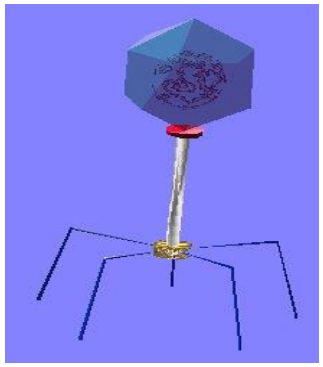
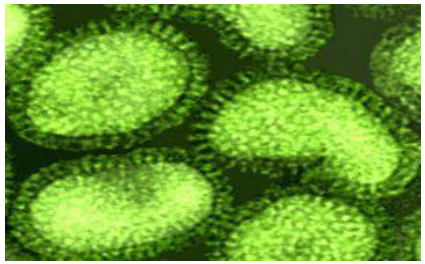
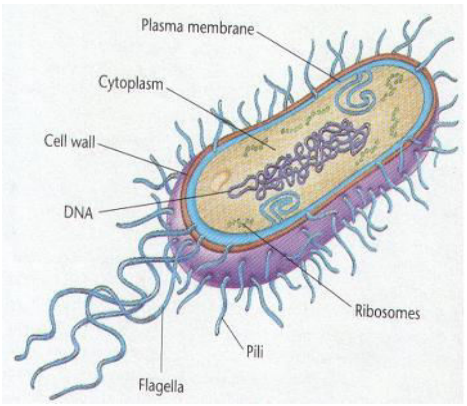




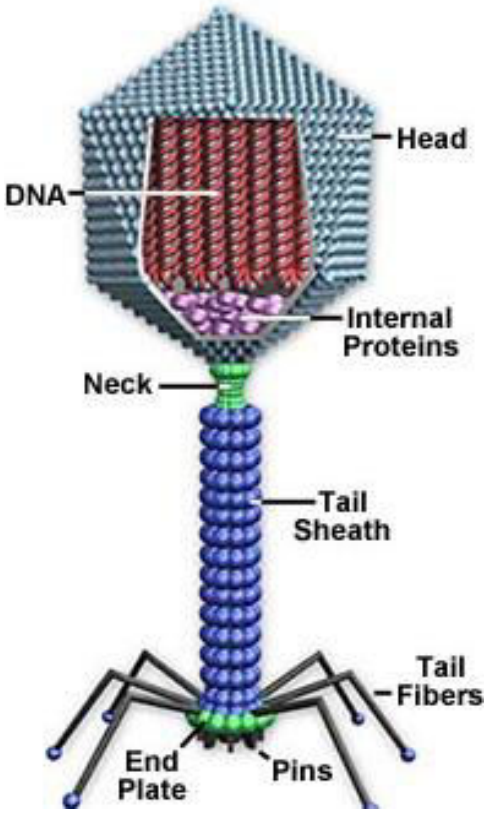


General Microbiology
Lec 3
An introduction to Virus

Ammar Algburi

Ph.D. in Microbial Biology

Introduction



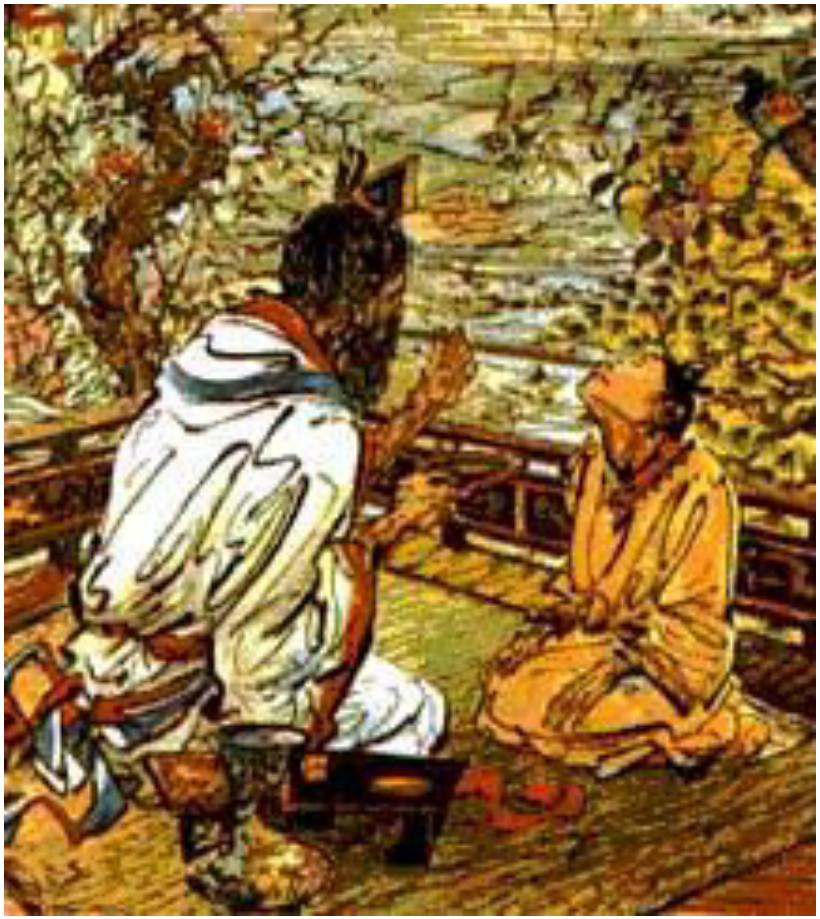
- **Virology is the bioscience for study of viral nature, and the relationship between viruses and hosts. Viruses often cause serious diseases, relate to some cancers and congenital deformities, also can be used as tool for genetic engineering.**



- 3000BC

History

- Smallpox was endemic in China by 1000BC. In response, the practice of **variolation** was developed. Recognizing that survivors of smallpox outbreaks were protected from subsequent infection, variolation involved inhalation of the dried crusts from smallpox lesions like snuff, or in later modifications, inoculation of the pus from a lesion into a scratch on the forearm of a child.



Definition of Virus

Viruses may be **defined** as **acellular organisms** whose **genomes** consist of **nucleic acid**, and which obligately **replicate inside host cells** using **host metabolic machinery** and **ribosomes** to form a **pool of components** which assemble into particles called **VIRIONS**, which serve to **protect the genome** and to **transfer it to other cells**

Viral Properties

- **Viruses are inert (nucleoprotein) filterable Agents**
- **Viruses are obligate intracellular parasites**
- **Viruses cannot make energy or proteins independent of a host cell**
- **Viral genome are RNA or DNA but not both.**
- **Viruses have a naked capsid or envelope with attached proteins**
- **Viruses do not have the genetic capability to multiply by division.**
- **Viruses are non-living entities**

Challenges the way we define life

- viruses do not respire
- they do not move
- they do not grow
- they do most certainly reproduce, and may adapt to new hosts.

Size and Shape

- **Methods**
- **Size of Viruses**
- **Shapes of Viruses**

Methods of Analysis

Electron microscopy :
The resolution is 5nm (1nm = 10^{-9} m)

X-ray crystallography

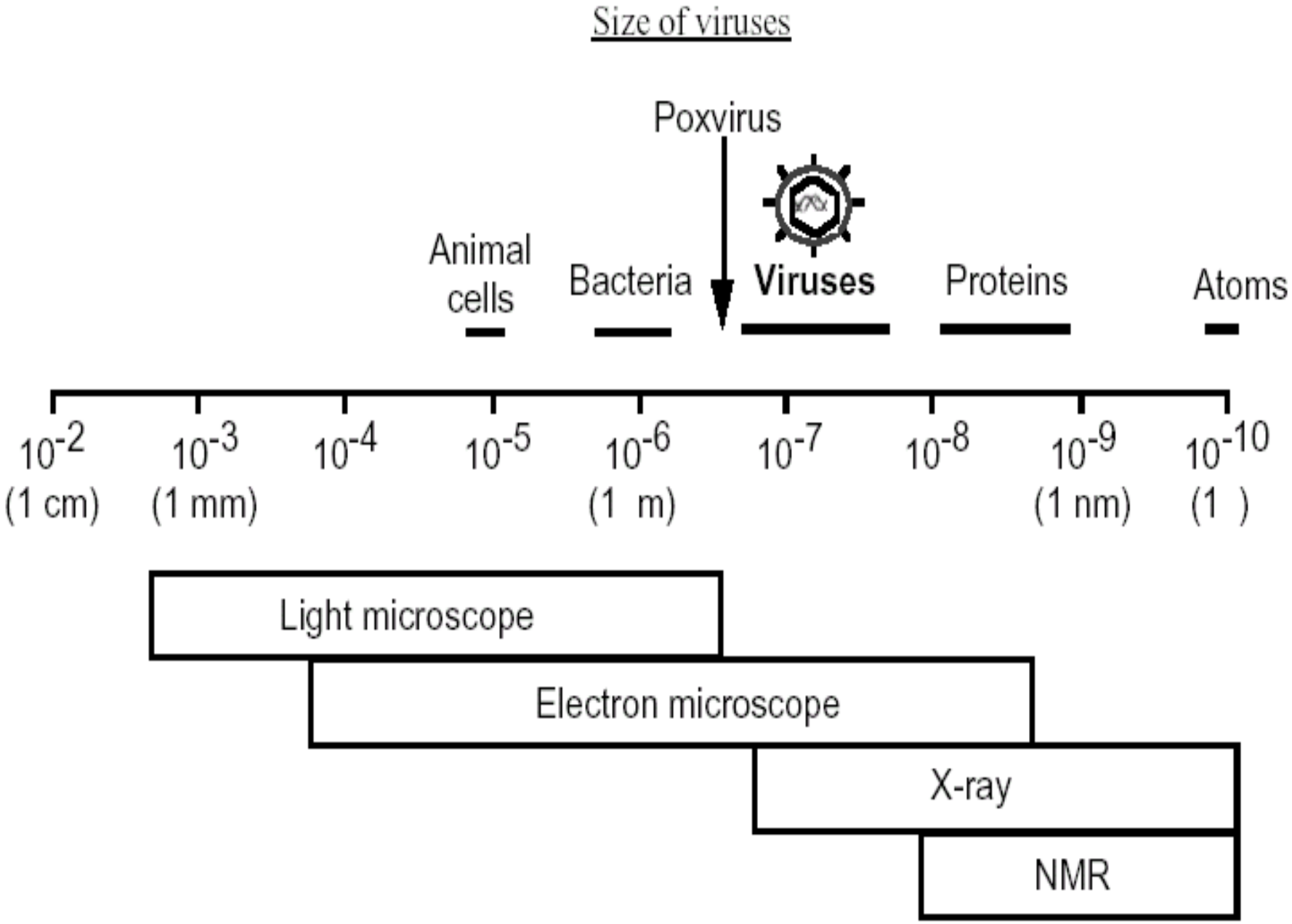
Size of Viruses

A small virus has a diameter of about 20nm.

Parvovirus

A large virus have a diameter of up to 400nm.

Poxviruses


Size of viruses
Poxvirus
Animal cells
Bacteria
Viruses
Proteins
Atoms
10-2 (1 cm)
10-3 (1 mm)
10-4
10-5
10-6 (1 m)
10-7
10-8
10-9 (1 nm)
10-10 (1)
Light microscope
Electron microscope
X-ray
NMR

Shape of Viruses

Spherical

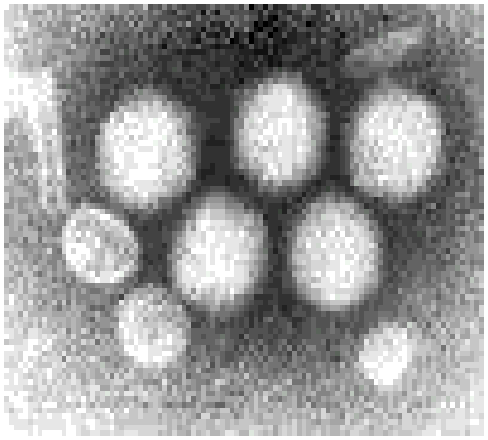
Rod-shaped

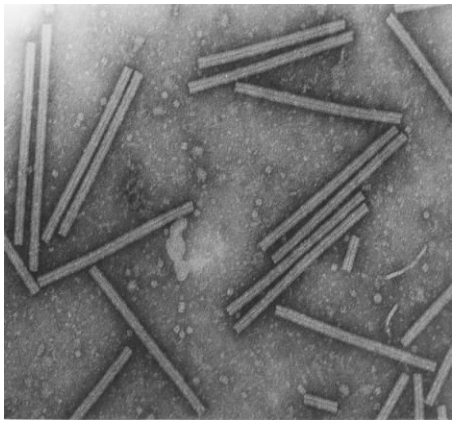
Brick-shaped

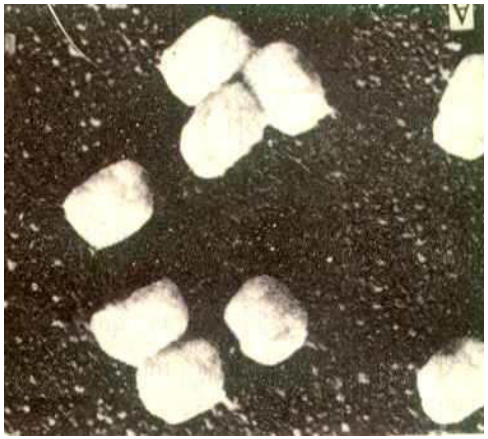
Tadpole-shaped

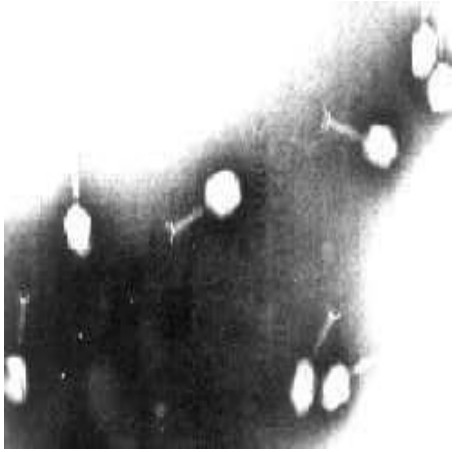
Bullet-shaped

Filament

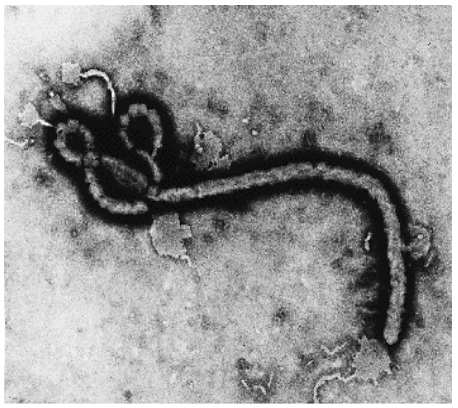






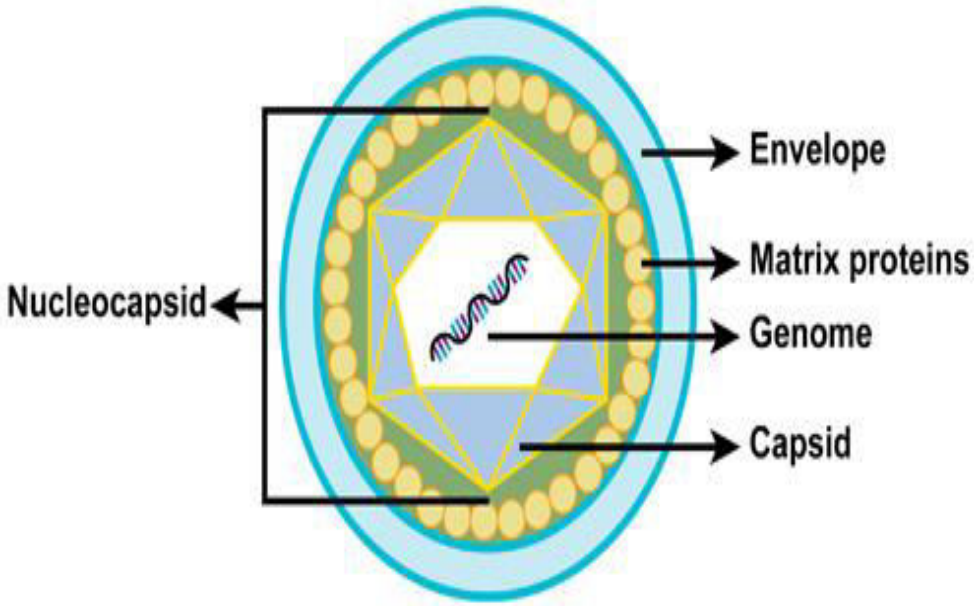






Structure of Viruses
Virion

- The complete infectious unit of virus particle
- Structurally mature, extracellular virus particles.



Structure of Viruses
Viral genome (core)

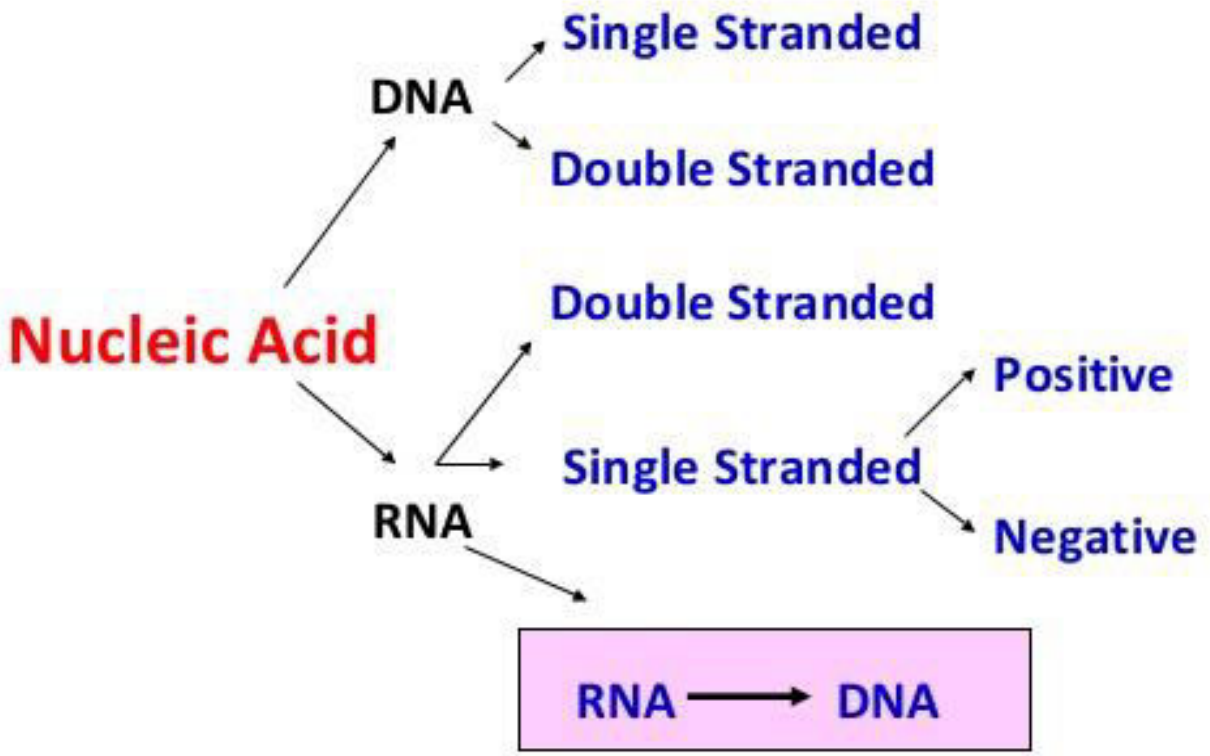
- Viral core
  - The viral nucleic acid genome, In the center of the virion
  - Control the viral heredity and variation, responsible for the infectivity.

Structure of Viruses
Genome

- **The genome of a virus can be either DNA or RNA**

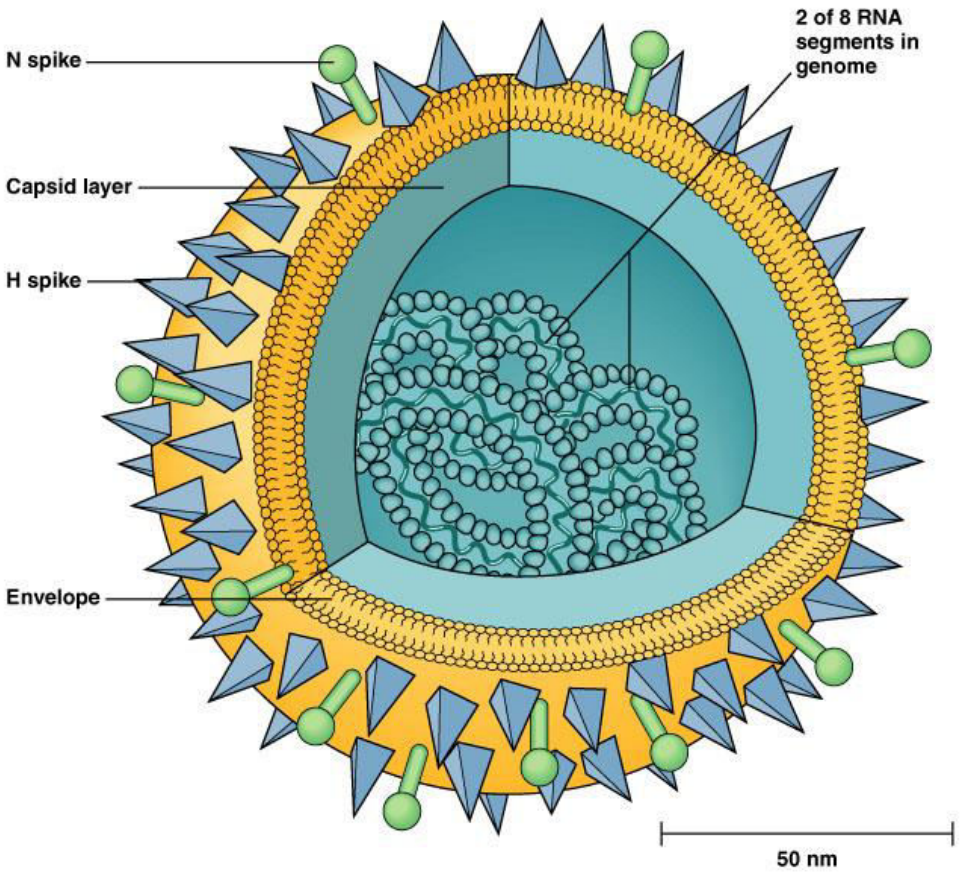
- **DNA-double stranded (ds): linear or circular**
  Single stranded (ss) : linear or circular
- **RNA- ss:segmented or non-segmented**
  ss:polarity+(sense) or polarity –(non-sense)
  ds: linear (only reovirus family)

Viral Genomes



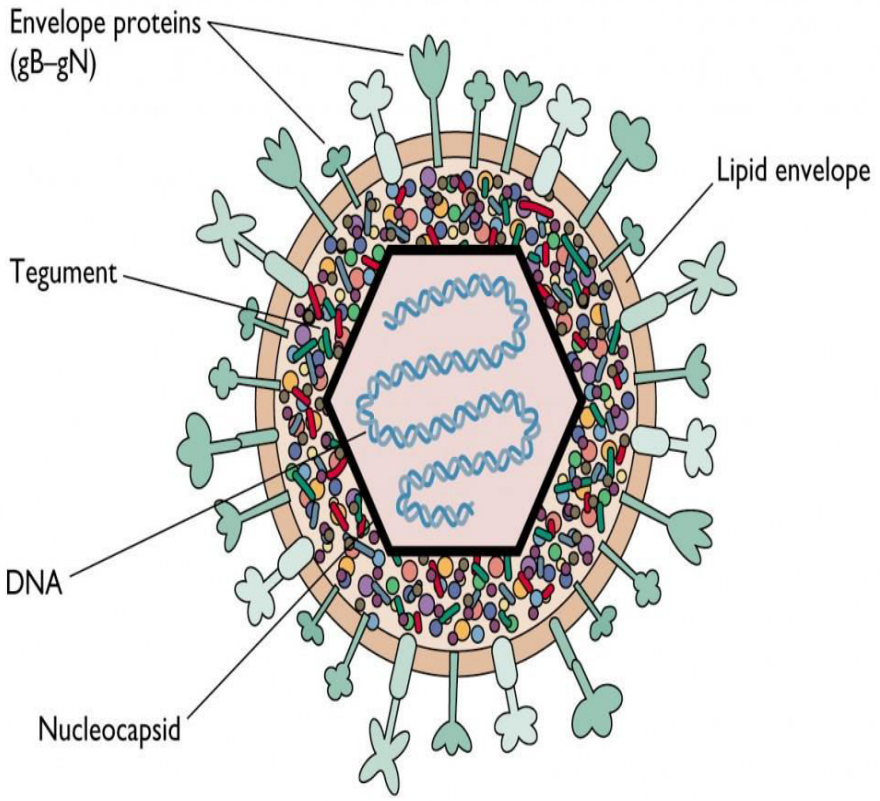
Structure of Viruses
Viral Capsid

- The protein shell, or coat, that encloses the nucleic acid genome.
- Functions:
  - Protect the viral nucleic acid.
  - Participate in the viral infection.
  - Share the antigenicity



Structure of Viruses
Nucleocapsid

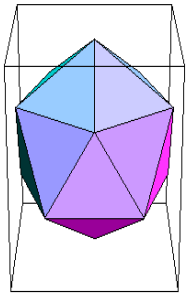
- The core of a virus particle consisting of the genome plus a complex of proteins.
- complex of proteins = Structural proteins +Non-Structural proteins (Enzymes &Nucleic acid binding proteins)

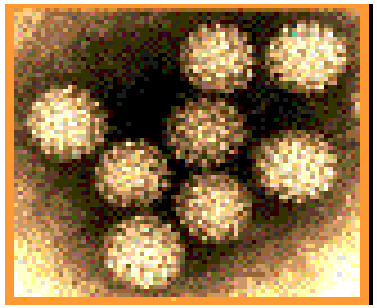


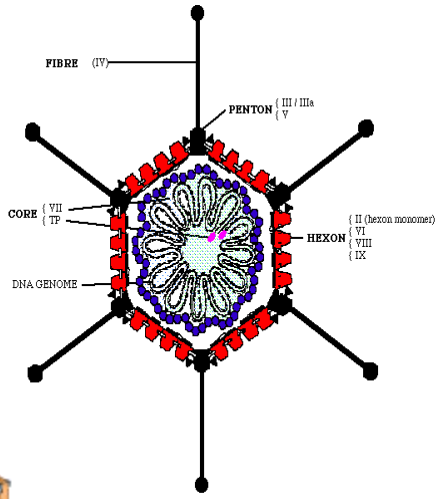
Symmetry of Nucleocapsid

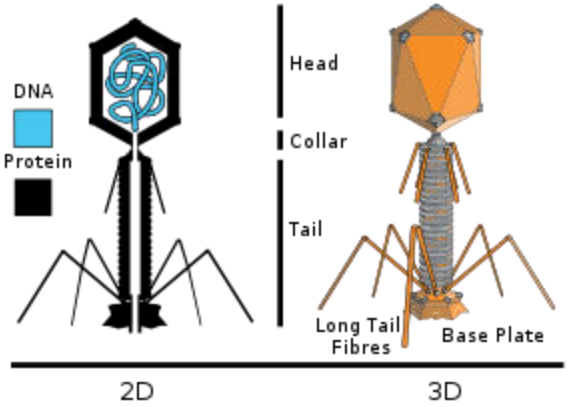
- Helical
- Cubic /Icosahedral
- Complex











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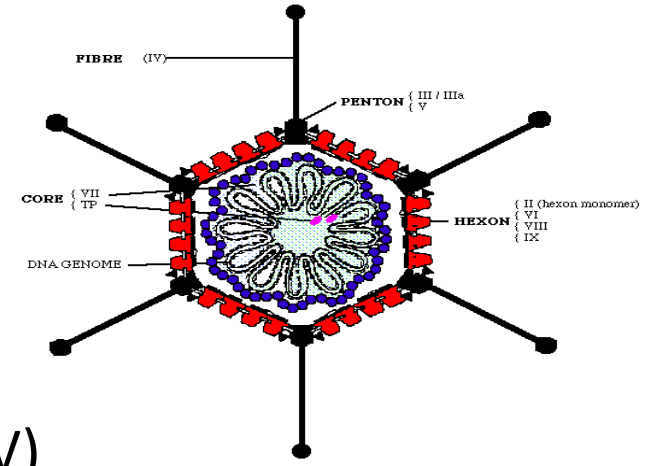
Helical

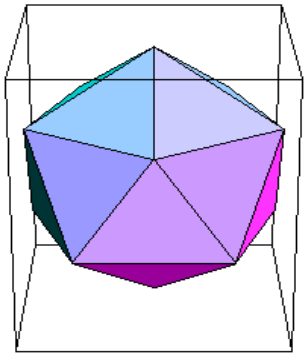
- California Encephalitis Virus
  Coronavirus
  Hantavirus
  Influenza Virus (Flu Virus)
  Measles Virus (Rubeola)
  Mumps Virus
  Parainfluenza Virus
  Rabies Virus
  Respiratory Syncytial Virus(RSV)



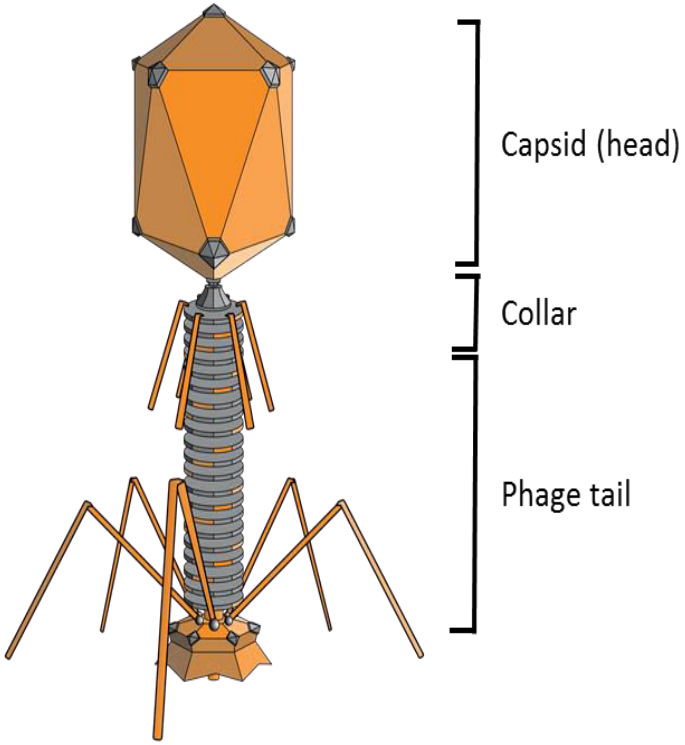
Cubic or icosahedral symmetry

- Adeno-associated Virus (AAV)
  Adenovirus
  B19
  Coxsackievirus - A
  Coxsackievirus - B
  Cytomegalovirus (CMV)
  Eastern Equine Encephalitis Virus (EEEV)
  Echovirus
  Epstein-Barr Virus (EBV)
  Hepatitis A Virus (HAV)
  Hepatitis B Virus (HBV)
  Hepatitis C Virus (HCV)
  Hepatitis Delta Virus (HDV)
  Hepatitis E Virus (HEV)



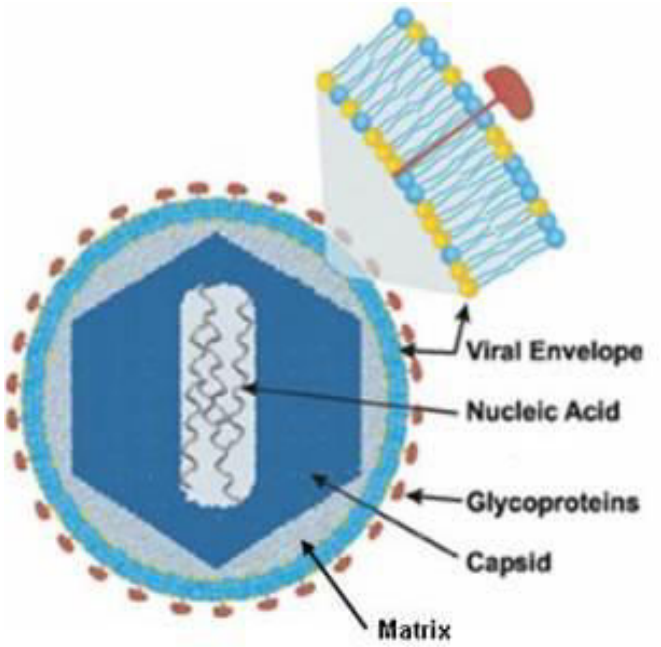


Complex Virus Structures



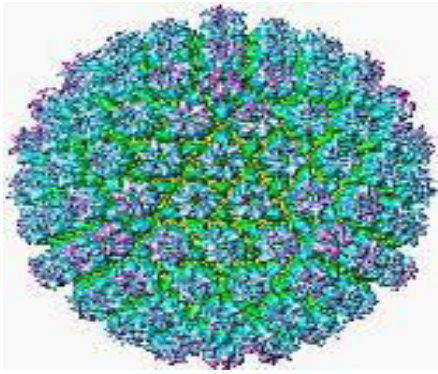
- **A well known example is the tailed bacteriophages such as T4.**
- **The head of these viruses is cubic with a triangulation number of 7. This is attached by a collar to a contractile tail with helical symmetry.**

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

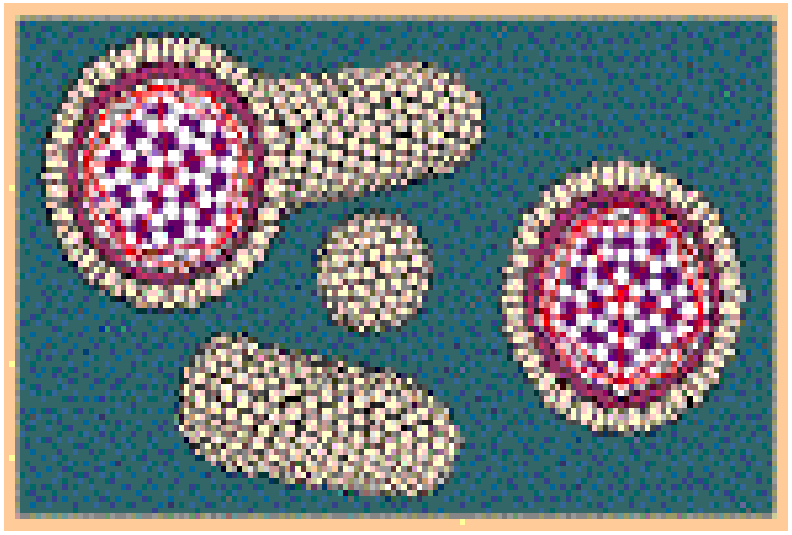


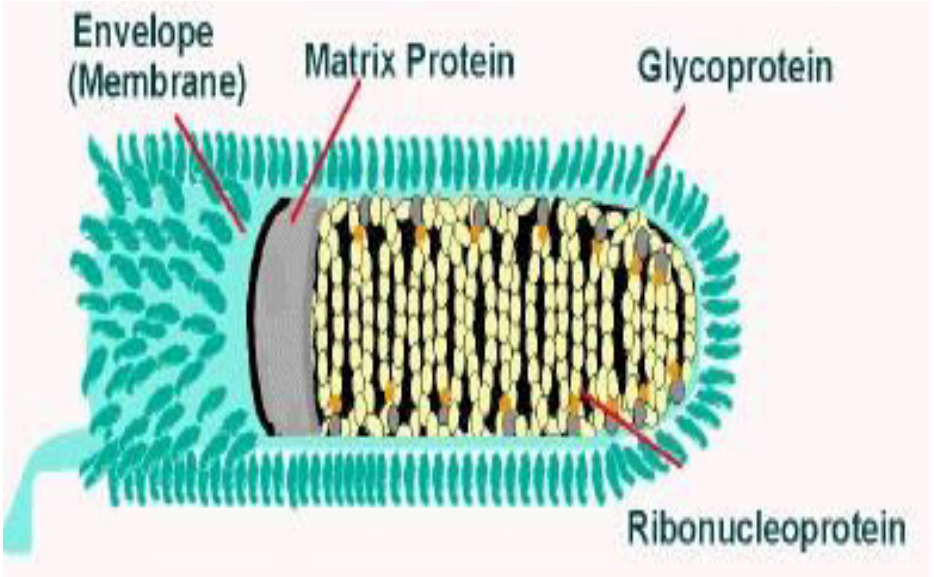
- Antigenicity

  some viruses possess neuraminidase

- Infectivity

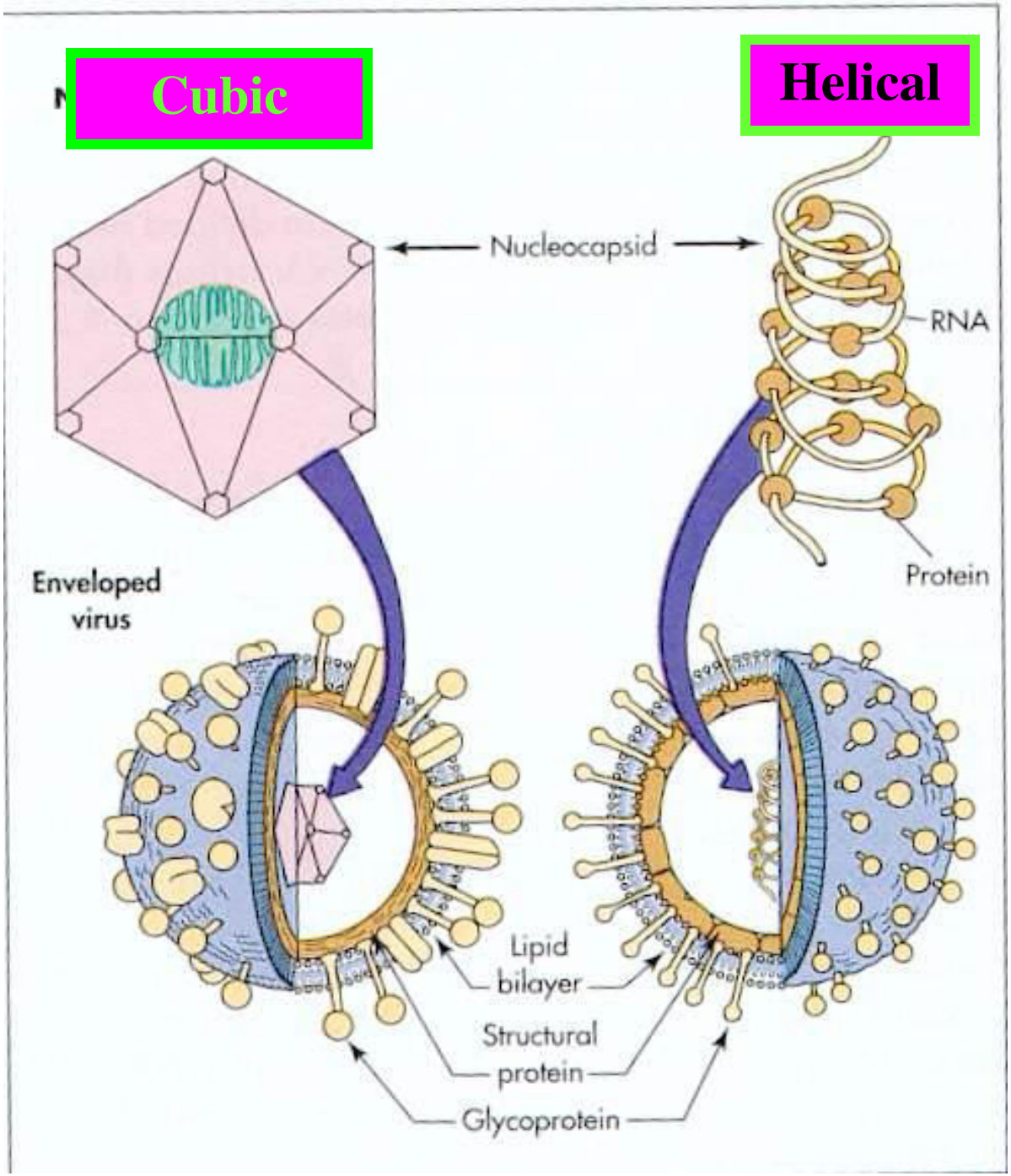
- Resistance





Virion structure
Naked and Enveloped

- **Nucleocapsid (Naked Virus) = DNA or RNA +Structural proteins +Enzymes &Nucleic acid binding proteins**
- **Enveloped Virus =Nucleocapsid+ Viral specific glycoproteins and Host Membrane**



Naked Virus

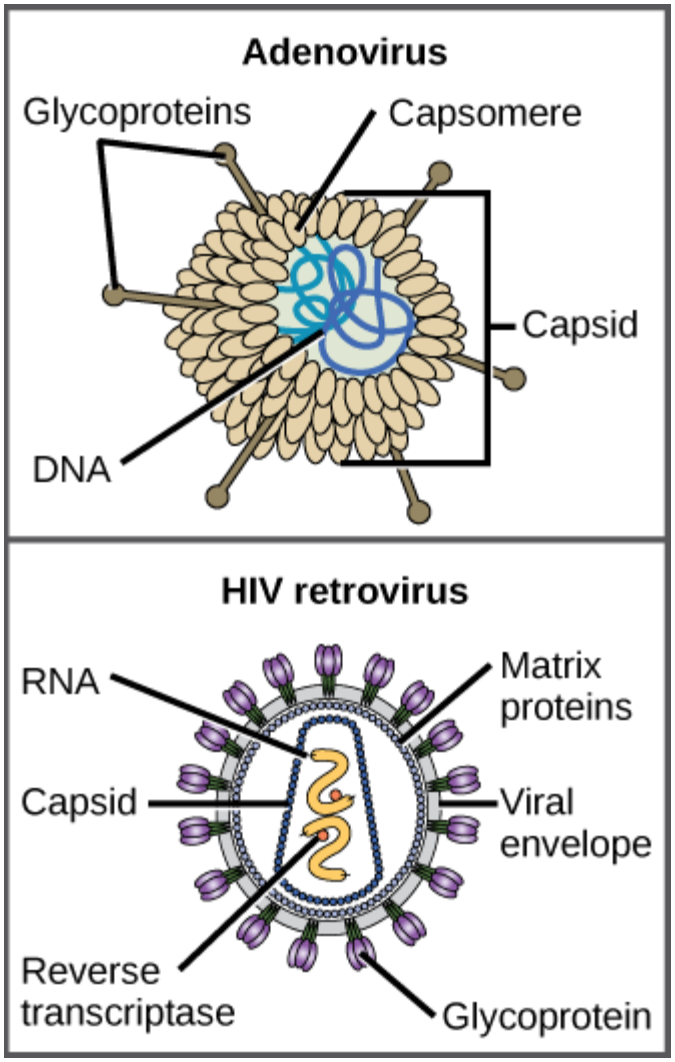
Enveloped Virus

CHEMICAL COMPOSITION OF VIRUSES

- **Viral Protein**
- **Viral Nucleic Acid**
- **Viral Lipids**
- **Viral carbohydrate**

Viral Protein

- **Structural protein (Capsomere)**
- **Enzyme**
- **glycoproteins (spike/viral attachment protein, VAP)**



Viral Nucleic Acid

- **DNA-double stranded (ds): linear or circular**

  Single stranded (ss) : linear or circular
- **RNA- ss:segmented or non-segmented**

  ss:polarity+(sense) or polarity –(non-sense)

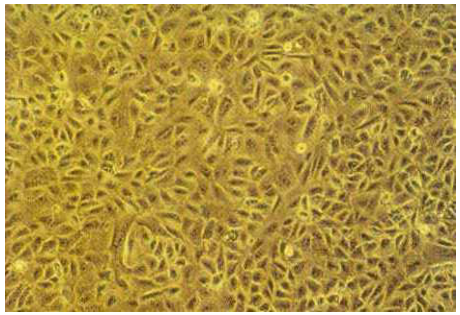
  ds: linear (only reovirus family)

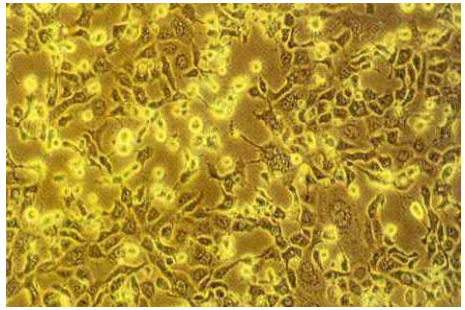
System for the propagation of viruses

- Human
- Animals : cows; chickens; mice; rats; suckling mice
- Embryonated eggs
- Organ and tissue culture
  - Organ culture
    - primary tissue culture
    - cell lines: diploid
    - Tumor or immortalized cell line

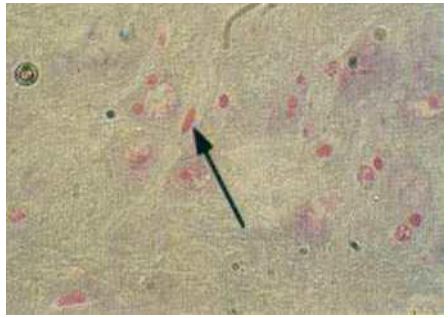
Pathgenisity of viruses

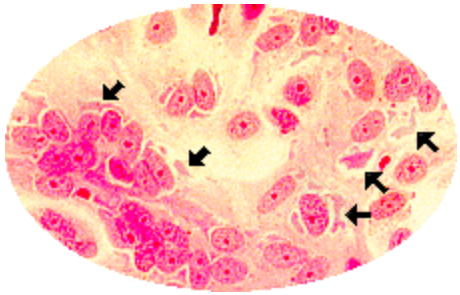
- Cytopathic effect, CPE
  - Inclusion Bodies





Normal cell and CPE





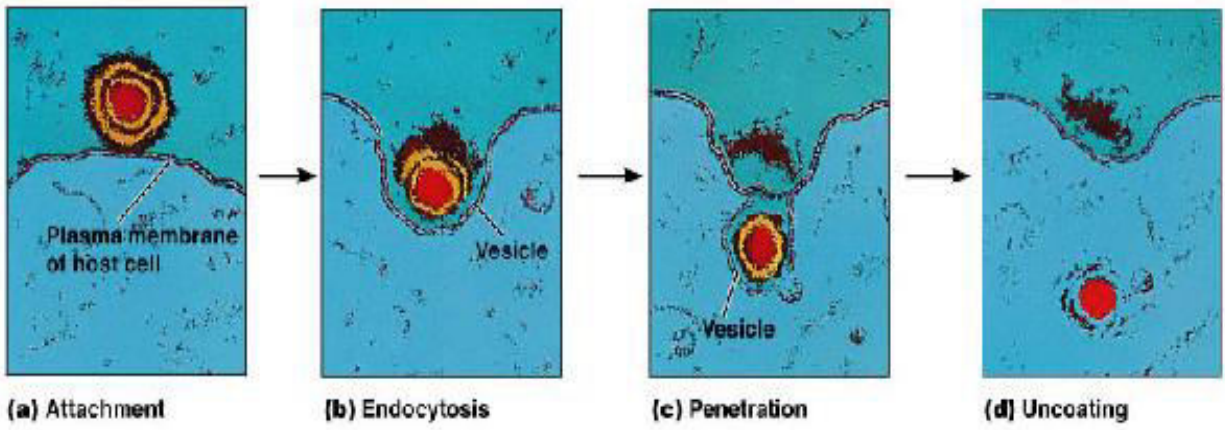
Negri body

CPE:Viral Cytopathological Effects

- Cell death
  - Cell rounding/Degeneration/Aggregation
  - Lass of attachments to substrate
- Inclusion bodies in the nucleus or cytoplasm, margination of chromatin
- Syncytia: multinucleated giant cells caused by virus-induced cell-cell fusion
- Cell surface changes
  - Viral antigen expression
  - Hemadsorption (hemagglutinin expression)

Replication of Viruses
Initiation Phase

- **Attachment**
- **Penetration**
- **Uncoating**

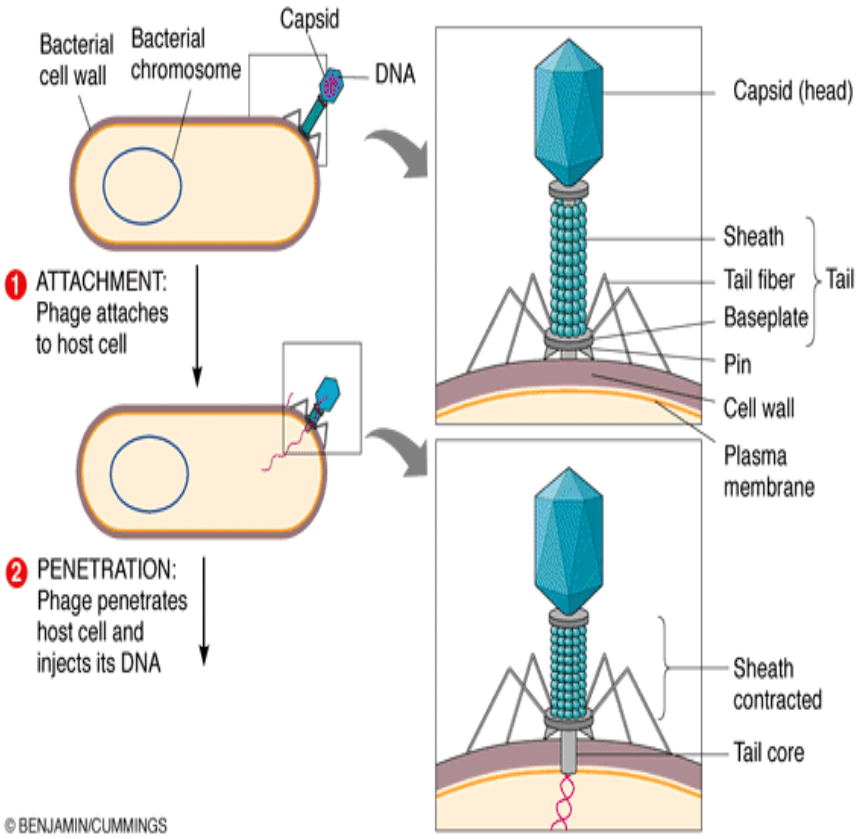


Attachment/Adsorption

- Attachment is via ionic interactions which are temperature-independent.
- Viral attachment protein recognizes specific receptors on the cell surface (These may be protein or carbohydrate or lipid components of the cell surface).

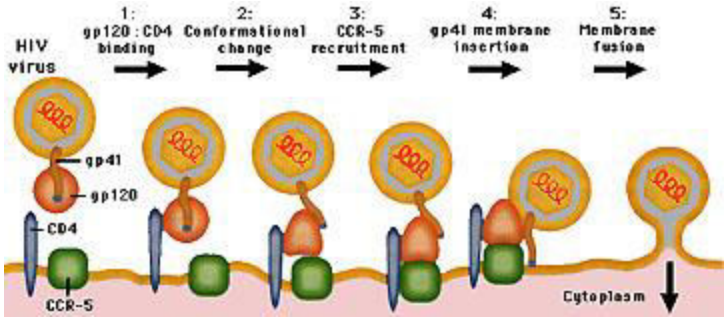
PENETRATION
(Virus enters the cell)

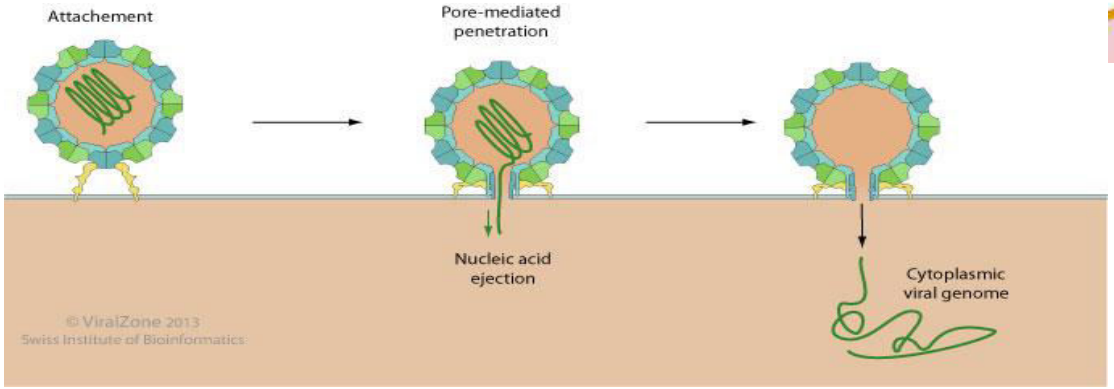
- **Virions are either engulfed into vacuoles by "endocytosis" or the virus envelope fuses with the plasma membrane**
- **Enveloped viruses**
- **Non-enveloped viruses**



Fusing

- (A) Entry by **<u>fusing with the plasma membrane</u>**. Some enveloped viruses fuse directly with the plasma membrane. Thus, the internal components of the virion are immediately delivered to the cytoplasm of the cell.

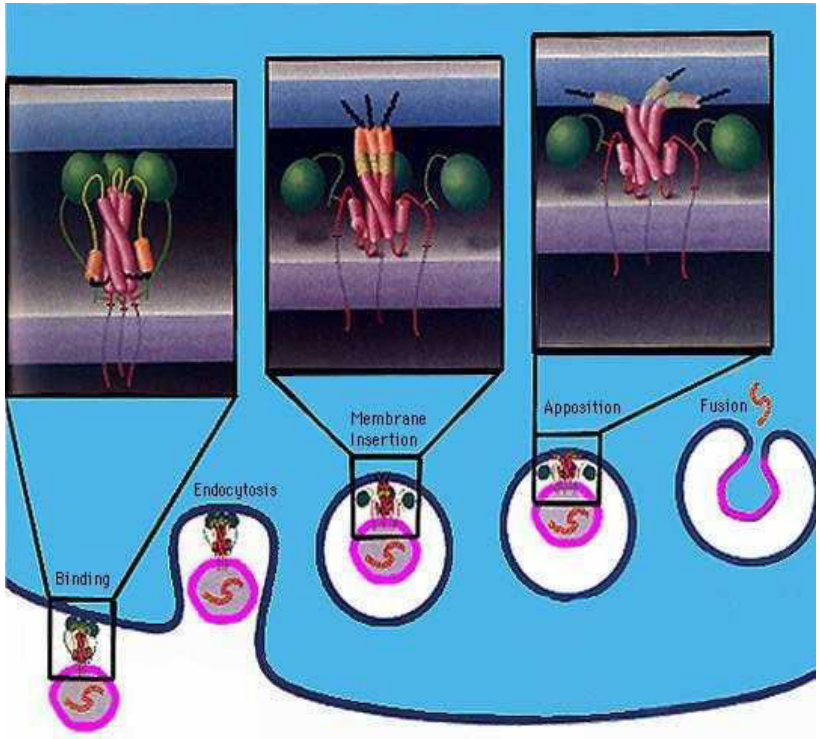




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Endocytosis

- (B) Entry **via endosomes at the cell surface**

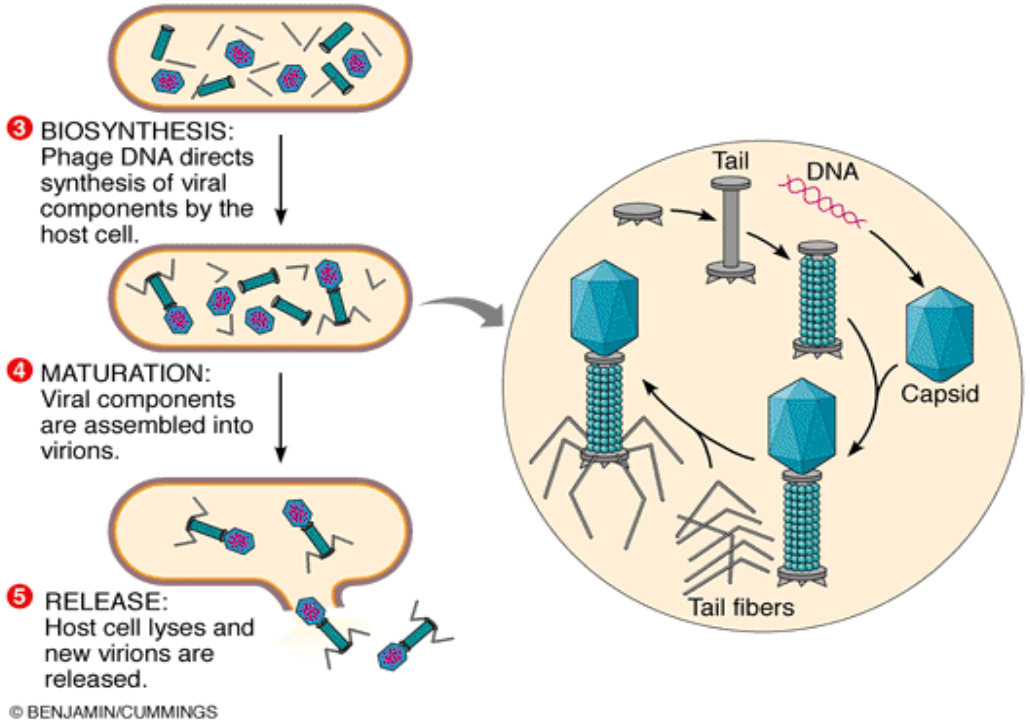


UNCOATING

- Uncoating is usually achieved by cellular proteases “opening up” the capsid

Maturation

- The stage of viral replication at which a virus particle becomes infectious; nucleic acids and capsids are assembled together.



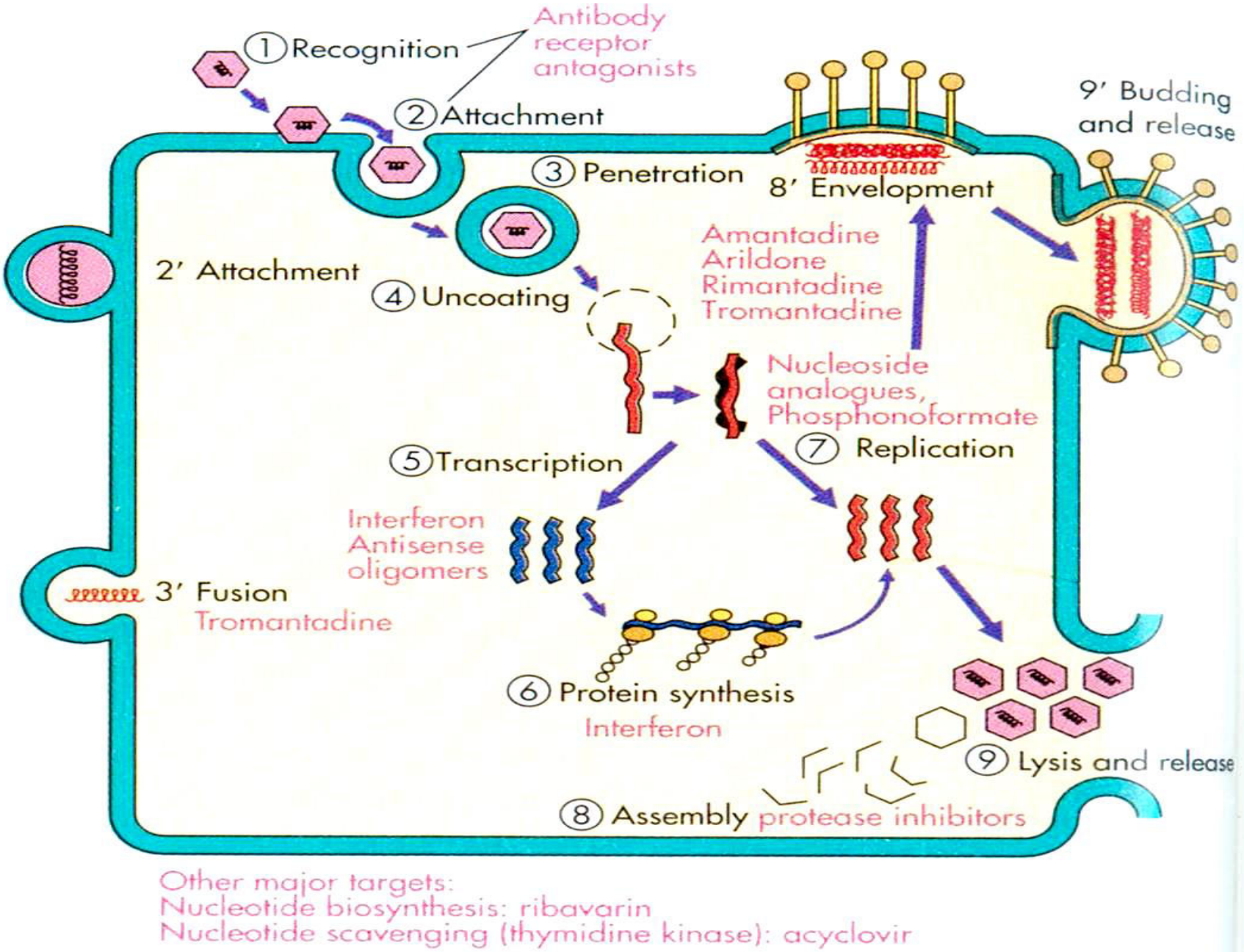
ASSEMBLY

- The stage of replication during which all the structural components come together at one site in the cell and the basic structure of the virus particle is formed.

RELEASE

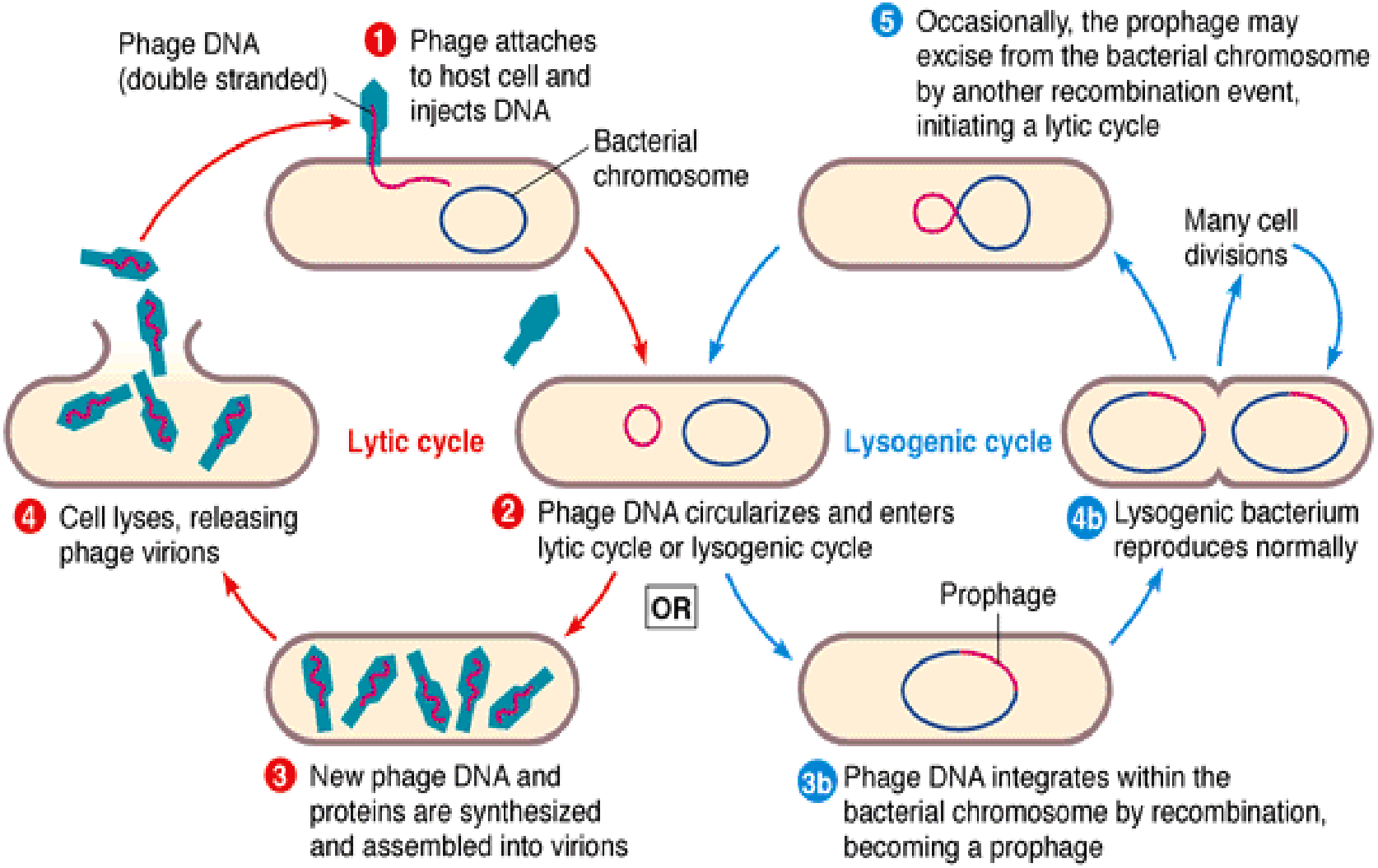
- Disintegration : naked virus cause the host cell lysis
- Budding: enveloped viruses

- Budding viruses do not necessarily kill the cell. Thus, some budding viruses may be able to set up persistence



Other major targets:
Nucleotide biosynthesis: ribavarin
Nucleotide scavenging (thymidine kinase): acyclovir

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Classification of Viruses

Levels of taxonomy

Taxonomic level	Suffix (comment)	Example
Order	-virales (a group of related families)	*Mononegavirales*
Family	-viridae	*Paramyxoviridae*
Subfamily	-virinae	*Paramyxovirinae*
Genus	-virus	*Morbillivirus*
Species	(an individual virus)	*Measles virus*

CLASSIFICATION OF VIRUSES
-------basis of classification

- Virion morphology
- Physicochemical properties of the virion
- Virus genome properties
- Virus protein proteries
- Genome organization and replication
- Antigenic properties
- Biologic properties

Emerging Viral Diseases

Filovirus: A virus harbored in animals without harming them*; then* passed on to another animal who is harmed

FOR EXAMPLE: **Ebola** :30-90% mortality hemorrhagic fever.

Other Infectious Agent--Prions

Small abnormal **forms of proteins** necessary for operation of neuronsproteins

Proteins coagulate as large deposits in brain-

Linked to human diseases

- Kuru
- Creutzfeldt-Jakob disease (CJD)

Animal diseases

- Scrapie in sheep
- Bovine spongiform encephalopathy(mad cow disease)

Defense Against Viruses

1. ??Antibiotics—INEFFECTIVE—

   because they target cellular processes (viruses are not alive—no cell/processes)

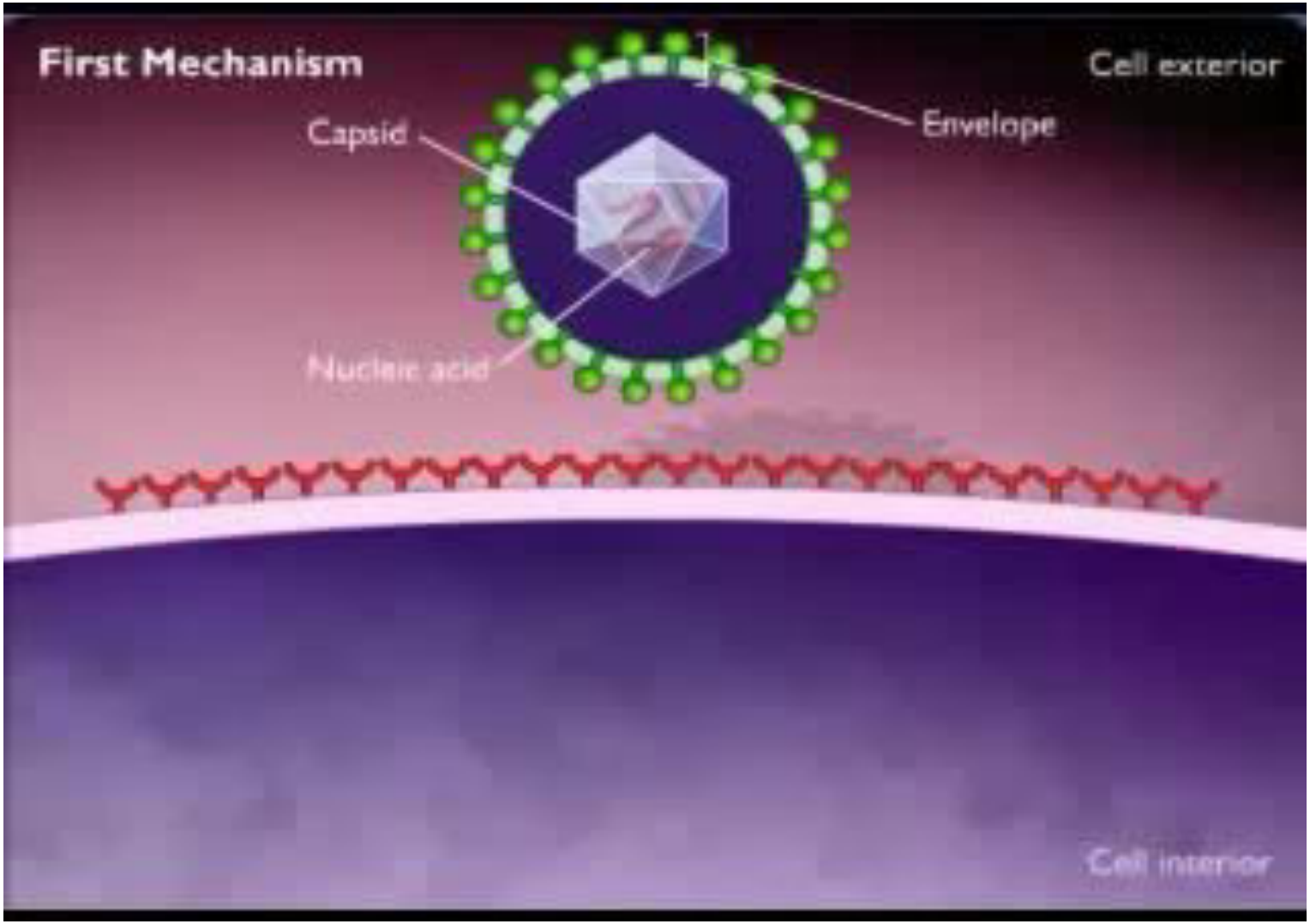
2. Vaccinations—Made of viruses which have been treated so they are harmless

   Create our own self-defense-build internal antibodies against *specific* viruses.

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Defense Against Viruses

- 3. Virus-Destroying Drugs. They destroy the virus BUT ALSO DESTROY HOST CELL
  - Example: AZT-slows down AID's; it's toxic therefore side effects


First Mechanism
Cell exterior
Envelope
Capsid
Nucleic acid
Cell interior

Replication Cycle of an Envelope Virus

By: Tom Thalhuber, Kim Linson and Max Burton