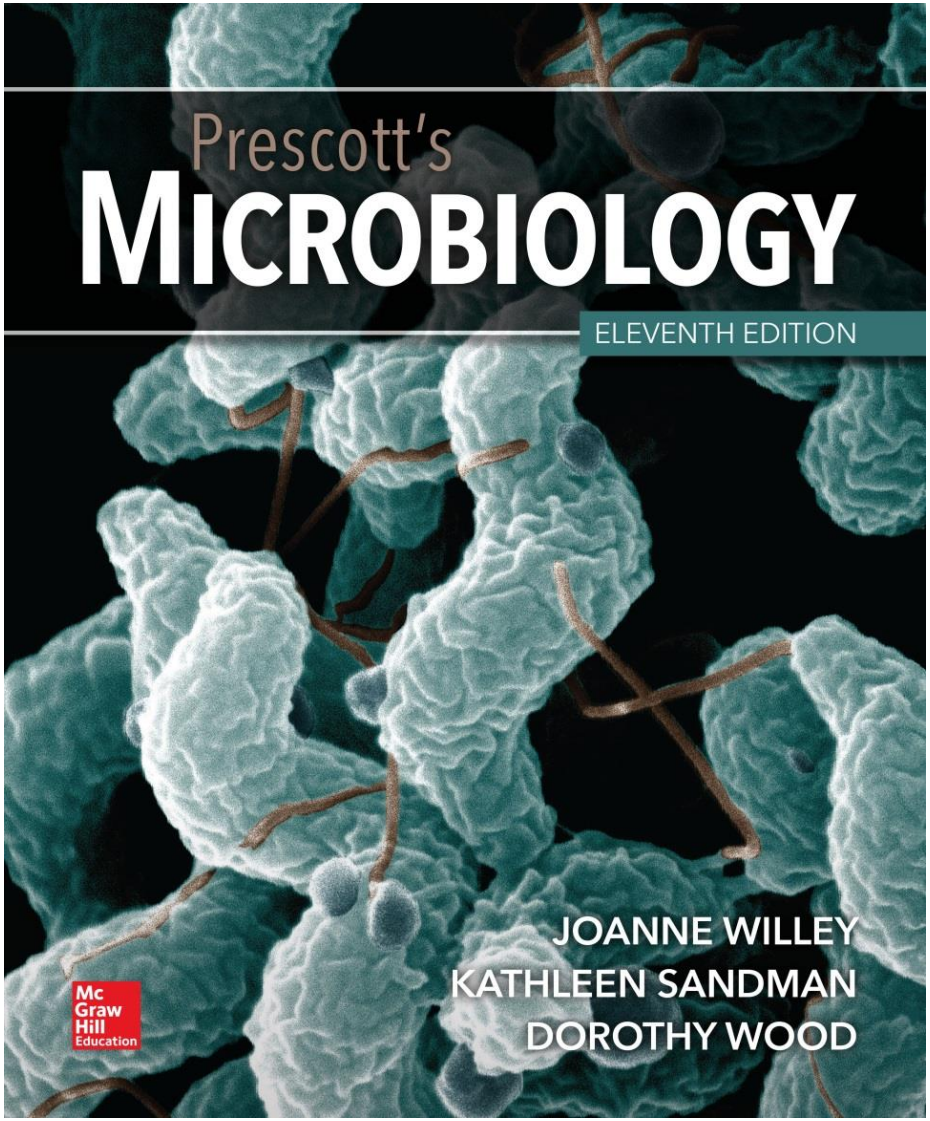


Prescott's MICROBIOLOGY

ELEVENTH EDITION

JOANNE WILLEY
KATHLEEN SANDMAN
DOROTHY WOOD

Chapter 6

Viruses and Other Acellular Infectious Agents

Acellular Agents

Viruses—protein and nucleic acid.

Viroids—only RNA.

Satellites—only nucleic acids.

Prions—proteins only.

Viruses

Major cause of disease.

- Also importance as a new source of therapy.
- New viruses are emerging.

Important members of aquatic world.

- Move organic matter from particulate to dissolved.

Important in evolution.

- Transfer genes between bacteria, others.

Important model systems in molecular biology.

Viruses Can Infect All Cell Types

Bacterial viruses called bacteriophages (phages).

Few archaeal viruses.

Most are eukaryotic viruses.

- Plants, animals, protists, and fungi.

Classified into families based on:

- Genome structure.
- Life cycle.
- Morphology.
- Genetic relatedness.

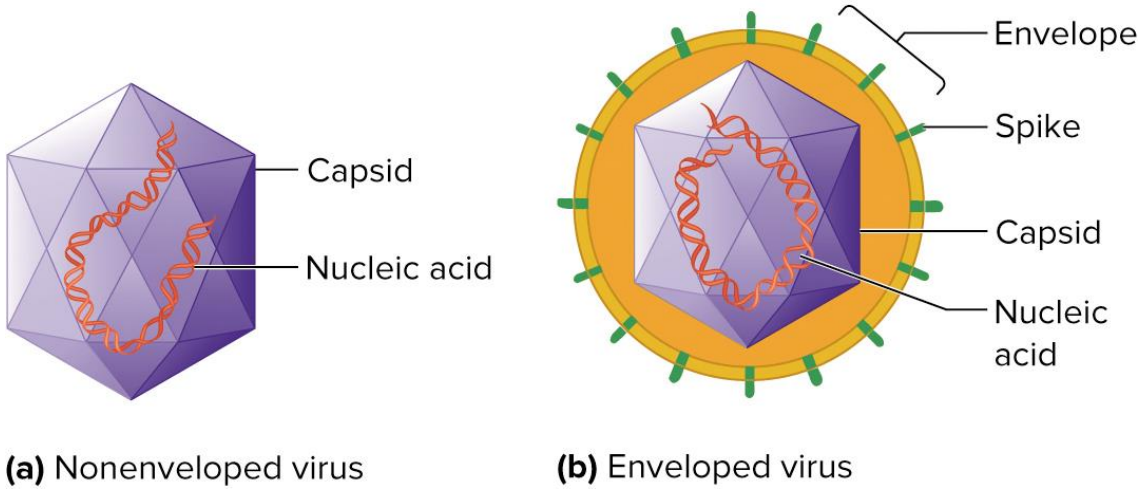
The Structure of Viruses

Virions are tiny (Approximately 20 nm in diameter) and most viruses must be viewed with an electron microscope.

All virions contain a nucleocapsid which is composed of nucleic acid (DNA or RNA) and a protein coat (capsid).

- Some viruses consist only of a nucleocapsid, others have additional components.

Envelopes.



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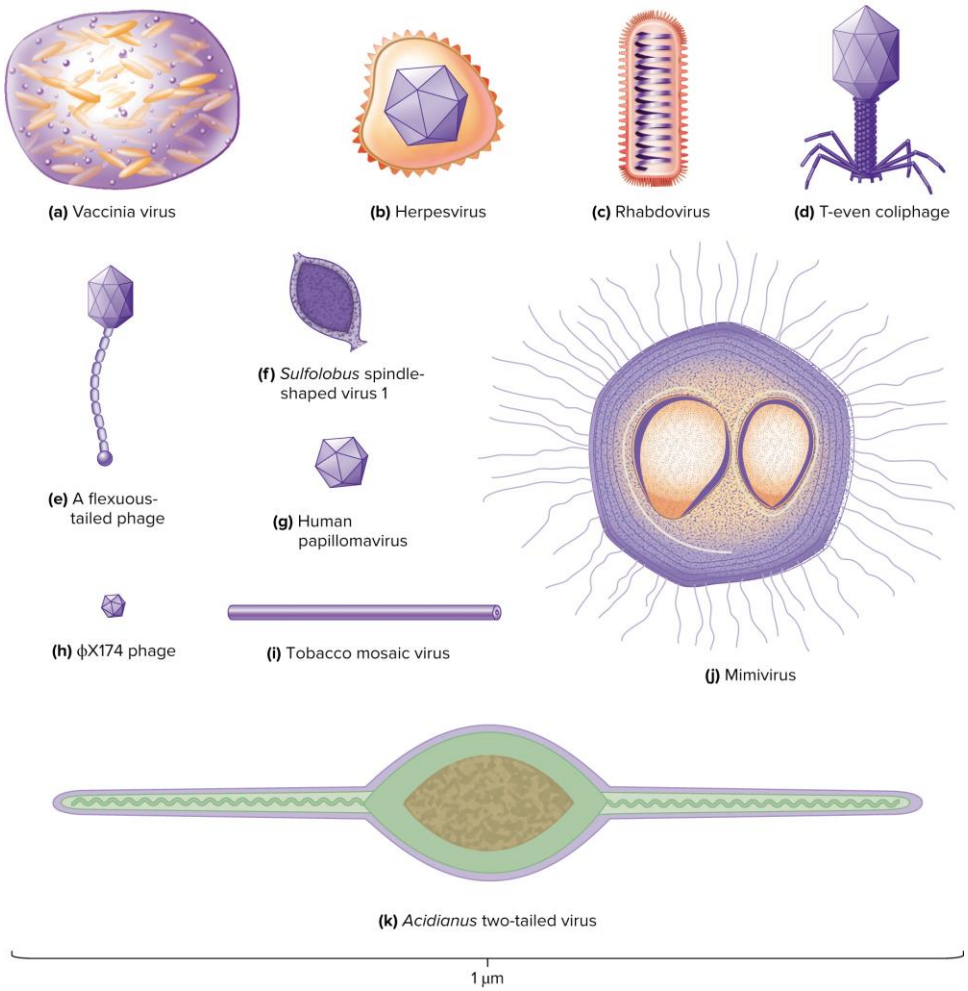
Size and Morphology of Select Viruses



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Capsids

Large macromolecular structures which serve as protein coat of virus.

Protect viral genetic material and aid in its transfer between host cells.

Made of protein subunits called protomers.

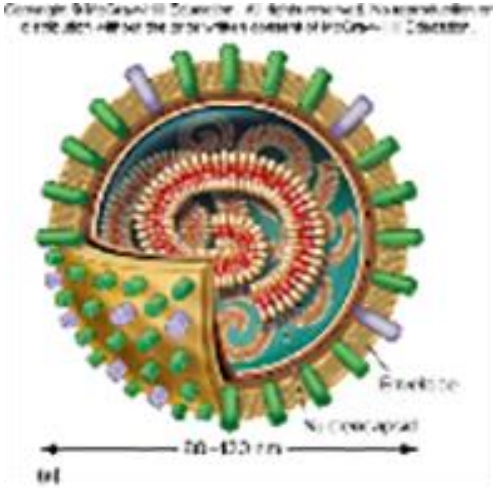
Capsids are helical, icosahedral, or complex.

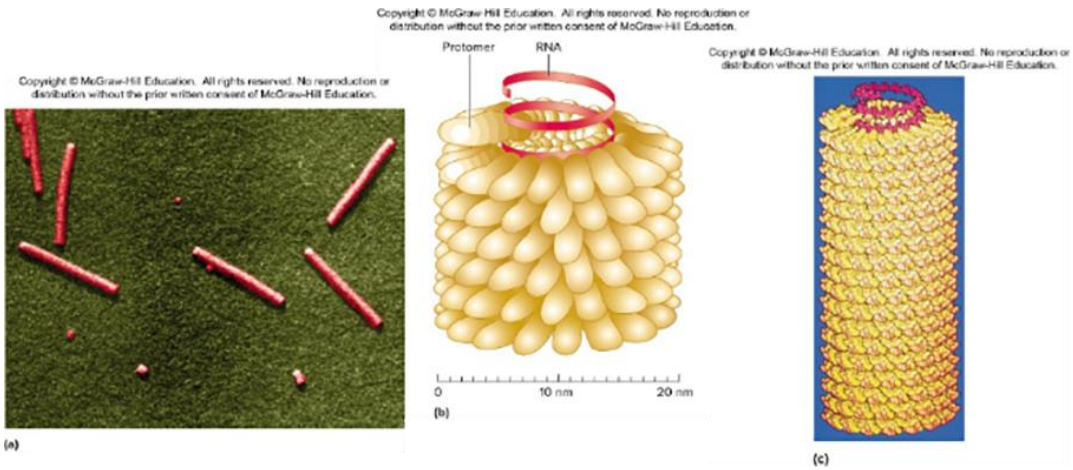
Helical Capsids

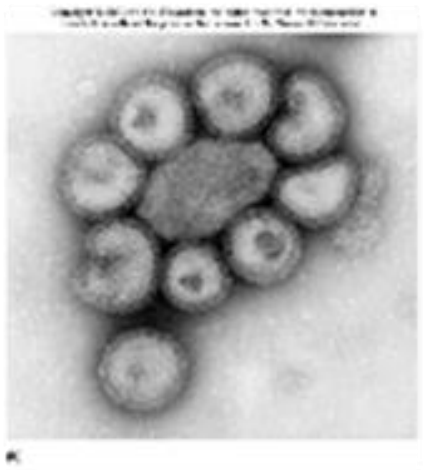
Shaped like hollow tubes with protein walls.

Protomers self assemble.

Length of capsid is a function of nucleic acid.







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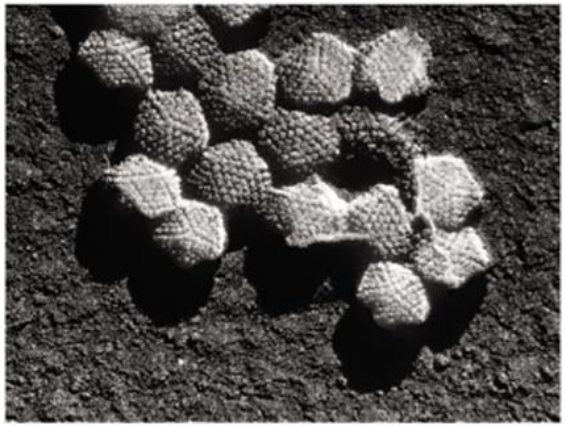
Icosahedral Capsids

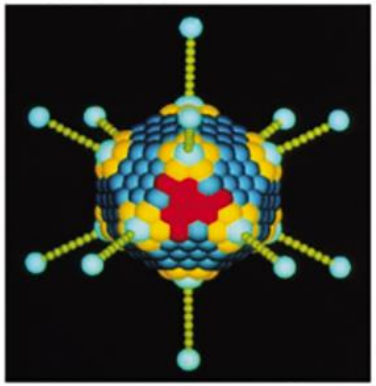
An icosahedron is a regular polyhedron with 20 equilateral faces and 12 vertices.

Capsomers.

- Ring or knob-shaped units made of 5 or 6 protomers.
- Pentamers (pentons)—5 subunit capsomers.
- Hexamers (hexons)—6 subunit capsomers.



(a)



(b)

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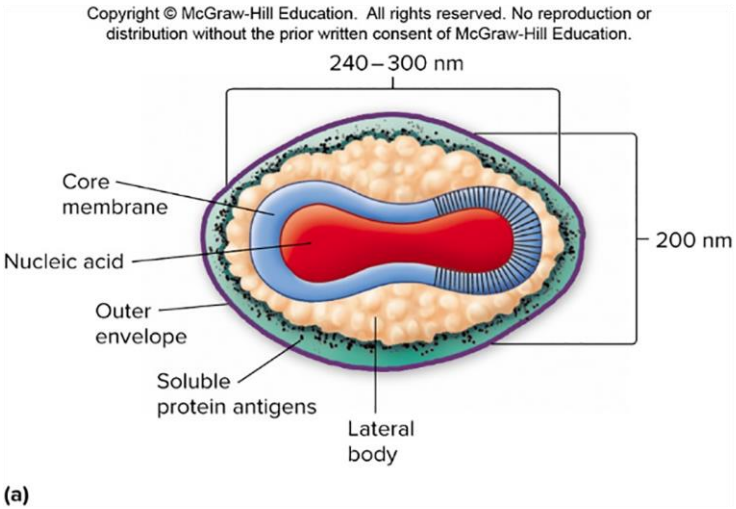
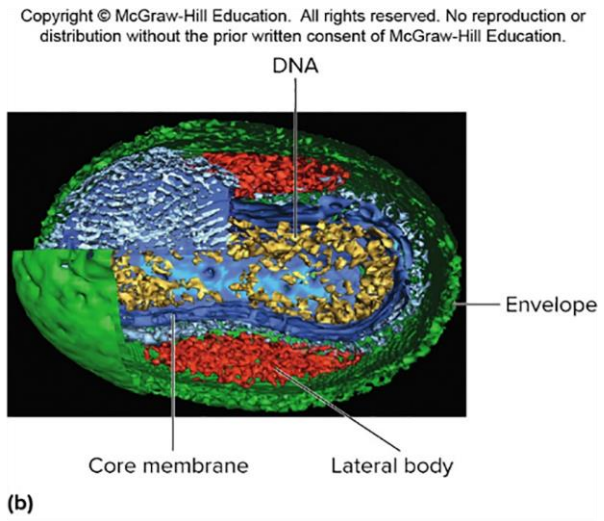
Capsids of Complex Symmetry

Some viruses do not fit into the category of having helical or icosahedral capsids.

- Poxviruses—largest animal virus.
- Large bacteriophages—binal symmetry (head resembles icosahedral, tail is helical).





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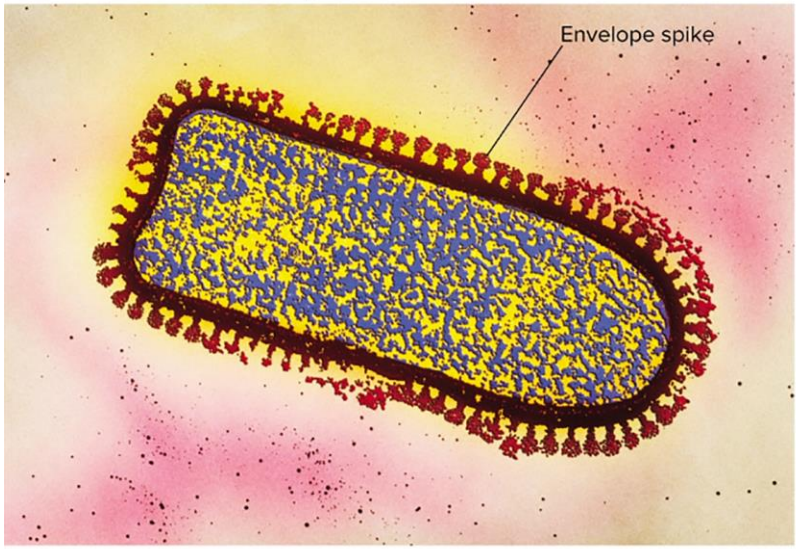
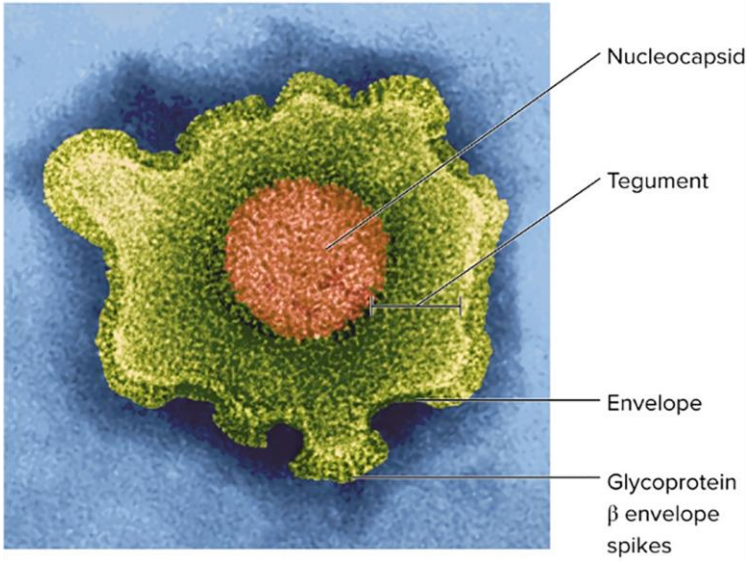
Viral Envelopes and Enzymes



(a) Rabies virus



(b) Herpesvirus

Many viruses are bound by an outer, flexible, membranous layer called the envelope.

Animal virus envelopes (lipids and carbohydrates) usually arise from host cell plasma or nuclear membranes.

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Viral Envelope Proteins

Envelope proteins, which are viral encoded, may project from the envelope surface as spikes or peplomers.

- Involved in viral attachment to host cell.
- Used for identification of virus.
- May have enzymatic or other activity (For example, neuraminidase of influenza virus).
- May play a role in nucleic acid replication.

Viral Genomes Are Structurally Diverse

A virus may have single- or double-stranded DNA or RNA.

The length of the nucleic acid also varies from virus to virus.

Genomes can be linear or circular.

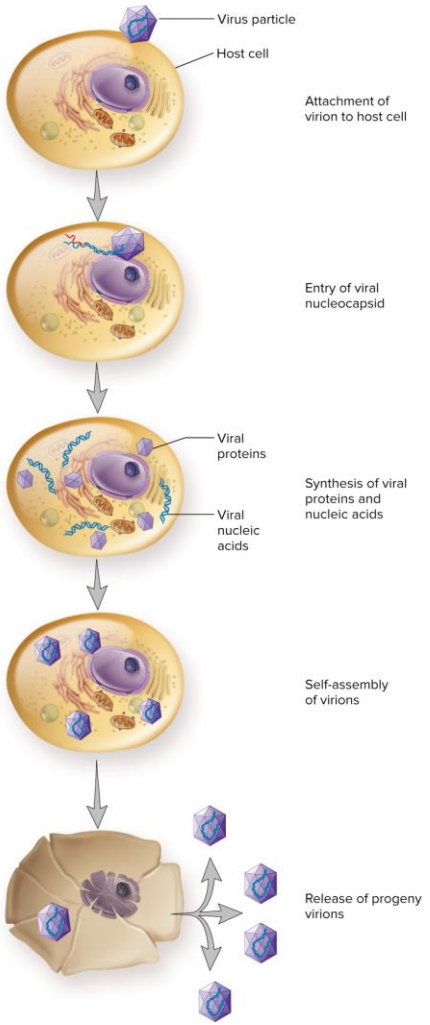
- Some RNA viruses have segmented genomes.

Viral Multiplication

Mechanism used depends on viral structure and genome.

Steps are similar:

- Attachment to host cell.
- Entry and uncoating of genome.
- Synthesis .
- Assembly.
- Release.



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Attachment (Adsorption)

Specific receptor attachment.

Receptor determines host preference:

- May be specific tissue (tropism).
- May be more than one host.
- May be more than one receptor.

Entry Into the Host

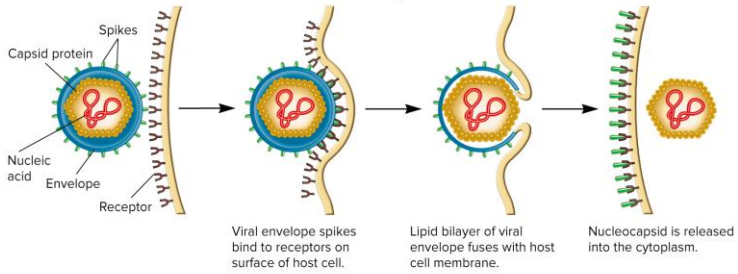
Entire genome or nucleocapsid.

Varies between naked or enveloped virus.

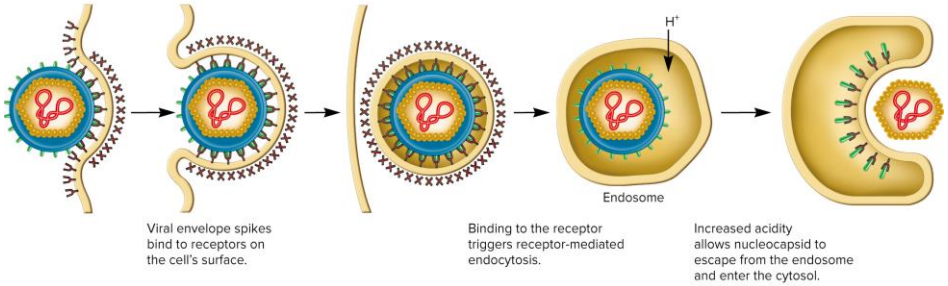
Three methods used:

- Fusion of the viral envelope with host membrane; nucleocapsid enters.
- Endocytosis in vesicle; endosome aids in viral uncoating.
- Injection of nucleic acid.

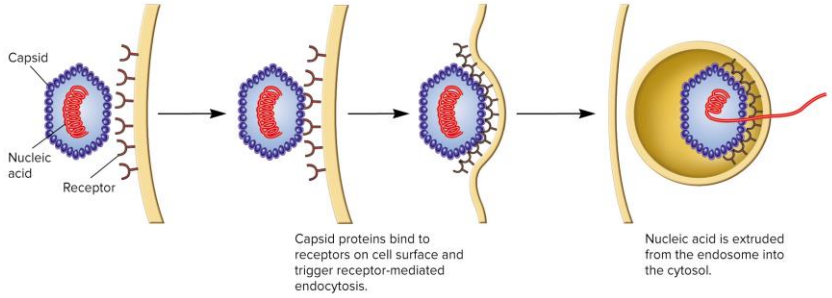
Animal Virus Entry Mechanisms



(a) Entry of enveloped virus by fusing with plasma membrane



(b) Entry of enveloped virus by endocytosis



(c) Entry of nonenveloped virus by endocytosis

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Synthesis Stage

Genome dictates the events.

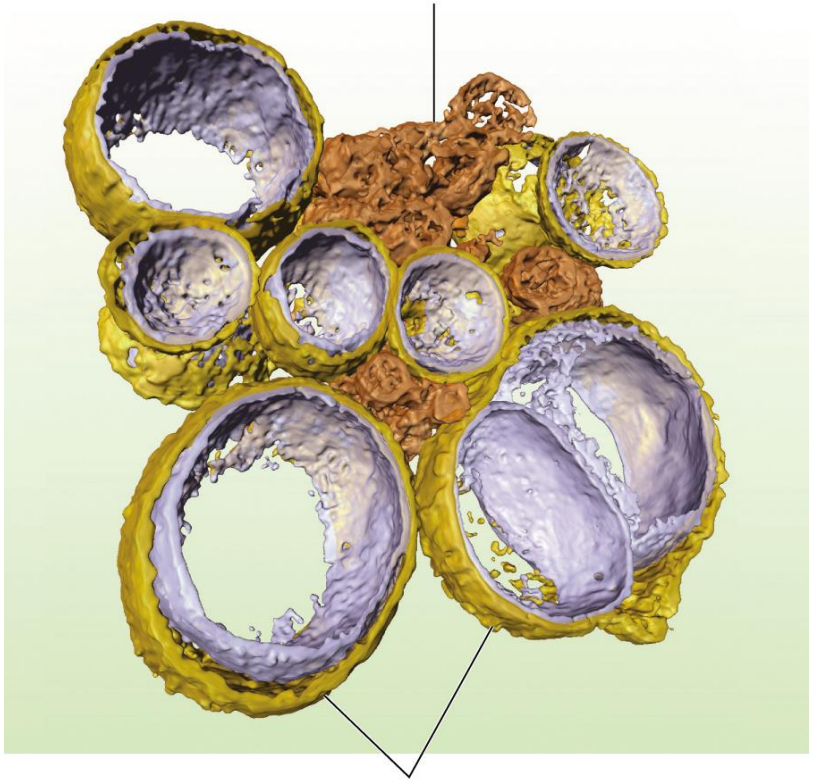
ds DNA typical flow.

RNA viruses.

- Virus must carry in or synthesize the proteins necessary to complete synthesis.

Genes and proteins may be referred to as early, middle, or late.

May induce formation of membrane-protected replication complexes.



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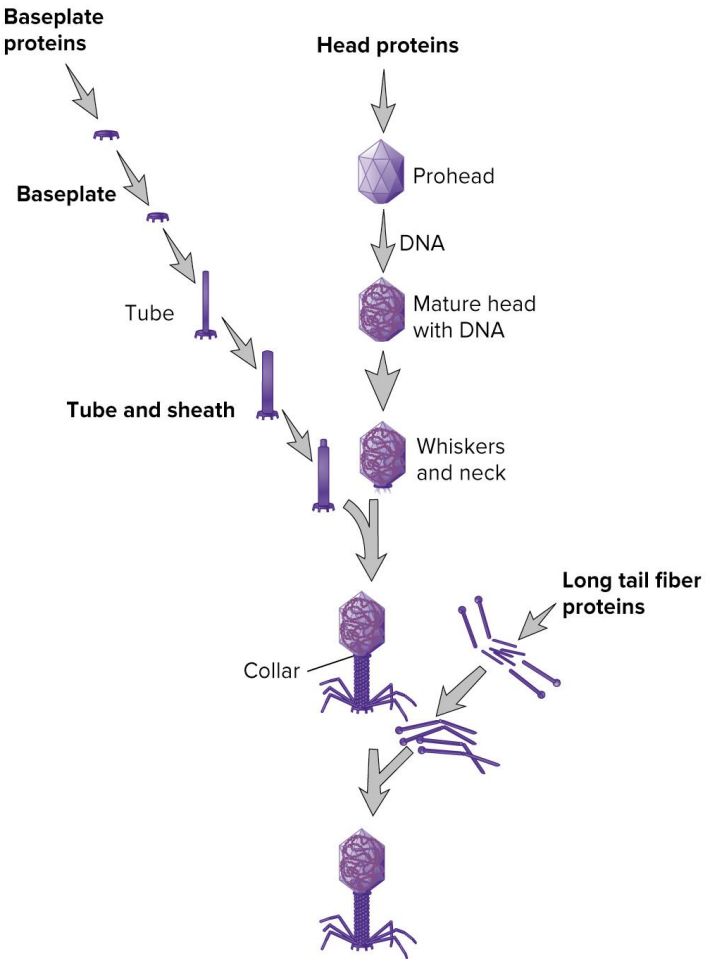
Assembly



Late proteins are important in assembly.

Assembly process is complex.

Baseplate, tail fibers, and head components of bacteriophage T4 are assembled separately.

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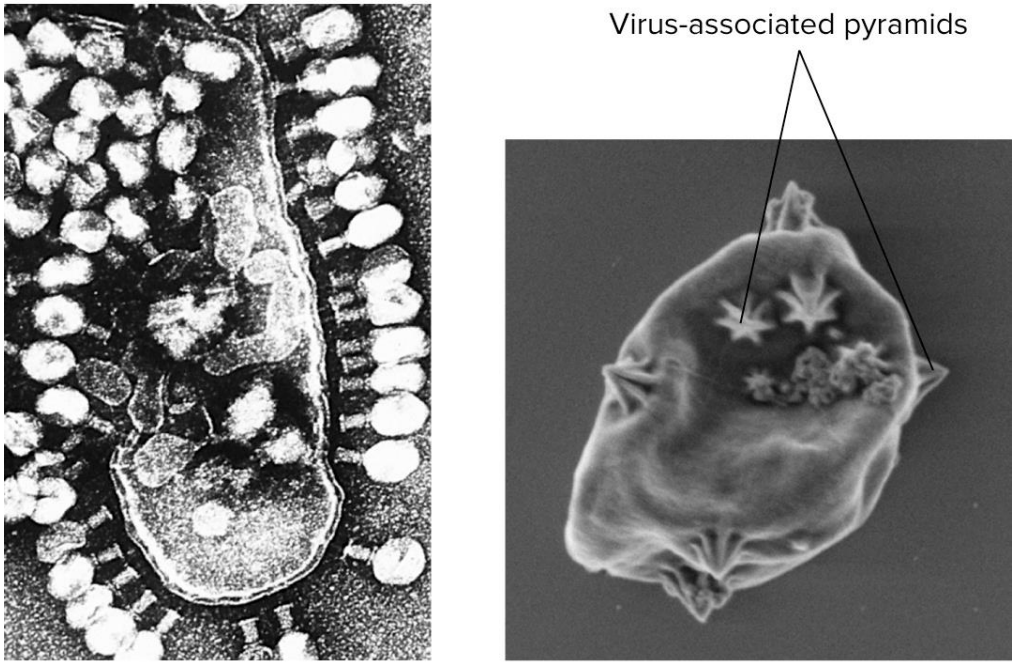
Virion Release 1

Nonenveloped viruses lyse the host cell.

- Viral proteins may attack peptidoglycan or membrane.



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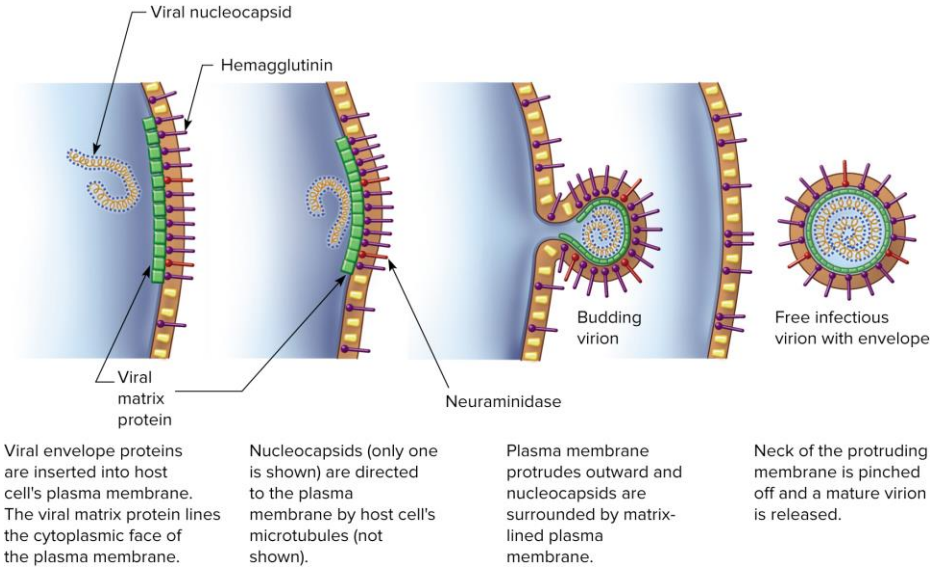
Virion Release 2



Enveloped viruses use budding.

- Viral proteins are incorporated into host membrane.
- Nucleocapsid may bind to viral proteins.
- Envelope derived from host plasma membrane, but may be Golgi, ER, or other.
- Virus may use host actin tails to propel through host membrane.

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Infection in Eukaryotic Cells

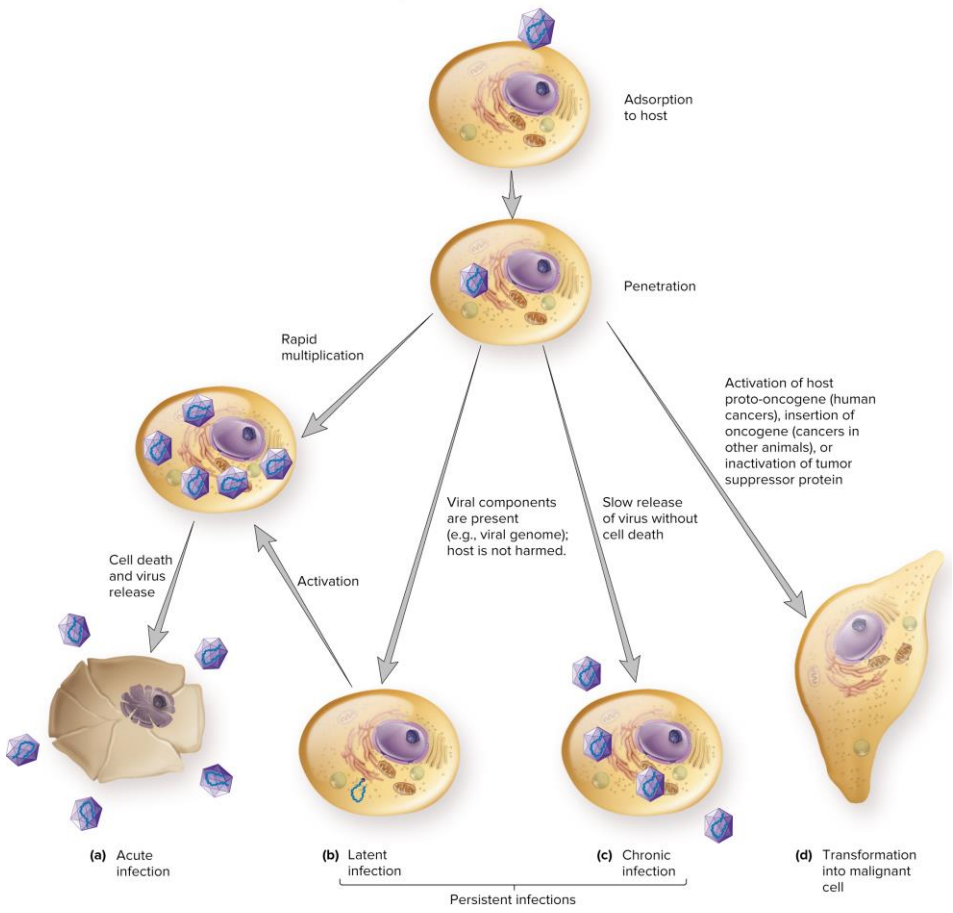
Cytocidal infection results in cell death through lysis.

Persistent infections may last years.

Cytopathic effects (CPEs).

- Degenerative changes.
- Abnormalities.

Transformation to malignant cell.



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Viruses and Cancer

Tumor.

- Growth or lump of tissue;
- Benign tumors remain in place.

Neoplasia.

- Abnormal new cell growth and reproduction due to loss of regulation.

Anaplasia.

- Reversion to a more primitive or less differentiated state.

Metastasis.

- Spread of cancerous cells throughout body.

Carcinogenesis

Complex, multistep process.

Often involves oncogenes.

- Cancer causing genes.
- May come from the virus OR may be transformed host proto-oncogenes (involved in normal regulation of cell growth/differentiation).

Possible Mechanisms by Which Viruses Cause Cancer

Viral proteins bind host cell tumor suppressor proteins.

Carry oncogene into cell and insert it into host genome.

Altered cell regulation.

Insertion of promoter or enhancer next to cellular oncogene.

Viroids

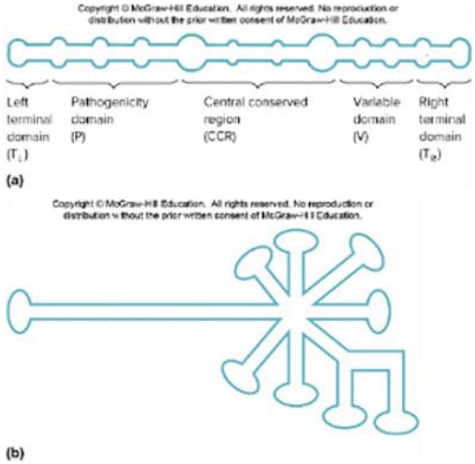
Infectious agents composed of closed, circular ssRNAs.

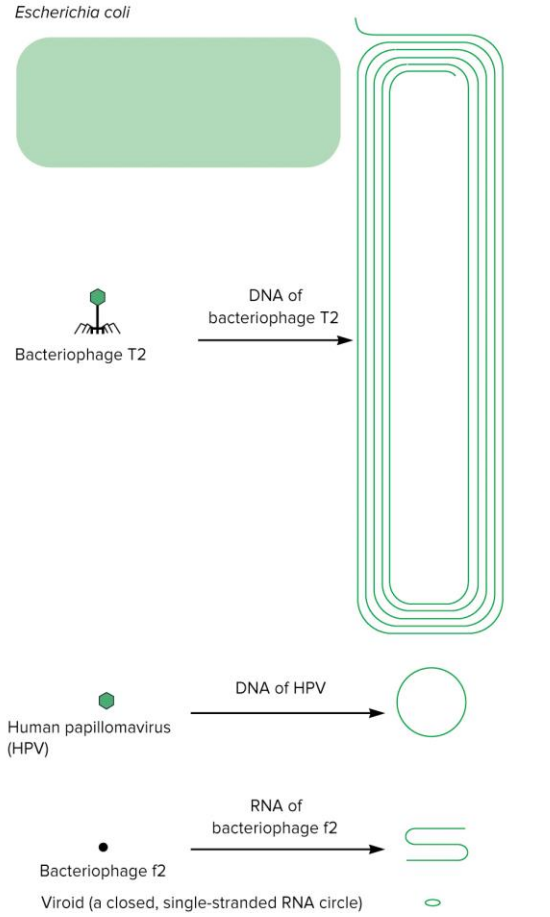
Do not encode gene products.

Replication requires host cell.

DNA-dependent RNA polymerase.

Cause plant diseases.





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Satellites

Infectious nucleic acids (DNA or RNA).

- Satellite viruses encode their own capsid proteins when helped by a helper virus.
- Satellite RNAs/DNAs do NOT encode their own capsid proteins .

Encode one or more gene products.

Require a helper virus for replication.

- Human hepatitis D virus is satellite.
- Requires human hepatitis B virus.

Prions—Proteinaceous Infectious Particle

Cause a variety of neurodegenerative diseases in humans and animals.

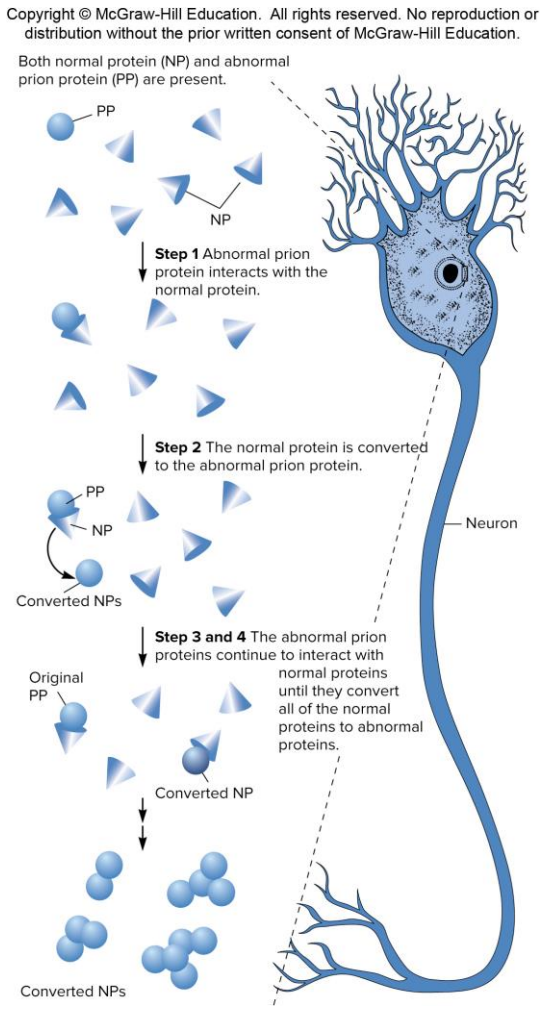
- Scrapie in sheep.
- Bovine spongiform encephalopathy (BSE) or “mad cow disease.”
- Human diseases kuru, fatal familial insomnia, Creutzfeldt-Jakob disease (CJD), and Gerstmann-Strässler-Scheinker syndrome (GSS).

Current Model of Disease Production by Prions

PrP^{C} (prion protein) is present in "normal" form (abnormal form of prion protein is PrP^{Sc}).

PrP^{Sc} causes PrP^{C} protein to change its conformation to abnormal form.

Newly produced PrP^{Sc} molecules convert more normal molecules to the abnormal form through unknown mechanism.



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