A study material for M.Sc. Biochemistry (Semester: IV) Students
on the topic (EC-1; Unit II)

Structure of VIRUS

The Selfish Genes

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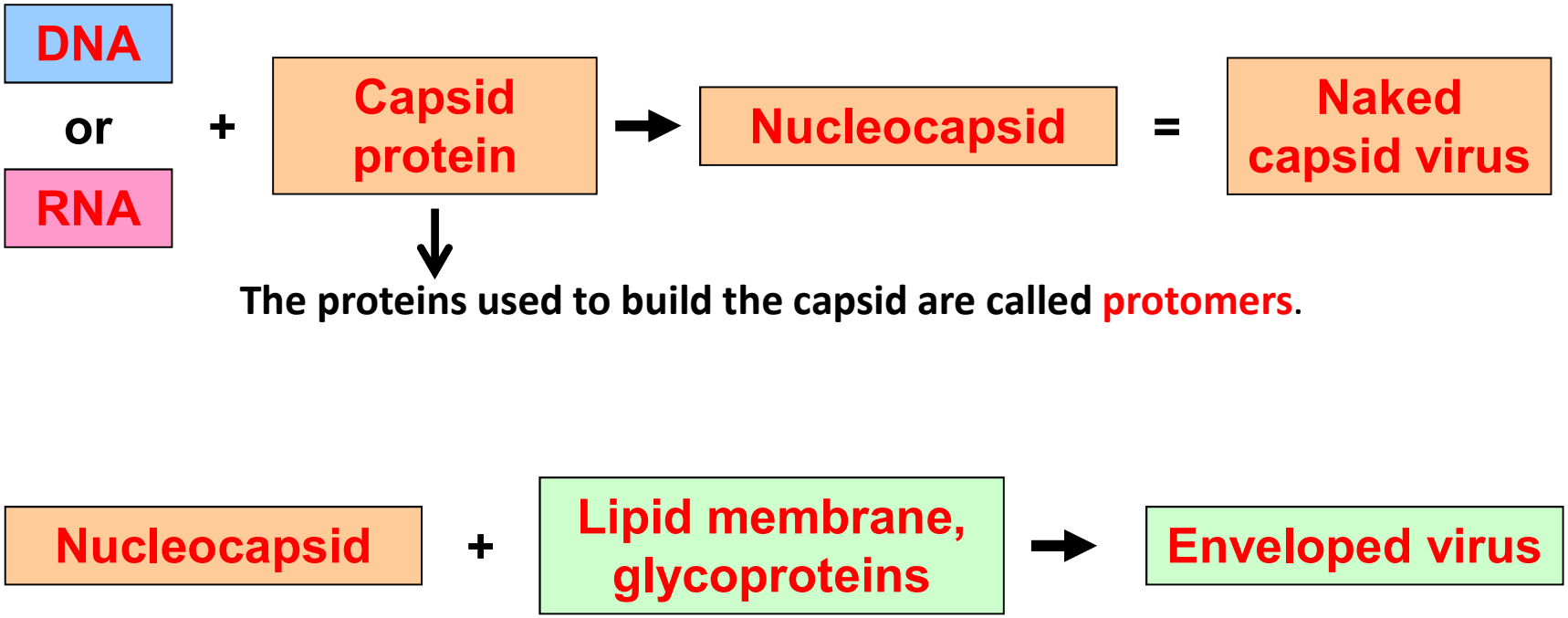
Virus

- Viruses are simple, acellular entities.
- They can reproduce only within living cells because they are obligate intracellular parasites.
- Viruses have a nucleocapsid composed of a nucleic acid genome surrounded by a protein capsid. Some viruses have a membranous envelope that lies outside the nucleocapsid.
- The nucleic acid of the virus can be RNA or DNA, single-stranded or double-stranded, linear or circular.
- Capsids may have helical, icosahedral, or complex symmetry. They are constructed of protomers that self-assemble through noncovalent bonds.
- Although each virus has unique aspects to its life cycle, a general pattern of replication is observable. The typical virus life cycle consists of five steps: attachment to the host cell, entry into the host cell, synthesis of viral nucleic acid and proteins within the host cell, self-assembly of virions within the host cell, and release of virions from the host cell.
- Viruses are classified primarily on the basis of their nucleic acid's characteristics, reproductive strategy, capsid symmetry, and the presence or absence of an envelope.

History

- In 1892 Dmitri Ivanovsky's describe a non-bacterial pathogen infecting tobacco plants. His experiments showed that crushed leaf extracts from infected tobacco plants remain infectious after filtration. Ivanovsky suggested the infection might be caused by a toxin produced by bacteria, but did not pursue the idea.
- In 1898, the Dutch microbiologist Martinus Beijerinck (1851–1931) repeated the experiments and became convinced that the filtered solution contained a new form of infectious agent. He observed that the agent multiplied only in cells that were dividing and he called it a *contagium vivum fluidum* (soluble living germ) and re-introduced the word *virus.*
- *The investigations of tobacco mosaic disease and subsequent discovery of its viral nature were instrumental in the establishment of the general concepts of virology*

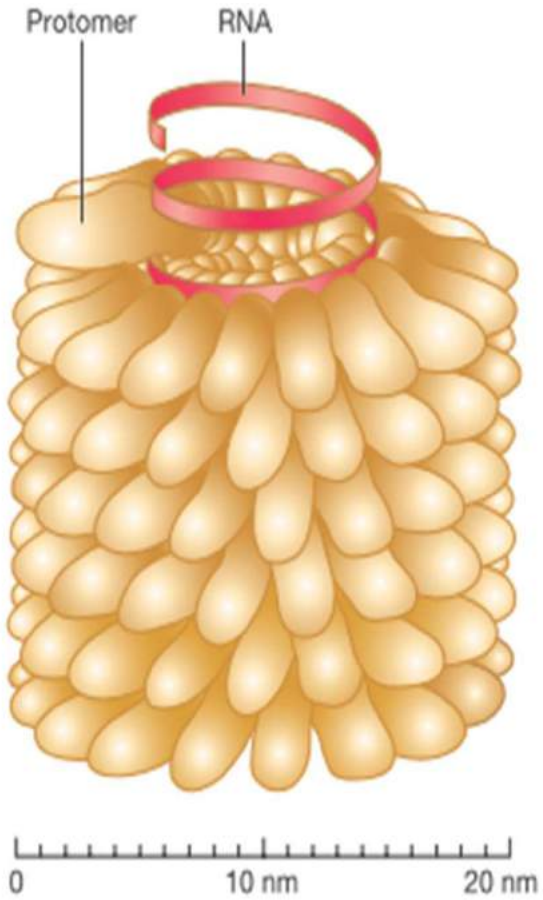
Basic virus structure



There are three types of capsid symmetry: **helical, icosahedral, and complex**. Those virions having an envelope are called enveloped viruses; whereas those lacking an envelope are called naked viruses.

Helical Capsids

- Helical capsids are shaped like hollow tubes with protein walls.
- The tobacco mosaic virus provides a well-studied example of helical Capsid structure.
- In this virus, the self-assembly of protomers in a helical or spiral arrangement produces a long, rigid tube, 15 to 18 nm in diameter by 300 nm long.



- The capsid encloses an RNA genome, which is wound in a spiral and lies within a groove formed by the protein subunits.
- The size of a helical capsid is influenced by both its protomers and the nucleic acid enclosed within the capsid.

Icosahedral Capsids

- The icosahedron is a regular polyhedron with 20 equilateral triangular faces and 12 vertices.
- The capsids are constructed from ring- or knob-shaped units called capsomers, each usually made of five or six protomers.
- Most icosahedral capsids appear to contain both pentamers and hexamers.

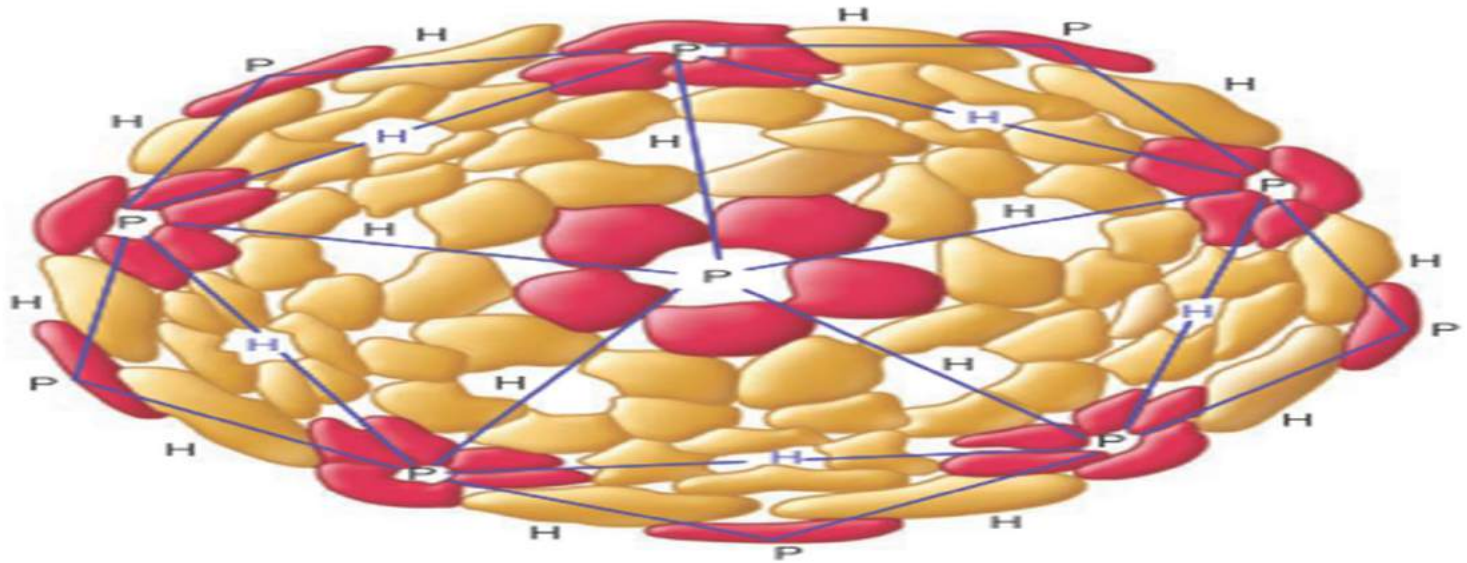


Figure 16.6 The Structure of an Icosahedral Capsid Formed from a Single Type of Protomer. The protomers associate to form either pentons (P), shown in red, or hexons (H), shown in gold. The blue lines define the triangular faces of the icosahedron. Notice that pentons are located at the vertices and that the hexons form the edges and faces of the icosahedron. This capsid contains 42 capsomers.

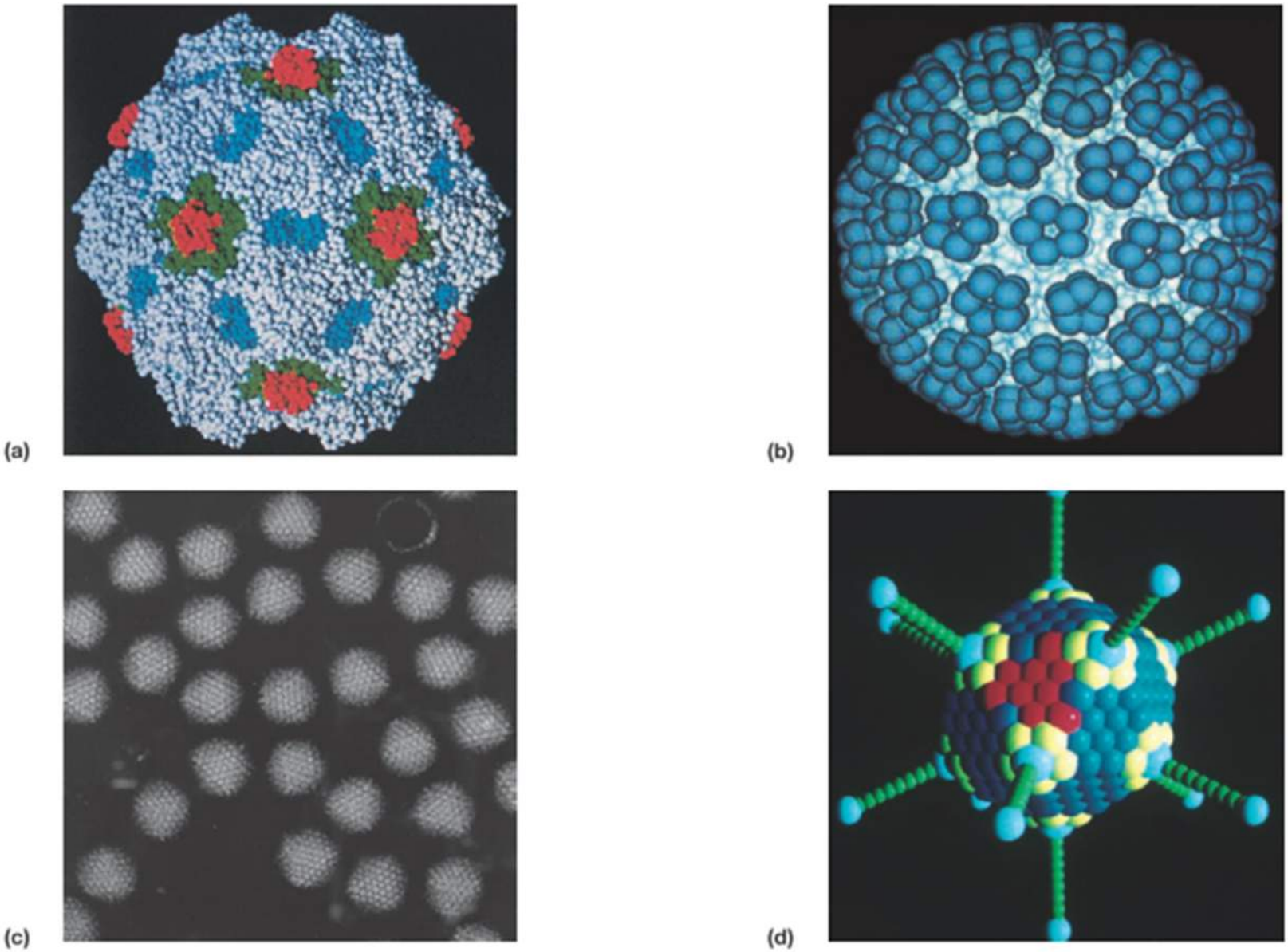


Figure 16.5 Examples of Icosahedral Capsids. **(a)** Canine parvovirus model, 12 capsomers. **(b)** Computer-simulated image of the polyomavirus (72 capsomers) that causes a rare demyelinating disease of the central nervous system. **(c)** Adenovirus, 252 capsomers (×171,000). **(d)** Computer-simulated model of adenovirus.

Viruses with Capsids of Complex Symmetry

- Although most viruses have either icosahedral or helical capsids, many viruses do not fit into either category. The poxviruses and large bacteriophages are two important examples.

Poxvirus

- The poxviruses are the largest of the animal viruses (about 400 X 240 X 200 nm in size) and can even be seen with a phase-contrast microscope.
- They possess an exceptionally complex internal structure with an ovoid- to brick-shaped exterior.
- The double-stranded DNA is associated with proteins and contained in the nucleoid, a central structure shaped like a biconcave disk and surrounded by a membrane.
- Two elliptical or lateral bodies lie between the nucleoid and its outer envelope, a membrane and a thick layer covered by an array of tubules or fibers.

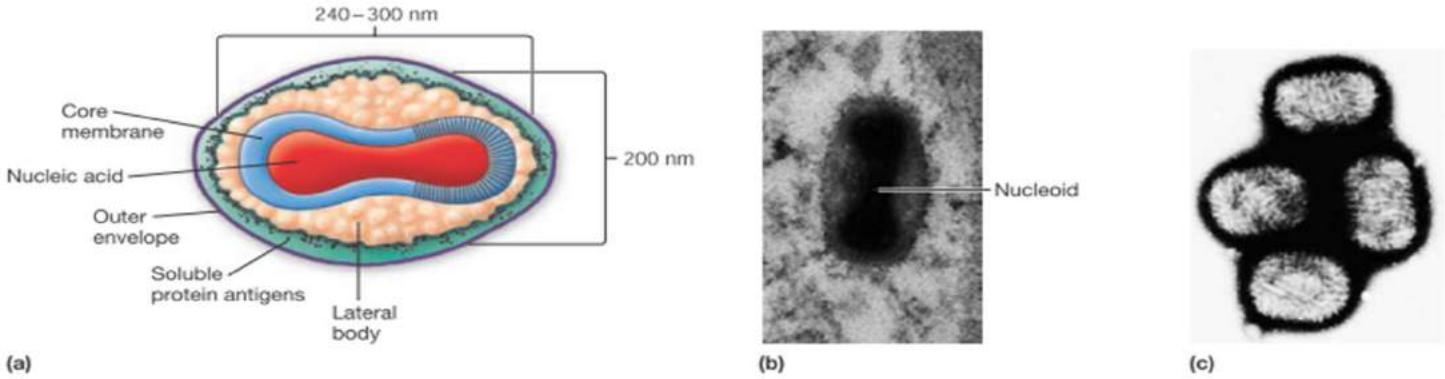
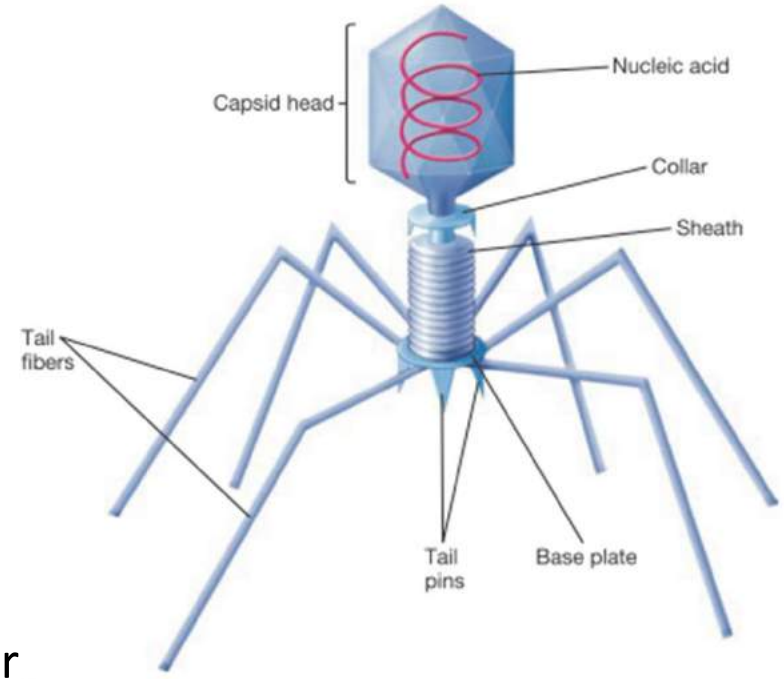


Figure 16.8 Vaccinia Virus Morphology. **(a)** Diagram of vaccinia structure. **(b)** Micrograph of the virion clearly showing the nucleoid (×200,000). **(c)** Vaccinia surface structure. An electron micrograph of four virions showing the thick array of surface fibers (×150,000).

Bacteriophages

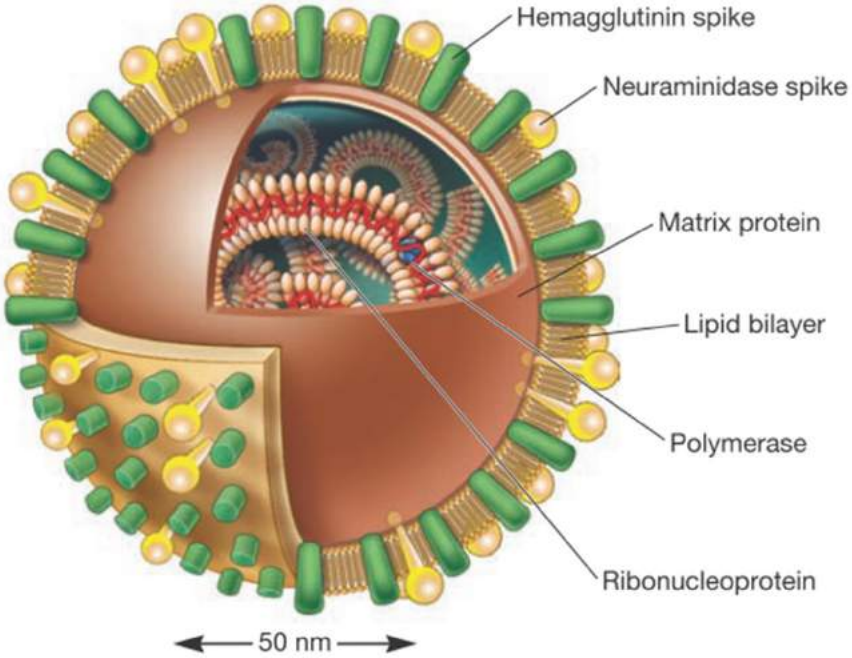
- The T2, T4, and T6 phages (T-even phages) that infect Escherichia coli are said to have binal symmetry because they have a head that resembles an icosahedron and a tail that is helical.
- The icosahedral head is elongated by one or two rows of hexamers in the middle and contains the DNA genome .
- The tail is composed of a collar joining it to the head, a central hollow tube, a sheath sur complex baseplate.



- The sheath is made of 144 copies of the gp18 protein arranged in 24 rings, each containing six copies.
- In T-even phages, the baseplate is hexagonal and has a pin and a jointed tail fiber at each corner.
- T1, T5, and lambda phages have sheathless tails that lack a baseplate and terminate in rudimentary tail fibers.
- Coliphages T3 and T7 have short, non-contractile tails without tail fibers.

Viral Envelopes and Enzymes

- Many animal viruses, some plant viruses and bacterial virus are bounded by an outer membranous layer called an envelope.
- Animal virus envelopes usually arise from host cell nuclear or plasma membranes; their lipids and carbohydrates are normal host constituents. In contrast, envelope proteins are coded for by virus genes and may even project from the envelope surface as spikes, which are also called peplomers.
- The envelope is a flexible, membranous structure, so enveloped viruses frequently have a somewhat variable shape and are called pleomorphic.



(a) Influenza virus

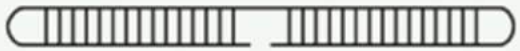
(b) Rabies virus

Viral Genome

It contains all four possible nucleic acid types: single-stranded DNA, double-stranded DNA, single-stranded RNA, and double-stranded RNA.

All four types are found in animal viruses. Most plant viruses have single-stranded RNA genomes and most bacterial viruses contain double-stranded DNA

Table 16.1 Types of Viral Nucleic Acids

Nucleic Acid Type	Nucleic Acid Structure	Virus Examples
DNA		
Single Stranded	Linear, single-stranded DNA	Parvoviruses
	Circular, single-stranded DNA	ϕX174, M13, fd phages
Double Stranded	Linear, double-stranded DNA	Herpesviruses (herpes simplex viruses, cytomegalovirus, Epstein-Barr virus), adenoviruses, T coliphages, lambda phage, and other bacteriophages
	Linear, double-stranded DNA with single chain breaks 	T5 coliphage
	Double-stranded DNA with cross-linked ends 	Vaccinia, smallpox viruses
	Closed, circular, double-stranded DNA	Polyomaviruses (SV-40), papillomaviruses, PM2 phage, cauliflower mosaic virus
RNA		
Single-Stranded	Linear, single-stranded, positive-strand RNA	Picornaviruses (polio, rhinoviruses), togaviruses, RNA bacteriophages, TMV, and most plant viruses
	Linear, single-stranded, negative-strand RNA	Rhabdoviruses (rabies), paramyxoviruses (mumps, measles)
	Linear, single-stranded, segmented, positive-strand RNA	Brome mosaic virus (individual segments in separate virions)
	Linear, single-stranded, diploid (two identical single strands), positive-strand RNA	Retroviruses (Rous sarcoma virus, human immunodeficiency virus)
	Linear, single-stranded, segmented, negative-strand RNA	Paramyxoviruses, orthomyxoviruses (influenza)
Double-Stranded	Linear, double-stranded, segmented RNA	Reoviruses, wound-tumor virus of plants, cytoplasmic polyhedrosis virus of insects, phage ϕ6, many mycoviruses

- Some ssRNA genomes have a base sequence that is identical to that of viral mRNA, in which case the genomic RNA strand is called the plus strand or positive strand. Polio, tobacco mosaic, brome mosaic, and Rous sarcoma viruses are all positive strand RNA viruses

- In fact, plus strand RNAs can direct protein synthesis immediately after entering the cell. However, other viral RNA genomes are complementary rather than identical to viral mRNA, and are called minus or negative strands. Rabies, mumps, measles, and influenza viruses are examples of negative strand RNA viruses.

Acknowledgement and Suggested Readings:

1. Microbiology, An Introduction; Tortora, Funke and Case; Pearson Publication
2. Microbiology; Prescott, Harley and Klein; The MacGraw-Hill Companies
3. Microbiology: Principles and Explorations; Jacquelyn G Black; John Wiley and Sons Inc.
4. Brock Biology of Microorganisms; Madigan, Martinko, Stahl and Clark; Benjamin Cummings (Pearson Publication)

Thanks