stranded or double stranded.**
- **The nucleic acid (RNA) may also present either as a single molecule or in segments. The DNA may present either as linear or circular molecule.**
- **The RNA may present either as positive sense or negative sense. The molecular weight ranges from 2 million to 200 million.**
- **In some viruses the nucleic acids are just packed inside the capsid, whereas in some viruses, they are integrated with the nucleocapsid.**

ENVELOPE:

- **The capsid of some viruses are surrounded by a membrane called envelope. Viral envelopes are derived from cellular membranes of host, which are acquired during the release of virus from host cell.**
- The envelope also **contain proteins** that are referred **as matrix proteins** and are specified by viral genes. The **envelope proteins appear as spikes** and are also referred as **spike proteins.** The spike proteins are responsible for attachment of virus to cells.
- **The viral structures are studied by electron microscopic techniques** like **negative staining, freeze etching and shadowing. The method that is more commonly used in X ray crystallography. Of late nuclear magnetic resonance (NMR) imaging is used to study structural details**.

Productive infection: **The cells allow viruses to replicate and the progeny virions are released from the infected cell.**

Abortive infection: **The cells do not allow viruses to replicate & as a result of this daughter virions are not produced.**

Restrictive infection: **The cells allow minimal replication of viruses and as a result only few daughters alone are produced.**

However, the viral genome persists and can lead to serious consequence for the host.

Eg. Epstein Barr & herpes simplex