Properties of Animal Viruses

Animal Viruses

At one time or another, we have all most likely been infected with a virus. **The common cold and chicken pox** are two common ailments caused by animal viruses.

Animal viruses are intracellular obligate parasites, meaning that they rely on the host animal cell completely for reproduction.

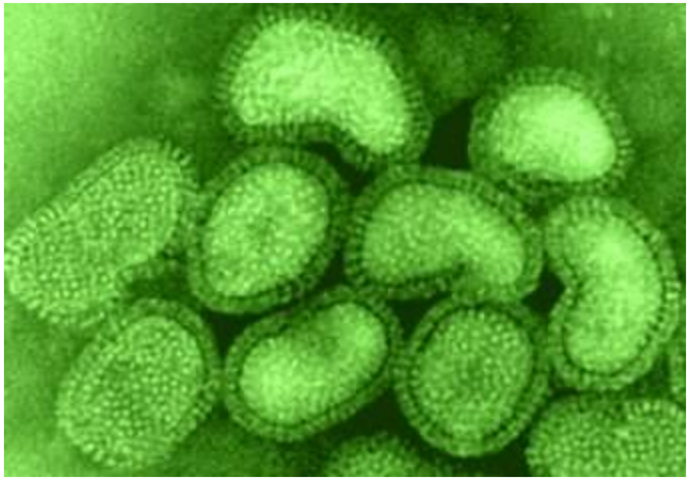
They use the host's cellular components to replicate, then leave the host cell to infect other cells.

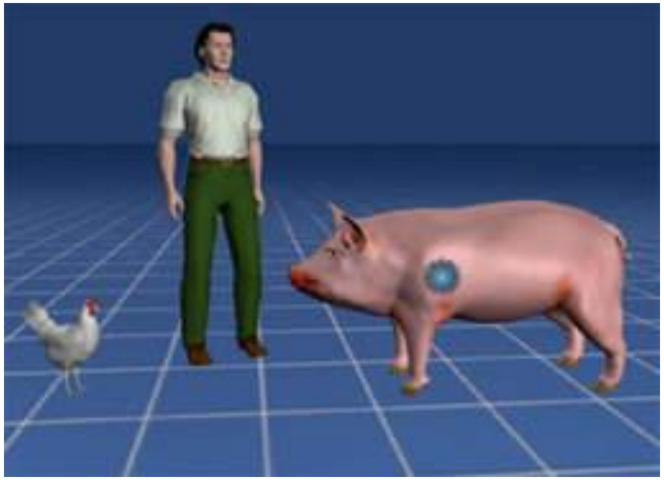
Viruses gain entry into host cells via several sites such as the **skin, gastrointestinal tract, and respiratory tract.**

Once an infection has occurred, the virus may replicate in host cells at the site of infection or they may also spread to other locations. Animal viruses typically spread throughout the body mainly by way of the bloodstream, but can also be spread via the nervous system.

Different viruses can infect all the organs and tissues of the body and the outcomes range **from mild or no symptoms**, to life-threatening diseases.

Humans cannot be infected by **plant or insect viruses**, but they are susceptible to infections with viruses **from other vertebrates**. These are called **viral zoonosis or zoonotic infections**. Examples include, **rabies, and yellow fever, NDV, AIV.**





The emergence of the **parvovirus in the 1970s** was the most significant in the history of infectious diseases.

The disease spread rapidly across the world, and thousands of dogs died from the infection.

The virus originated in cats, the vector of feline panleukopenia, but a mutation that changed just **two amino acids** in the viral capsid protein VP2 allowed it to cross the species barrier, and dogs, unlike cats, had no resistance to the disease.

Canine distemper virus is closely related to **measles virus** and is the most IMPORTANT viral disease of **dogs**.

The disease (which was first described in 1760, by **Edward Jenner**.

In the 1990s, thousands of African lions died from the infection, which they contracted from feral dogs.

The study of animal viruses is important from a veterinary viewpoint and many of these viruses causes diseases that are economically devastating. Many animal viruses are also important from a human medical perspective. The emergence of the **SARS (Severe Acute Respiratory Syndrome)** virus in the human population, coming from an animal source like (Syrian hamsters, several bat species, predominately horseshoe bats, racoon dogs harbored viruses highly similar to SARS-CoV) highlights the IMPORTANCE of animals in harbouring infectious agents; **avian influenza viruses** can directly infect humans.

The recent viral disease coming from the camel called (MERS) middle east respiratory syndrome in soudia Arabia.

In addition research into animal viruses has made an important contribution to our understanding of viruses in general, their replication, molecular biology, evolution and interaction with the host.

How Viruses Counter Your Immune System

Viruses have several methods to counter host immune system responses. Some viruses, like HIV, destroy white blood cells. Other viruses, such as influenza viruses, experience changes in their genes leading to **antigenic drift or antigenic shift**.

In antigenic drift, viral genes mutate altering virus surface proteins. This results in the development of a **new virus** strain that may **not be** recognized by **host antibodies**. Antibodies connect to specific virus antigens to identify them as 'invaders' that must be destroyed.

While **Antigenic drift** happens gradually over time, antigenetic shift occurs rapidly.

In Antigenetic shift, a new virus subtype is produced through the **combination of genes from different viral strains**. Antigenetic shifts are associated with **pandemics** as host populations have no immunity to the new viral strain.

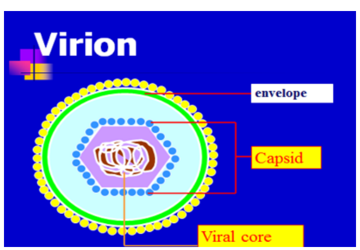
Like other viruses, animal viruses are tiny packages of protein and nucleic acid. **They have a protein shell**, or **capsid**, and **genetic material made of DNA or RNA** that's placed inside the capsid.
They may also feature an envelope, a sphere of membrane made of lipid .Animal virus capsids come in many shapes.

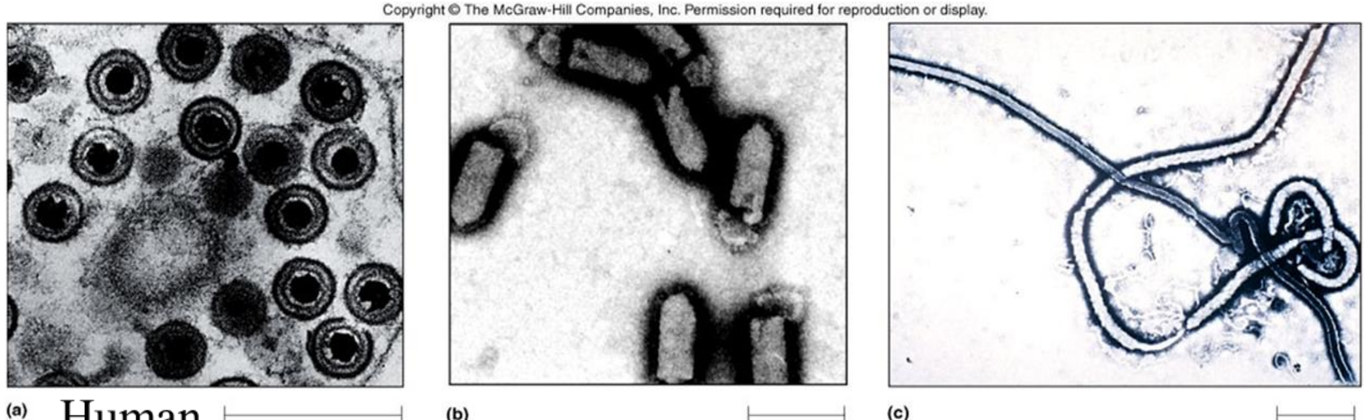
Animal viruses are associated with a variety of human diseases. Some of them follow the classic pattern of acute disease, where symptoms worsen for a SHORT period followed by the elimination of the virus from the body by the immune system with eventual recovery from the infection. **Examples of acute** viral diseases are the **common cold and influenza**. Other viruses cause long-term **chronic** infections, such as the virus causing **hepatitis C**, whereas others, like **herpes simplex virus**, cause only intermittent symptoms.

Structure and Classification of Animal Viruses:

-Structure

- **DNA or RNA genome**
- Double stranded (ds) or single stranded (ss)
- Surrounded by a capsid (protein coat)
- The nucleic acid and capsid are termed nucleocapsid
- Some viruses have an envelope
- The envelope is a phospholipid bilayer membrane that was obtained from the cell in which the virus arose
- Viruses are obligate intracellular parasites
- They occur in many shapes, some of which are distinctive





Human papillomavirus

Rhabdovirus

Ebola virus

All viruses contain the following two components :

1-Core of genetic material (nucleic acid)

2- **Protein coat or Capsid:** That covers the genome. **Core +capsid= nucleocapsid**

BUT some virus contain 3- Envelope

1- Nucleic acid genome:

(Viral Genomes): The core of the virion is made up of nucleic acids. The genome of a virus can be either DNA or RNA **never both together.** The genomes of viruses can be comprised of **single or double stranded** DNA or RNA.

They can vary greatly in size, from approximately 5-10 kb (Papovaviridae, Parvoviridae), to greater than 100-200 kb (Herpesviridae, Poxviridae). The virus have few thousand to 250,000 nucleotides, Bacteria have 4 million.

The genome of a virus can be either DNA or RNA

DNA: Double Stranded - linear or circular.

All DNA are linear except (Papova family) circular.

All DNA are double stranded except **One family DNA ss(single strand) (Parvoviridae).**

All DNA (Icosahedral or Cubic Symmetry) except Poxviridae (Complex symmetry).

All DNA can seen only by EM except Poxviridae can see by normal microscope.

All DNA replicated in nucleus except Poxviridae replicated in the cytoplasm.

DNA

Either ⟹ **Double stranded**

Or ⟹ **Single stranded**

Either ⟹ **Linear**

Or ⟹ **Circular**

DNA don't have segment.

Purine Bases	**Pyrimidine Bases**
Adenine=A	**Thymine=T**
Guanine=G	**Cytosine=C**

While uracil from pyrimidine bases is not included

A=T

G=C

RNA: **Single Stranded** - linear: and **one family RNA double strand liner(Reoviridae).**

These single stranded genomes can be either(+)sense,(-) sense. The sense strand is the one that can serve directly as mRNA and code for protein, so for these viruses, the viral RNA is infectious.

The viral mRNA from(-)strand viruses is not infectious, since it needs to be copied or converted into the(+) strand before it can be translated.

The genome of **some** RNA viruses is ss: segmented or non-segmented , meaning that a virus particle contains several different molecules of RNA, like different chromosomes.

All RNA virus (**Helical Symmetry).**

Double-stranded RNA viruses (Double-stranded RNA viruses(Rotavirus is the most common cause of diarrheal disease among infants and young children. It is a genus of double-stranded RNA viruses in the family ***Reoviridae****)*.

RNA

Either → Single stranded

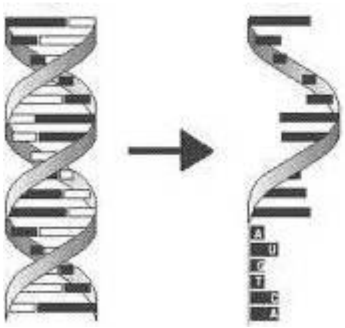
Or → Double stranded

Either → Linear

Or → Circular

Either → One piece

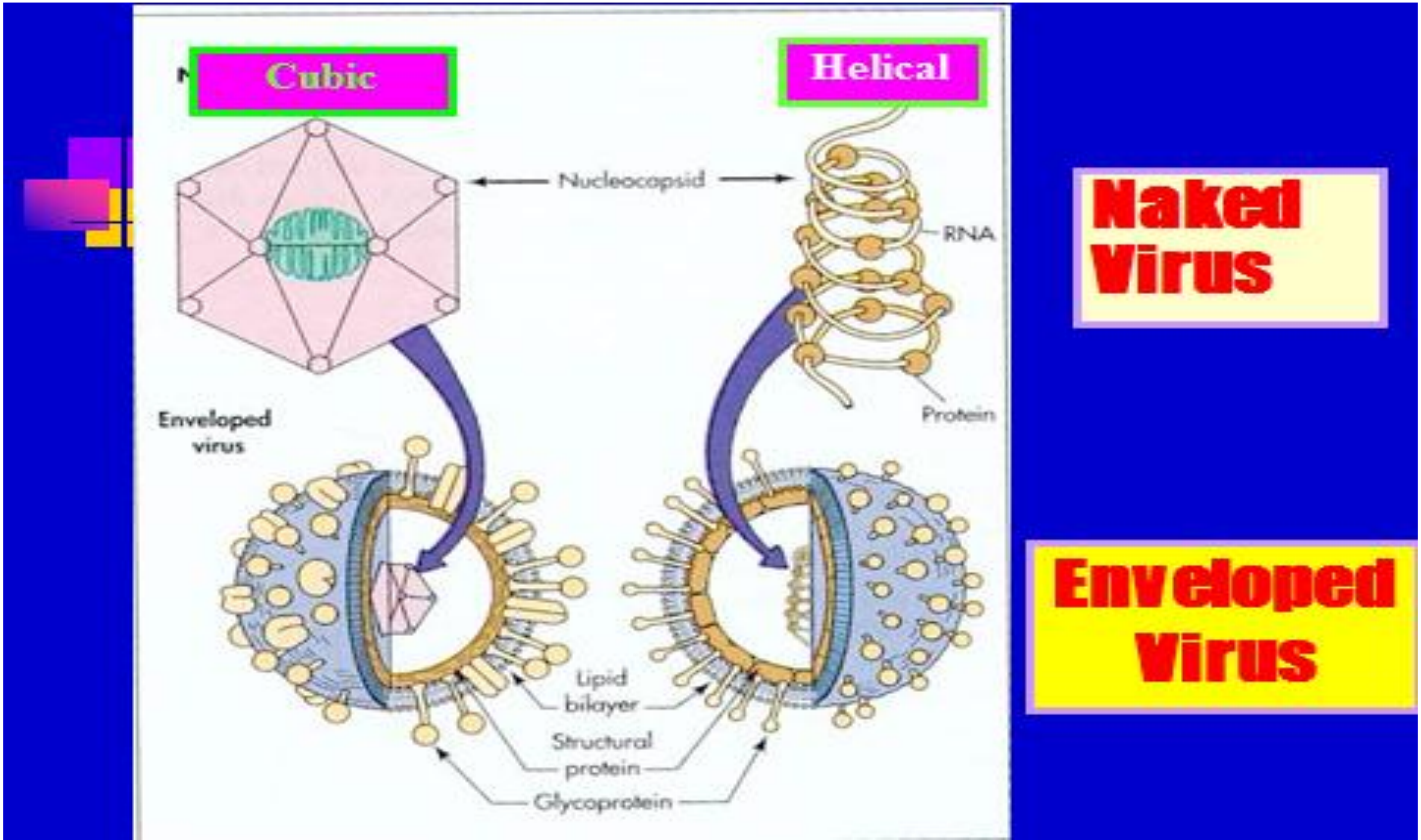
Or → Segmented



Virion structure

Nucleocapsid (**Naked Virus**) = DNA or RNA +Structural proteins +Enzymes &Nucleic acid binding proteins.

Enveloped Virus =Nucleocapsid+ Viral specific glycoproteins and **Host Membrane?**



2-Capsid

Viral genomes are surrounded by protein shells known as capsid. Capsid is the storage site for genome; a capsid is made up of protein and almost always made up of repeating structural subunits that are arranged in one of two symmetrical structures, a **helix** or **icosahedrons**. Also there are other additional symmetry (Complex and Binal Symmetry).

The function of the capsid

1- To protect viral nucleic acid.
2- Interact specifically with the viral nucleic acid for packaging.
3- Interact with vector for specific transmission.
4- Interact with host receptors for entry to cell.
5- Allow for release of nucleic acid upon entry into new cell and assist in processes of viral and/or host gene regulation.
6-Composed of a large number of subunits capsomers.

3-Viral Envelope

In some animal viruses, the nucleocapsid is surrounded by a membrane, also called an envelope.

This envelope is a membrane composed of lipid, proteins and glycoproteins. All **enveloped virus** acquire envelopes from **plasma membrane of infected cells**. Exception is: Herpesviruses, which acquire envelopes **from nuclear membranes** because it replicate in side the nucleus.

These viral proteins serve many purposes, such as **binding to receptors on the host cell**, **playing a role in membrane fusion and cell entry**. They can also form **channels in the viral membrane**.

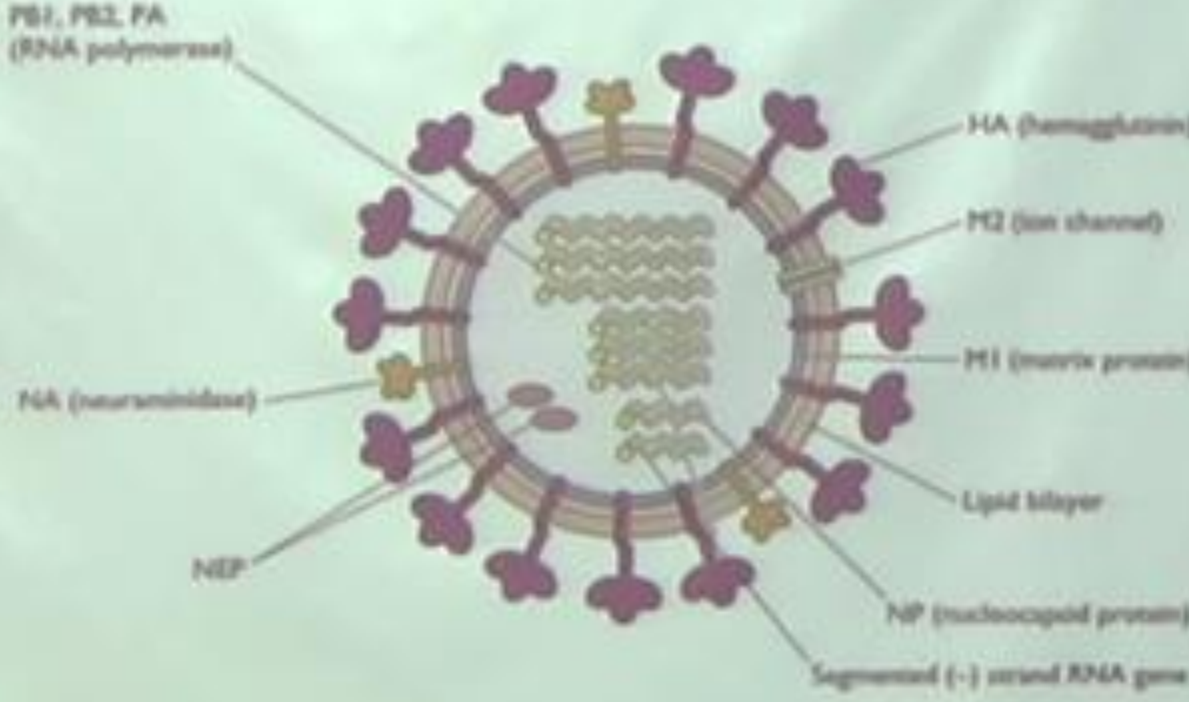
Enveloped viruses are readily infectious only if the envelope is intact (since the viral attachment proteins which recognize the host cell receptors are in the viral envelope).

• This means that agents that damage the envelope, such as alcohols and detergents, reduce infectivity.

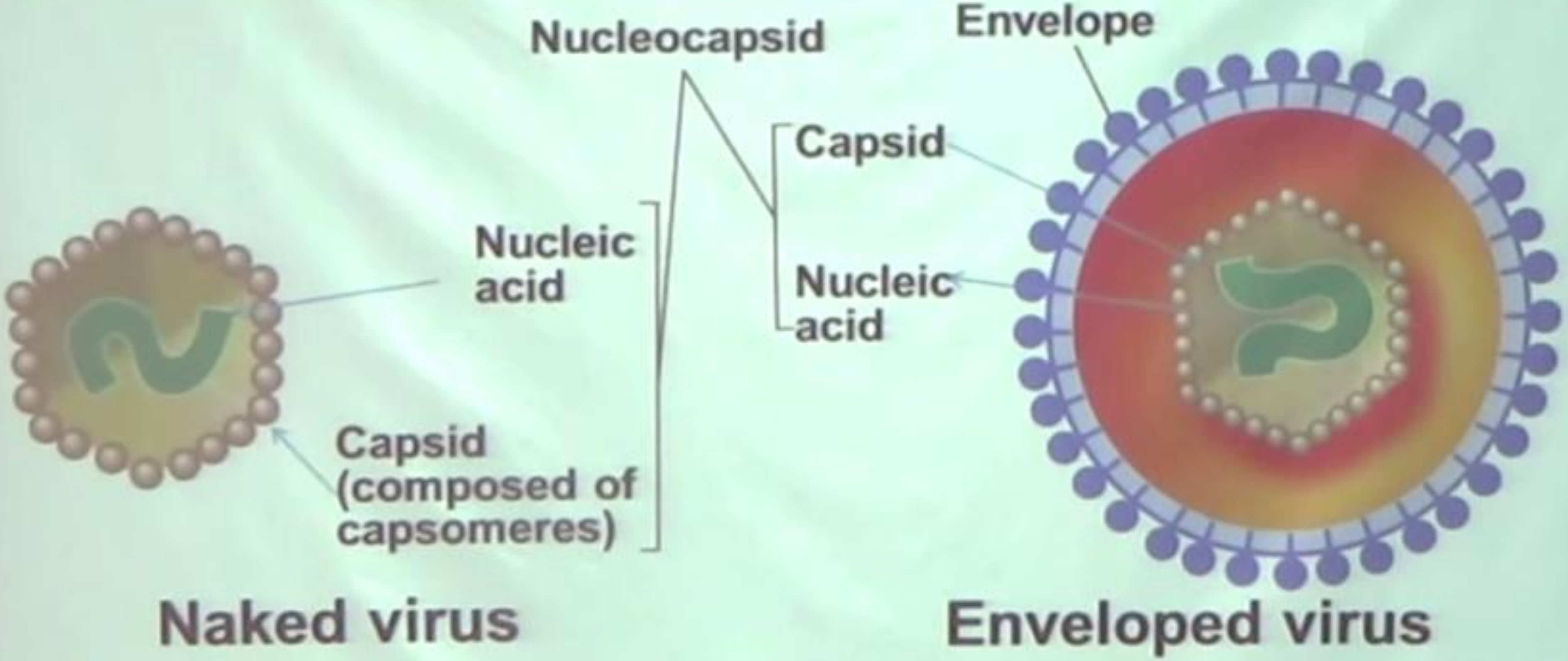
Functions of envelope

- ***Antigenicity:*** *Some viruses possess neuraminidase and hemagglutinin*
- ***Infectivity:*** *Attachment, fussion, elution of the viruses*

Influenza virus:
HA: attachment,
NA: elution,
gp40: fussion



Comparison of naked and enveloped virus particles.



Enveloped

- California Encephalitis Virus
- Coronavirus
- Cytomegalovirus (CMV)
- Eastern Equine Encephalitis Virus (EEEV)
- Epstein-Barr Virus (EBV)
- Hantavirus
- Hepatitis B Virus (HBV)
- Hepatitis C Virus (HCV)
- Hepatitis Delta Virus (HDV)
- Herpes Simplex Virus 1 (HHV1)
- Rotavirus
- Rubella Virus
- Saint Louis Encephalitis Virus
- Smallpox Virus (Variola)
- Vaccinia Virus
- Herpes Simplex Virus 2 (HHV2)
- Human Immunodeficiency Virus (HIV)
- Human T-lymphotrophic Virus (HTLV)
- Influenza Virus (Flu Virus)
- Molluscum contagiosum
- Papilloma Virus (HPV)
- Polio virus
- Rhinovirus
- Varicella-Zoster Virus (HHV3)
- Venezuelan Equine Encephal. Vir. (VEEV)
- Western Equine Encephalitis Virus (WEEV)
- Yellow Fever Virus

Envelope

- ❑ A lipid-containing membrane that surrounds some viral particles.
- ❑ It is acquired during viral maturation by a budding process through a cellular membrane, Viruses-encoded glycoproteins are exposed on the surface of the envelope.
- ❑ Not all viruses have the envelope, and viruses can be divided into 2 kinds: enveloped virus and naked virus.
- ❑ **Functions of envelope**

1-Antigenicity

2-some viruses possess neuraminidase

2- Infectivity

3-Resistance

Properties of enveloped viruses

- Labile in dry environment
- Damaged by drying, acid, detergent, and heat
- Pick up new cell membrane during multiplication
- Insert new virus-specific proteins after assembly
- Virus is released by budding

Naked viruses(**Non Enveloped**)

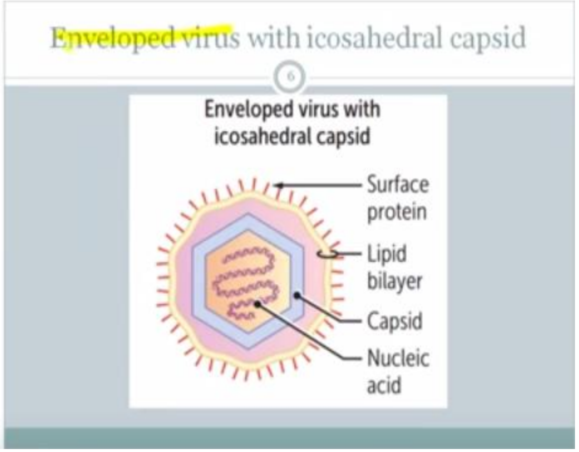
* Adeno-associated Virus (AAV)
  Adenovirus
  B19
  Coxsackievirus - A
  Coxsackievirus - B
  Echovirus
  Hepatitis A Virus (HAV)
  Hepatitis E Virus (HEV)
  Norwalk Virus

Properties of naked viruses

* Stable in hostile environment
* Not damaged by drying, acid, detergent, and heat
* Released by lysis of host cells
* Can infect the gastrointestinal tract and survive the acid and bile
* Can spread easily via hands, dust, fomites, etc

Virtually all virus that are transmitted by feco-oral rout do not have an envelope because enveloped virus are destruction by gastric acid in the stomach.

Some envelop virus have icosahedral capsid, and have a membrane and on the surface membrane the virus have some surface proteins which responsible for host specificity, organ specificity, serotypes and this membrane composed of lipid bilayer, in side the membrane there is a capsid and nucleic acid,

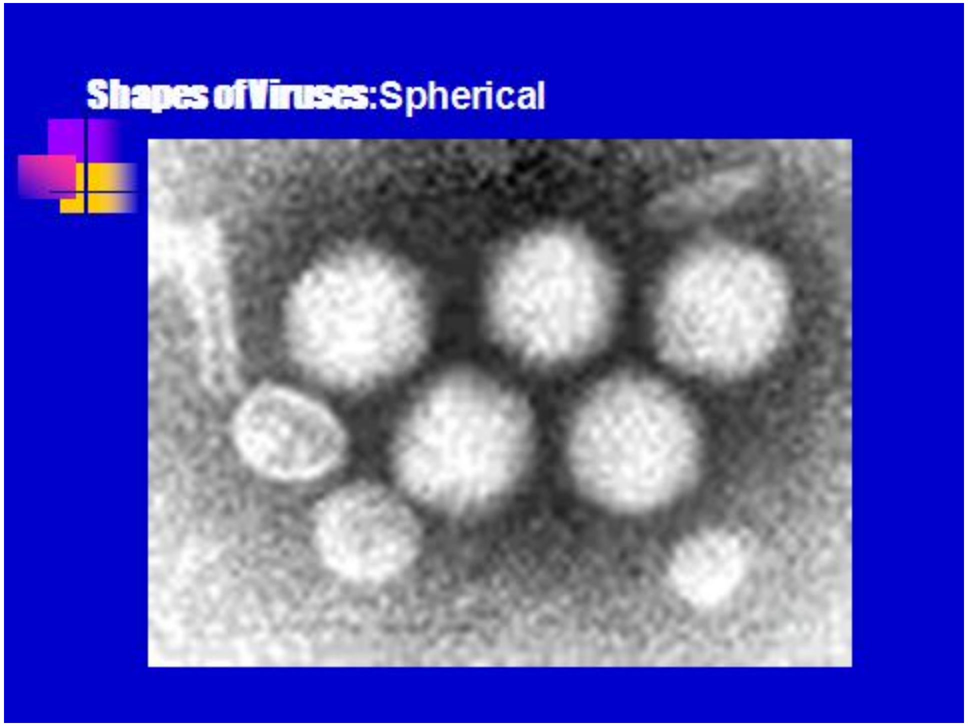


Properties of enveloped viruses

* Damaged by drying, acid, detergent, and heat
* Pick up new cell membrane during multiplication
* Insert new virus-specific proteins after assembly
* Virus is **released by budding**

Shape of Viruses

- Spherical
- Rod-shaped
- Brick-shaped
- Tadpole-shaped
- Bullet-shaped
- Filament



The arrange and the number of capsomer usd for classification of the viruses. The number of capsomers can be calculated by the following formula

$M=10\ (N-1)^2+2$

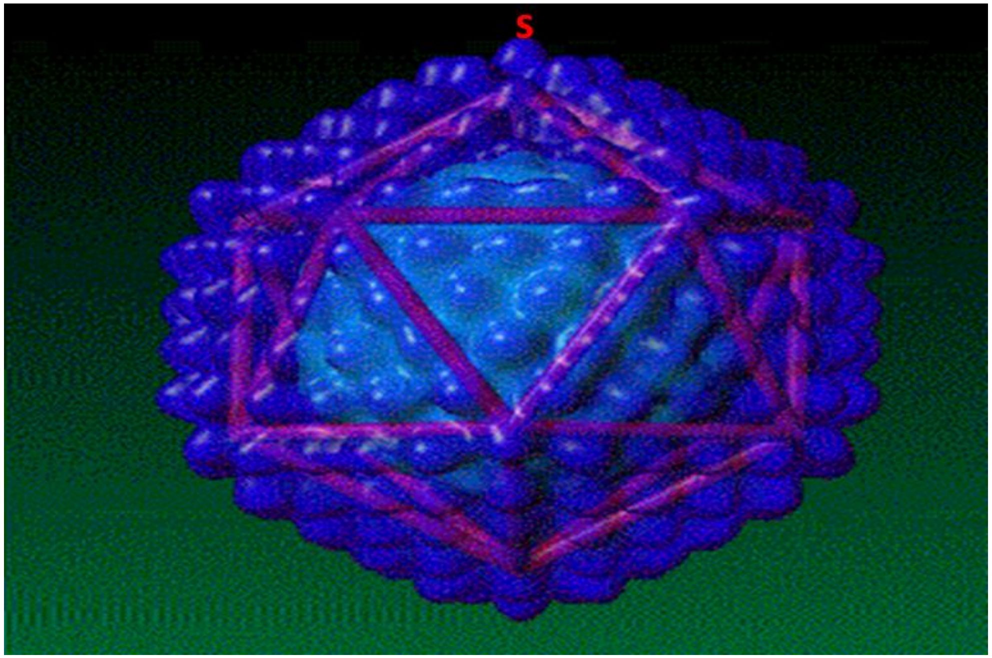
If $N=6$

$M=10(N-1)^2+2$

$M=10(6-1)^2+2$ $M=252$ This is for Adenovirus

M/ number of capsomer, N /number of capsomer in the edges.

Adenoviru
s



CHEMICAL COMPOSITION OF VIRUSES

- Viral Protein
- Viral Nucleic Acid
- Viral Lipids
- Viral carbohydrate
- Viral antigen

❑ Viral protein

The functions included;

1-The major purpose is to facilitated transfer of the viral nucleic acid from one host cell to another.

2-They serve to protect the viral genome against inactivation by nucleases.

3-Participate in the attachment of the virus particle to a susceptible cell.

4-Provide the structural symmetry of the virus particle.

5- The protein determine the antigenic characteristics of the virus.

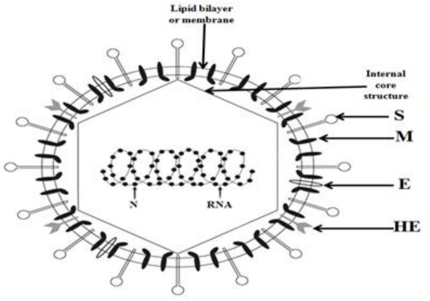
6-Some surface proteins may also exhibit specific activities, eg. **Influenza virus hemagglutinin agglutinates red blood cells.**

7- Some viruses carry enzymes (which are proteins) inside the virions that essential for initiation of viral replicative cycle when the virion enters a host cell, examples include an **RNA polymerase** carried by viruses with **negative-sense** RNA genome (eg, orthomyxovirus)that is need to cope the first mRNA.

Also **Reverse Transcriptase**, an enzyme in **retroviruses** that makes a DNA copy of the viral RNA, an essential step in replication and transformation.

Viral Proteins can be divided into:

A-structural proteins: Are part of the virus provide a protective coat to viral N.C such protein included the followings. A-capsomers, B-nucleoproteins, C-receptor proteins , D-glycoproteins of spikes, E-Matrix protein



B-Non-structural proteins

In virology, a **nonstructural protein** is a protein encoded by a virus but it is **not part** of the viral particle. The functions of most of these non-structural proteins are widely unknown.

The nonstructural proteins associated with virions genome are mainly enzymes, most of which are involved in nucleic acid transcription, regulation, processing or replication. These are:

***Transcriptases**

***Revers transcriptases**

***Ligases**

Nucleocapsid

The core of a virus particle consisting of the genome plus a complex of proteins.

- ***Complex of proteins*** = Structural proteins +Non- Structural proteins (Enzymes &Nucleic acid binding proteins)

DNA or RNA + Structural proteins ± Enzymes and nucleic acid binding proteins = Nucleocapsid = Naked capsid virus

Nucleocapsid + Glycoproteins and membrane = Enveloped virus

Some other proteins included the followings:

1-Cell shutdown proteins which are produced by cytopathic RNA viruses(CPE).

They prevent translation of host cell messenger RNA at the ribosomes so that viral protein may be synthesized instead.

2-DNA binding proteins

They are produced by most DNA viruses early in replication.

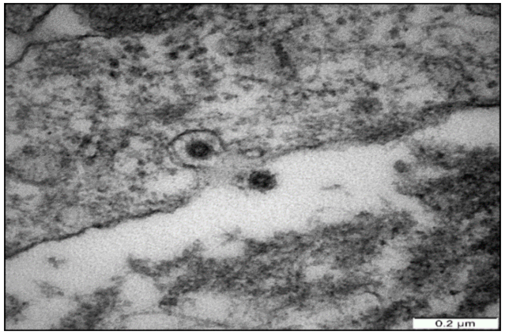
They activated host cell DNA synthesis and thereby provide extra host catalytic enzymes for use in viral replication.

❑ Viral Lipid envelopes

A number of different viruses contain lipid envelopes as part of their structure. Many viruses (e.g. influenza and many animal viruses) have **viral envelopes** covering their protective protein capsids.

The envelopes typically are derived from **portions of the host cell membrane** (phospholipids and proteins), but include some viral glycoproteins.

Functionally, viral envelopes are used to **help viruses enter host cells**. **Glycoproteins on the surface of the envelope serve to identify and bind to receptor sites on the host's membrane**. **The viral envelope then fuses with the host's membrane, allowing the capsid and viral genome to enter and infect the host**.



❑ Viral Carbohydrates

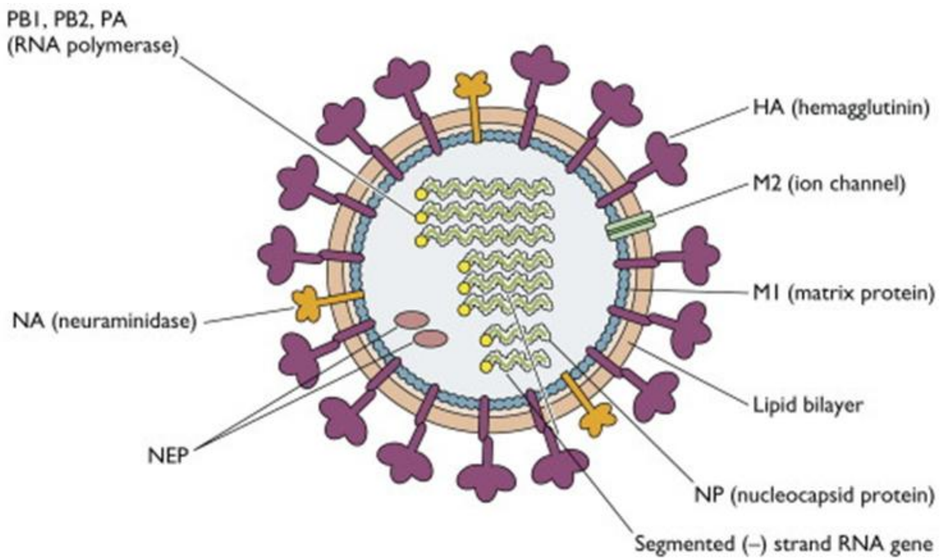
Viral envelopes contain glycoproteins. In contrast to the lipids in viral membranes, which are derived from the host cell, the envelope glycoproteins are virus-encoded.

Most of them are Oligosaccharides or glycolipids or mucopolysaccharides. These carbohydrates are originated from host cells, so that cannot be considered as structural content. Their types depend mainly on the type of host cell.

❑ Viral Antigens

Viruses may contain 4-100 structural proteins. **Every member of a particular virus species will have the same number of different proteins.**

Each protein is different in molecular weight and function. For instance, influenza virus particles always are composed of several hundred **hemagglutinins, neuraminidases**, **capsids, matrix and polymerase molecules.**



Each viral protein usually has 1-4 different epitopes. Some of these are readily detected by serology.

Viral antigens are usually subdivided into two groups:

1-GROUP SPECIFIC ANTIGENS: Group specific antigens which are shared by several members of a virus genus.

We have **certain antigenic structure** of viruses can help as to put them in one group. Ex, all pox virus has a common Ag which can differentiated them from other viruses like herpes virus. The virus within each family have a common Ag.

2-Species specific and strain specific Ag

The serotyping of viruses is performed by a range of tests of which neutralization is the most traditional and most likely to reveal differences. There are certain epitopes can differentiated between the viruses of the some family, e.g, In pox viruses family we have sheep pox, fowel pox and we have contagious ectyma and so on.

Viral Symmetry

Is the arrangement of the capsomers to give the final morphology of the viruses.

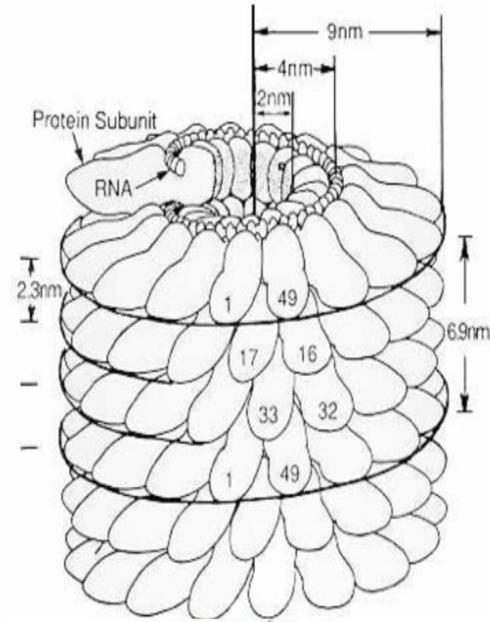
Types of Viral Symmetry:

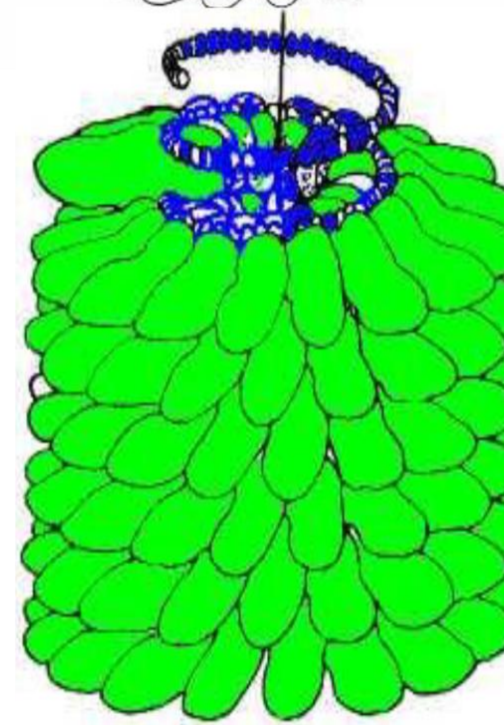
Viral architecture can be grouped into four types based on the arrangement of morphologic subunits.

1- Helical symmetry:

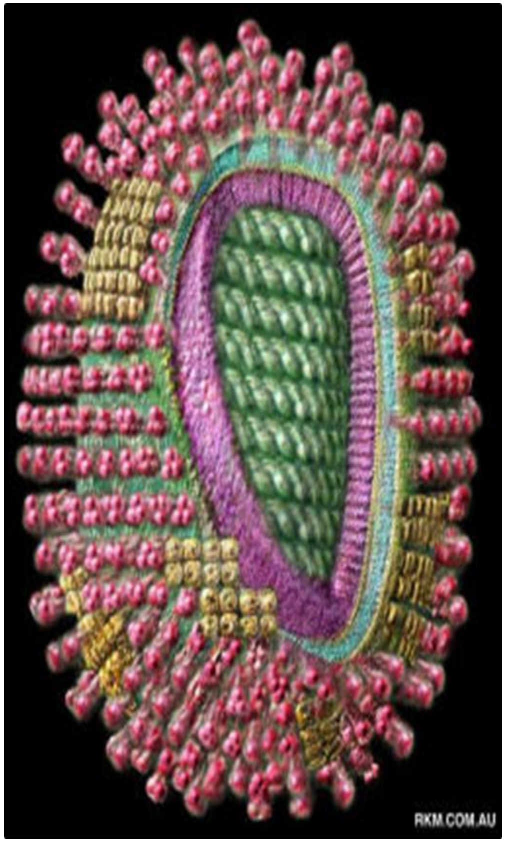
In case of helical symmetry, it has helix protein subunits are bound in a periodic way to the viral nucleic acid, winding. The filamentous viral nucleic acid-protein complex(nucleocapsid) is then coiled inside a lipid containing envelope. In all such animal viruses the helical nucleocapsid is wound into a secondary coil and enclosed within a lipoprotein envelope. The best studied virus with helical symmetry is **the non-enveloped plant virus**, **tobacco mosaic virus**, which contains a SS RNA genome. This protein is arranged in a helix around the viral RNA, In tobacco mosaic virus, a single polypeptide forms a capsomer and 2130 capsomers assemble in ahelix.

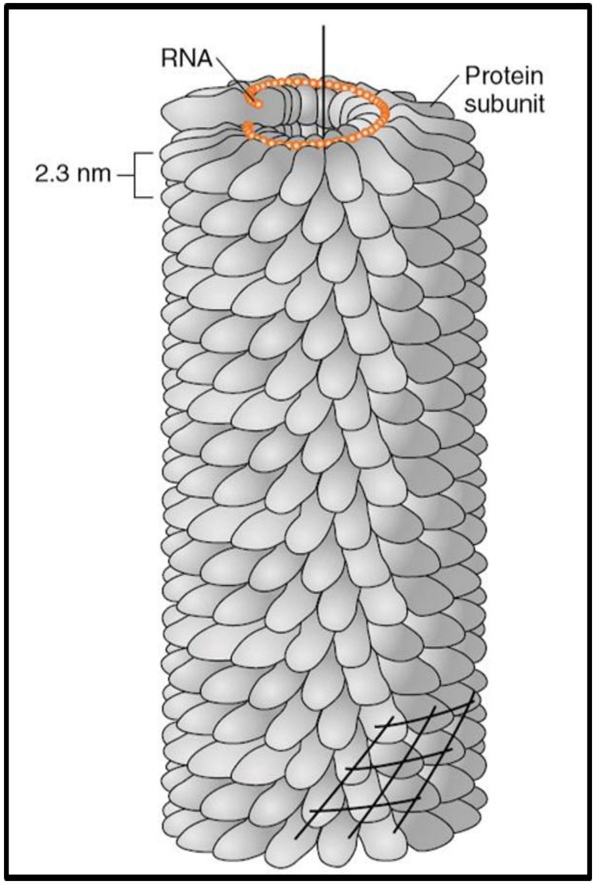
In enveloped, helically symmetrical viruses (e.g. influenza virus, rabies virus, parainfluenza virus, mumps virus, measles virus), the capsid is more flexible (and longer) and appears in negative stains rather like a telephone cord.





The helical nucleocapsid





Influenza Virion

Tobacco Mosaic Virus

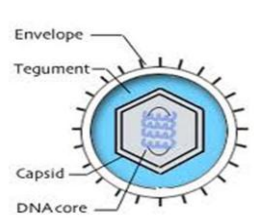
2-Icosahedral or Cubic Symmetry: Icosahedral morphology is characteristic of the nucleocapsids of many **"spherical"** viruses

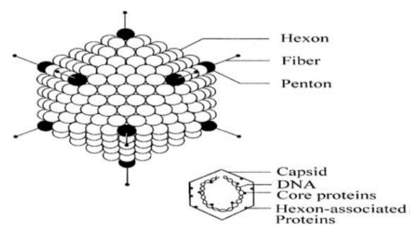
A body with cubic symmetry possesses a number of axes about which it maybe rotated to give a number of identical appearances.

In these structures, the subunits are arranged in the form of a hollow, spherical structure, with amount of nucleic acid that can be packaged by the particles.

An icosahedron is defined as being made up **of 12 vertices (corners), 30 edges and 20 faces, each an equilateral triangle.** It has axes of two, three and fivefold rotational symmetry passing through its edges, faces and vertices respectively.

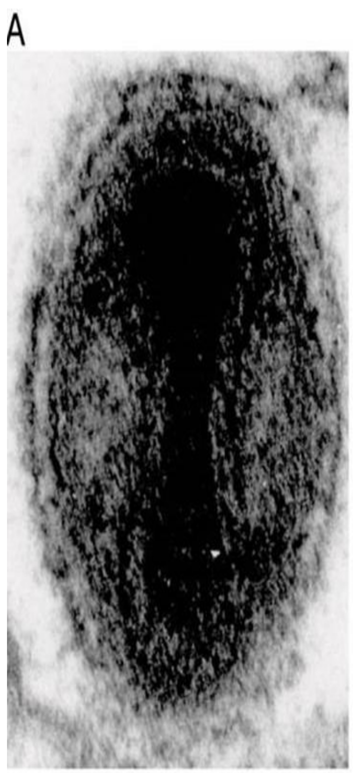
The icosahedral symmetry virus including **envelope virus** such as (Herpesvirus and togavirus, yellow fever virus, rubella virus), whereas the **non-envelope**(naked) virus included (poliovirus, adenovirus, hepatitis A virus.

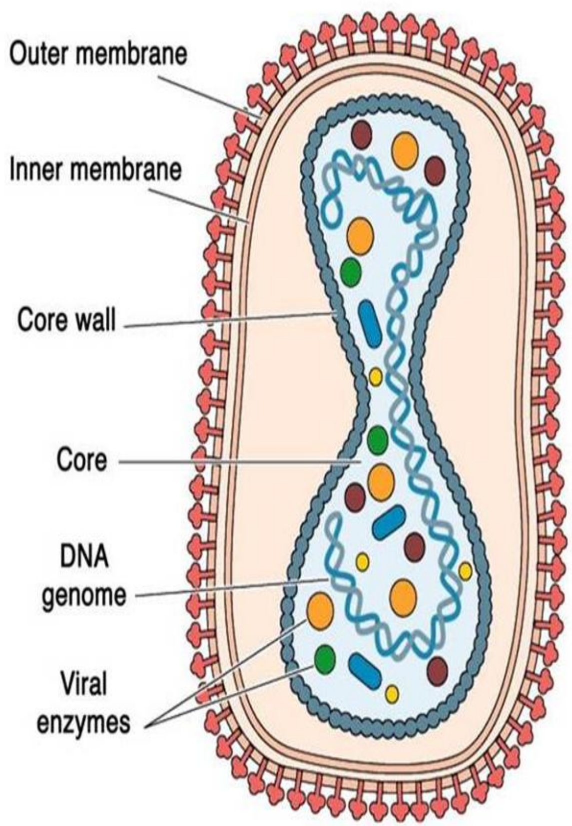




3- Complex Symmetry:

Some large viruses like **poxviruses** have a multilayer complex structure, details of which have not been clarified and capsomers have not yet identified like (Pox virus) have a complex symmetry, it means not helical and not Icosahedral and have shape look like a brick.





4-Binary Symmetry:

Some viruses like Bacteriophages have both cubical and complex or helical symmetry.

They have a complex structure consisting of icosaheadral head carry the genetic material, bound to helical tail. The genetic material can be ssRNA, dsDNA, or dsDNA along with either circular or liner arrangement.

Bacteriophage Structure

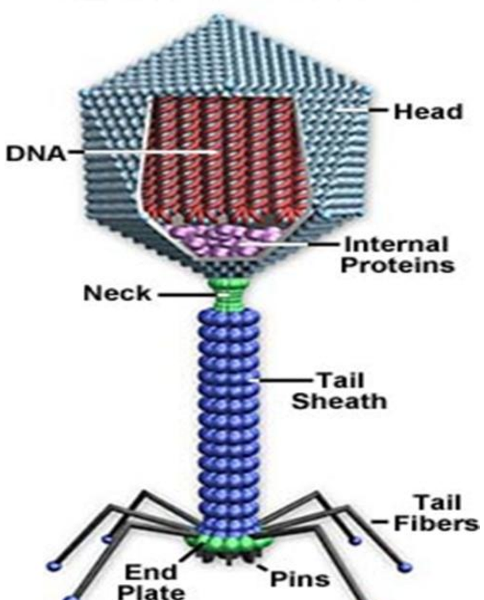


Figure 1