#Microbiology

Prescott's MICROBIOLOGY

ELEVENTH EDITION

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Chapter 6

Viruses and Other Acellular Infectious Agents

6.1 Viruses Are Acellular

a. Define the terms *virology*, *bacteriophages*, and *phages*.

b. List organisms that are hosts to viruses.

not a real cell without a cell ← **Acellular Agents** ⇒ need a cell in order to Replicate and enter the genome.

Viruses—protein and nucleic acid.

Viroids—only RNA.

Satellites—only nucleic acids.

Prions—proteins only.

why we can't use Antiviral drug effectively?

Because Viruses Change their DNA
- we can't Study their function unless when they enter a Host cell.
- Virus can enter the eukaryotic cell and Integrate with it's Genome and effect the Replication of the eukaryotic cell (Effecting the eukaryotic cell).

Viruses

What are Pros and Cons of Having Viruses?
* We Cause viruses to transfer Gene, from on to Onther Cell

✓Major cause of disease.

- **Also importance as a new source of therapy.**
- **New viruses are emerging.** → they can change their Genom

Important members of aquatic world.

- Move organic matter from particulate to dissolved.

Important in evolution. Bacteriophages → Viruses which effects the Bacteria.

- **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. Majority.

Host.

- Plants, animals, protists, and fungi.

Classified into families based on:

- 1) **Genome structure.** → RNA DNA RNA transcriptase
- 2) **Life cycle.**
- 3) **Morphology.** → Shape/Structure
- 4) **Genetic relatedness.** → Genetic Material

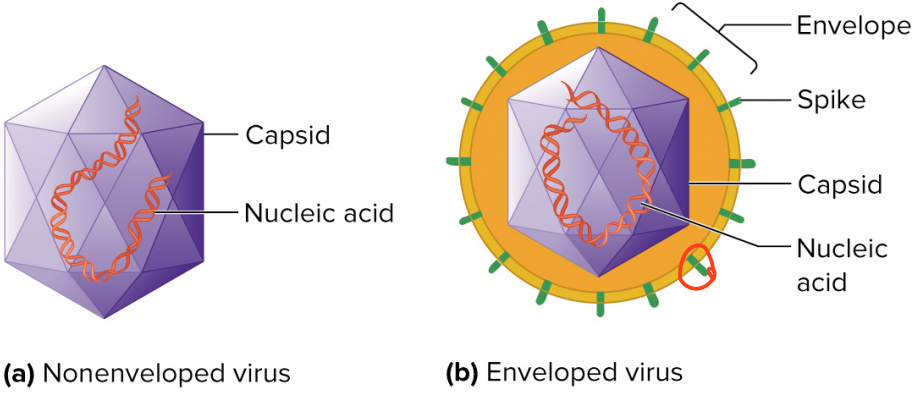
The Structure of Viruses

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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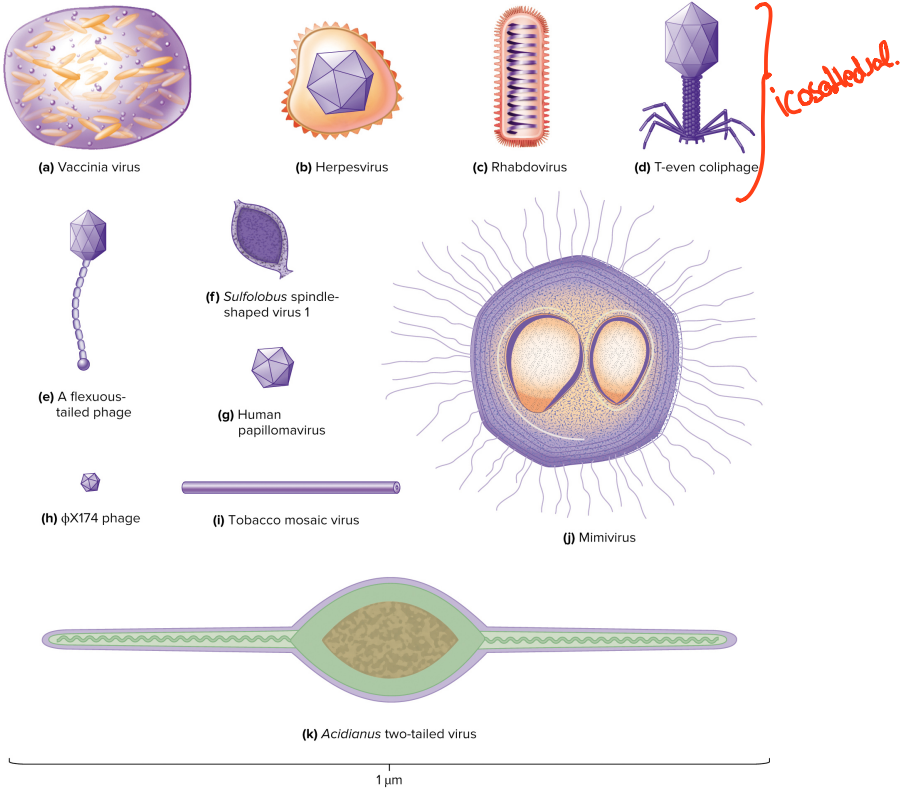
Size and Morphology of Select Viruses



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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.

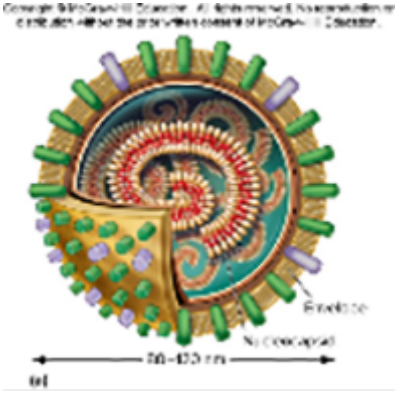
Capsids are helical, icosahedral, or complex.

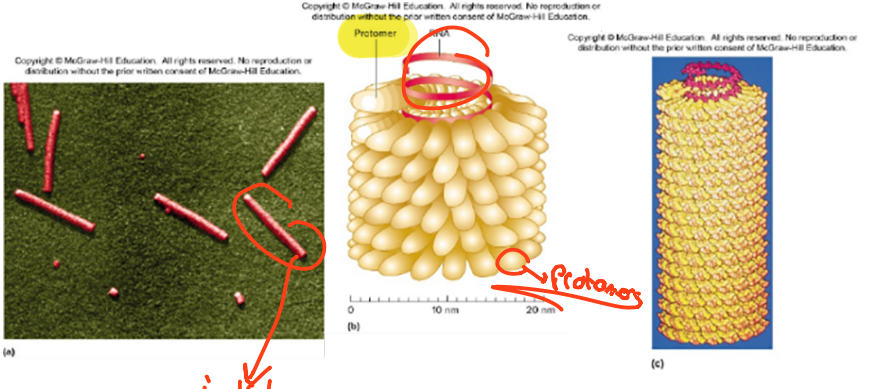
Helical Capsids

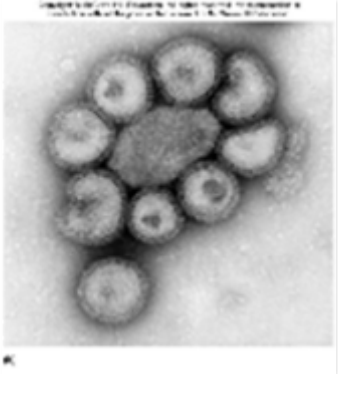
Shaped like hollow tubes with protein walls.

Protomers self assemble.

Length of capsid is a function of nucleic acid.







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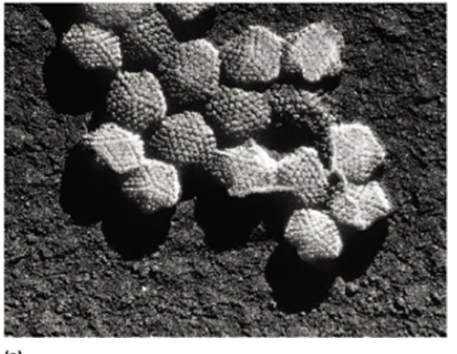
Icosahedral Capsids

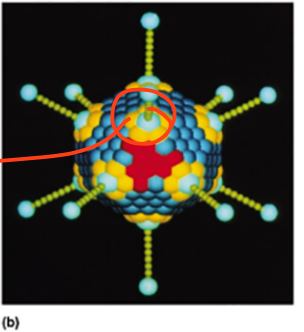
An icosahedron is a regular polyhedron with 20 equilateral faces and 12 vertices.

Capsomers.

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



(a)



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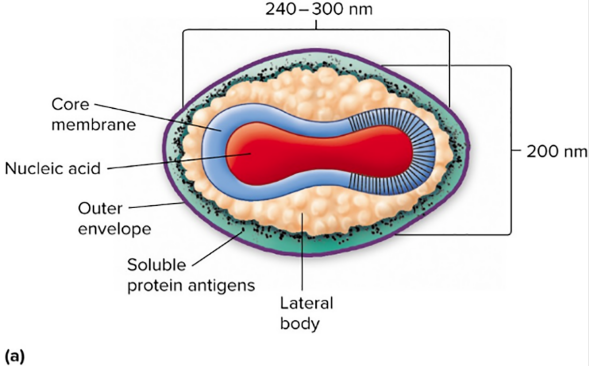
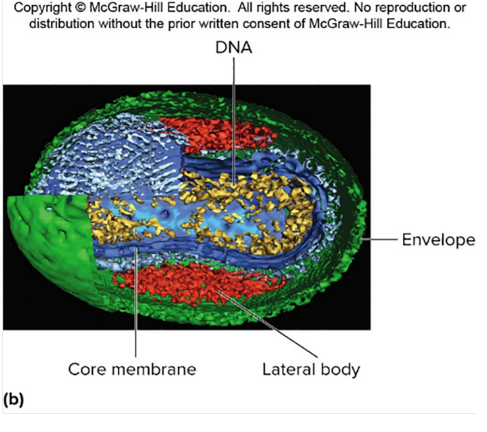
Capsids of Complex Symmetry

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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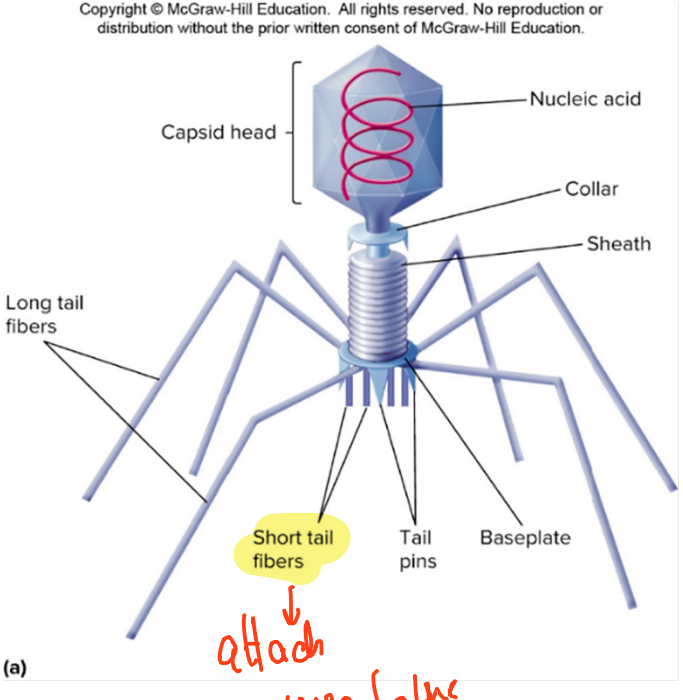
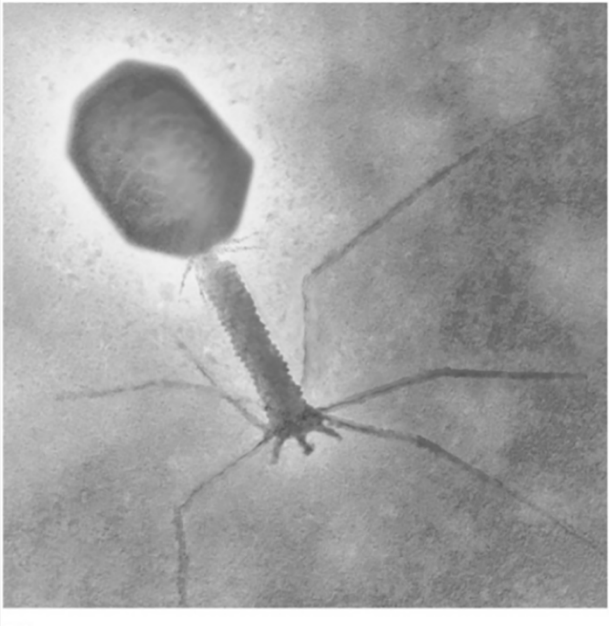
Phages: An Example of Complex Capsid Symmetry



attach the virus to the eukaryotic cell



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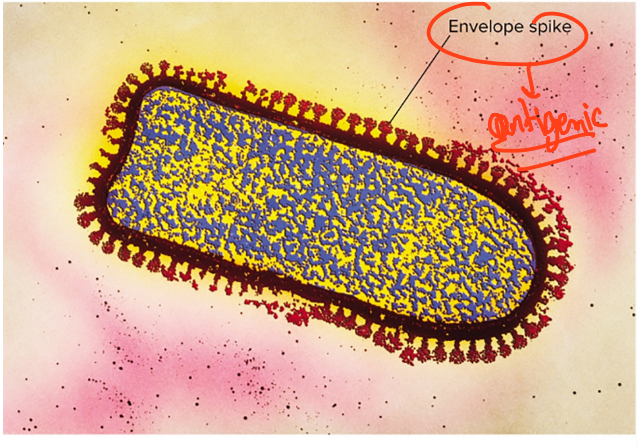
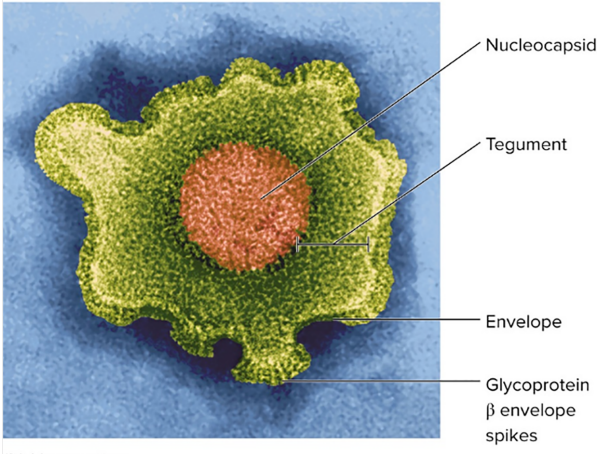
Viral Envelopes and Enzymes



(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.**

we can disign antibody that binds with virus

- 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 has spikes (Proteins)
- May play a role in nucleic acid replication.

* Some Proteins Aids in the Replication.

Genomes of viruses vary according to the type of the virus -

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.

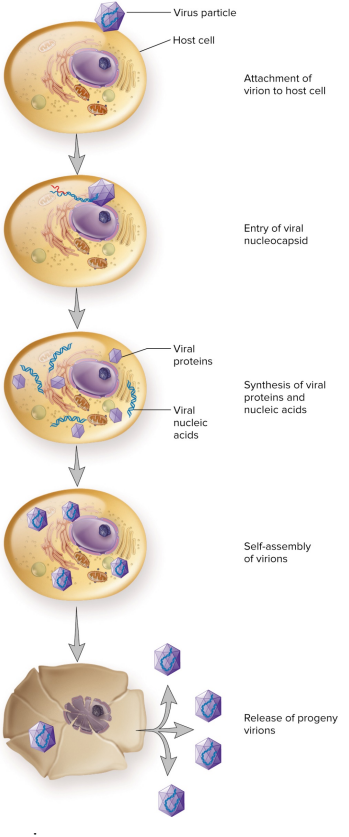
How do viruses multiply in the eukaryotic cells:

Viral Multiplication

Mechanism used depends on viral structure and genome. Depending on them.

Steps are similar:

- (1) Attachment to host cell.
- (2) Entry and uncoating of genome.
- Synthesis → DNA / RNA Replication.
- Assembly.
- Release. → Differ from virus to virus



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How do they attach to eukaryotic cell?

Attachment (Adsorption)

1.

→ they attached by Receptors on the eukaryotic cells.

Specific receptor attachment.

Receptor determines host preference:

- May be specific tissue (tropism). → the virus effect more than one type of cells.
- May be more than one host.
- May be more than one receptor.

② Entry Into the Host

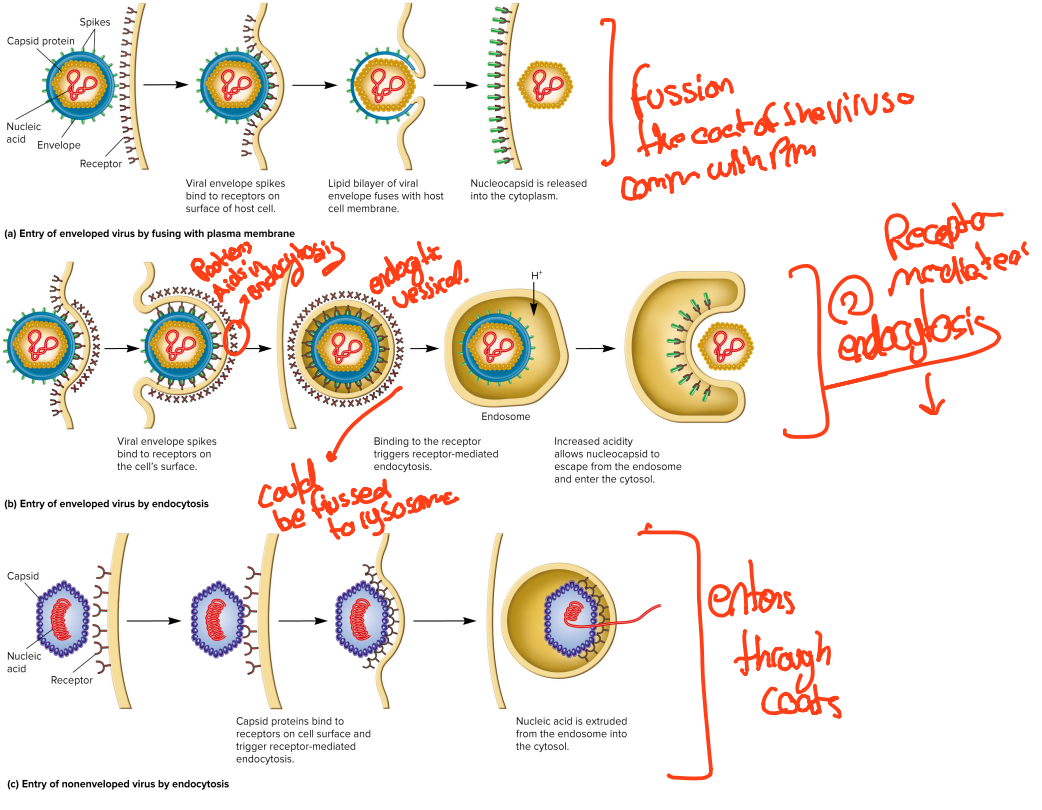
Entire genome or nucleocapsid.

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



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Synthesis Stage

Genome dictates the events.

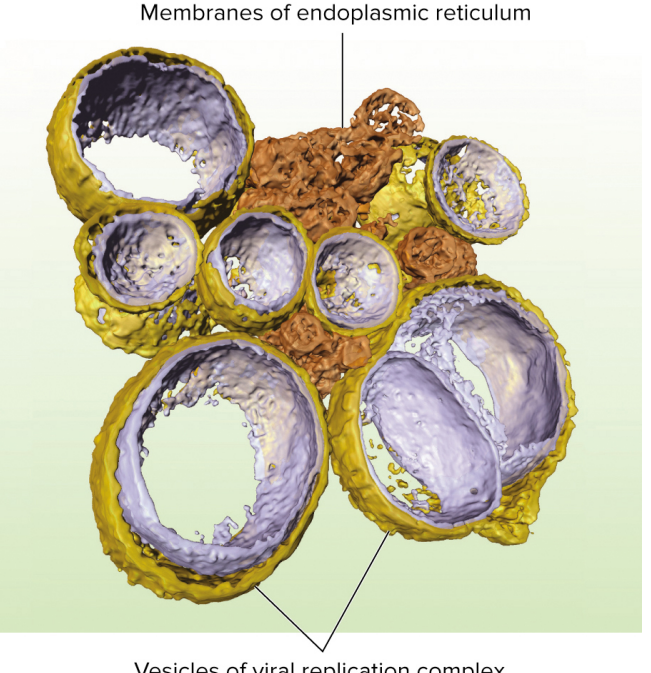
ds DNA typical flow.

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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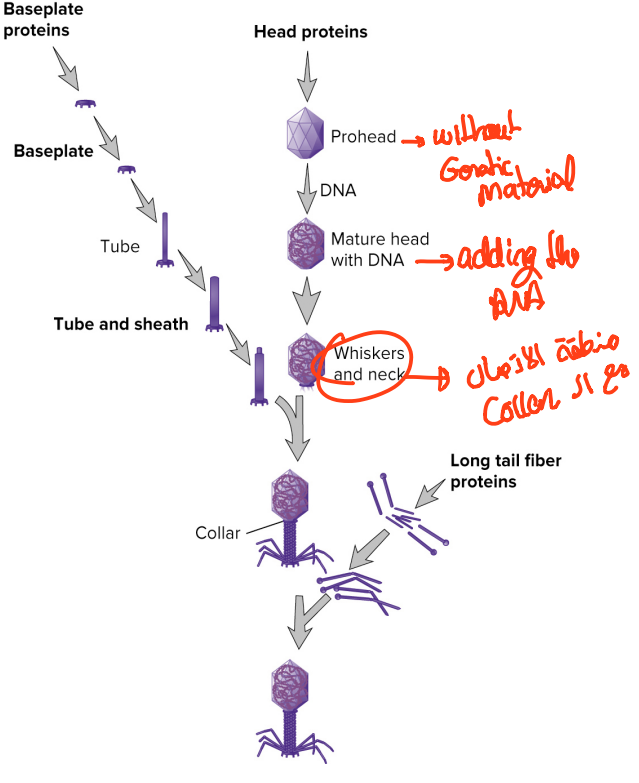
Assembly



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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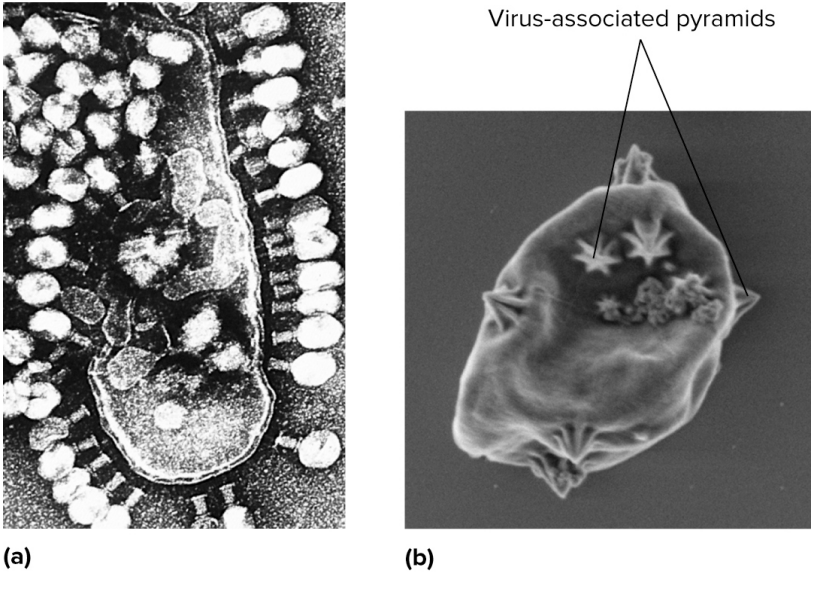
Virion Release

Nonenveloped viruses lyse the host cell.

- Viral proteins may attack peptidoglycan or membrane.



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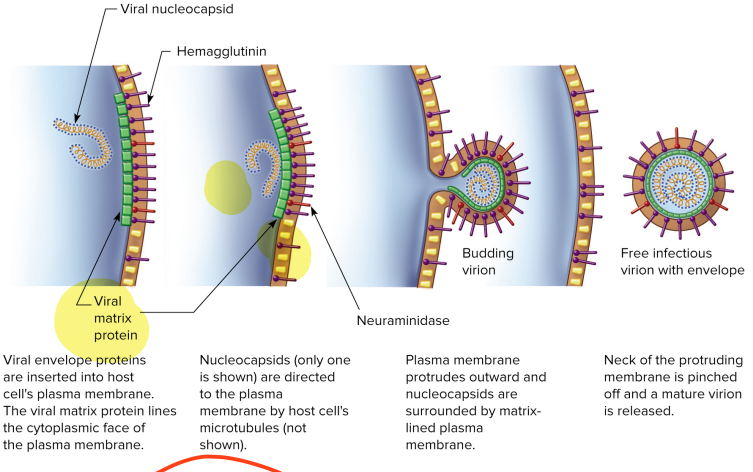
Virion Release 2



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.

Virus use the cytoskeletal elements in the eukaryotic cell.

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Bacterial and Archaeal Viral Infections

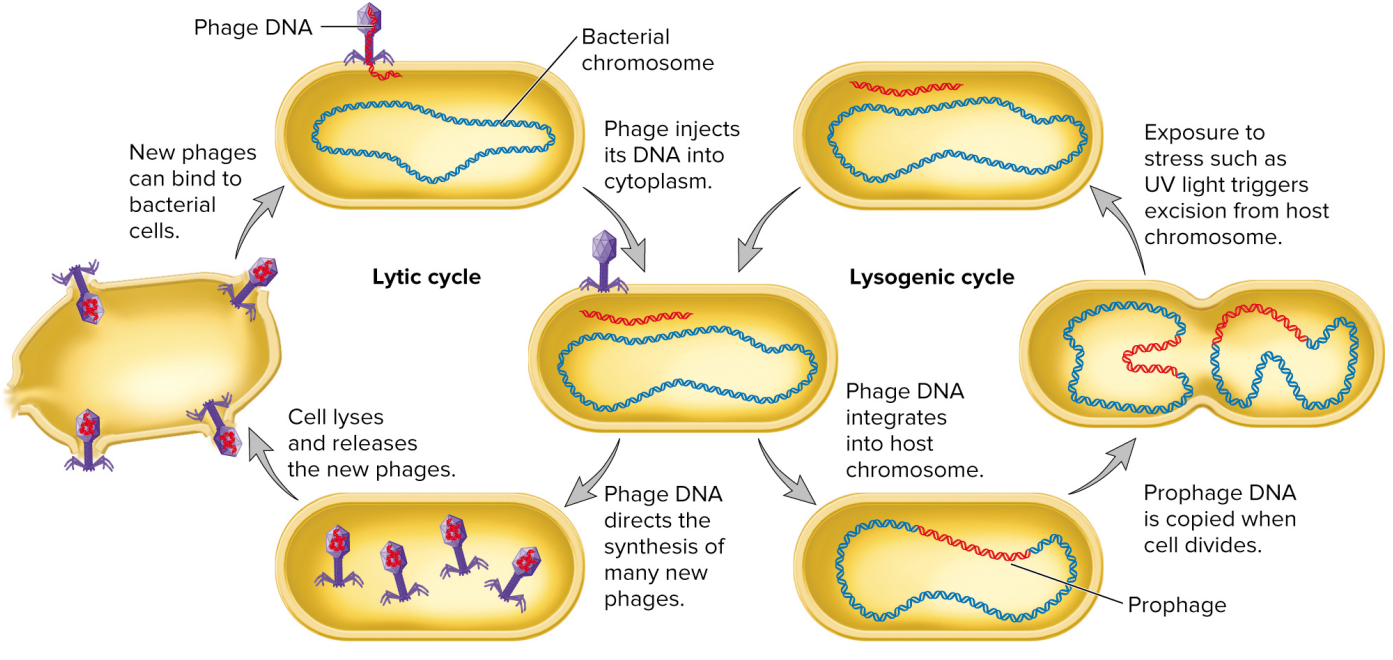
Virulent phage—one reproductive choice.

- Multiplies immediately upon entry.
- Lyses bacterial host cell.

Temperate phage—two reproductive options.

- **Reproduce lytically as virulent phages do.**
- **Remain within host cell without destroying it.**
- Many temperate phages integrate their genome into host genome (becoming a 'prophage' in a 'lysogenic bacterium') in a relationship called lysogeny.

Lytic and Lysogenic Cycles



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Lysogenic Conversion

Temperate phage changes phenotype of its host.

- Bacteria become immune to superinfection.
- Phage may express pathogenic toxin or enzyme.

Two advantages to lysogeny for virus.

- Phage remains viable but may not replicate.
- Multiplicity of infection ensures survival of host cell.

Under appropriate conditions infected bacteria will lyse and release phage particles.

- Occurs when conditions in the cell cause the prophage to initiate synthesis of new phage particles, a process called induction.

Archaeal Viruses

May be virulent or temperate.

Many establish chronic infections.

Little is known about the mechanisms they use to regulate their replicative cycles.

Infection in Eukaryotic Cells

Infection starts with the adherence of the virus on a Receptor on the eukaryotic cell.

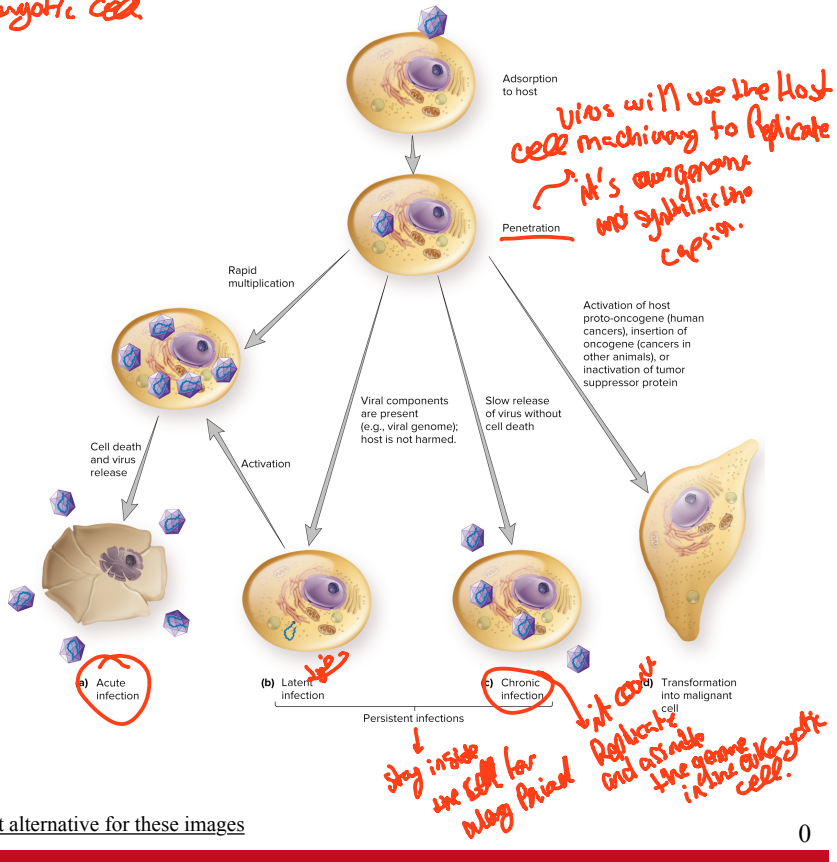
Cytocidal infection results in cell death through lysis.

Persistent infections may last years.

Cytopathic effects (CPEs). → Change Morphologies.

- 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.

The Cultivation of Viruses

Requires inoculation of appropriate living host.

Hosts for Bacterial and Archaeal Viruses.

Usually cultivated in broth or agar cultures of suitable, young, actively growing bacteria.

Broth cultures lose turbidity as viruses reproduce.

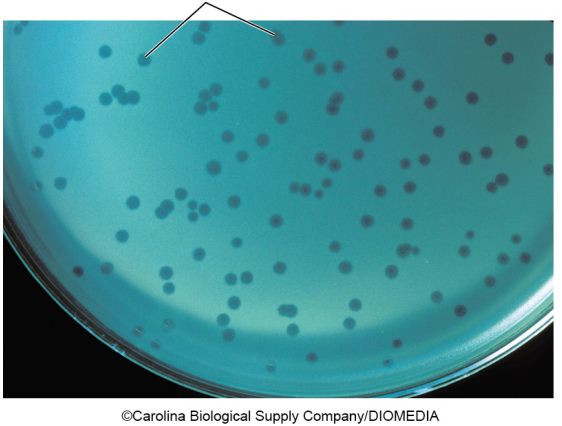
Plaques observed on agar cultures.

Hosts for Animal Viruses

Tissue (cell) cultures. → Cell From plants Animals...

- Cells are infected with virus (phage).
- Viral plaques—Localized area of cellular destruction and lysis that enlarge as the virus replicates.

Plaques formed by the multiplication of T4 in a lawn of *E. coli* cells



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Cytopathic effects (CPEs).

- Microscopic or macroscopic degenerative changes or abnormalities in host cells and tissues.

Embryonated eggs. → we can grow the virus in the Chicken egg →

Hosts for Plant Viruses

Plant tissue cultures.

Cultures of separated cells.

Plant protoplast cultures.

Suitable whole plants.

- May cause localized necrotic lesions or generalized symptoms of infection.

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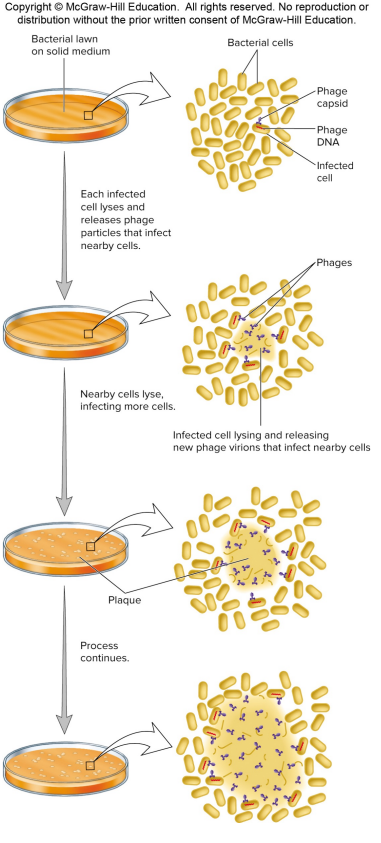
Quantification of Virus

Direct counting of viral particles.

Indirect counting by an observable effect of the virus.

- Hemagglutination assay.
  ↳ depends on RBCs which having Corbohy Notes antigens on
- Plaque assays.
  - Dilutions of virus preparation made and plated on lawn of host cells.
  - Number of plaques counted.
  - Results expressed as plaque-forming units (PFU). → Areas where lysis happened



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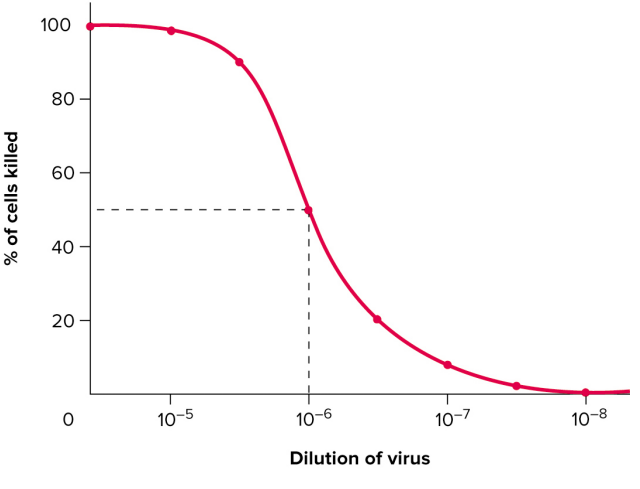
the Dose from virus to infect 50% of the cells.

Measuring Biological Effects

Infectious dose and lethal dose assays. ✓ → to kill 50%.

- Determine smallest amount of virus needed to cause infection (ID) or death (LD) of 50% of exposed host cells or organisms (ID50 or LD50).



Viroids in Plants

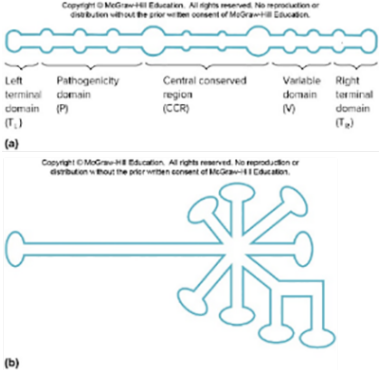
Infectious agents composed of closed, circular ssRNAs.

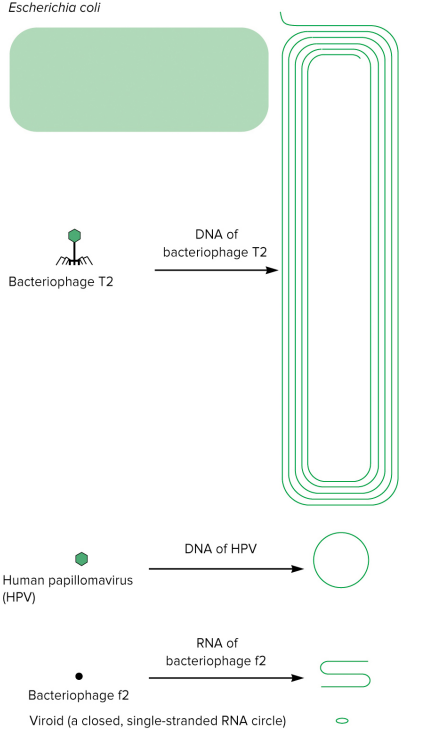
Do not encode gene products.

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. → But However they are unable to infect A cells without 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.

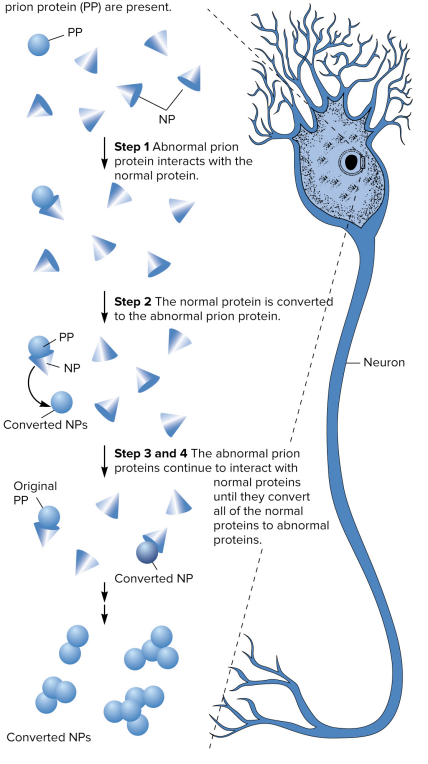
- Scrapie in sheep.
- Bovine spongiform encephalopathy (BSE) or "mad cow disease."
- Human diseases kuru, fatal familial insomnia, Creutzfeldt-Jakob disease (CJD), and Gerstmann-Strässler-Scheinker syndrome (GSS).

Current Model of Disease Production by Prions

PrPC (prion protein) is present in "normal" form (abnormal form of prion protein is PrPSc).

PrPSc causes PrPC protein to change its conformation to abnormal form.

Newly produced PrPSc molecules convert more normal molecules to the abnormal form through unknown mechanism.



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