General structure and classification of viruses

BBZ BOTANY

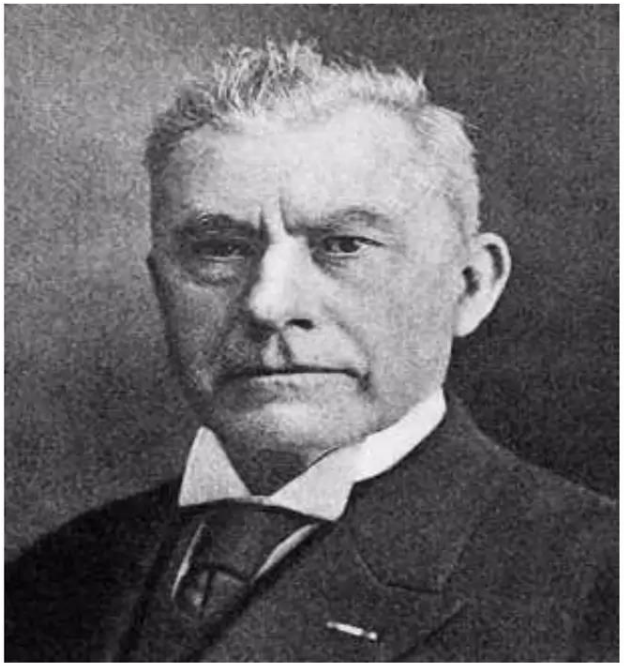
SEM I

The concept of virus

- Edward Jenner (1798), introduced the term virus in microbiology.
- Virus in Greek means poison.
- Edward Jenner noticed that milk maids who infected with cowpox develop immunity against smallpox.
- He inoculated a boy with the vesicle fluid taken from the hand of infected maid.
- The boy developed sustained immunity against smallpox.

History of virology

- In 1898 Martinus Beijerinck is considered one of the founders of virology
- Bacteriophages were discovered in the early 20th century, by the English bacteriologist Frederick Twort



MARTINUS BEIJERINCK

Essential Microbiology, Stuart Hogg

The concept of virus.

- Edward Jenner assumed that the vesicle fluid that has been taken from the hand of the milk maid contained a poison (virus), that was responsible for immunity.

General characteristics of viruses

- Viruses are smaller than bacteria, they range in size between 20-300 nanometer (nm).
- Viruses contain only one type of nucleic acid, either DNA or RNA, but never both.
- Viruses consist of nucleic acid surrounded by a protein coat. Some viruses have additional lipoprotein envelope.
- Viruses lack cellular organelles, such as mitochondria and ribosomes.

General characteristics of viruses

- Viruses are obligate cellular parasites. They replicate only inside living cells.
- Viruses replicate through replication of their nucleic acid and synthesis of the viral protein.
- Viruses do not multiply in chemically defined media.
- Viruses do not undergo binary fission.

Difference Between Bacteria And Virus

BACTERIA

- Living organism, unicellular, one cell
- Larger (1000nm)
- In latin means little sticks
- Usually treated with antibiotics

VIRUSES

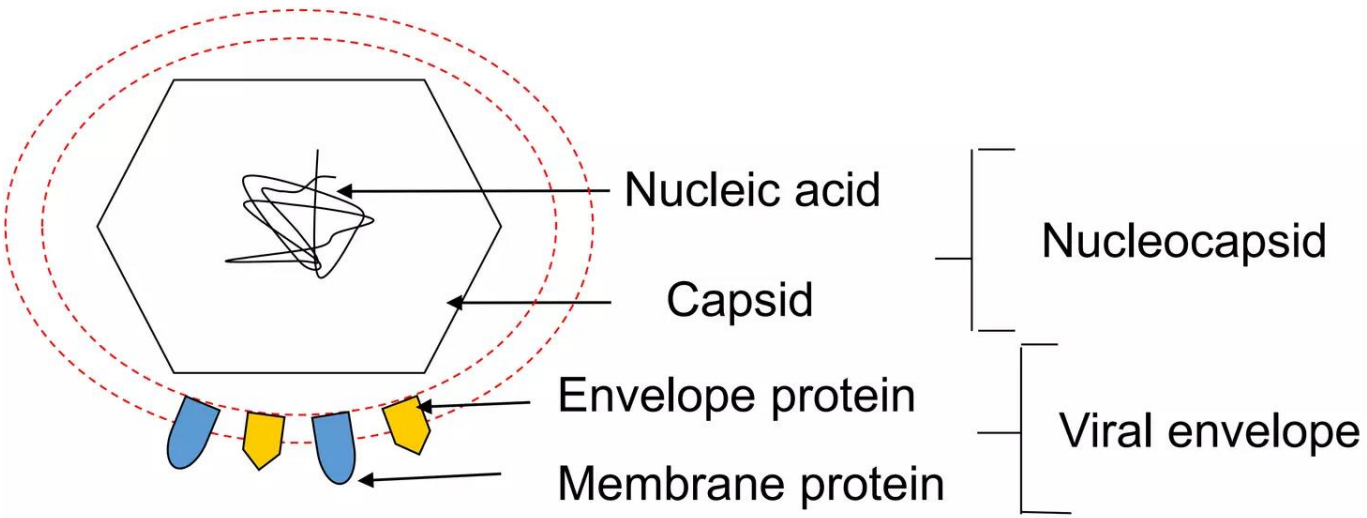
- Not living, no cells
- Smaller (20-300nm)
- In latin means poison
- Antibiotics will not effect the disease

1. Ananthanarayan & paniker's textbook of microbiology, seventh edition

Terminology

- Virion: The complete virus particle.
- Capsid: The protein coat that surrounds nucleic acid.
- Nucleocapsid: The nucleic acid plus the capsid.
- Capsomeres: The structural protein units that made up the capsid.
- Defective virus: the virus cannot replicate by its own, it requires helper virus.
- Nanometer : milli-micron.

Viral Structure - Overview



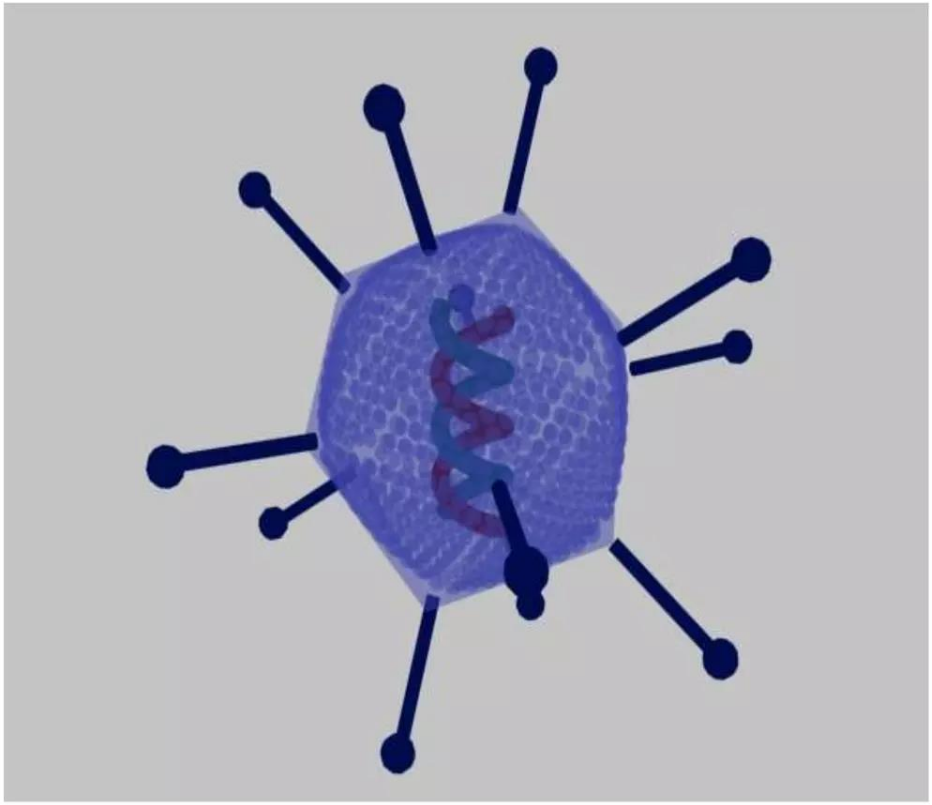
The nucleic acid plus the capsid shell of a virus particle is often called nucleocapsid

Virion: The complete virus particle

✓nucleic acid + protein coat, which **may** be surrounded by an envelope

Structure of Viruses

- Size
  - Between 20-300 nm diameter.
- Basic shape
  - Rod-like
  - “Spherical”
- Genomic material
  - DNA or RNA never both
  - Single- or double-stranded



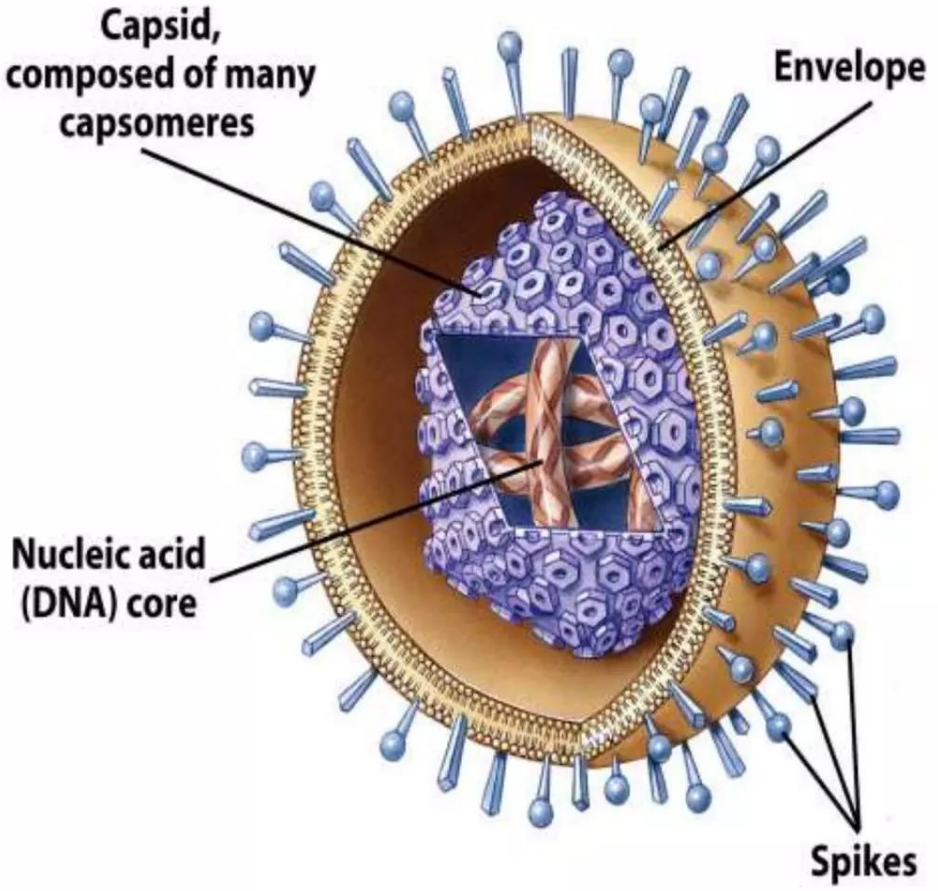
Jawetz, Melnick, & Adelberg’s, Medical Microbiology, Twenty-Sixth Edition

Structure of Viruses

- Protective Shell – Capsid
  - Made of many identical protein subunits
  - Protect the genetic material
  - May be involved in cell entry
  - Symmetrically organized
  - 50% of weight
  - Enveloped or non-enveloped
- Envelope: A lipid-containing membrane that surrounds some virus particles.

✓located outside the capsid)

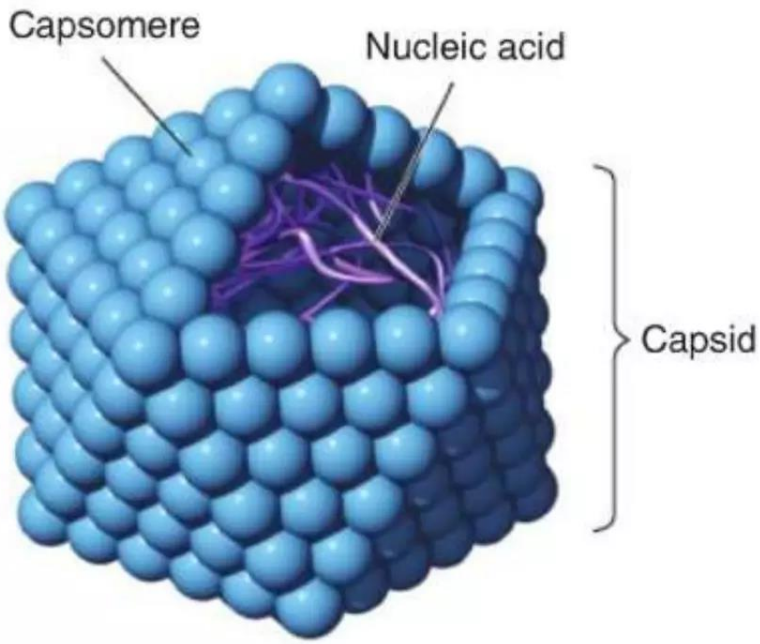
✓It is acquired during viral maturation



Viral Structure: Capsid

Capsid = protein coat that encloses and protects the nucleic acid of a virus

- Accounts for most of the viral mass
- Composed of single or multiple proteins
  - Each subunit = capsomeres



Virus Classification [2]

Based on Shape

- Polyhedral viruses
- Helical Viruses
- Complex viruses

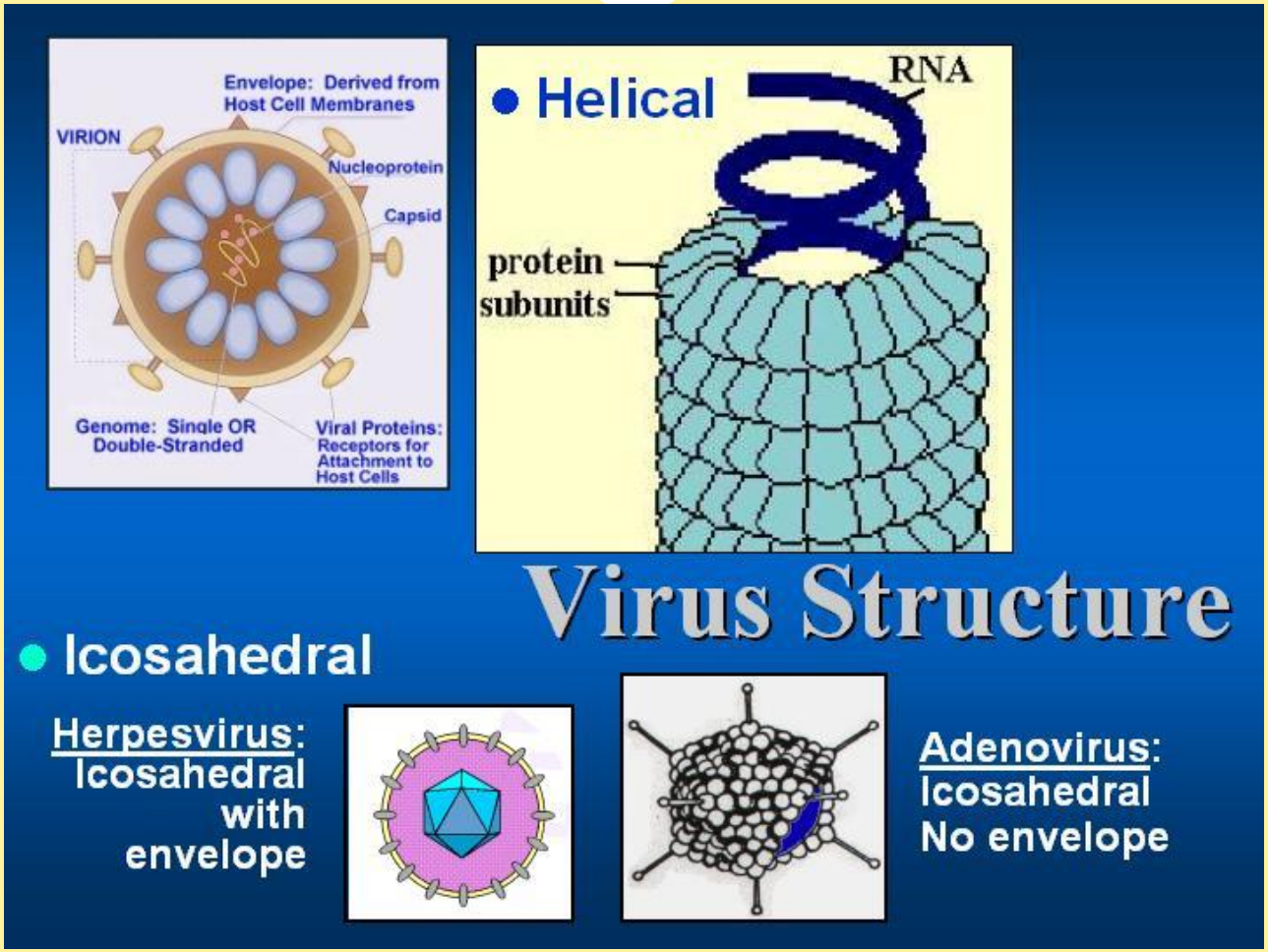
Based on Envelope

- Naked viruses
- Enveloped viruses

Based on genetic material

- **DNA Viruses**
- **RNA Viruses**

Structure of viruses



General Morphology

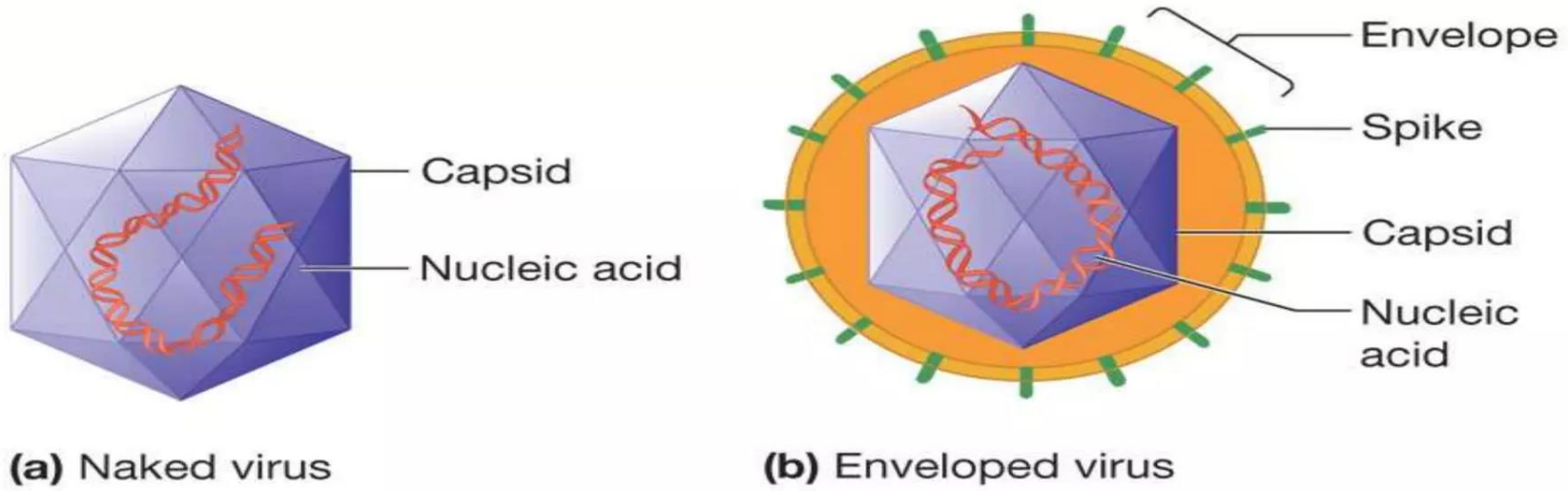
Capsid Structure determines shape:

- **Helical Viruses** = nucleic acid is inside a hollow cylindrical capsid with a helical structure
- Rabies, Ebola viruses, Tobacco Mosaic Virus

- **Polyhedral viruses** = many sided; icosahedron is common with 20 equilateral triangles as sides and 12 vertices
- Poliovirus, Adenovirus, herpes,

- **Complex structures**
- Pox virus & bacteriophage

Viral Structure: Envelope

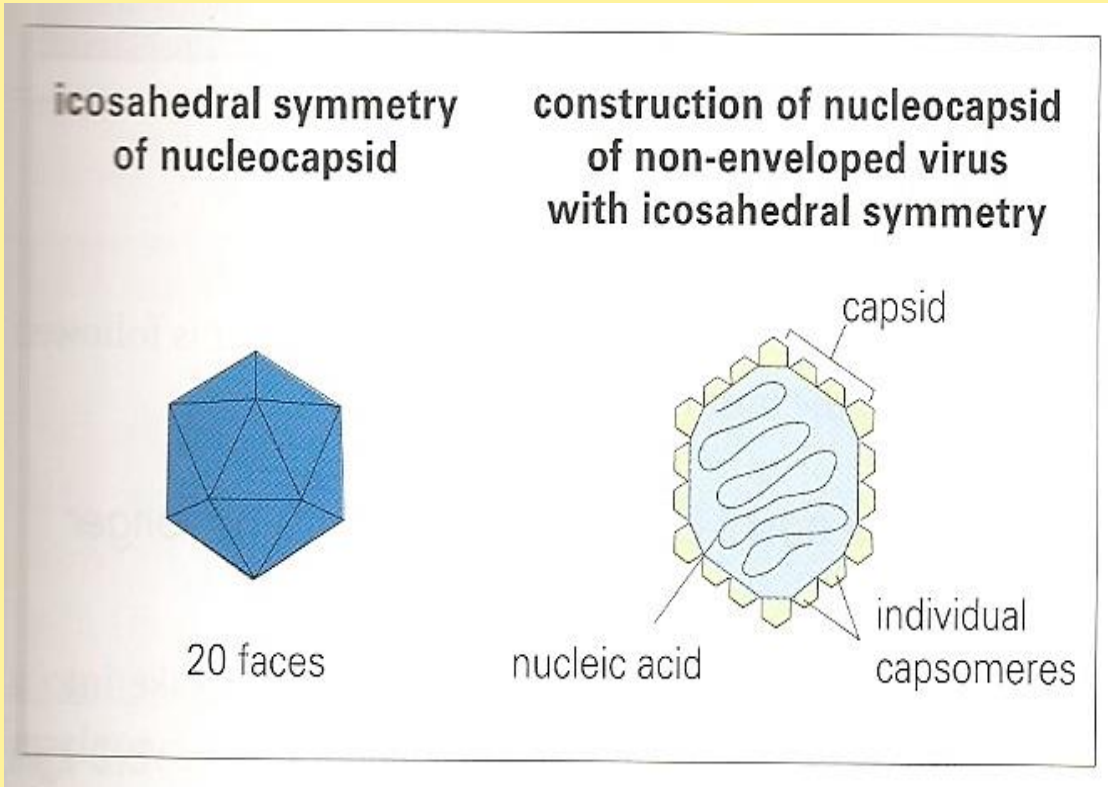


a) Non-enveloped viruses/ Naked Viruses = viruses whose capsids are not covered by an envelope

b) Sometimes, Capsid covered with envelope

- **SPIKES** = carbohydrate-protein complexes (glycoproteins) that project from the envelope
  - Can be used to attach to host cell

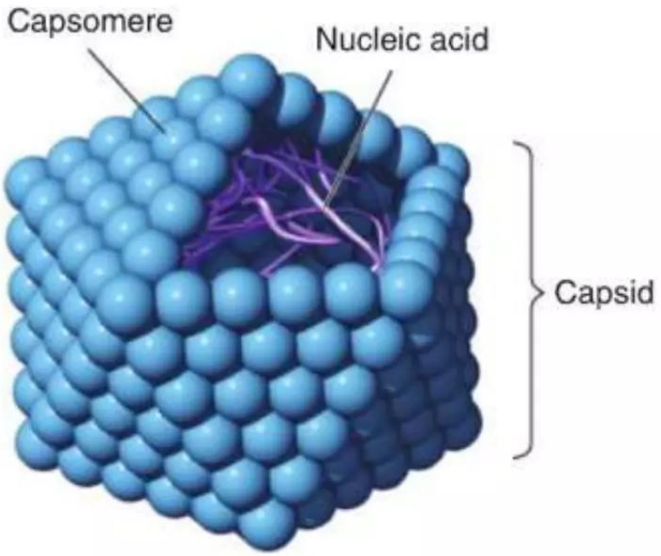
Structure of icosahedral unenveloped virus



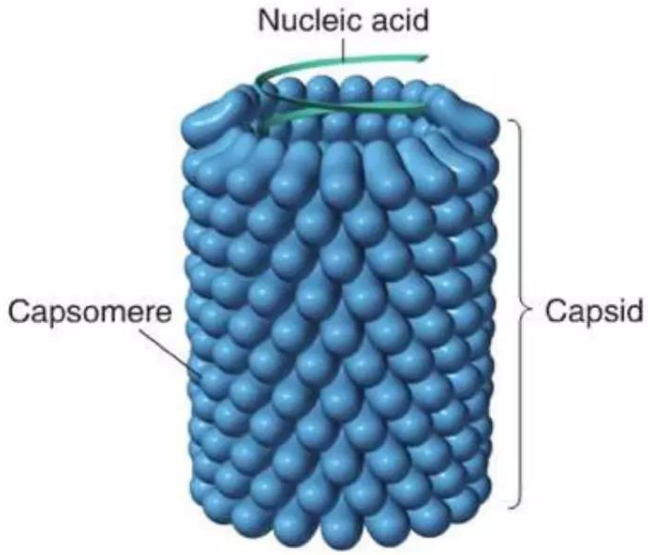
Viral Structure: General Morphology

Enveloped Viruses = can be helical or polyhedral, but the capsid is surrounded by an envelope

- Helical: influenza virus
- Polyhedral (icosahedral): Herpes simplex virus

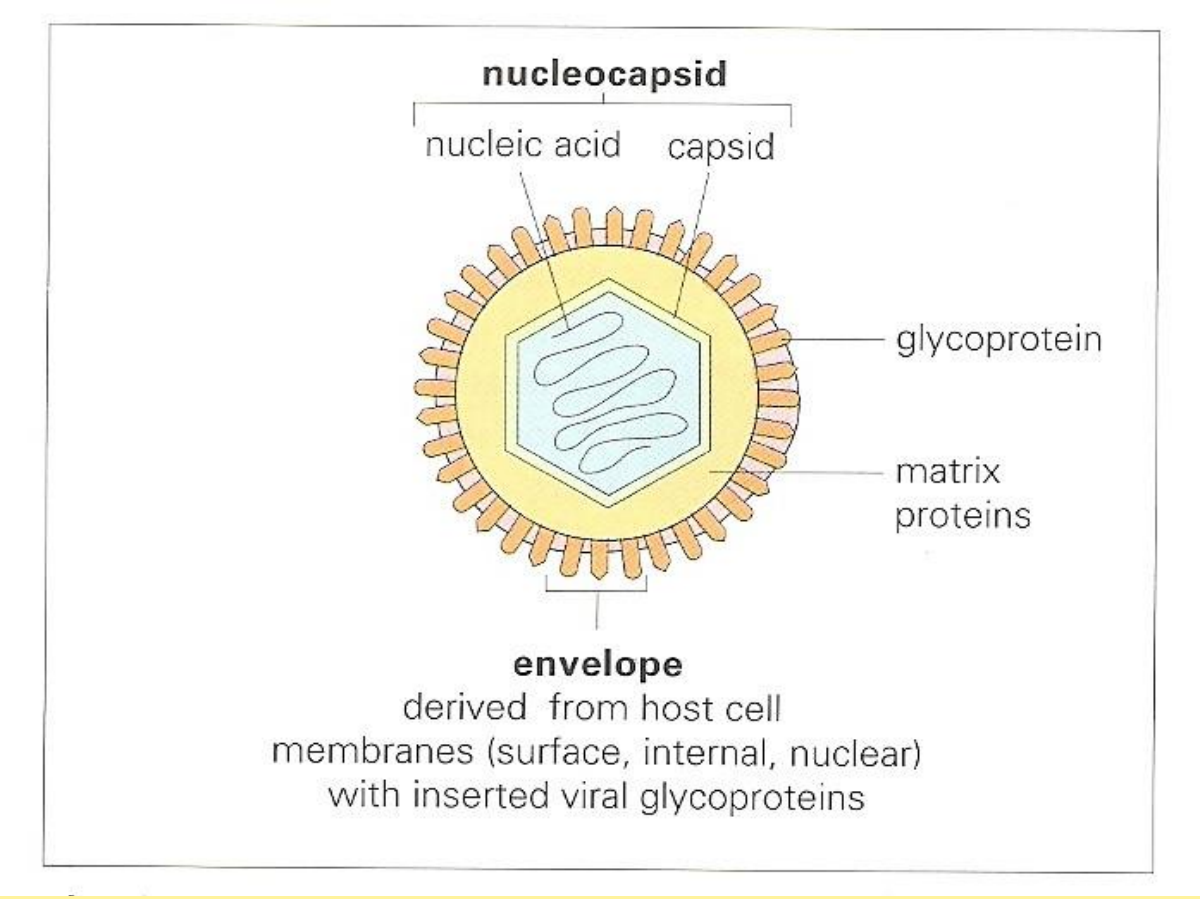


(a) A polyhedral virus



(a) A helical virus

Structure of icosahedral enveloped virus.



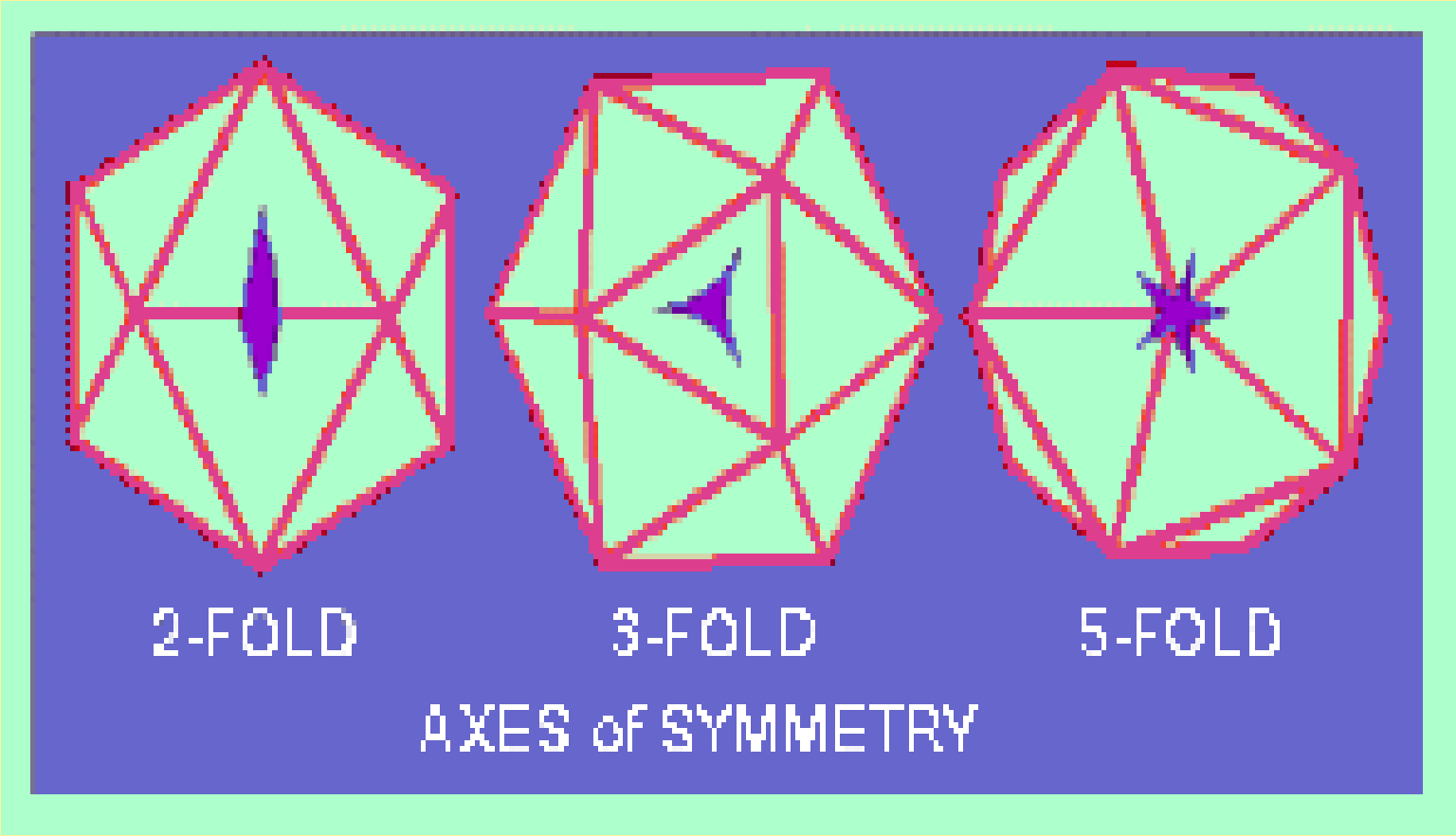
Symmetry of viruses

Viruses are divided into three groups, based on the morphology of the nucleocapsid and the arrangement of capsomeres.

- 1-Cubic symmetry:

The virus particle is icosahedral in shape (almost spherical particle) and the nucleic acid contained inside the capsid. The icosahedron particle is composed of 20 equilateral triangles , 12 vertices and has 2,3,5 rotational symmetry.

Cubic symmetry



Symmetry of viruses

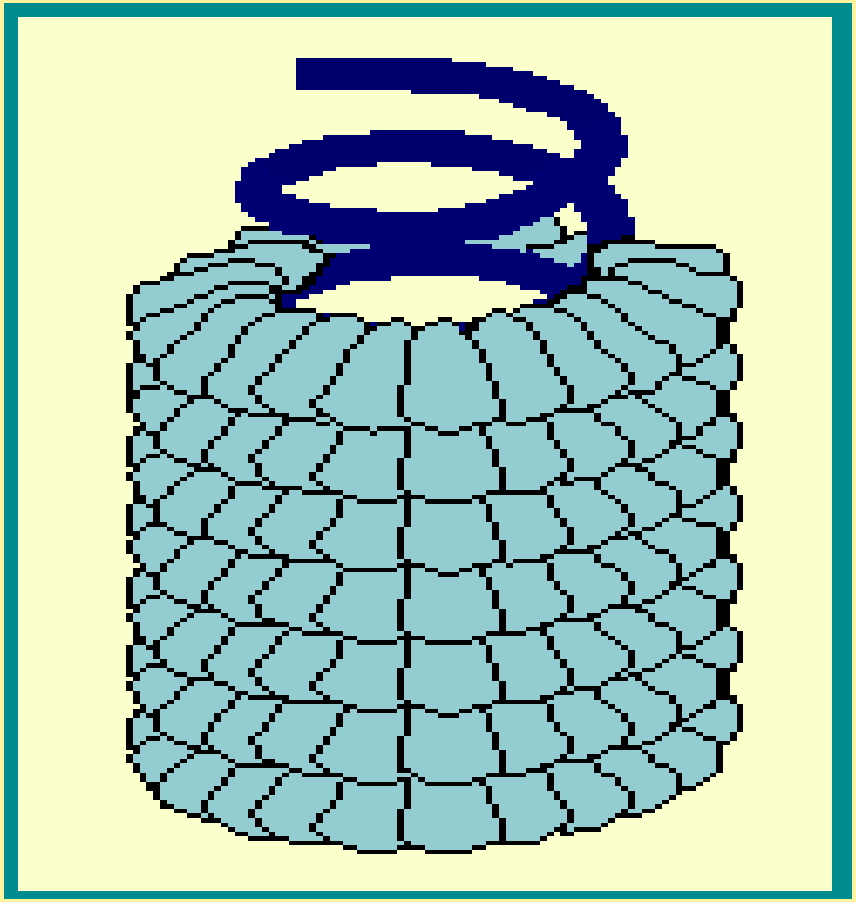
- 2- helical symmetry :

The virus particle is elongated or pleomorphic (not spherical), and the nucleic acid is spiral. Caposomeres are arranged round the nucleic acid.

- 3- complex symmetry:

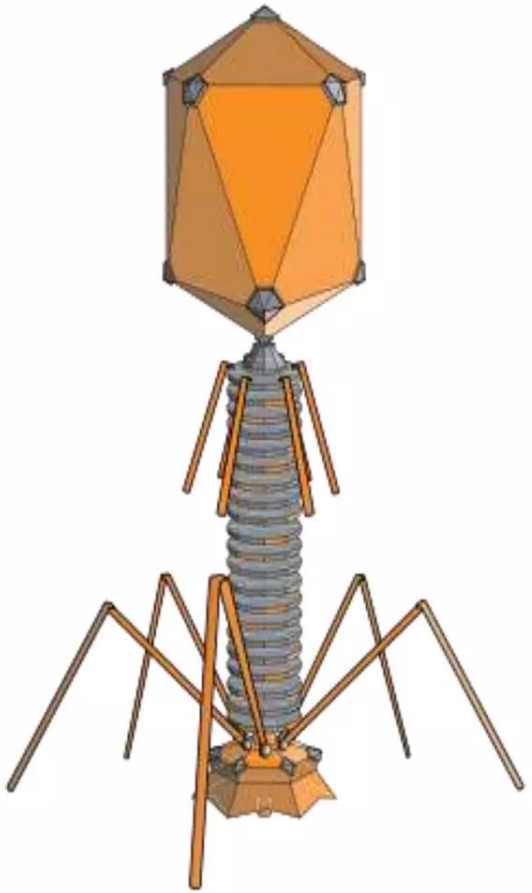
The virus particle does not confirm either cubic or helical symmetry.

Helical symmetry

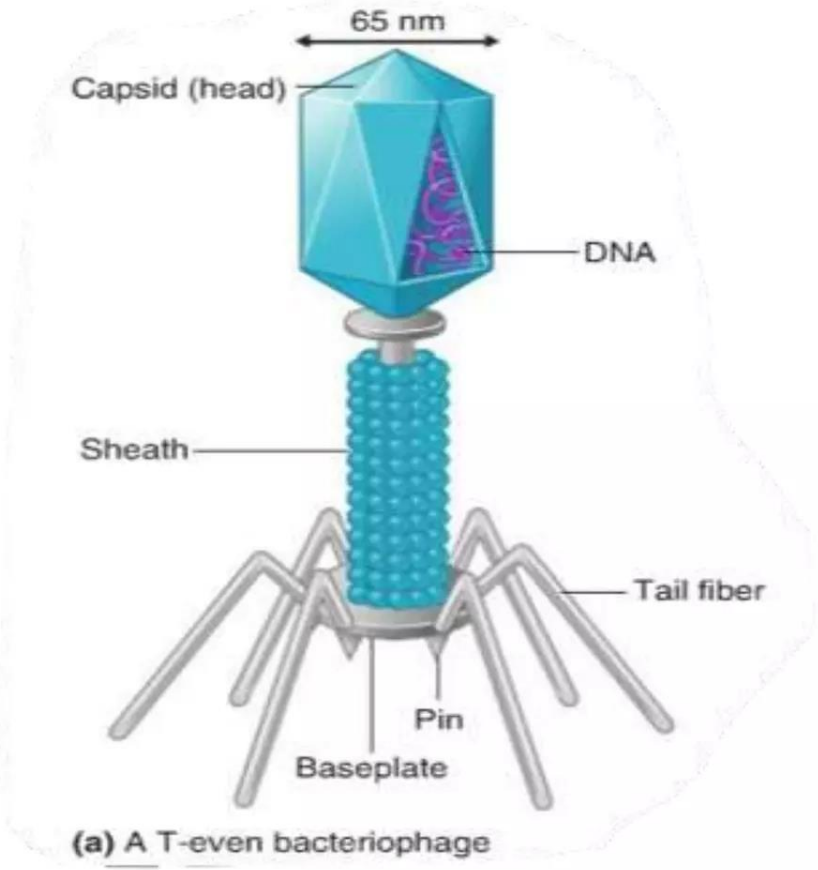


Complex viruses

- Complex structures; additional structures attached to capsids, combos of helical and polyhedral, may have several coats around nucleic acid
- Bacteriophage, poxviruses



- Capsid (head): polyhedral and the tail sheath is helical.
- **Head** - the nucleic acid.
- **Tail** : hollow tube through which the nucleic acid passes during infection
- T4 -largest phage.
- T4 tail - surrounded by a contractile sheath, which contracts during infection of the bacterium.
- End of the tail: **base plate** and one or more **tail fibers** attached to it.
- The base plate and tail fibers - **involved in the binding of the phage to the bacterial cell**.
- Not all phages have base plates and tail fibers.



BACTERIOPHAGE[4]

- Viruses that infect bacterial cells are called bacteriophages (phages for short), which means ‘bacteria eaters’
- These are large, complex viruses, with a characteristic head and tail structure
- The double-stranded, linear DNA genome contains over 100 genes, and is contained within the icosahedral head

Essential Microbiology, Stuart Hogg, The University of Glamorgan, UK

Classification of viruses on basis of genetic material

Viruses are divided into two large groups:

- RNA containing viruses.
- DNA containing viruses.

Baltimore classification

Viruses were divided into six groups based on the their nucleic acid and m-RNA production.

- 1- ds-DNA viruses.
- 2- ss-DNA viruses.
- 3- ds- RNA viruses.
- 4- ss-RNA viruses with positive strands(positive polarity).
- 5- ss-RNA viruses with negative strands(negative polarity).
- 6- ss-RNA viruses associated with the enzyme reverse transcriptase.

1- Double stranded DNA families of medical importance

- 1- Poxviridae.
- 2- Herpesviridae.
- 3- Hepadnaviridae.
- 4- Adenoviridae.
- 5- Papovaviridae.

2- Single stranded DNA families.
3- Double stranded RNA families.

- Single stranded DNA family:

1- Parvovoridae.

- Double stranded RNA family:

1- Reoviridae .

4- Single stranded RNA families with positive strands

- 1-Picornaviridae.
- 2- Caliciviridae.
- 3- Astroviridae.
- 4- Coronaviridae.
- 5- Flaviviradae.
- 6- Togaviridae.
- The viral genome acts directly as m-RNA.

5- Single stranded RNA families with negative strands

- 1- Orthomyxoviridae.
- 2- Paramyxoviridae.
- 3- Rhabdoviridae.
- 4- Filoviridae.

- The viral genome does not act as m-RNA.
- It must be transcribed by the viral enzyme transcriptase into m-RNA.
- Virions contain the enzyme transcriptase.

6-Single stranded RNA viruses associated with the enzyme reverse transcriptase

- Retroviruses.
- The viral genome is reverse transcribed into a complementary DNA strand using the enzyme reverse transcriptase.

Classification of major virus groups

DNA VIRUSES

1. Herpesvirus
2. Poxvirus
3. Adenovirus
4. Parvovirus
5. Papovavirus

RNA VIRUS

1. Orthomyxovirus
2. Paramyxovirus
3. Rhabdovirus
4. Tagovirus
5. Retrovirus
6. Reovirus
7. Picornavirus
8. Coronavirus

Shafer's textbook of oral pathology, 6th edition

THANK YOU