Virology I

Lecture 22

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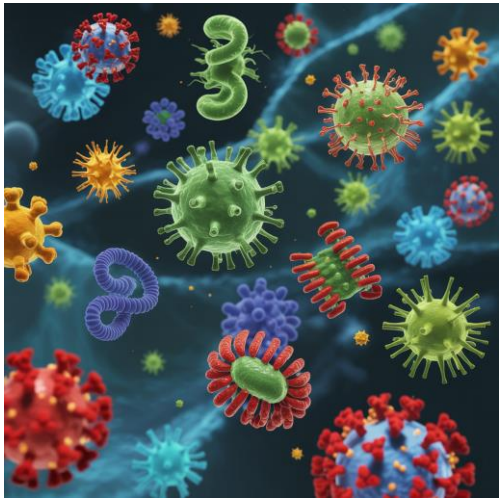


Objectives

- What is a virus?
- Can we consider it to be alive or alive cell?
- What is the structure/function of the virus?
- How do viruses infect?
- What are prions?

History

- Louis Pasteur postulated that rabies was caused by a virus (1884).
- Ivanovsky showed a disease in tobacco was caused by a virus (1890s)
- 1950s virology was a multifaceted discipline
  - Viruses: noncellular particles with a definite size, shape, and chemical composition

The Position of Viruses in the Biological Spectrum

- Smallest infectious agents.
- There is no universal agreement on how and when viruses originated.
- Viruses are considered the most abundant microbes on earth.
- Viruses played a role in the evolution of Bacteria, Archaea, and Eukarya.
- Viruses are obligate intracellular parasites.

Virus properties

- Obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants, and animals.
- Ultramicroscopic size ranging from 20 -750 nm(diameter) (EM); only Pox viruses by LM.
- Based on size viruses considered Ultracentrifugation.
- Not cellular in nature.
- Inactive macromolecules outside the host cell and active only inside host cells.
- Basic structure consists of protein shell (capsid) surrounding nucleic acid core.

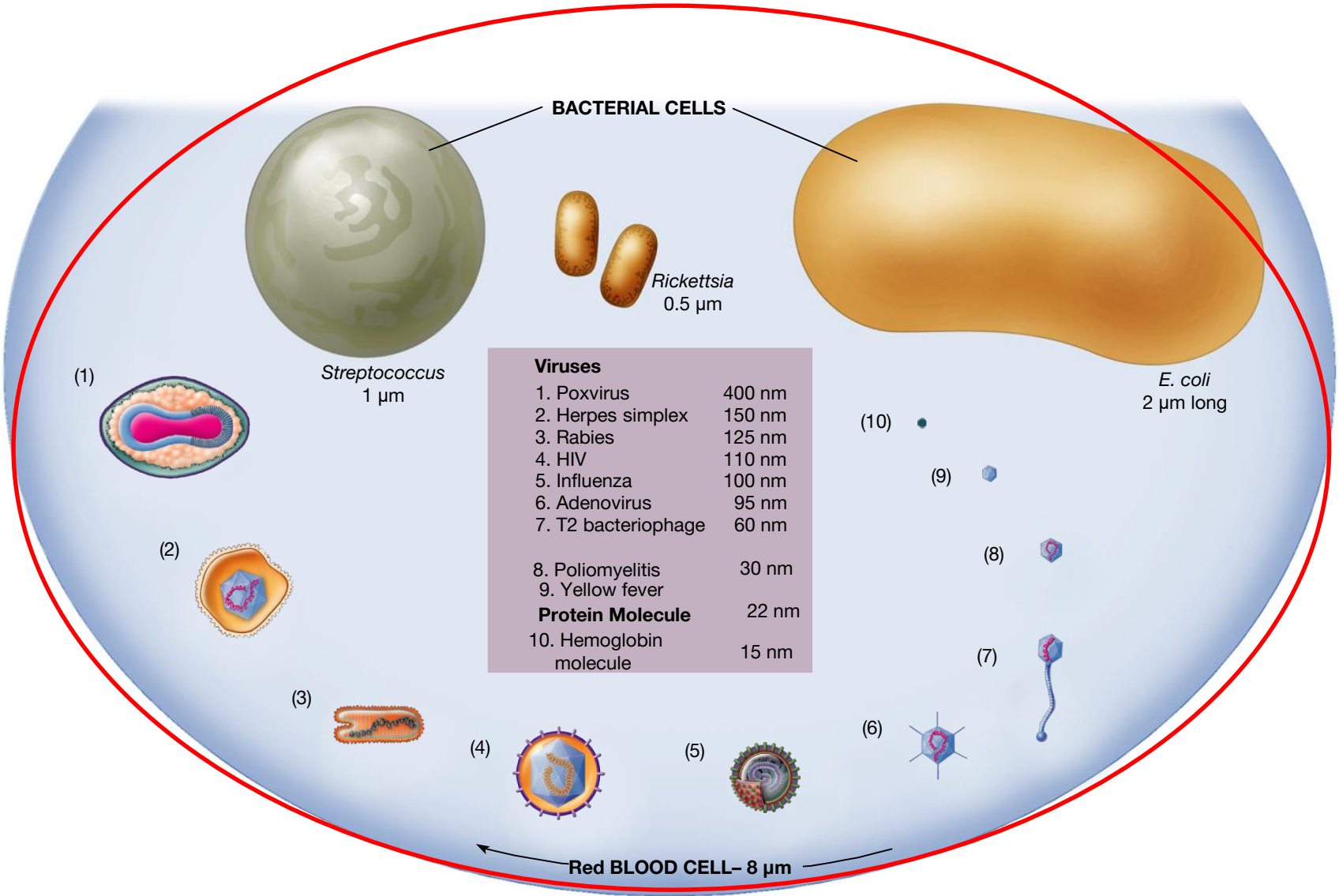
Con…

Virus properties

- Nucleic acid can be either DNA or RNA but not both.
- Nucleic acid can be double-stranded DNA, single-stranded DNA, single-stranded RNA, or double-stranded RNA.
- Molecules on virus surface impart high specificity for attachment to host cell. (Spike proteins)
- Multiply by taking control of host cell's genetic material and regulating the synthesis and assembly of new viruses.
- Lack enzymes for most metabolic processes. Only Ez for replication.
- Lack machinery for synthesizing proteins

General Size of Viruses

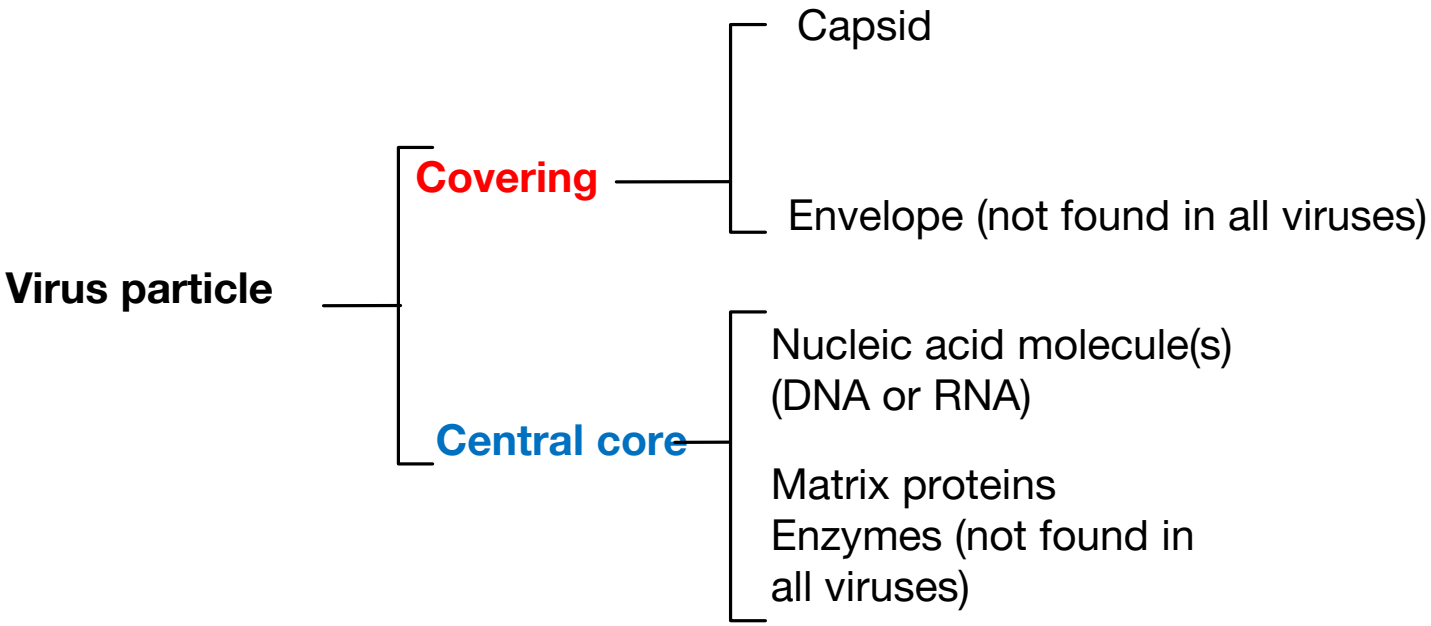
- Size range – most <0.2 μm; requires EM



Viral Structure

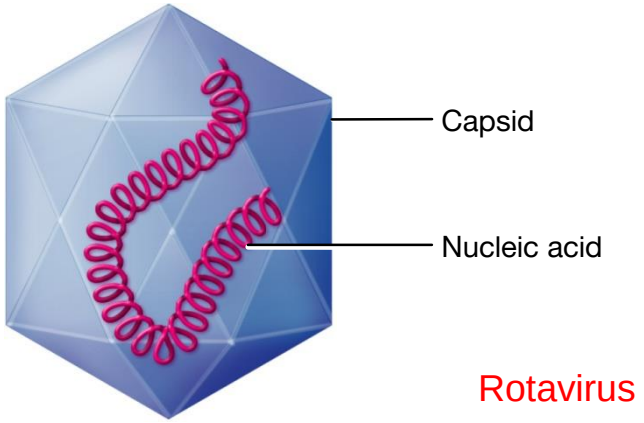
- Viruses bear no resemblance to cells
  - Lack protein-synthesizing machinery

- Viruses contain only the parts needed to invade and control a host cell

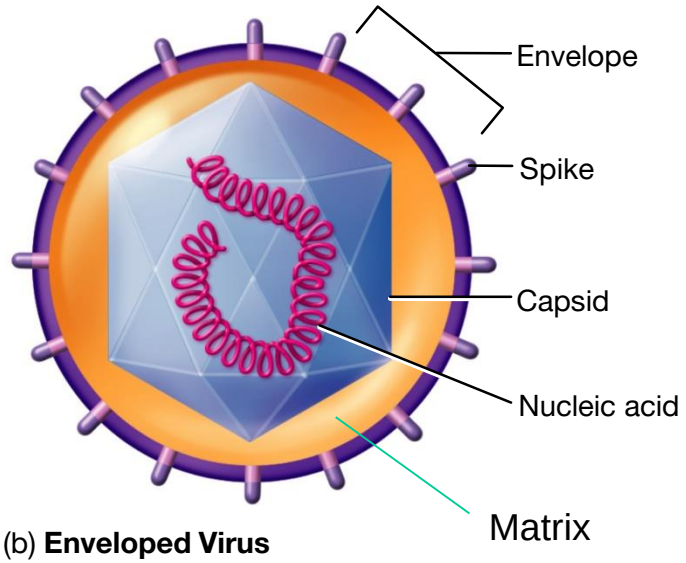


General Structure of Viruses

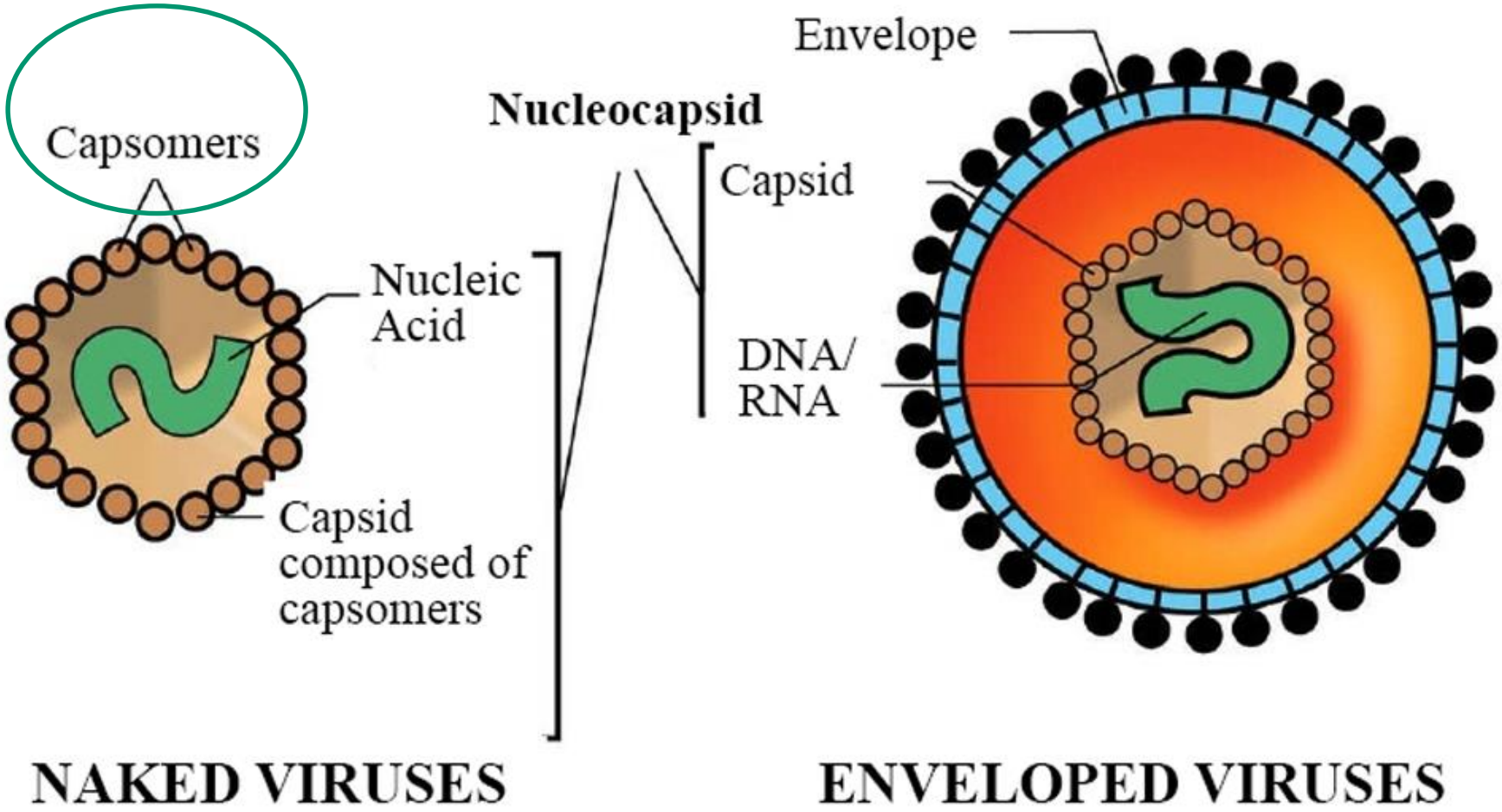
- **Capsids**
  - All viruses have capsids (protein coats that enclose and protect their nucleic acid)
  - The capsid together with the nucleic acid is the **nucleocapsid**
  - Some viruses have an external covering called an **envelope**; those lacking an envelope are **naked**
  - Each capsid is made of identical protein subunits called **capsomers**



(a) **Naked Nucleocapsid Virus**



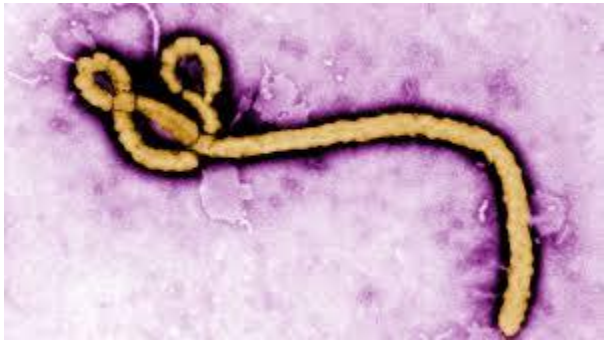
(b) **Enveloped Virus**


Capsomers
Nucleic Acid
Capsid composed of capsomers
Nucleocapsid
Capsid
DNA/ RNA
Envelope
NAKED VIRUSES
ENVELOPED VIRUSES

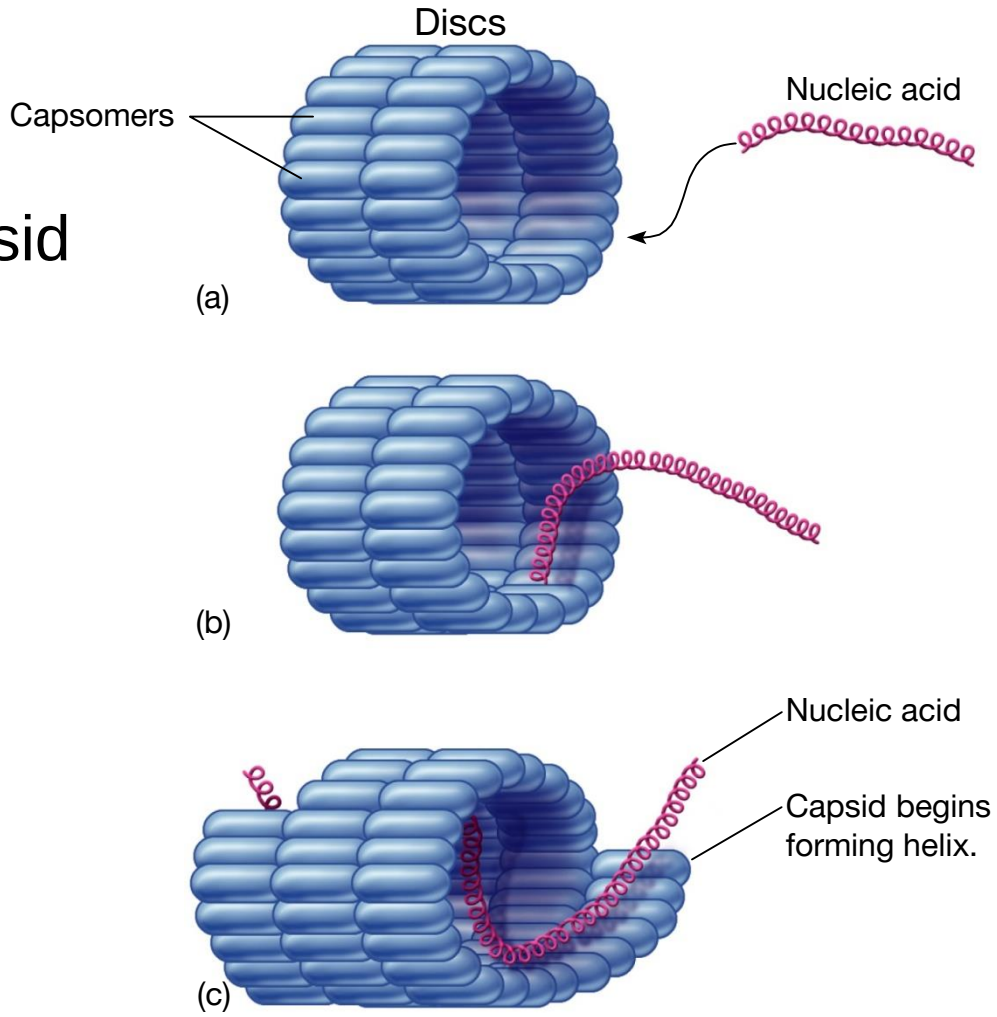
General Structure of Viruses

- Two structural capsid types:

A. Helical - continuous helix of capsomers forming a cylindrical nucleocapsid



Ebolavirus



B. Icosahedral

General Structure of Viruses

- Two structural capsid types:

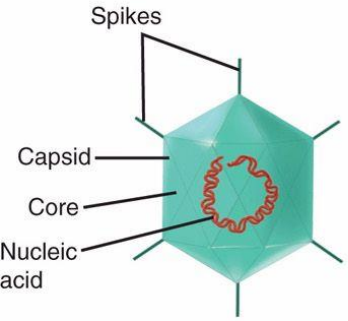
A. Helical: <u>All RNA viruses</u>.

Except (*Picornaviridiae*, *Flaviviridae*, *Togaviridae*, *Reoviridae*)

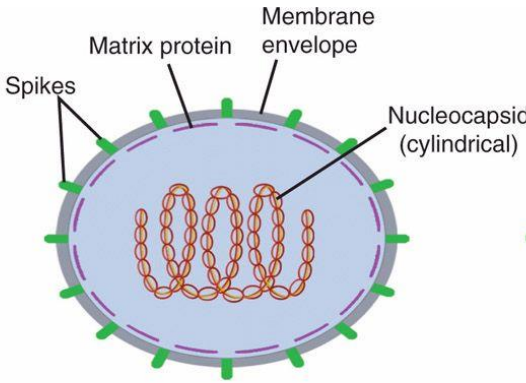
B. Icosahedral - 20-sided with 12 corners.

– During assembly of virus, the nucleic acid is packed into the center Icosahedral, forming nucleocapsid.

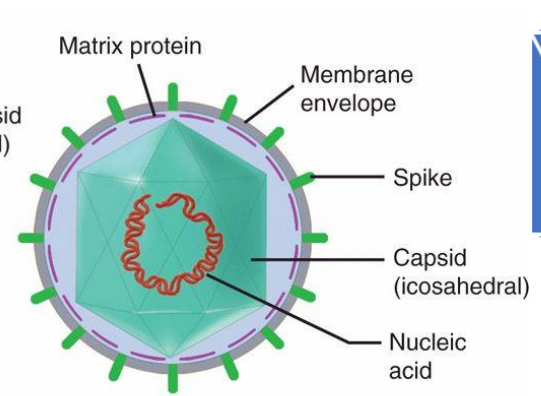
– All DNA viruses are **Icosahedral** only Poxviruses have complex structure.



Naked capsid virus (icosahedral capsid)



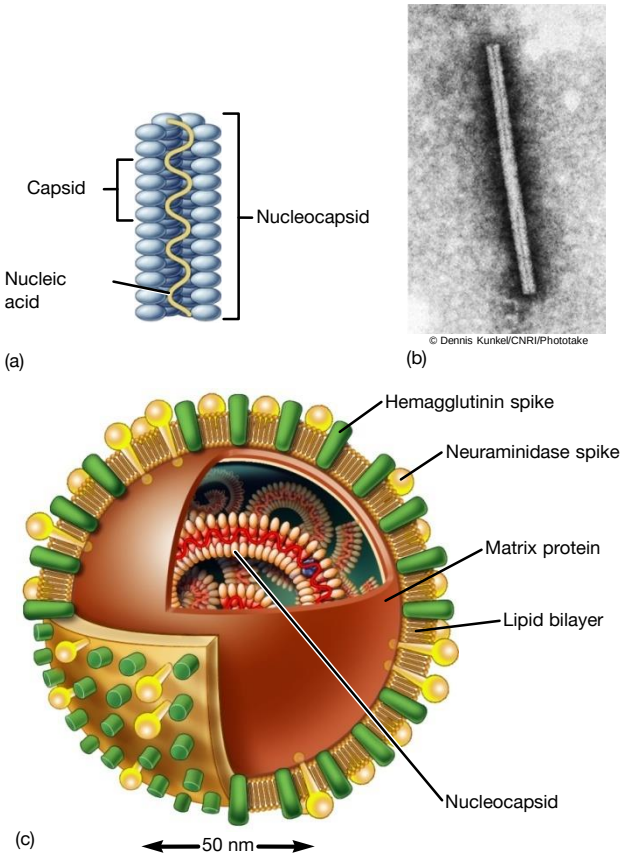
Enveloped virus (helical nucleocapsid)



Enveloped virus (icosahedral capsid)

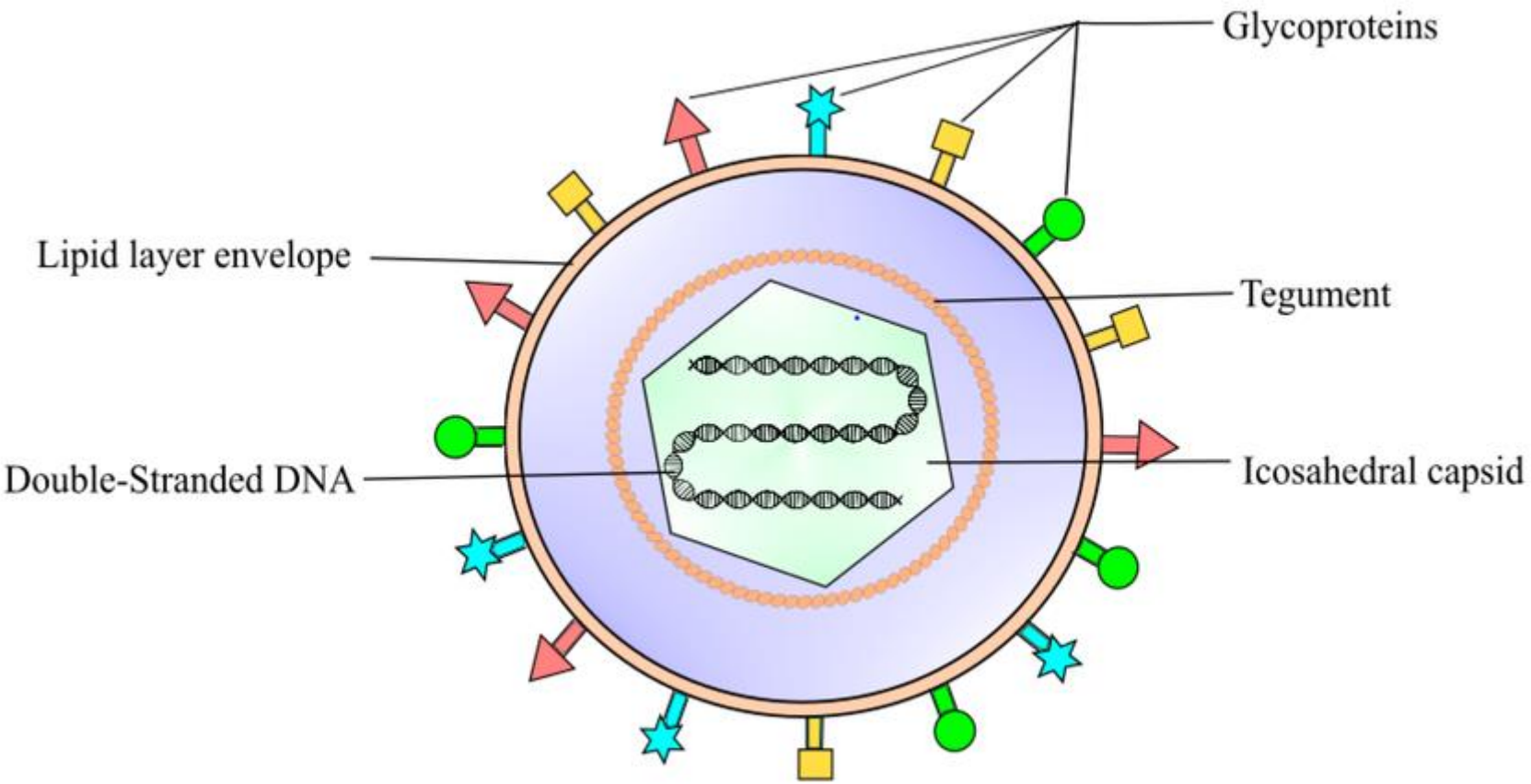
General Structure of Viruses

- **Viral envelope**
  - Mostly animal viruses
  - Acquired when the virus leaves the host cell
  - Its lipid or lipoproteins.
  - Exposed proteins on the outside of the envelope, called **spikes**, are essential for attachment of the virus to the host cell
  - Ether sensitive
  - E.g; Herpes simplex



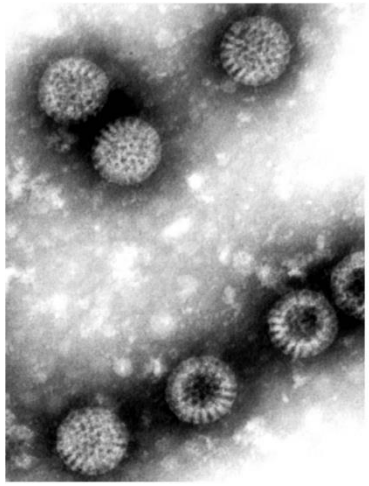
Flu virus

Herpes simplex virus



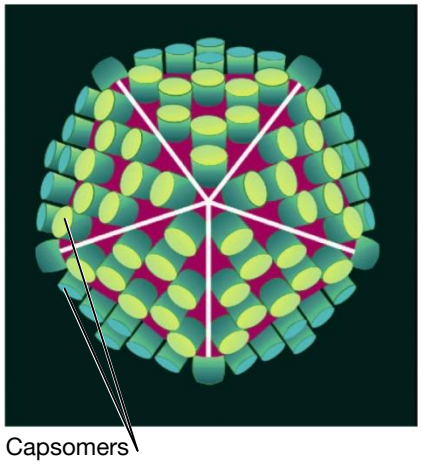
Functions of Capsid/Envelope

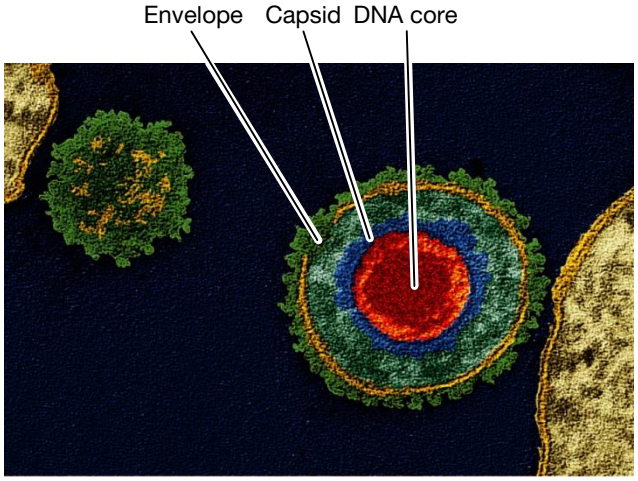
- Protects the nucleic acid when the virus is outside of the host cell
- Helps the virus bind to a cell surface and assists the penetration of the viral DNA or RNA into a suitable host cell.
- Immunogenic.



Fred P. Williams, Jr./EPA

(a)



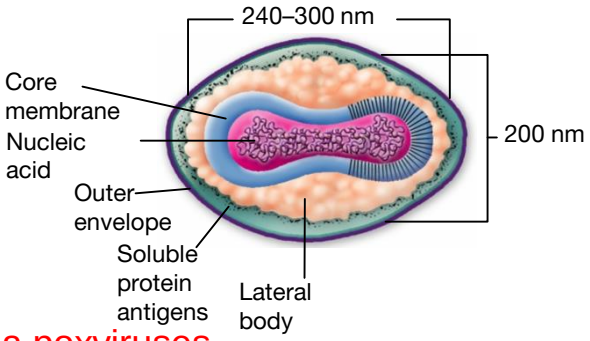


(b)

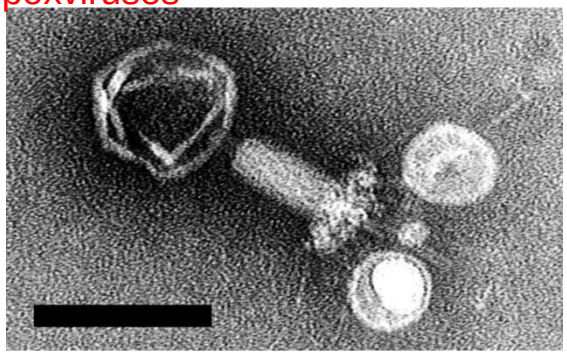
General Structure of Viruses

C. **Complex** viruses: atypical viruses

- Poxviruses lack a typical capsid and are covered by a dense layer of lipoproteins
- Some **bacteriophages** have a polyhedral nucleocapsid along with a helical tail and attachment fibers



(a) Vaccina virus, a poxviruses



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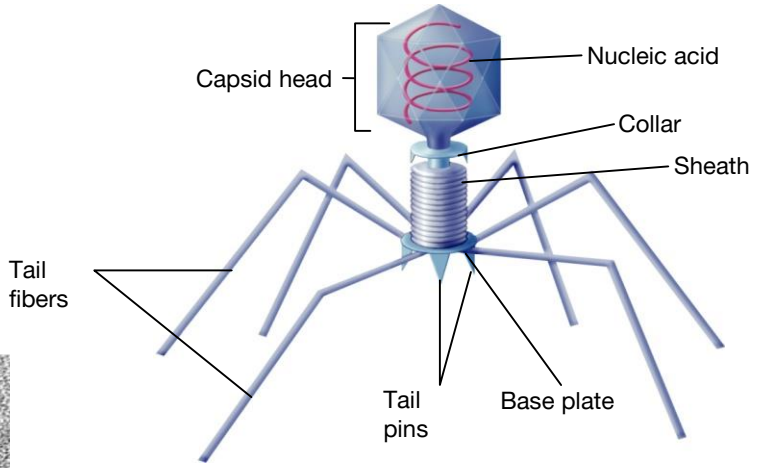


(c) T4 bacteriophage

Types of Viruses

A. Complex Viruses

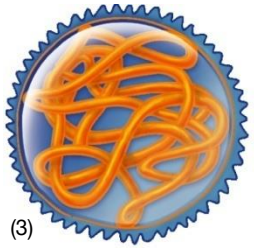
A. Complex viruses:
(1) poxvirus, a large DNA virus
(2) flexible-tailed bacteriophage


(1)


(2)

B. Enveloped Viruses

Helical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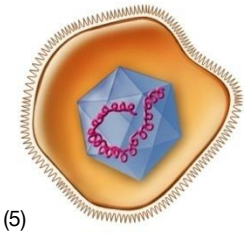
Icosahedral


(5)


(6)

C. Naked viruses:

Helical capsid:
(7) plum poxvirus

Icosahedral capsid:
(8) poliovirus
(9) papillomavirus

C. Nonenveloped Naked Viruses

Helical


(7)

Icosahedral


(8)


(9)

B. Enveloped viruses:

With a helical nucleocapsid:
(3) mumps virus
(4) rhabdovirus (Rabies)

With an icosahedral nucleocapsid:
(5) herpesvirus
(6) HIV (AIDS)

Nucleic Acids

- **Viral genome** – either DNA or RNA but never both.

- Carries genes necessary to invade host cell and redirect cell's activity to make new viruses.

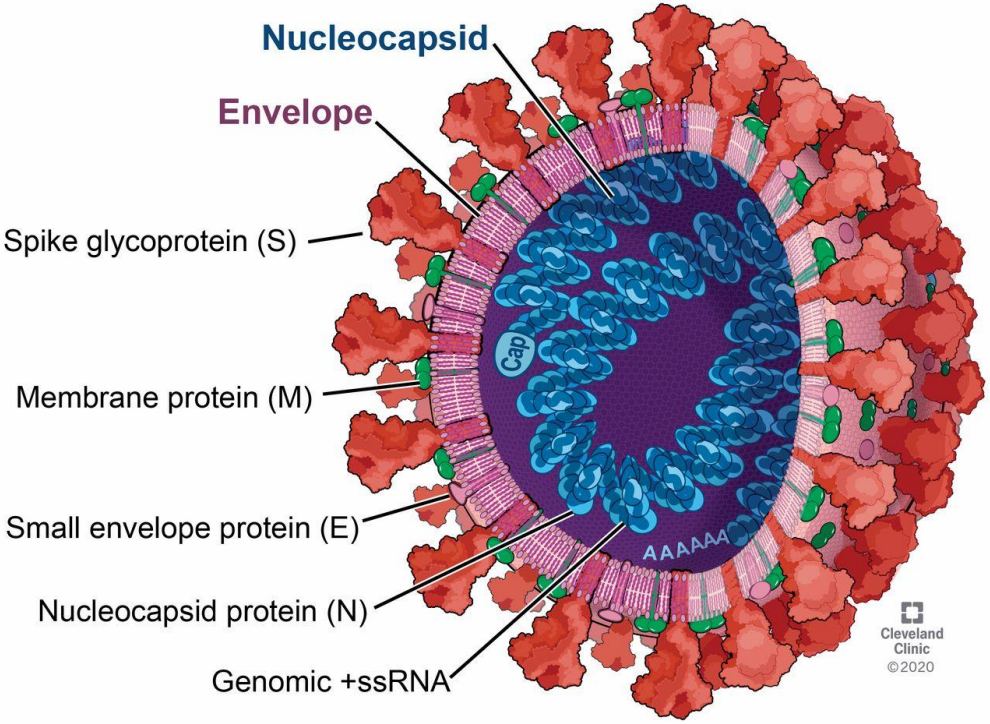
- Number of genes varies for each type of virus – few to hundreds.

Nucleic Acids

- DNA viruses
  - Usually double stranded (ds) but may be single stranded (ss)
  - Circular or linear
- RNA viruses
  - Usually (ss), may be (ds), may be segmented into separate RNA pieces.
  - ssRNA genomes ready for immediate translation are **positive-sense RNA**
  - ssRNA genomes that must be converted into proper form (positive-sense RNA) are **negative-sense RNA**; that required a viral RNA-dependent RNA polymerase. e.g: Influenza virus, Ebola virus, Rabies virus, Measles virus.

CORONAVIRUSES

- Containing a single strand of positive-sense RNA.
- H**elical** nucleocapsid structure.



General Structure

- Pre-formed enzymes may be present
  - Polymerases – DNA or RNA
  - Replicases – copy RNA
  - Reverse transcriptase – synthesis of DNA from RNA (AIDS virus)

How Viruses Are Classified

- Main criteria presently used are structure, chemical composition, and genetic makeup

- Currently recognized: 59 orders, 189 families, and 2224 genera of viruses

  - Family name ends in -***viridae***, i.e.*Herpesviridae*

  - Genus name ends in -virus, *Simplexvirus*

  - Species Herpes simplex virus I (*HSV-I*)

Classification & Taxonomy of viruses

1. **According to nucleic acid type**
2. **According to host**
3. **According to symmetry**
4. **According to presence of envelope**
5. **According to clinical or affected organ systems** (e.g., respiratory, enteric, hepatic, or arboviruses).
6. **Baltimore Classification** (based on how viruses produce mRNA).

Human Viruses & Viral Diseases

TABLE 6.2 Important Human Virus Families, Genera, Common Names, and Types of Diseases

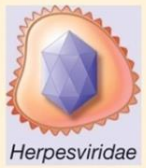
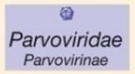
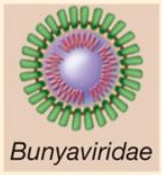
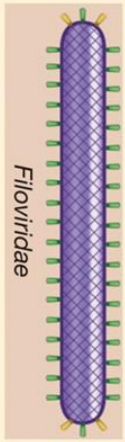
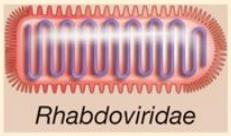
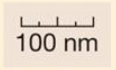
Nucleic Acid Type	Family	Genus of Virus	Common Name of Genus Members	Name of Disease
DNA Viruses				
 	Poxviridae	*Orthopoxvirus*	Variola and vaccinia	Smallpox, cowpox
	Herpesviridae	*Simplexvirus*	Herpes simplex 1 virus (HSV-1)	Fever blister, cold sores
			Herpes simplex 2 virus (HSV-2)	Genital herpes
		Varicellovirus	Varicella zoster virus (VZV)	Chicken pox, shingles
		Cytomegalovirus	Human cytomegalovirus (CMV)	CMV infections
	Adenoviridae	*Mastadenovirus*	Human adenoviruses	Adenovirus infection
	Papillomaviridae	*Papillomavirus*	Human papillomavirus (HPV)	Several types of warts
	Polyomaviridae	*Polyomavirus*	JC virus (JCV)	Progressive multifocal leukoencephalopathy
	Hepadnaviridae	*Hepadnavirus*	Hepatitis B virus (HBV or Dane particle)	Serum hepatitis
 	Parvoviridae	*Erythrovirus*	Parvovirus B19	Erythema infectiosum
 				
RNA Viruses				
	Picornaviridae	*Enterovirus*	Poliovirus	Poliomyelitis
			Coxsackievirus	Hand-foot-mouth disease
		Hepatovirus	Hepatitis A virus (HAV)	Short-term hepatitis
		*Rhinovirus*	Human rhinovirus	Common cold, bronchitis
	Caliciviridae	*Calicivirus*	Norwalk virus	Viral diarrhea, Norwalk virus syndrome
	Togaviridae	*Alphavirus*	Eastern equine encephalitis virus	Eastern equine encephalitis (EEE)
			Western equine encephalitis virus	Western equine encephalitis (WEE)
			Yellow fever virus	Yellow fever
			St. Louis encephalitis virus	St. Louis encephalitis

TABLE 6.2 (*Continued*)









	Rubivirus	Rubella virus	Rubella (German measles)
Flaviviridae	*Flavivirus*	Dengue fever virus	Dengue fever
		West Nile fever virus	West Nile fever
Bunyaviridae	*Bunyavirus*	Bunyamwera viruses	California encephalitis
	Hantavirus	Sin Nombre virus	Respiratory syndrome
	Phlebovirus	Rift Valley fever virus	Rift Valley fever
	Nairovirus	Crimean–Congo hemorrhagic fever (CCHF) virus	Crimean–Congo hemorrhagic fever
Filoviridae	*Filovirus*	Ebola, Marburg virus	Ebola fever
Reoviridae	*Coltivirus*	Colorado tick fever virus	Colorado tick fever
	Rotavirus	Human rotavirus	Rotavirus gastroenteritis
Orthomyxoviridae	*Influenza virus*	Influenza virus, type A (Asian, Hong Kong, and swine influenza viruses)	Influenza or "flu"
Paramyxoviridae	*Paramyxovirus*	Parainfluenza virus	Parainfluenza
		Mumps virus	Mumps
	Morbillivirus	Measles virus	Measles (red)
	Pneumovirus	Respiratory syncytial virus (RSV)	Common cold syndrome
Rhabdoviridae	*Lyssavirus*	Rabies virus	Rabies (hydrophobia)
Retroviridae	*Oncornavirus*	Human T cell leukemia virus (HTLV)	T-cell leukemia
	Lentivirus	HIV (human immunodeficiency viruses 1 and 2)	Acquired immunodeficiency syndrome (AIDS)
Arenaviridae	*Arenavirus*	Lassa virus	Lassa fever
Coronaviridae	*Coronavirus*	Infectious bronchitis virus (IBV)	Bronchitis
		Enteric corona virus	Coronavirus enteritis
		SARS virus	Severe acute respiratory syndrome

Effect physical and chemical agents on viruses

1. **Cold:**
   - Storage at -40 to -70c, or by lyophilization at 4c, via freezing then vacuum to remove water and O2 to be powder.
   - Stable at cold temp.

2. **Heat** at 50-60c/ 30min will be destroyed. Only HBV.

3. **Fluctuating temp**; will destroy viruses.
4. **Radiation**
5. **pH** 5-9 stable.
   - *Enteroviruses* are resistant to acidic.: Polioviruses
6. **Salts** (Mgcl2); stabilization used in Polio vaccine

Effect physical and chemical agents on viruses

7. **Phenols** compounds: Viruses resist

8. **Glycerol** 50% (destroys bacteria) ; and virus resist, so it used as preservative for viruses.

9. **Antibiotics**: Resistant

10. **Ether** and detergents : destroy viruses envelopes.

11. **Oxidizing agents** (H2O2, Chlorine, Iodine): destroyed virus envelope.

12. **Formaldehyde**: Destroy Nucleic acid without affecting viral antigenicity (Capsid). Used in vaccination