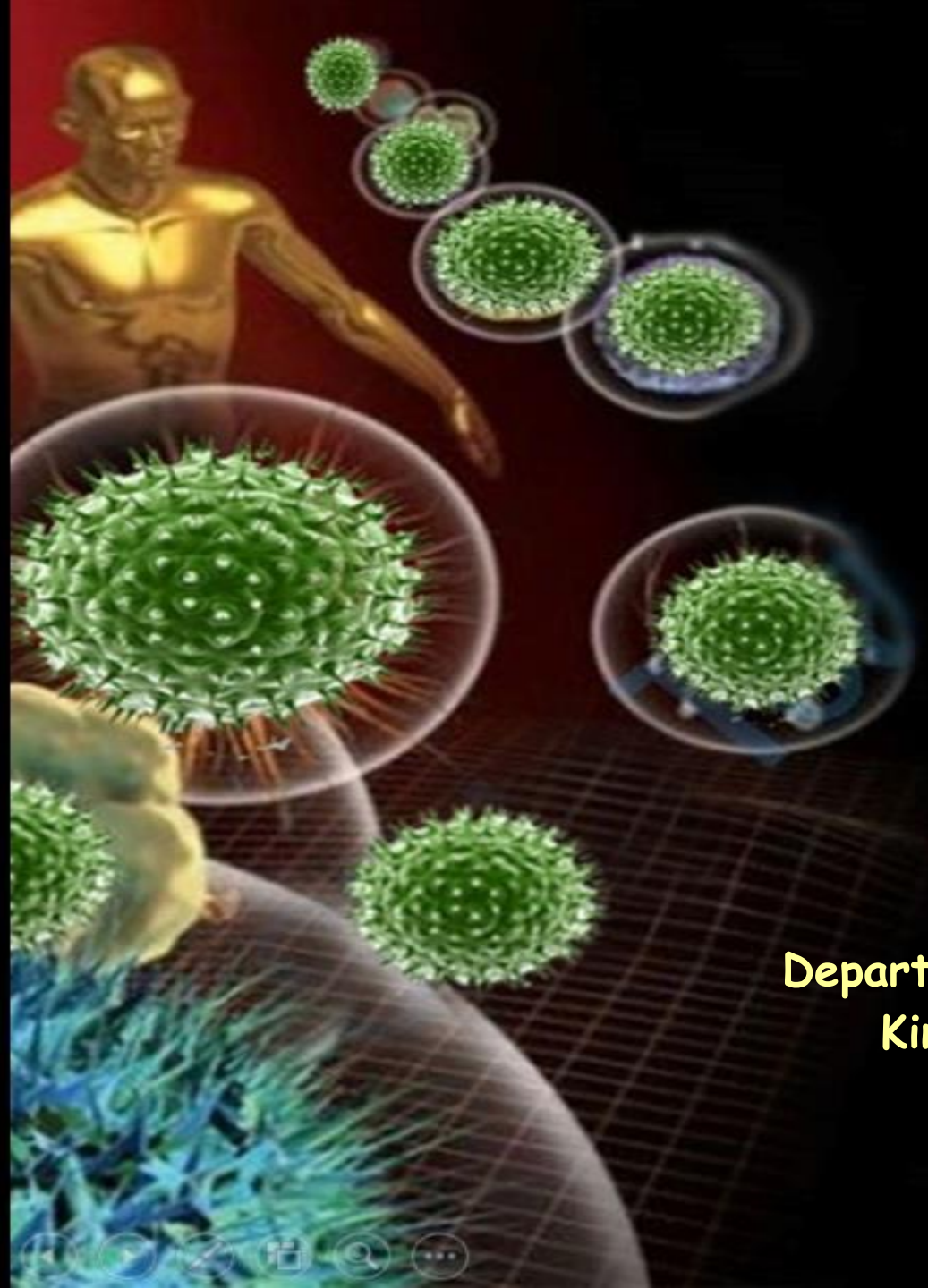

Lecture Two

Virus Properties

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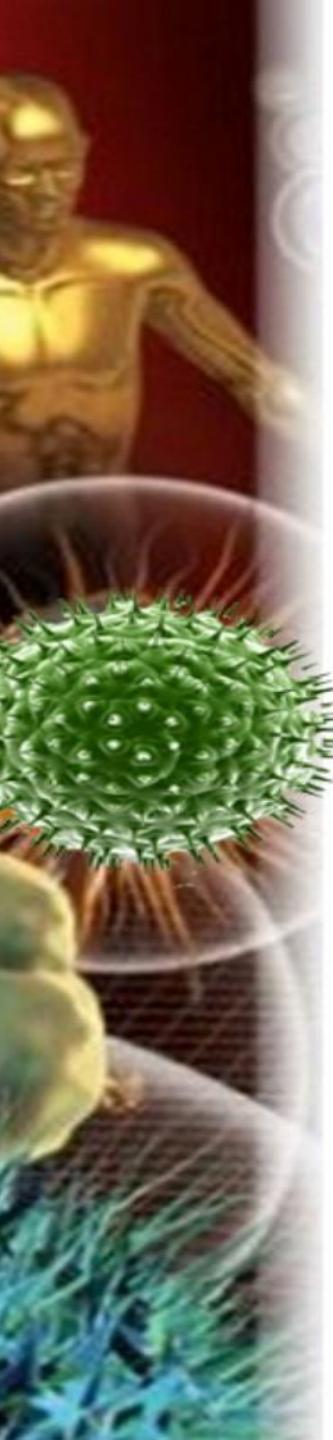
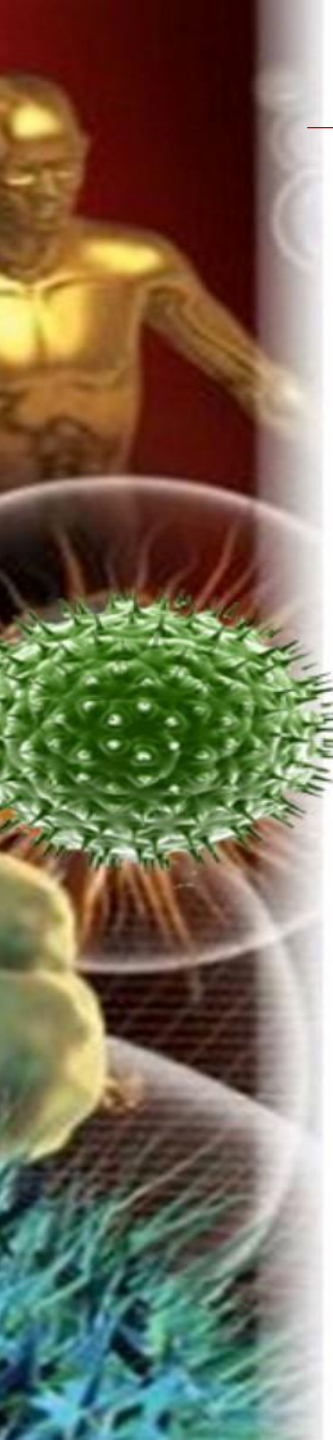
King Saud University, Riyadh, 14511, Saudi Arabia



Learning outcomes

By the end of this lecture students should

- Have the knowledge of virus shapes and sizes.
- Define virus structure and the function of virus coatings.
- Recognize different types of virus nucleic acids.
- Recognize different types of virus capsid.
- Familiar with different terms related to virus structure and pathogenesis.



General Properties of Viruses

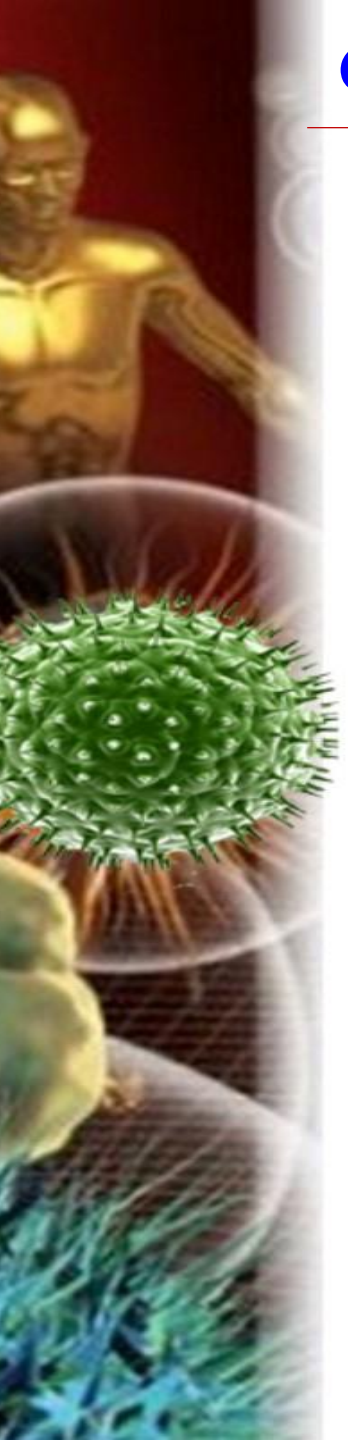
- Obligate intracellular parasites of bacteria, fungi, algae, plants and animals.
- Ultramicroscopic size, ranging from 20 nm up to 450 nm.
- Contain only one type of nucleic acid, either DNA or RNA
- Not cellular in nature.
- Do not independently fulfil the characteristics of life.
- Inactive macromolecules outside the host cell and active only inside host cells.
- Basic structure consists of protein shell and surrounding nucleic acid core.

Virus

Infectious units (obligate intracellular parasites) consisting of either RNA or DNA enclosed in a protective coat.

Submicroscopic agents that infect living organisms often causing disease. They are unable to replicate without a host cell and are not typically considered as living organisms.

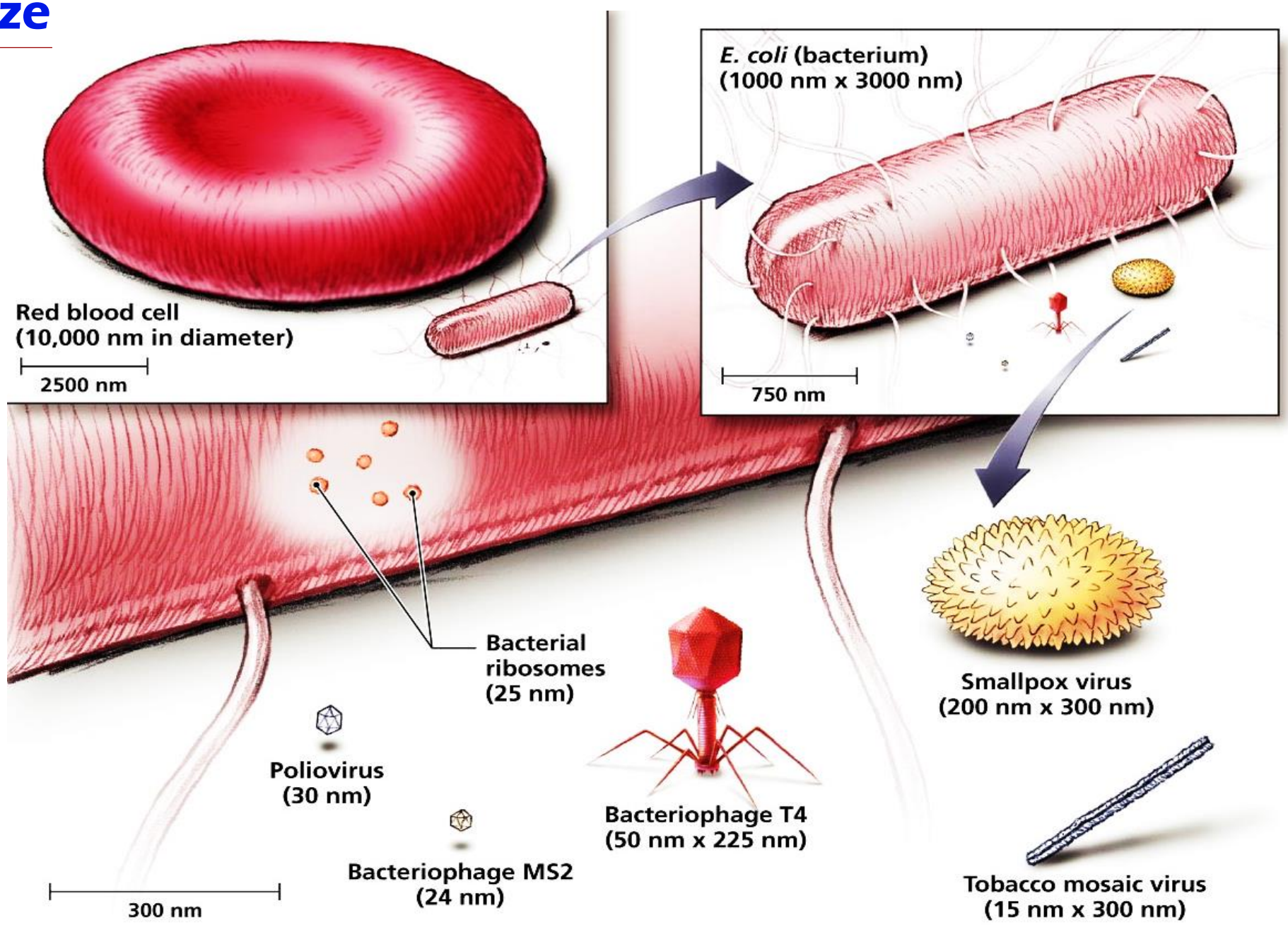
Ultramicroscopic metabolically inert infectious agent that replicates only within cells of living hosts; mainly human, animals, plants and bacteria.



General Properties of Viruses

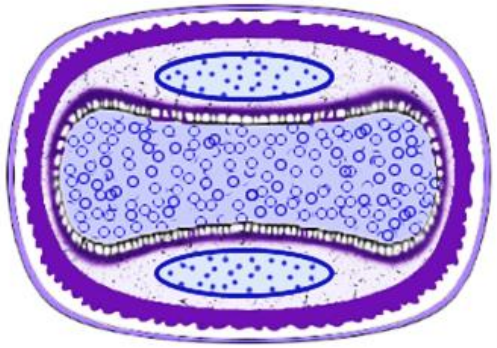
	Bacteria	Virus
Number of cells	Unicellular; one cell	No cells; not living
Living attributes	Living organism	At the edge of live (Not a true living organism)
Structures	DNA and RNA floating freely in cytoplasm. Has cell wall and cell membrane.	DNA or RNA enclosed inside a coat of protein.
Organelles and metabolism	Present	Absent
Treatment	Antibiotics	Vaccines and antiviral medications like interferon
Enzymes	Yes	Yes, in some
Reproduction	Binary Fission- a form of asexual reproduction	Replication cycle
Size	Larger (over 1000 nm)	Smaller (20 – 400) nm

Virus Size



Virus Size

Poxvirus
(e.g. smallpox)



200–300 nm

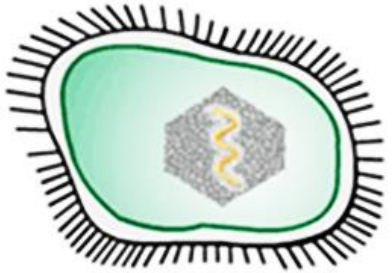
Adapted from ImageLib © 1994 David Proffitt

Myxovirus
(e.g. measles)

80–250 nm

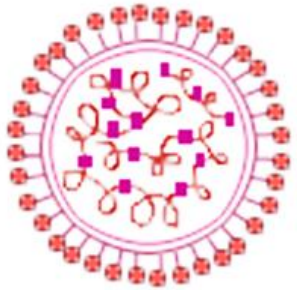
Adapted from ImageLib © 1994 David Proffitt

Herpesvirus
(e.g. herpes)



150–160 nm

Coronavirus
(e.g. SARS)



80–160 nm

Adenovirus
(e.g. common cold)

70–80 nm

Hepadnavirus
(e.g. hepatitis B)

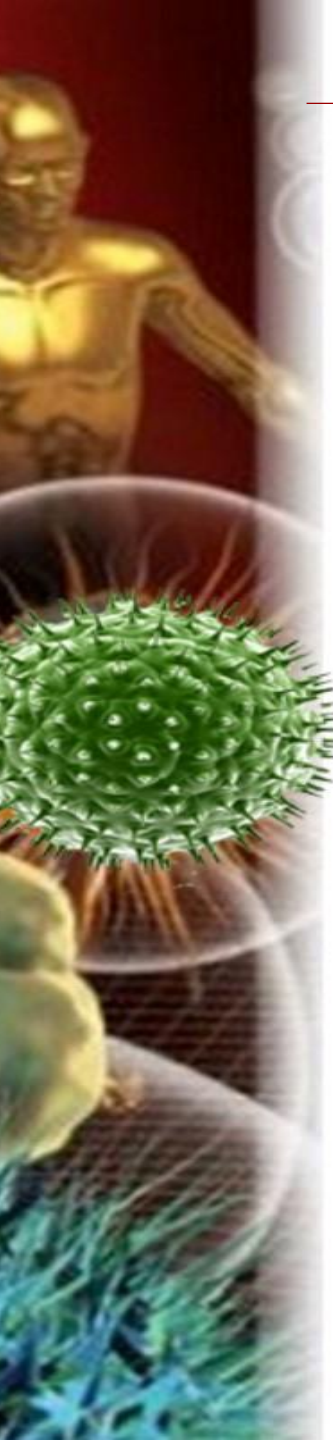
42 nm

Picornavirus
(e.g. polio)

20–30 nm

Parvovirus
(e.g. aplastic anaemia)

18–22 nm

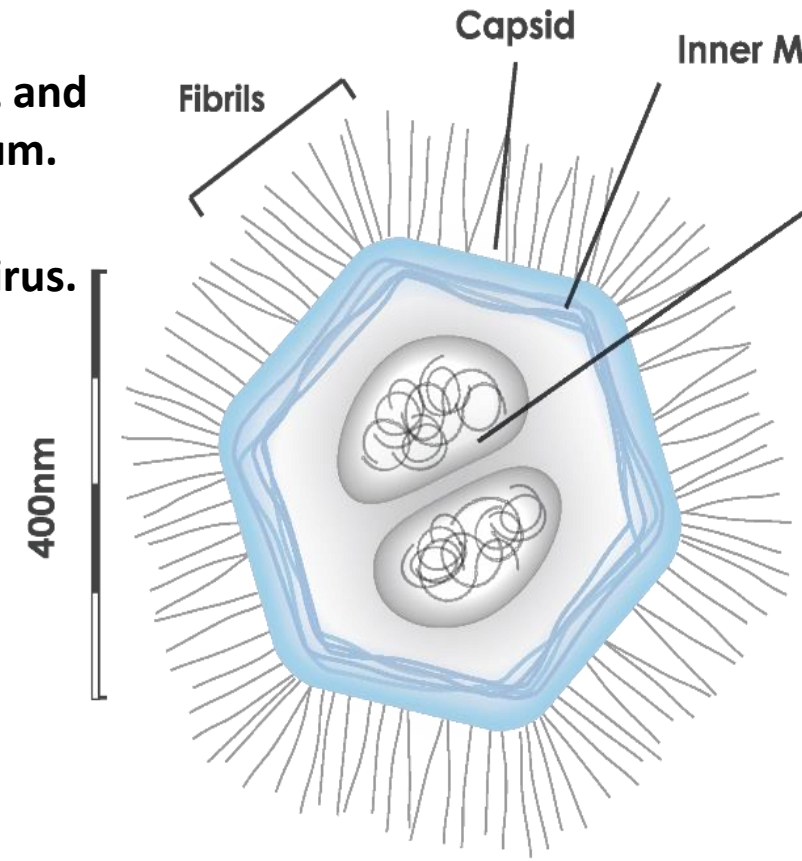


Virus Size

➢ **Giant viruses**

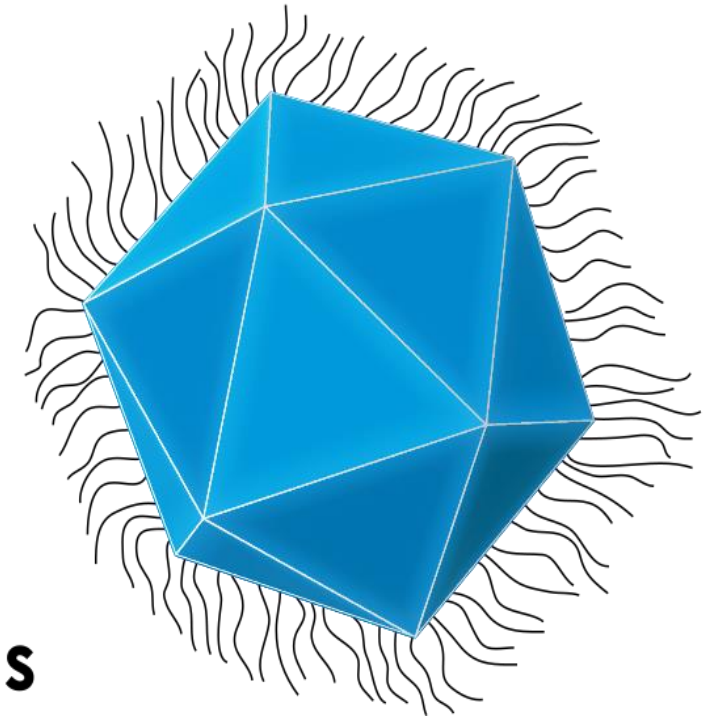
Discovered accidentally in 1992 and wrongly identified as a bacterium.

In 2003, it was identified as a virus.



- dsDNA virus
- 90% coding capacity
- 10% Junk DNA

- 1.2 million base pairs
- ~911 protein coding genes
- additional genes (inc. aminoactyl tRNA synthetases; sugar, lipid, and amino acid metabolism)



acanthamoeba polyphaga mimivirus

Virus Size

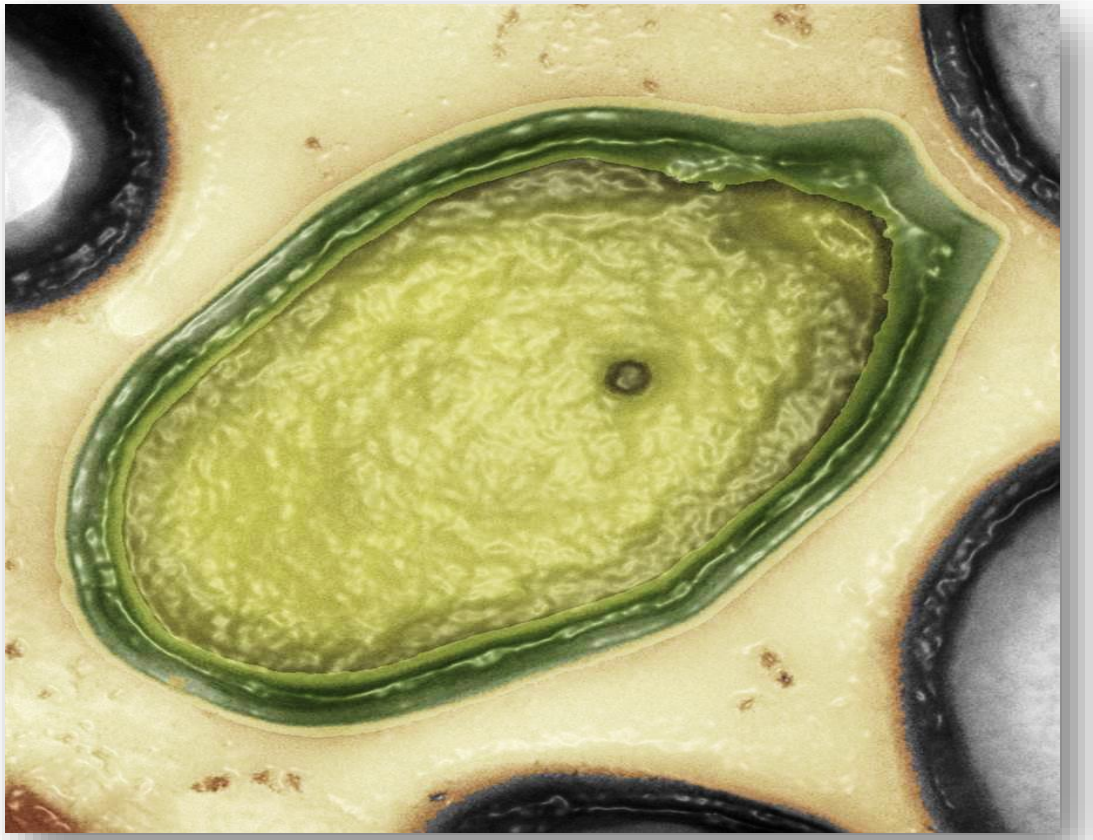
➢ **Giant viruses**

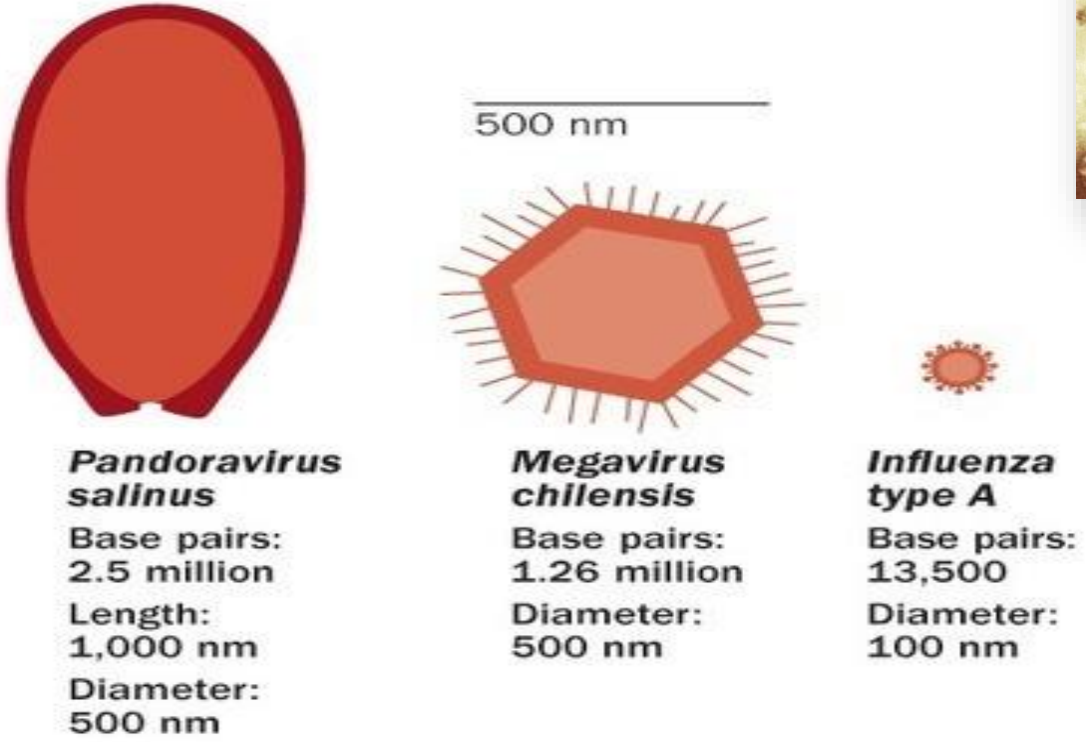
Pandoravirus

Discovered accidentally in 2013.

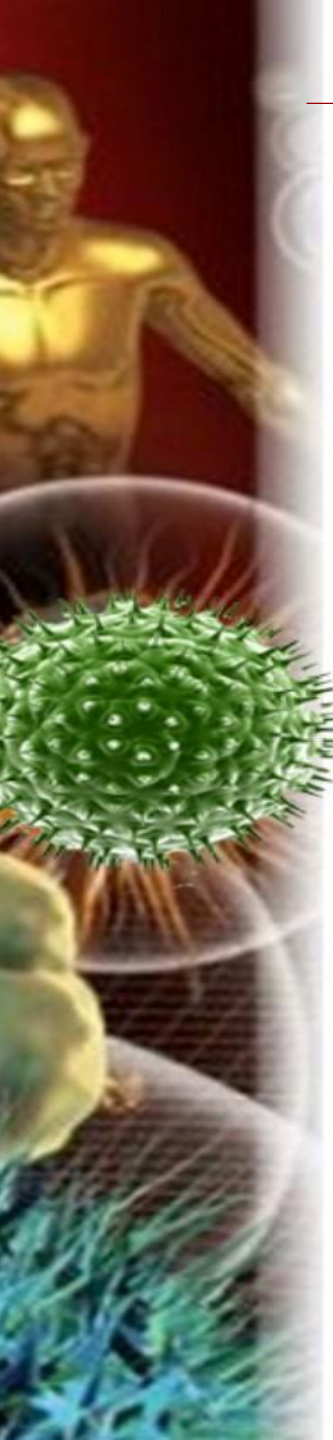
Have a large genome made up of 2,500 genes.

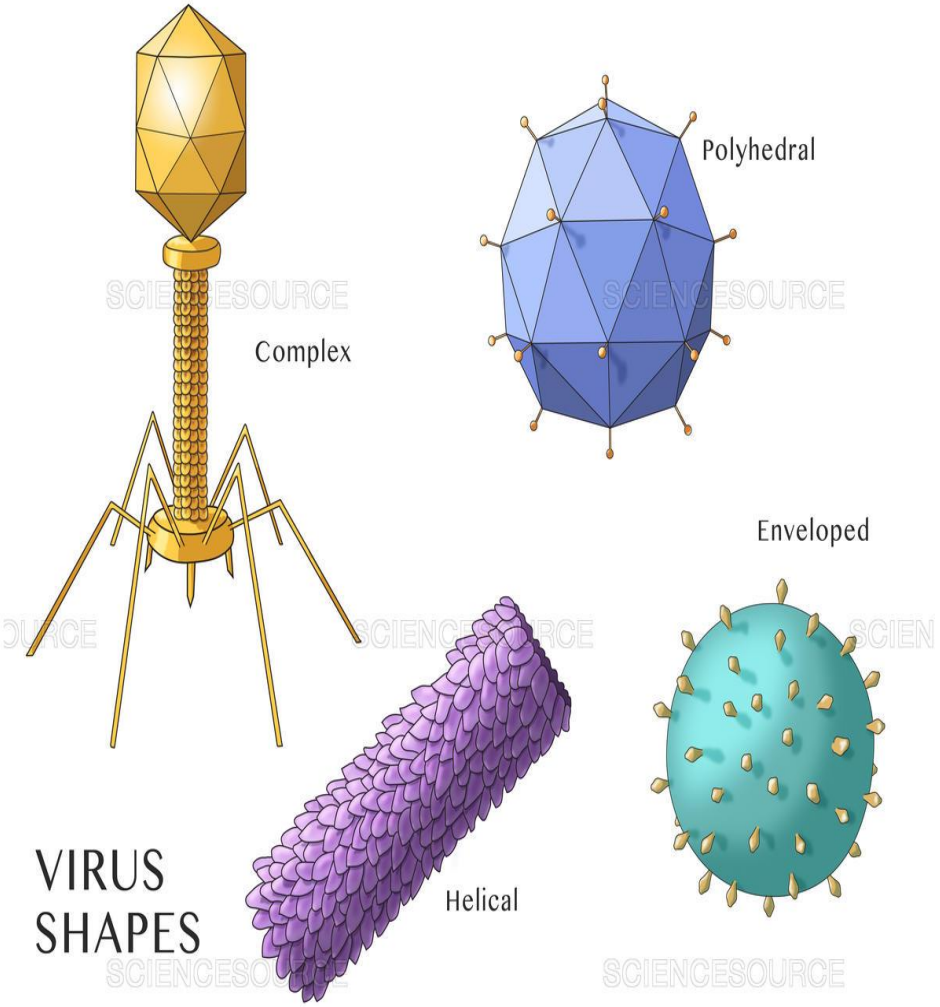
About 1 micrometer (1000 nanometers) in length



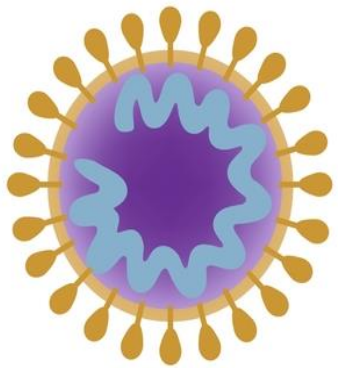


Virus Shape



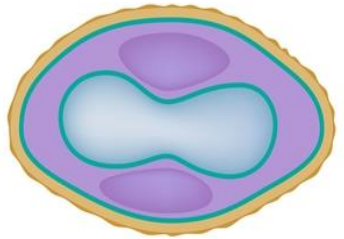


Papillomavirus
Enterovirus
Rhinovirus
Rotavirus



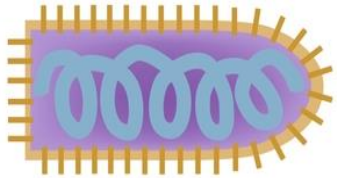
Coronavirus

Herpesvirus
Hepatitis B virus

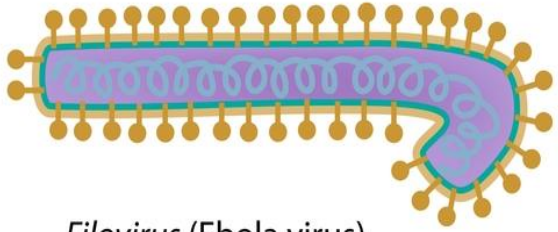


Smallpox virus

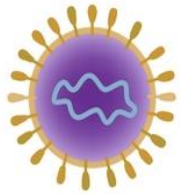
Mastadenovirus



Rabies virus



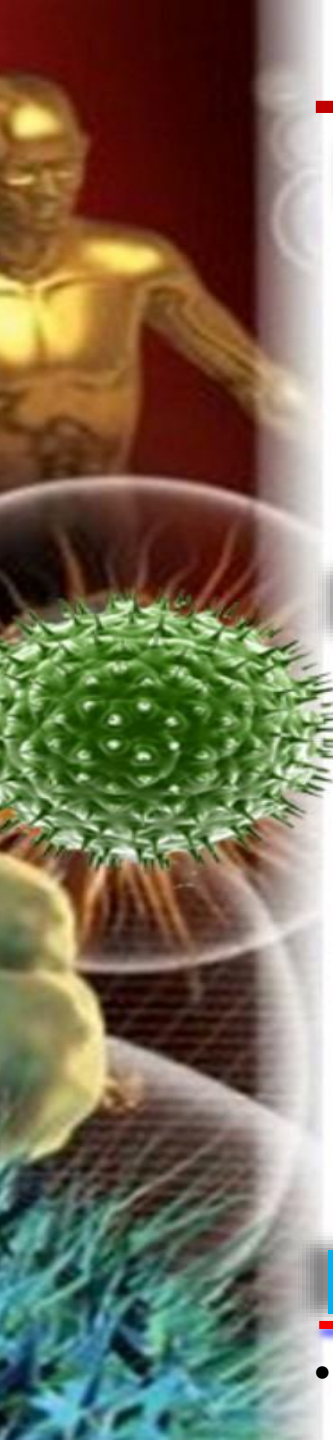
Filovirus (Ebola virus)



Hepatitis D virus

Hantavirus

Virus Structure



Envelope/Membrane

- Enveloped vs. naked viruses
- Lipid bilayer
- Acquired from host cell when budding through plasma membrane (paramyxoviruses), golgi apparatus and endoplasmic reticulum (hepatitis B) or nuclear membrane (herpes simplex virus)
- Damaged by detergents, alcohols, etc.

Genome/nucleic acid

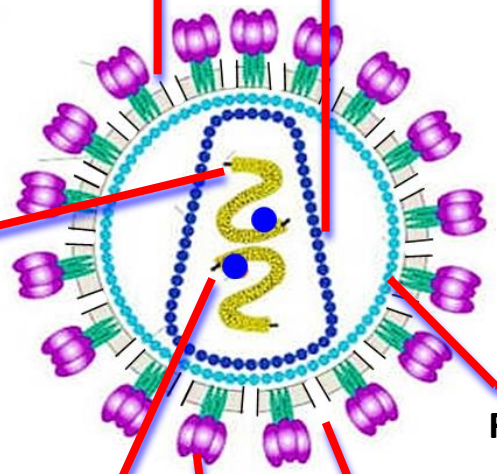
- DNA or RNA (not both!) • RNA viruses are either positive (+) sense or negative (–) sense. Positive sense RNA can function directly as mRNA
- Single stranded vs. double stranded
- Linear vs. circular • Continuous vs. segmented
- Functions:

Contains hereditary information Codes for synthesis of structural proteins (capsid)
± non-structural proteins (enzymes necessary for the replication of the genome)

- Genome replicates itself within a living system to pass on genetic information to the viral progeny.

Enzymes

- Many viruses package their own enzymes needed for replication.



Capsid/Shell

Consists of protein subunits, capsomeres

- Functions: Rigidity of virion.
  Protects genome against physical, chemical and enzymatic damage.
  Entry of host cells via receptor binding protein.
- Capsid morphology is observed by electron microscopy (EM) and may be: ***Icosahedrical*** or ***Helical*** – coiled, ribbon-like structure. Most RNA viruses have this morphology, e.g. TMV, orthomyxoviruses, paramyxoviruses.

Complex – symmetry not completely understood, e.g. *Poxviridae*.

(M protein

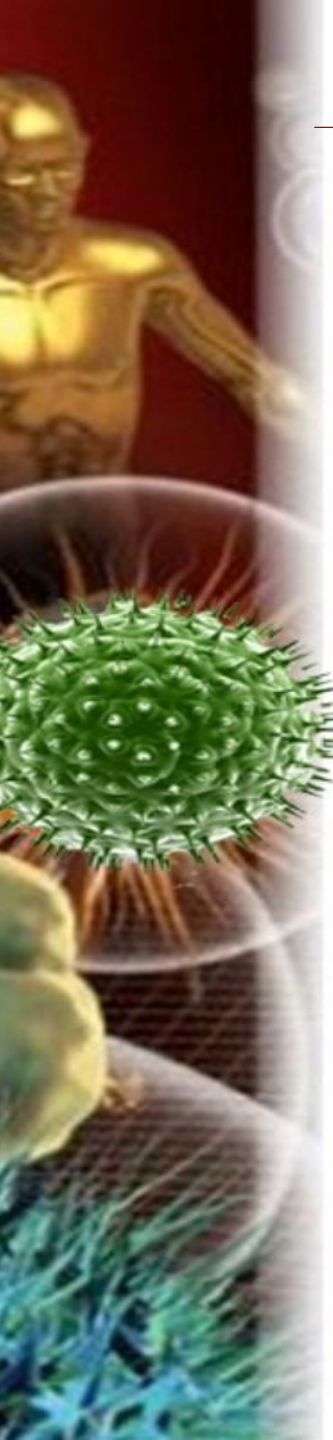
Function: Viral assembly by binding the nucleocapsid core to the viral envelope during the budding process.

Transport channels

Situated in the envelope of enveloped viruses • Alter permeability of the envelope/membrane • E.g. ion channels of influenza virus.

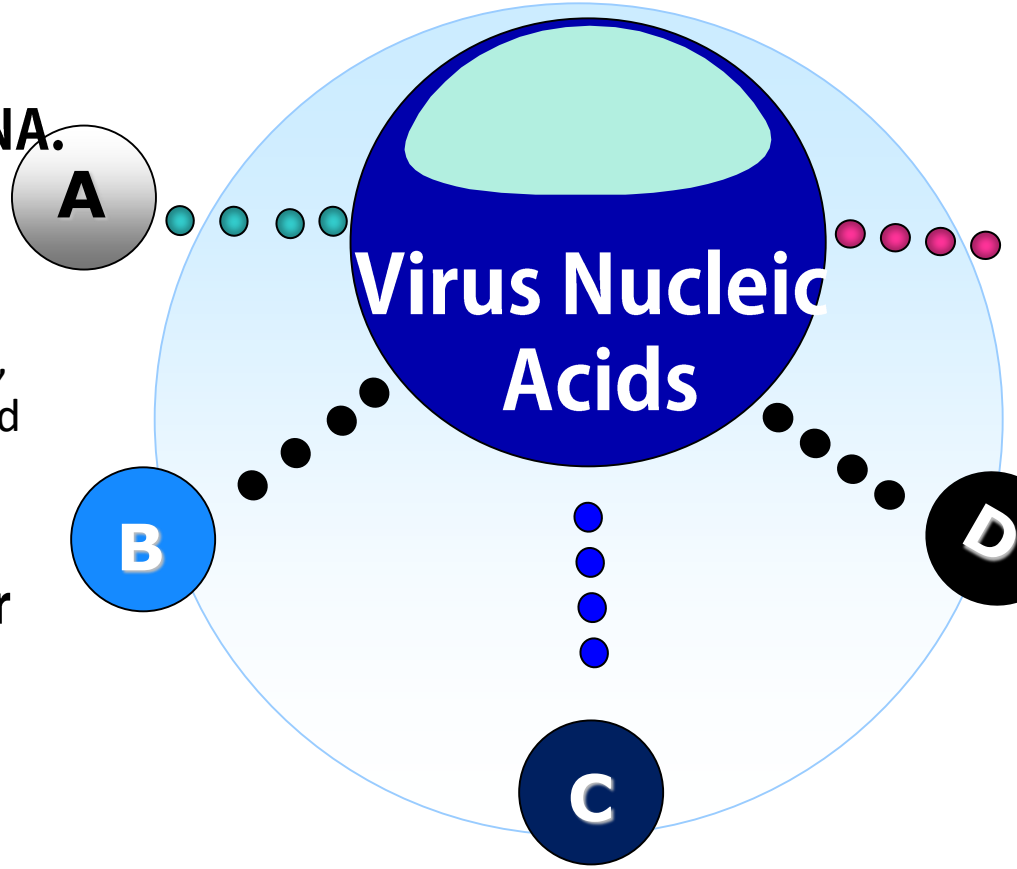
Transport channels

Situated in the envelope of enveloped viruses • Functions: attachment to host-cell receptor for viral entry • Major antigenic determinant(s) of irion. Host immune responses directed towards these ‘spikes’.



Virus Nucleic Acids

➢ DNA or RNA BUT never both



Single stranded or double stranded DNA.

Ex.
ssDNA: Circoviridae, Parvoviridae
dsDNA: Adenoviridae, Poxviridae, and Adenoviridae

Single stranded or double stranded RNA

Ex.
ssRNA:
+ve sence: Coronaviridae
-ve sense: Mononegavirales
dsRNA: Reoviridae

Circular or linear

Ex.
Circular: Circoviridae
Linear: Orthopneumoviridae

Segmented or non-segmented

Ex.
Segmented: Orthomyxoviridae
Non- Segmented: Adenoviridae

Diploid or haploid

Ex.
Diploid: HIV
Haploid: Herpesviridae

Nucleic Acid (Genome)

DNA or RNA

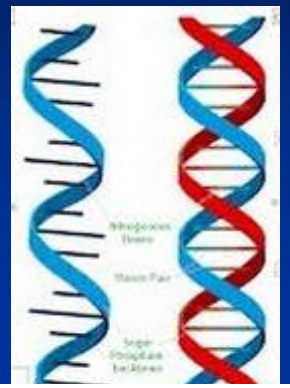
Single or double stranded

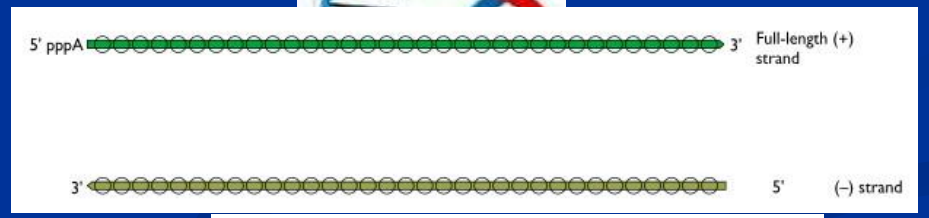
Positive or negative sense

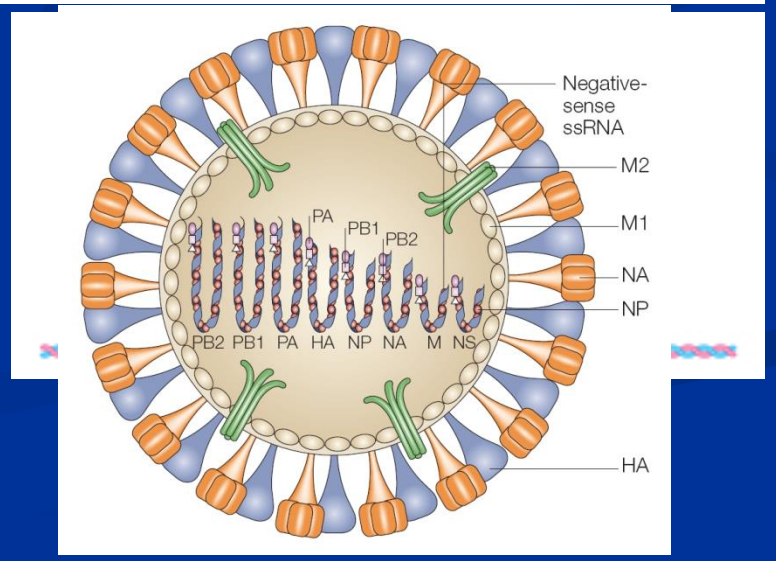
Linear or circular

Segmented or non-segmented

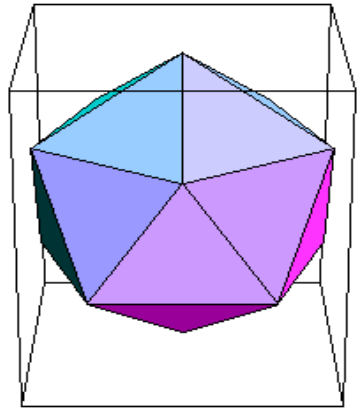
Diploid or haploid







The Capsid

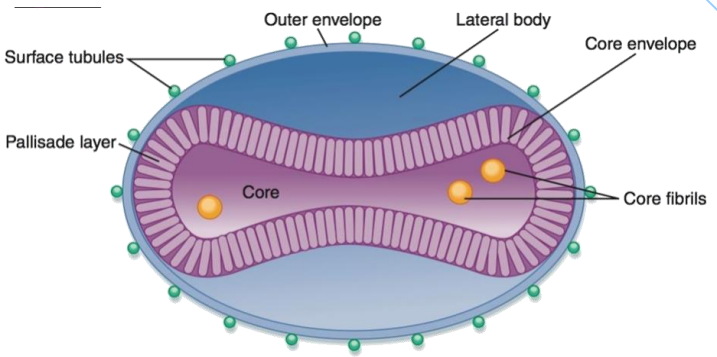


Capsid Symmetry

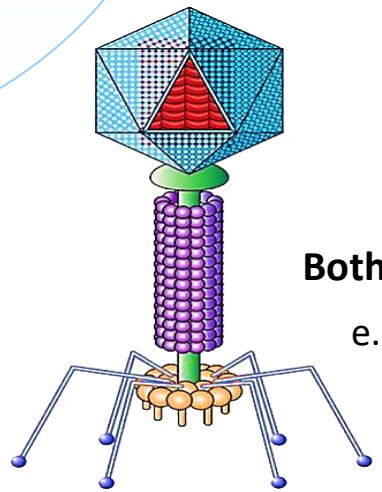
A Helical Symmetry

B **Icosahedral Symmetry**
20 faces (equilateral triangle) 30 borders - 12 angles

C Complex



Neither icosahedral nor helical
e.g. small pox virus

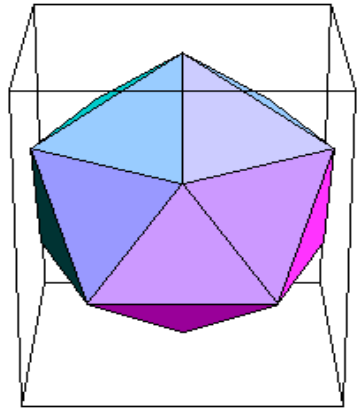


Both icosahedral nor helical (Binal)
e.g. Bacteriophage

Capsid

* Capsid is formed from protein sub-units arranged in a precise and highly repetitive pattern around NA
* Protein sub-units: **Protomers**
* Associate in a specific way to form larger assemblies /structures: **Capsomers**
* Capsomers make up the: **Capsid**

The Capsid



Capsid Symmetry

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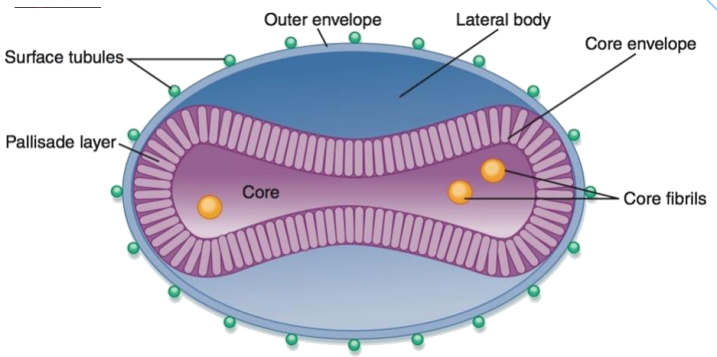
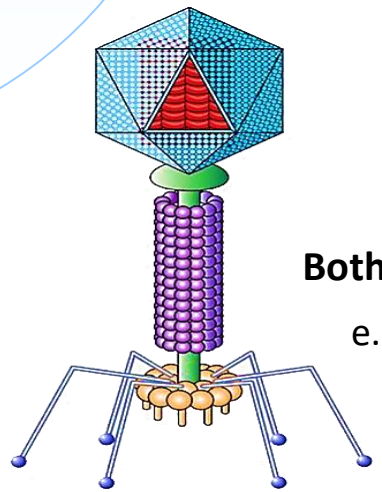


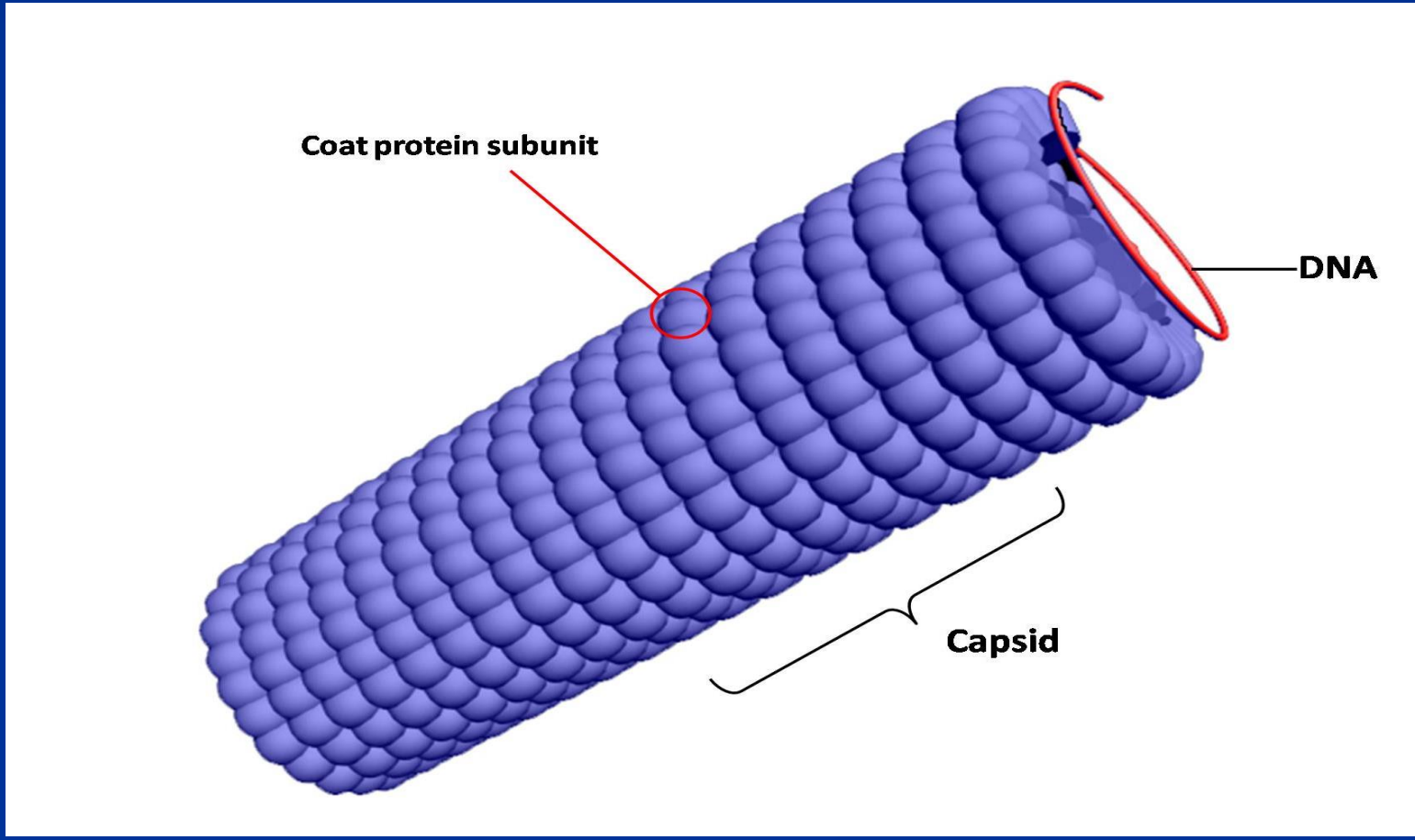
Neither icosahedral nor helical
e.g. small pox virus



Both icosahedral nor helical (Binal)
e.g. Bacteriophage

Capsid

Helical Capsid:

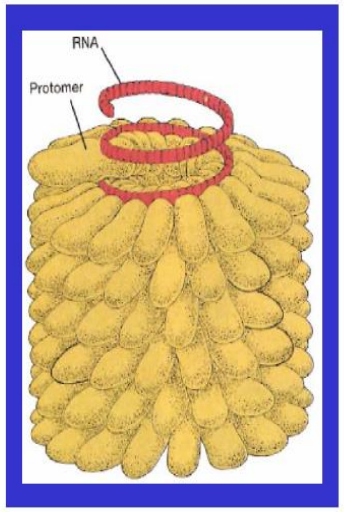


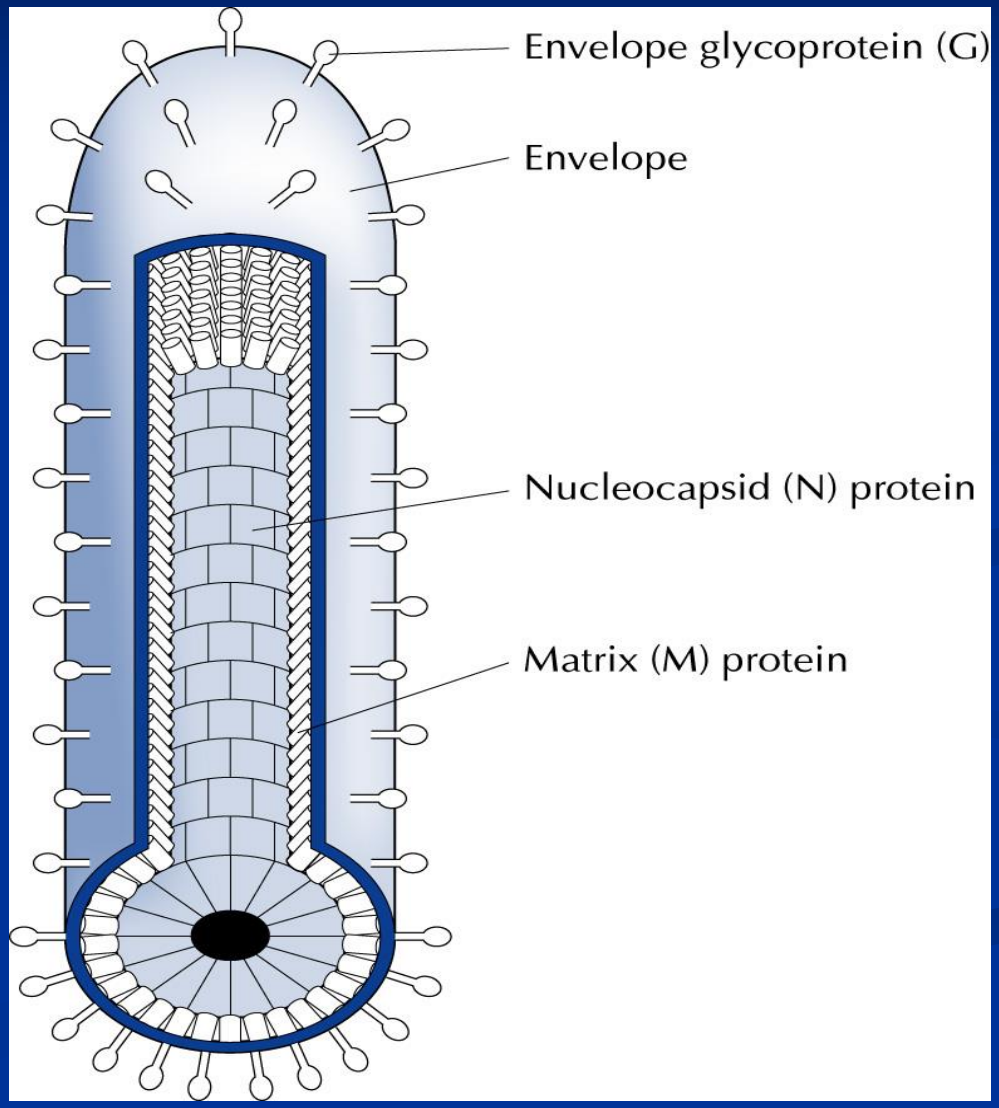
Capsid

Helical Capsid:

Rhabdoviridae

Protein subunits arranged in a helix





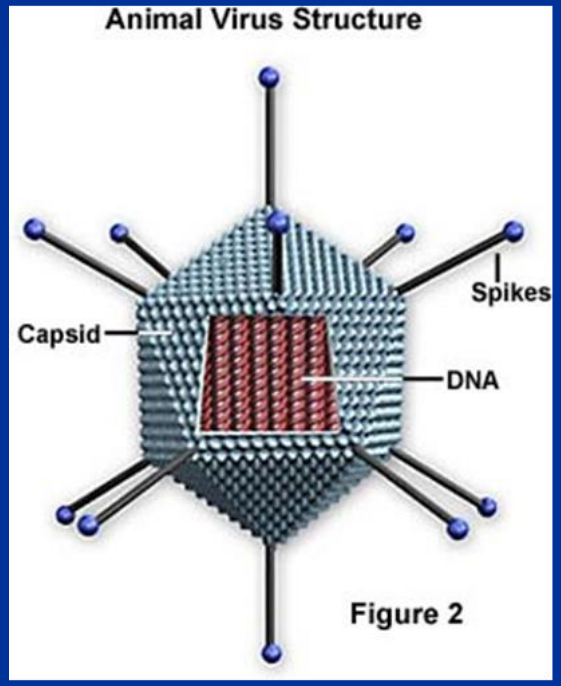
Capsid

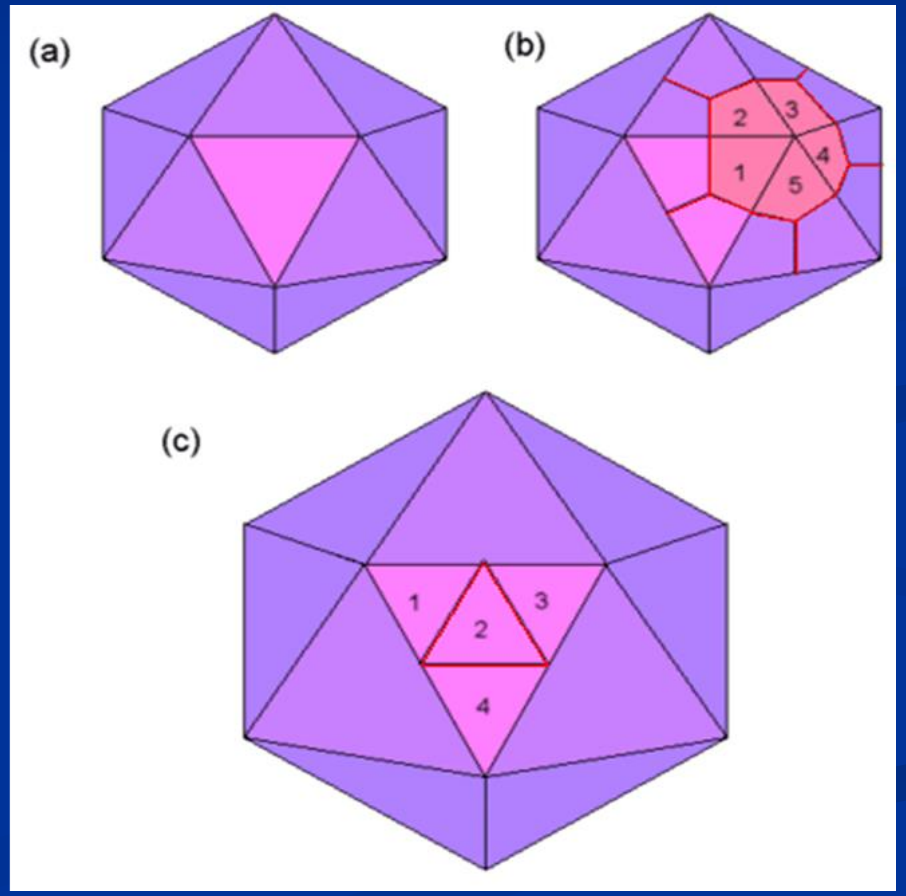
Helical Capsid:

- Helical, naked (i.e. non-enveloped) animal viruses do not exist, but the reasons are not clear
- This category includes many of the best known human and animal pathogens
  e.g. Avian Influenza virus, Mumps & measles viruses, Rinderpest Virus & *Rabies virus*
- Most helical animal viruses possess single-stranded, negative-sense RNA genomes

Capsid

Icosahedral Capsid:

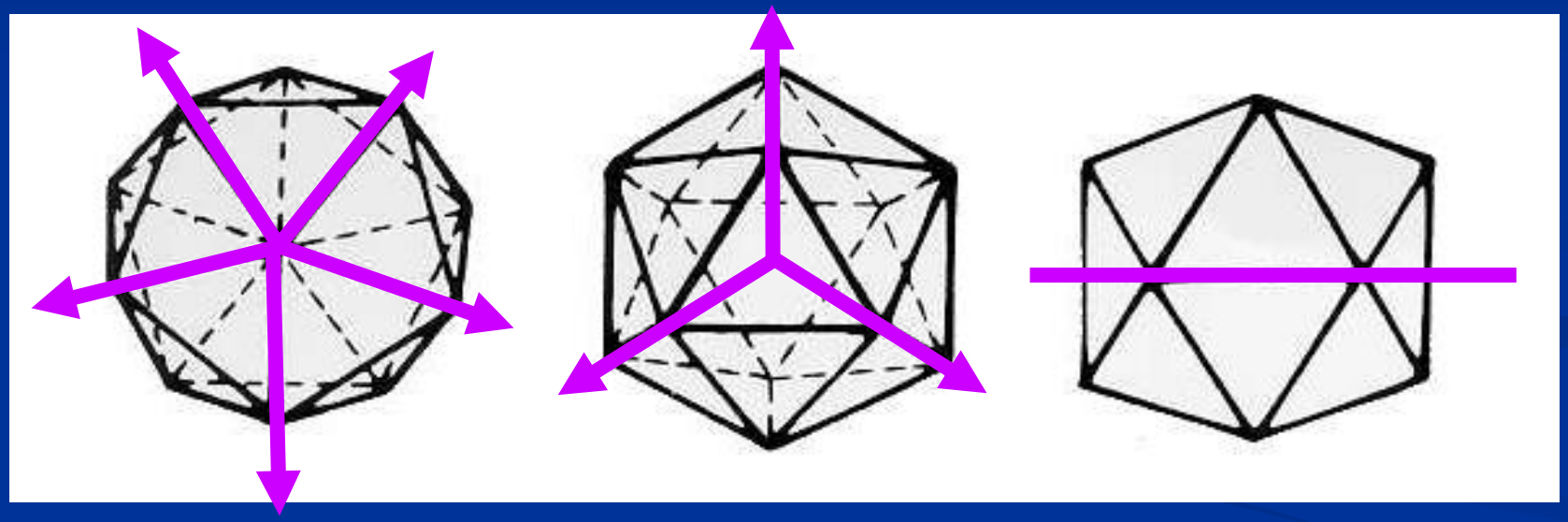




20 faces (equilateral triangle)
30 borders - 12 angles

Capsid

Icosahedral Capsid:



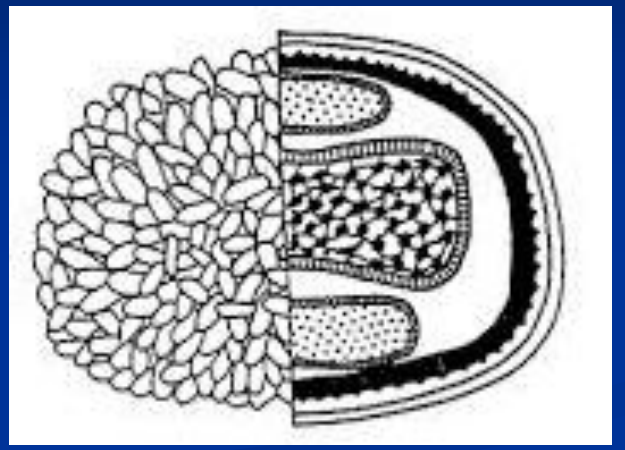
5-FOLD **3-FOLD** **2-FOLD**

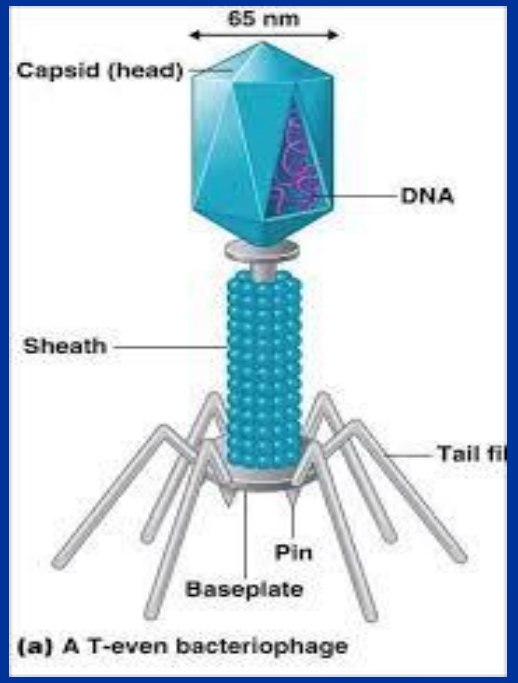
Capsid

Complex Capsid:

- **Neither icosahedral nor helical**

e.g. small pox virus



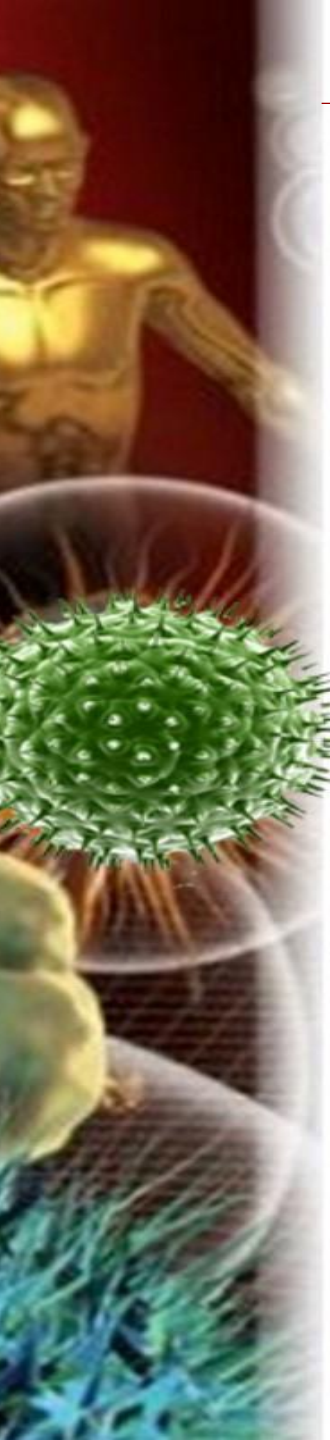


- **Both icosahedral nor helical (Binal)**

e.g. Bacteriophage

Functions of Virus Coatings

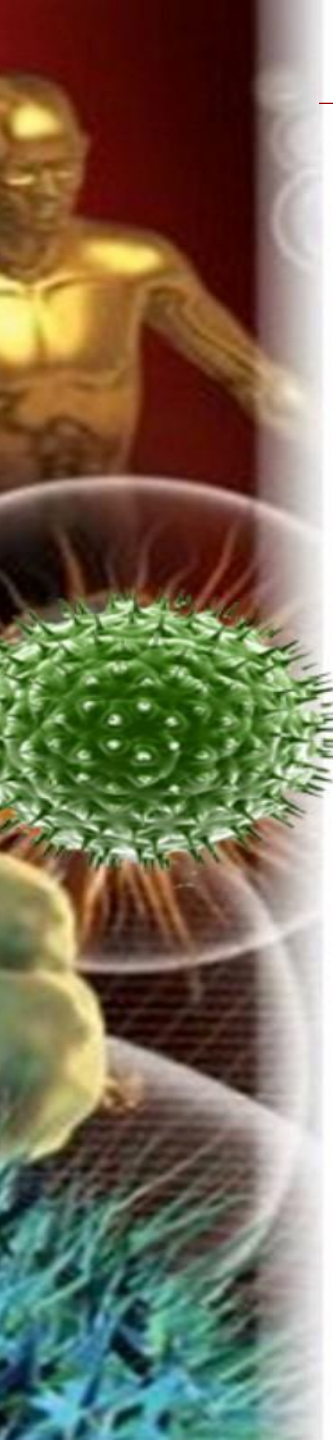
1. **Protects the fragile genome from physical, chemical or enzymatic damage**
2. **Responsible for recognition and first interaction with the host cell. Initially, this takes the form of binding of a specific virus-attachment protein to a cellular receptor molecule**
3. **Plays a role in initiating infection by delivering the genome in a form that can interact with the host cell**
4. **They are the principle target of host immunity.**

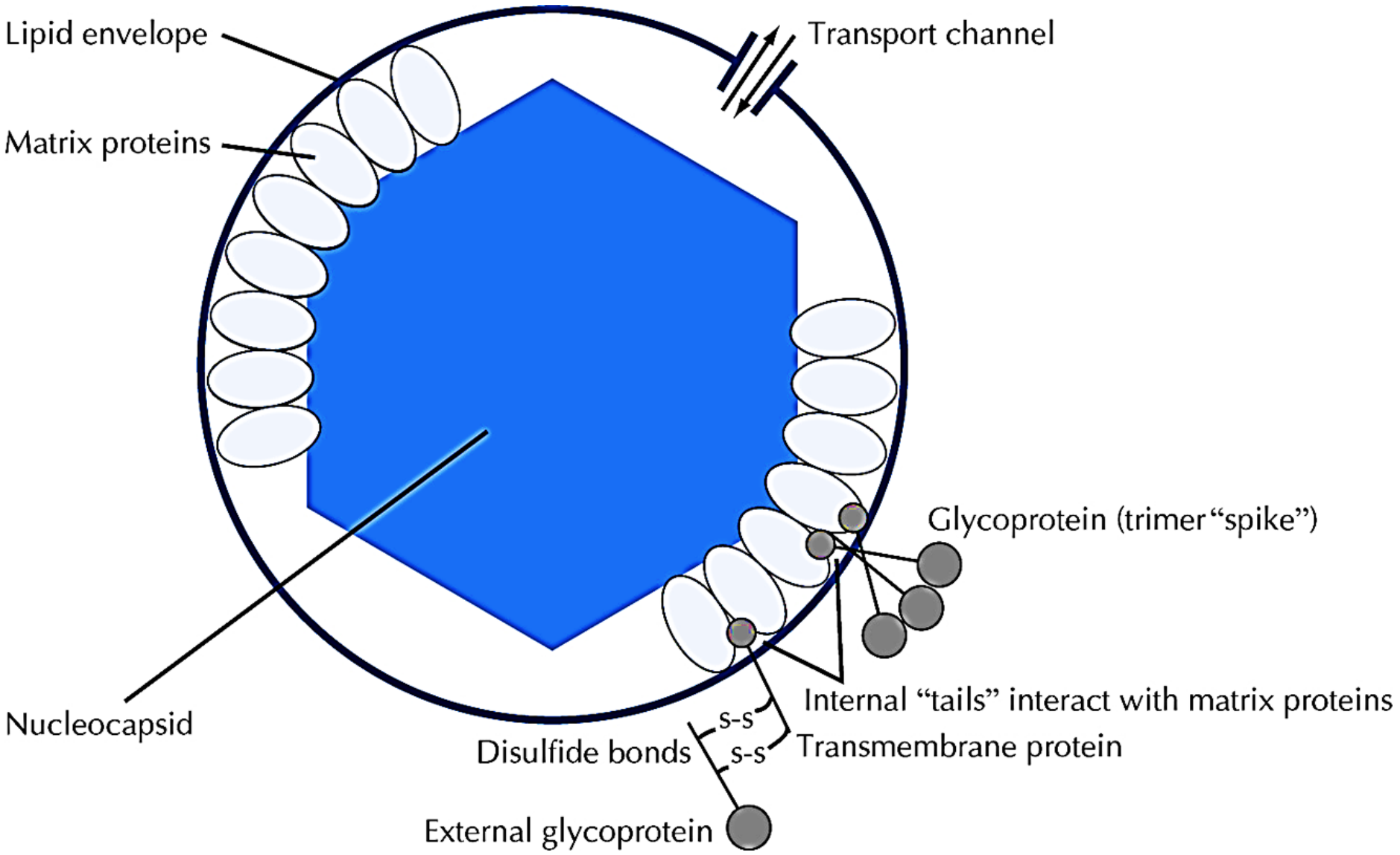


Functions of Virus Coatings

- Protects the fragile genome from physical, chemical or enzymatic damage.
- Recognition and attachment of virus to host cell.
- Initiation of infection by delivering the viral genome in the host cell.
- Assembly and release of new viruses from host cell.
- Principle targets of host immunity.

Virus Envelop

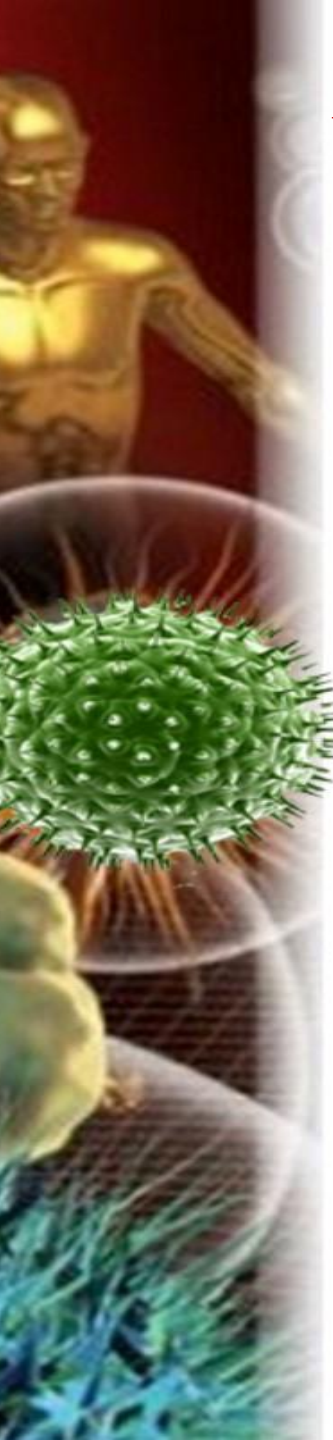




Envelope

- Obtained through the cellular membrane (except poxviruses, herpesviruses, coronaviruses).
- Budding possibility of exiting cell without killing it.
- Contains at least one virally coded protein.

- All living cells are covered by a membrane composed of lipid bilayer. Viruses leaving the cell usually acquire outer coat derived from the cell membrane.
- This is achieved by budding of the particle through the membrane, during which process the particle becomes coated in a lipid envelope.



Definitions

Viroid: Autonomously replicating plant pathogens consisting solely of unencapsidated, single-stranded, circular (rodlike) RNAs of 200 to 400 nucleotides. Viroids do not encode any protein products.

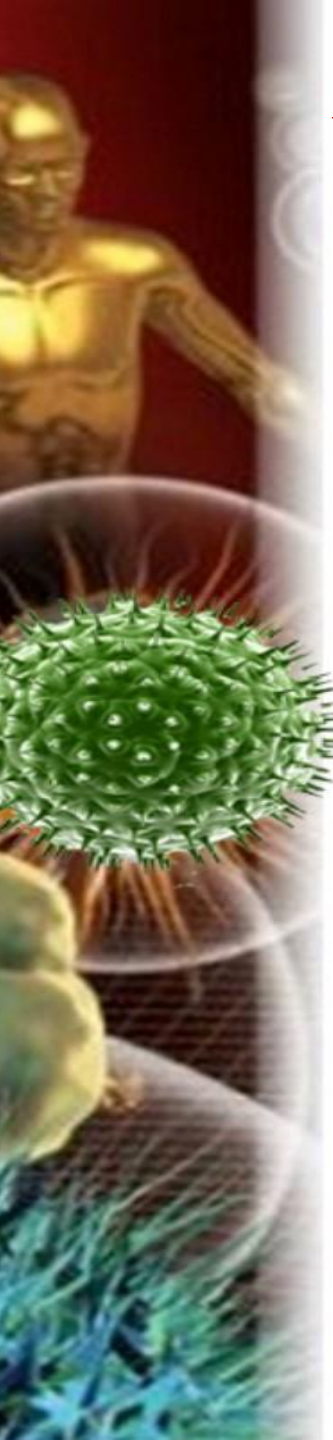
Virusoids: Small satellite RNAs with a circular, highly base-paired structure similar to that of a viroid; depend on a plant virus for replication and encapsidation but do not encode any proteins.

Prion: A proteinaceous infectious particle, believed to be responsible for transmissible spongiform encephalopathies such as Creutzfeldte-Jakob disease (CJD) or bovine spongiform encephalopathy.

Prophage: The lysogenic form of a temperate bacteriophage genome integrated into the genome of the host bacterium.

Provirus: The double-stranded DNA form of a retrovirus genome integrated into the chromatin of the host cell.

Virion: The complete virus particle.



Definitions

Capsid: The protein shell, or coat, that encloses the nucleic acid genome.

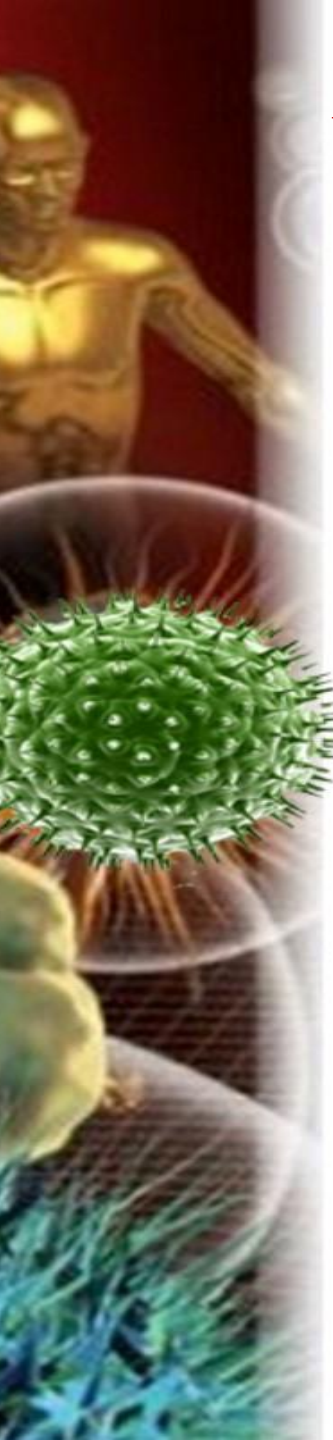
Capsomeres: Morphologic units seen in the electron microscope on the surface of icosahedral virus particles.

Envelope: A lipid-containing membrane that surrounds some virus particles. It is acquired during viral maturation by a budding process through a cellular membrane.

Nucleocapsid: The protein-nucleic acid complex representing the packaged form of the viral genome.

Protomer : The basic protein building blocks of the coat. They are usually a collection of more than one nonidentical protein subunit.

Icosahedron: A solid shape consisting of 20 triangular faces arranged around the surface of a sphere; the basic symmetry of many virus particles.



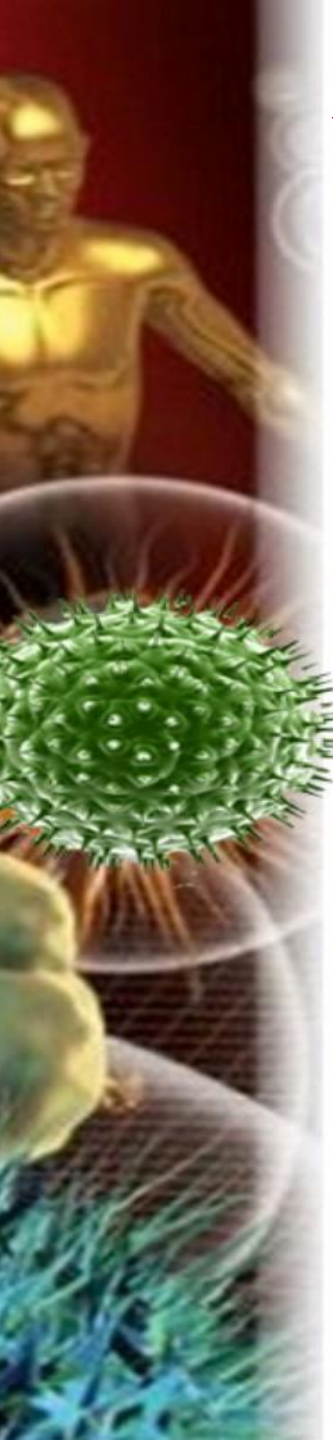
Definitions

Genome: The nucleic acid comprising the entire genetic information of an organism.

Helix: A cylindrical solid formed by stacking repeated subunits in a constant relationship with respect to their amplitude and pitch.

Negative-sense: The nucleic acid strand with a base sequence complementary to the strand that contains the protein-coding sequence of nucleotide triplets or a virus whose genome consists of a negative-sense strand.

Receptor: A specific molecule on the surface of a cell to which a virus attaches as a preliminary to entering the cell. May consist of proteins or the sugar residues present on glycoproteins or glycolipids in the cell membrane.



Definitions

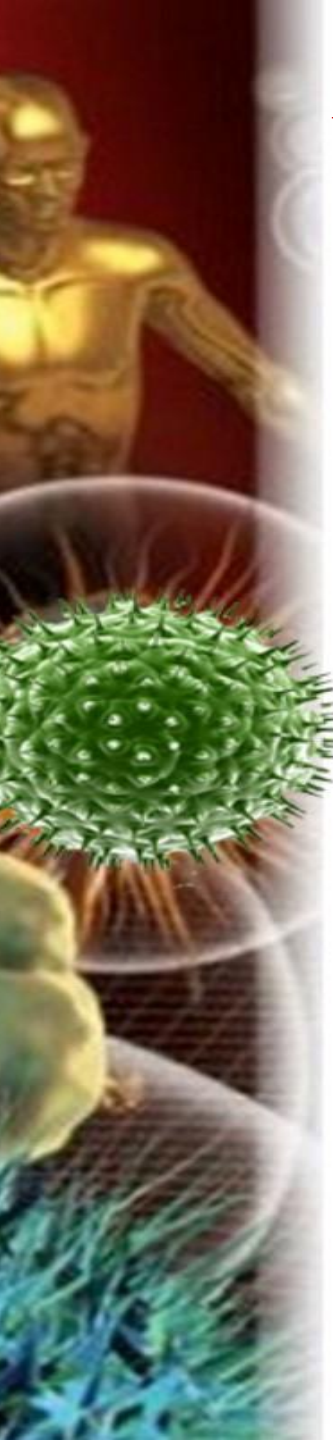
AIDS: Acquired Immunodeficiency Syndrome: A disease of humans caused by Human immunodeficiency viruses (HIV) 1 and 2.

Adjuvant: Substance added to antigens to enhance immune response. Salts of aluminum (e.g. hydroxide or phosphate) acceptable for use in humans. Saponin or Freund's adjuvant used only in experimental animals.

Acute infection: Severe, sudden and short period infection.

Anoxia: Oxygen deficiency.

Asthma: is a chronic lung disease that inflames and narrows the airways. Asthma causes recurring periods of wheezing (a whistling sound when you breathe), chest tightness, shortness of breath, and coughing.



Definitions

Bronchiolitis: is a common illness of the respiratory tract. It's caused by an infection that affects the tiny airways, called the bronchioles.

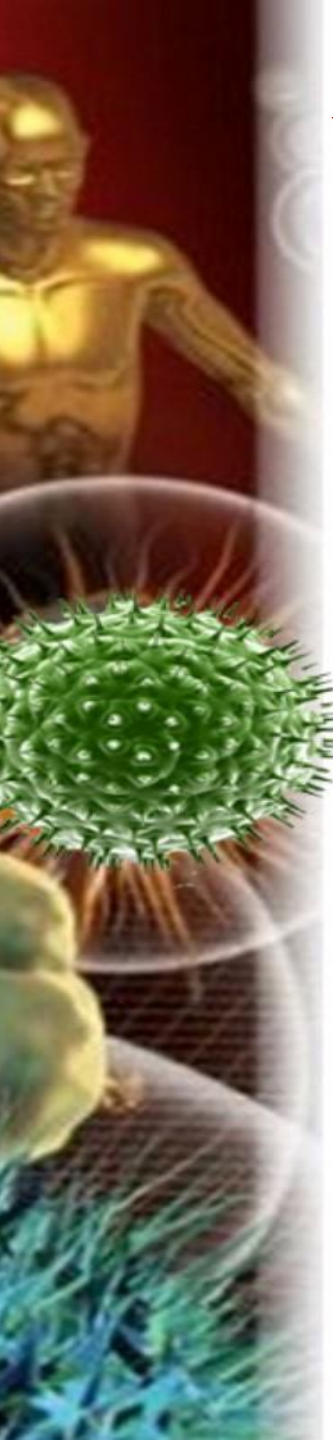
Bronchitis: infection of the larger airways of the lung.

Chronic infection: long-term infection.

Cirrhosis: the liver becomes shrunken, hardened and fails to function normally.

Croup: is a common respiratory problem in young children. It tends to occur in the fall and winter. Its main symptom is a harsh, barking cough. Croup causes swelling and narrowing in the voice box, windpipe, and breathing tubes that lead to the lungs.

Cytopathic Effect (CPE): Structural changes in host cells that are caused by viral invasion. The infecting virus causes lysis of the host cell or when the cell dies without lysis due to an inability to reproduce.



Definitions

Dyspnoea: A case of breathing difficulty.

Fever: A temperature above the normal level of 37°C.

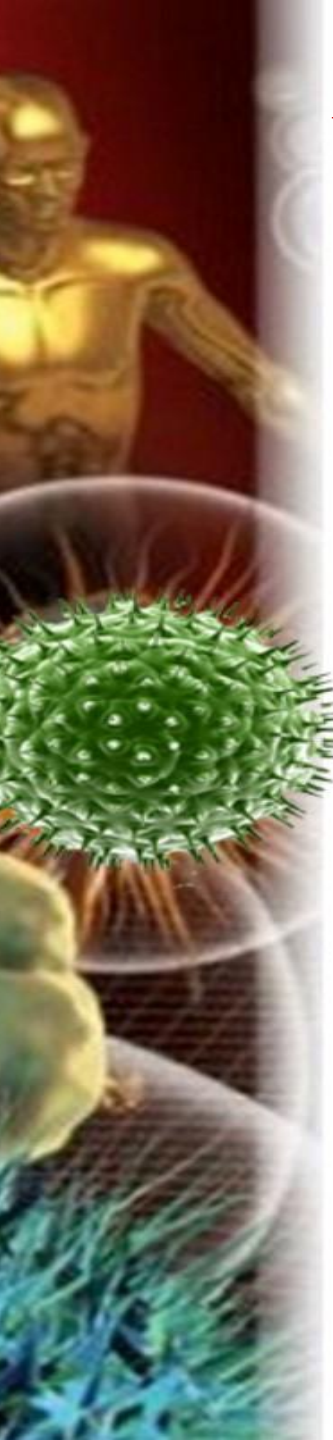
Febrile: The presence of Fever.

Gastroenteritis: inflammation of the stomach and intestine associated with vomiting and/or diarrhea.

Inflammation: Reaction of the body to an injury. Signs of inflammation are redness, heat, swelling, and tenderness.

Infection: infection of the body by harmful organisms that cause disease.

Nausea: an unpleasant sick feeling in the stomach area.



Definitions

Pneumonia: is an infection that inflames the air sacs in one or both lungs. The air sacs may fill with fluid or pus (purulent material), causing cough with phlegm or pus, fever, chills, and difficulty breathing.

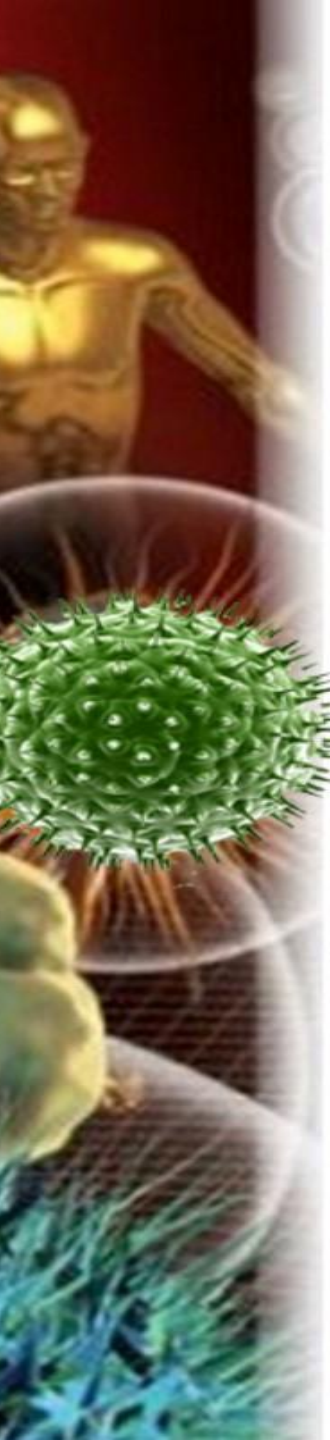
Prophylaxis: treatment given or action taken to prevent disease

Pathogenicity: The potential capacity of certain microbes to cause disease.

Pathogenesis : Description of the development of a particular disease (events, reactions and mechanisms) at cellular level.

Virulence: The capacity of a Pathogen (infectious agent) to produce disease in the host.

Infection: The invasion of host body tissues by pathogenic micro-organisms resulting in tissue injury that may progress to disease.



Definitions

Primary infection: A primary infection is the first time you are exposed to and infected by a pathogen. During a primary infection, your body has no innate defenses against the organism, such as antibodies.

Secondary infection: Does not refer to the second time a person becomes infected with the same illness. It is also called opportunistic infections.
It is a different infection, which can thrive in a person who has a primary infection.

Viral Hepatitis: inflammation of the liver by viruses such A, B, and C.

Vaccine: Is a biological preparation that provides active acquired immunity to a particular disease.

Viremia: The presence of the virus in the blood.

Virurea: The presence of the virus in the urine.


Thank
You