Lecture (9) Viruses

- Viruses were too small to be seen by microscopes
- The cause of viral infections was unknown for years
- Cannot exist independently from the host cell, so aren't considered living things
- Obligate intracellular parasites
- Can infect every type of cell so they Cannot multiply unless they invade a specific host cell and instruct its genetic to make and release new viruses
- Louis Pasteur proposed the term virus 1890s
- Ivanovski and Beijerinck showed that a disease in tobacco was caused by a virus
- So They can pass through the bacterial filters.

TABLE 6.1 Properties of Viruses

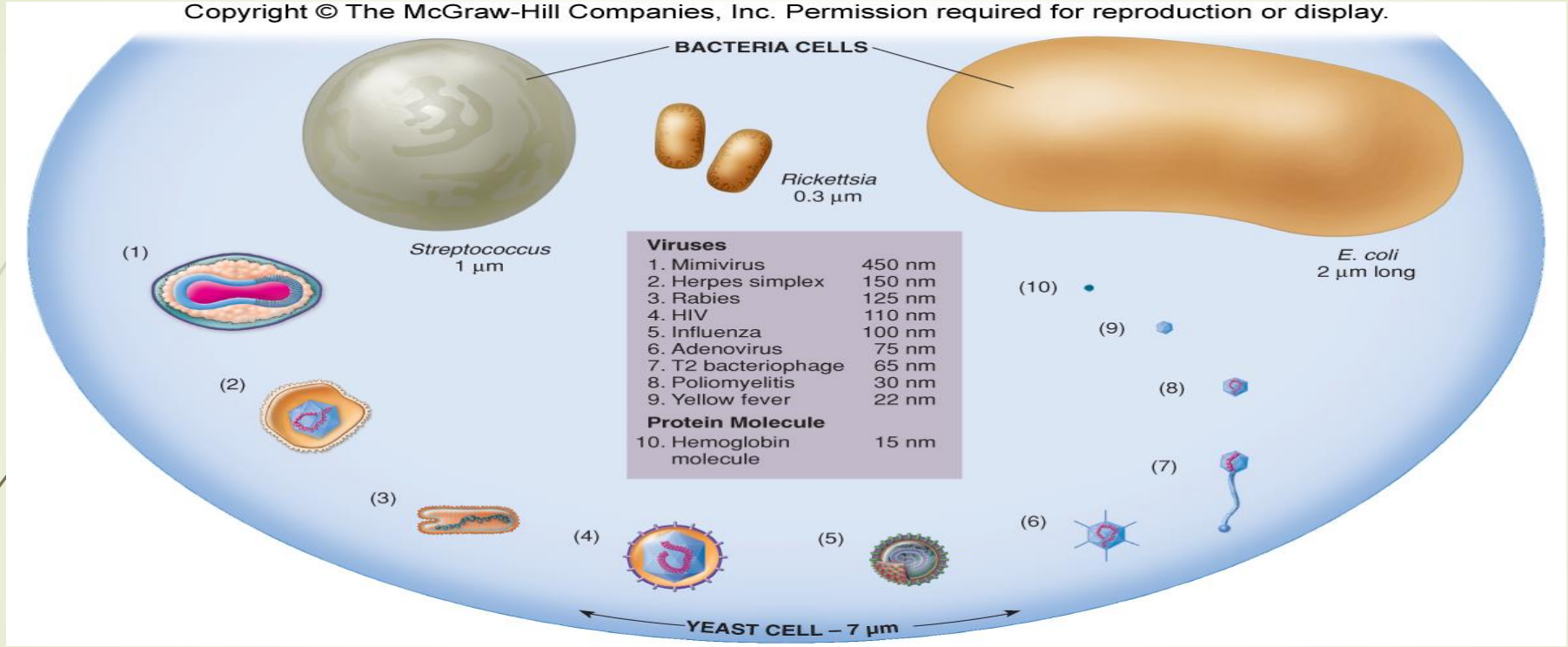
- Are obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants, and animals.
- Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter).
- Are not cells; structure is very compact and economical.
- Do not independently fulfill the characteristics of life.
- Are inactive macromolecules outside the host cell and active only inside host cells.
- Basic structure consists of protein shell (capsid) surrounding nucleic acid core.
- 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.
- 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.
- Lack machinery for synthesizing proteins.

They are obligatory intracellular parasites

Viruses are **obligatory intracellular parasites** as they are totally dependent upon a living cell for their replication because:

i. Viruses lack ATP generating system.
ii. Viruses lack Machinery for protein synthesis i.e. ribosomes and protein synthesizing apparatus.

The General Structure of Viruses

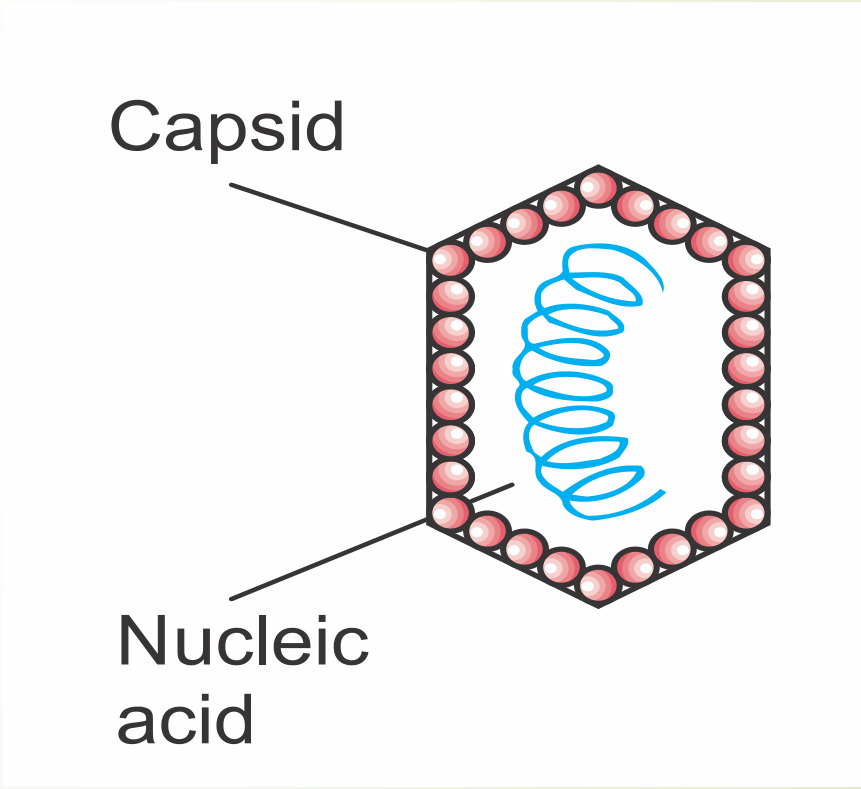


2. Viruses has a Minimal acellular structure

Viruses are minimally constructed of two components;

a **protein** coat that surrounds

the **nucleic acid genome**.

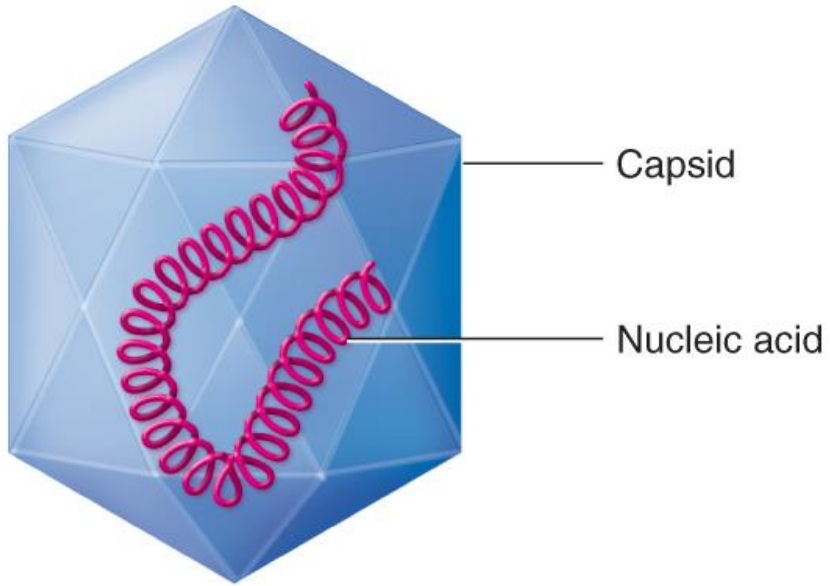


Classification

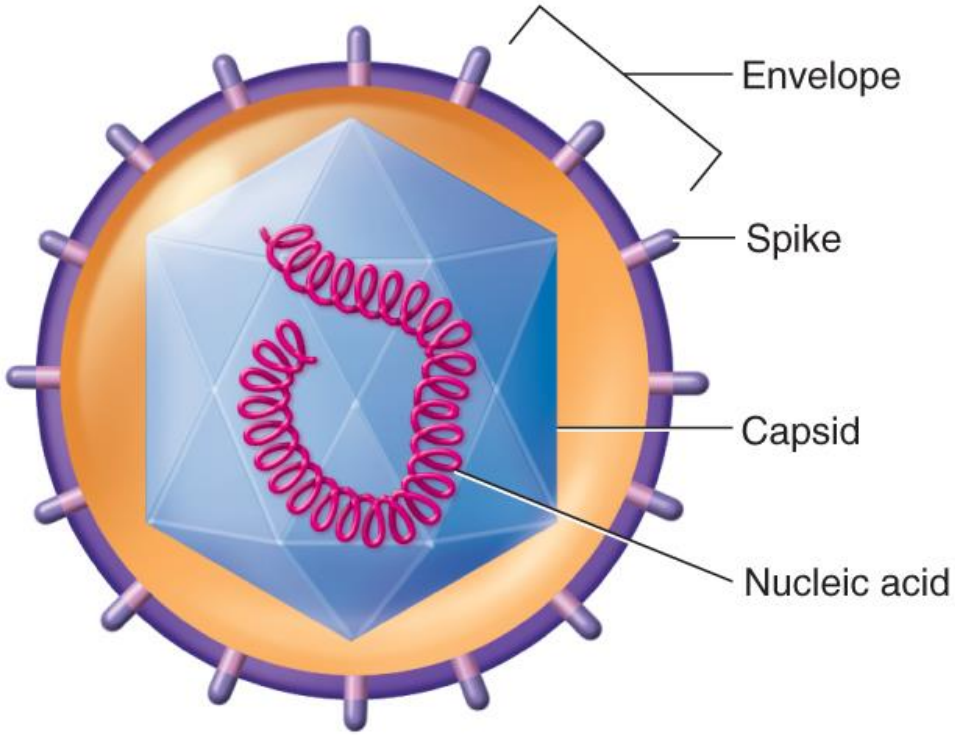
- Several Parameters Are Used for Classification
  - Structure - Capsid structure
  - Chemical composition
  - Similarities in genetic makeup
  - Type of genomic nucleic acid
  - Size of virion and genome
  - Host
  - Replication mechanism
- International Committee on the Taxonomy of Viruses, 2000
  - 3 orders
  - 63 famillies "-viridae"
  - 263 genera "-virus"

Essential structures

- Molecular structure- composed of
- regular, repeating subunits that give rise to their crystalline appearance
- Contain only those parts needed to invade and control a host cell
- External coating
  - Capsid
  - Envelope- in 13 of the 20 families of animal viruses
  - If no envelope, called naked virus
- Core
  - DNA
  - RNA
- The capsid and the nucleic acid together are called the nucleocapsid



(a) **Naked Nucleocapsid Virus**



(b) **Enveloped Virus**

The Viral Capsid

:The Protective Outer Shell

Constructed from identical subunits called **capsomers**

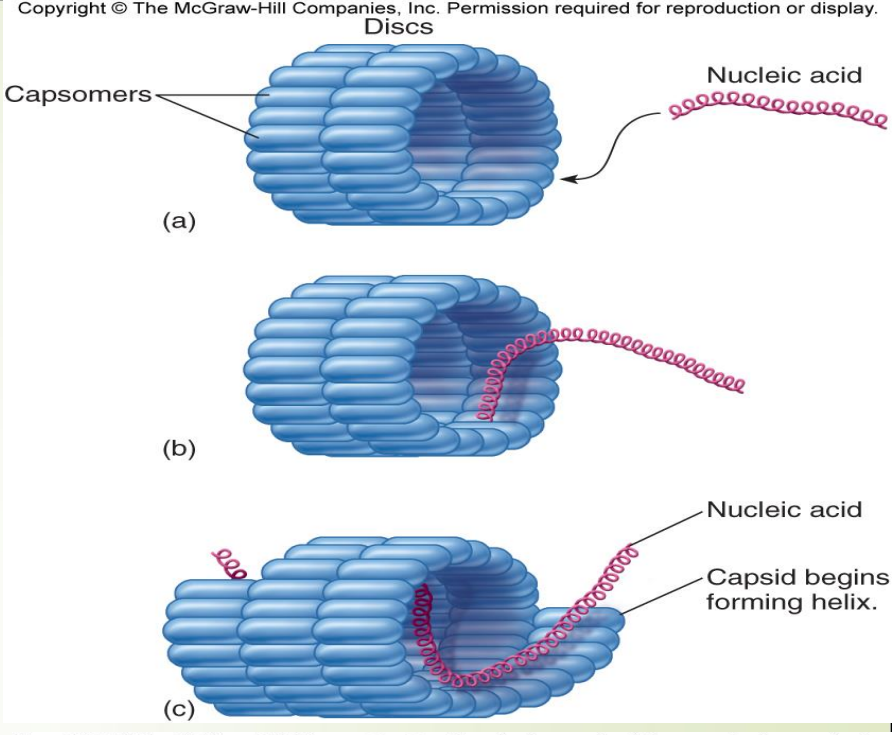
Made up of protein molecules

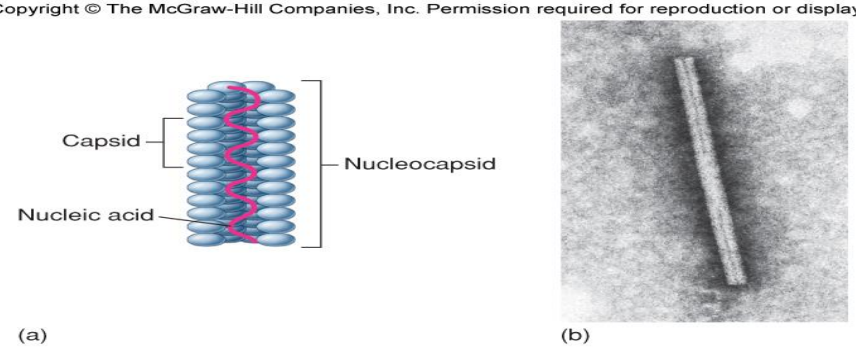
Two different types

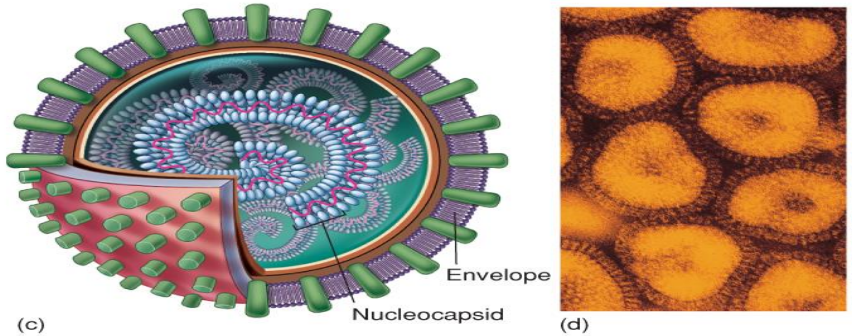
Helical

Rod-shaped **capsomers**

Assemble in to helical nucleocapsid

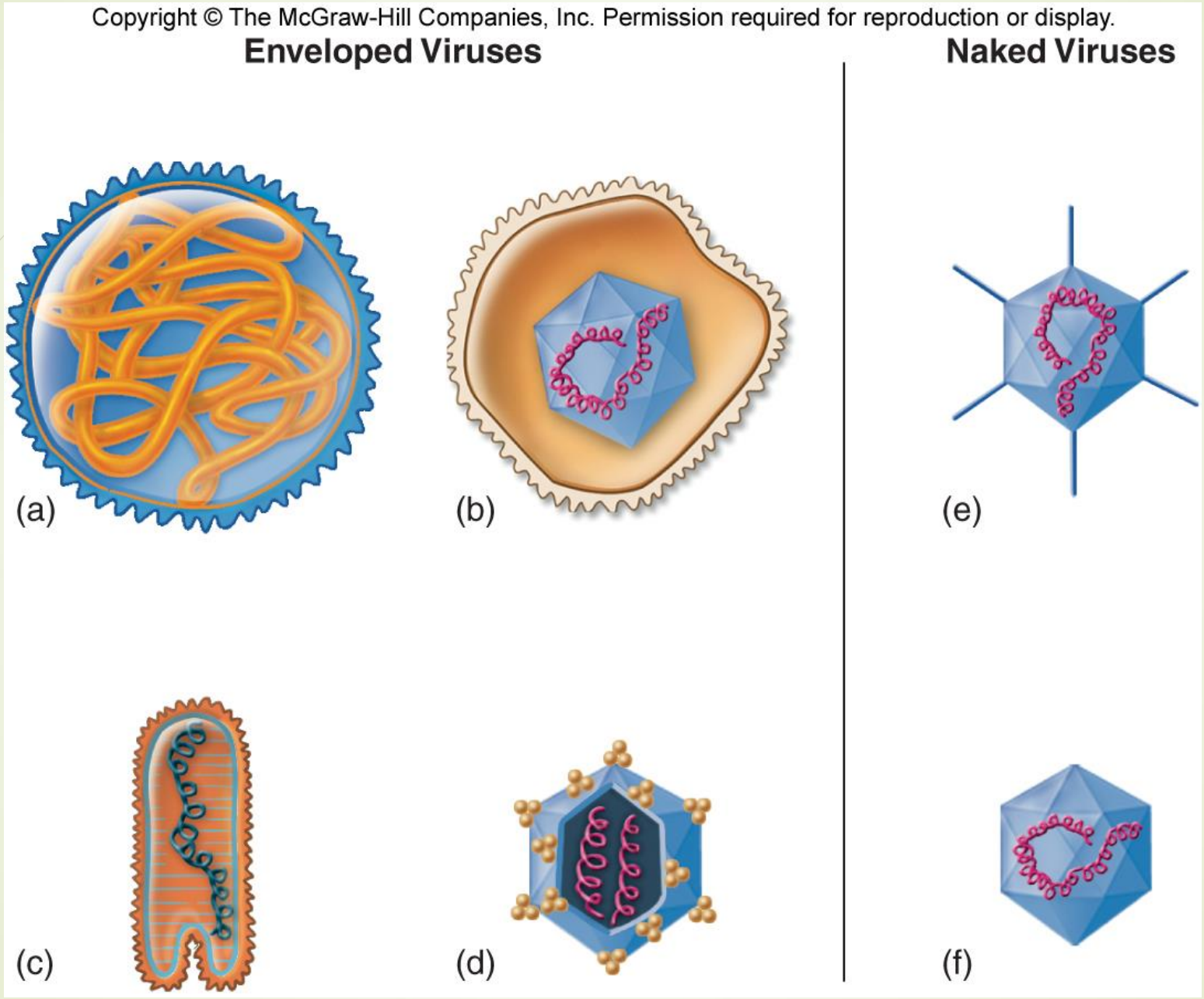






The Viral Envelope

- **Enveloped viruses** take a bit of the host cell membrane in the form of an envelope
- In the envelope, some or all of the regular membrane proteins are replaced with viral proteins
- Some proteins form a binding layer between the envelope and the capsid
- Glycoproteins remain exposed as **spikes** essential for attachment



Functions of Capsid & Envelope

- Protects nucleic acids
- Help introduce the viral DNA or RNA into a suitable host cell
- Stimulate the immune system to produce antibodies that can protect the host cells against future infections

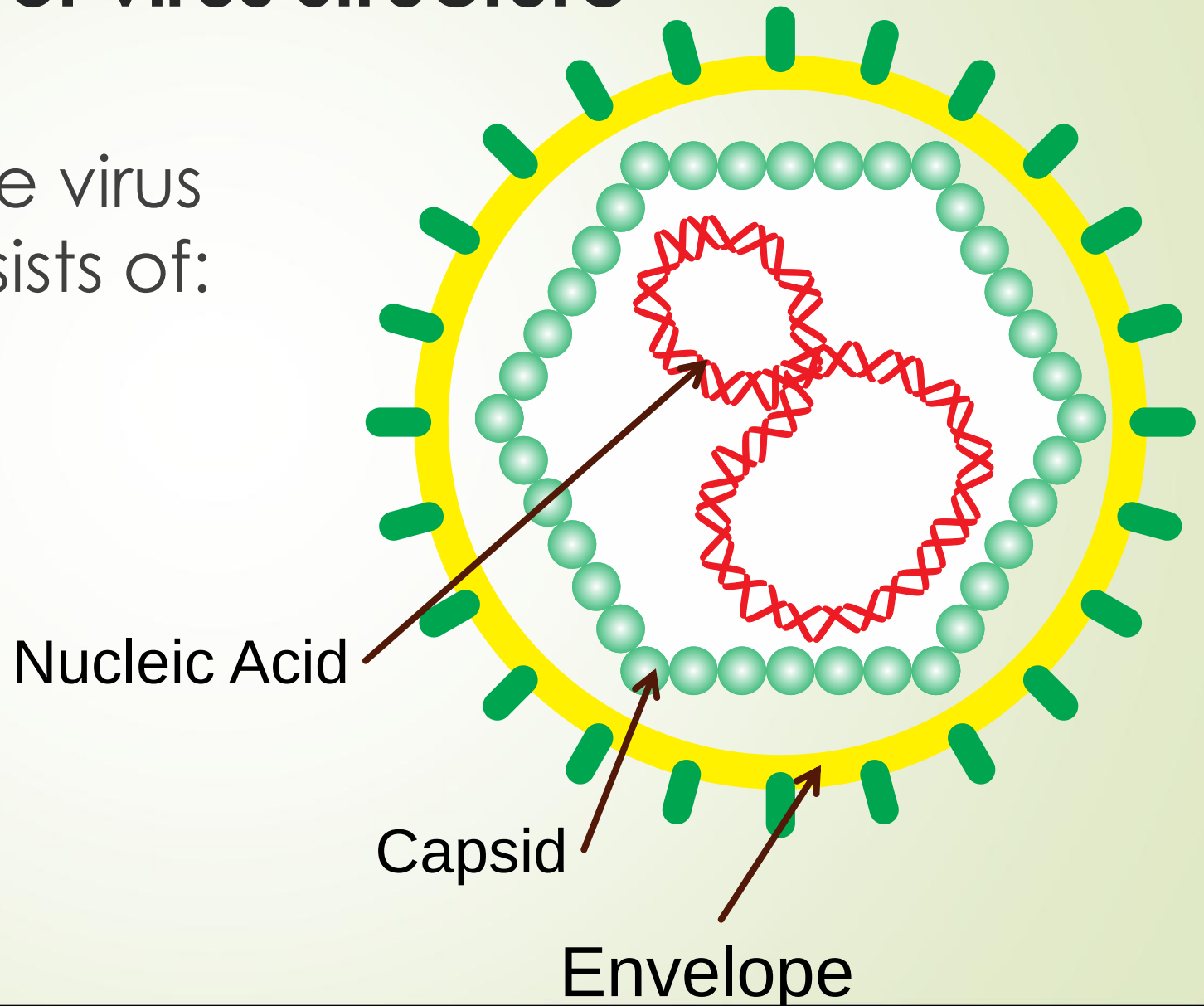
Nucleic Acids

- Number of viral genes quite small
- They only have the genes necessary to invade host cells and redirect their activity
- Some viruses are exceptions to the rules are: DNA and RNA
  - Parvoviruses contain single-stranded DNA
  - Reoviruses contain double-stranded RNA

Principles of virus structure

A complete infective virus particle (virion) consists of:

1. Nucleic acid
2. Capsid
3. Envelope



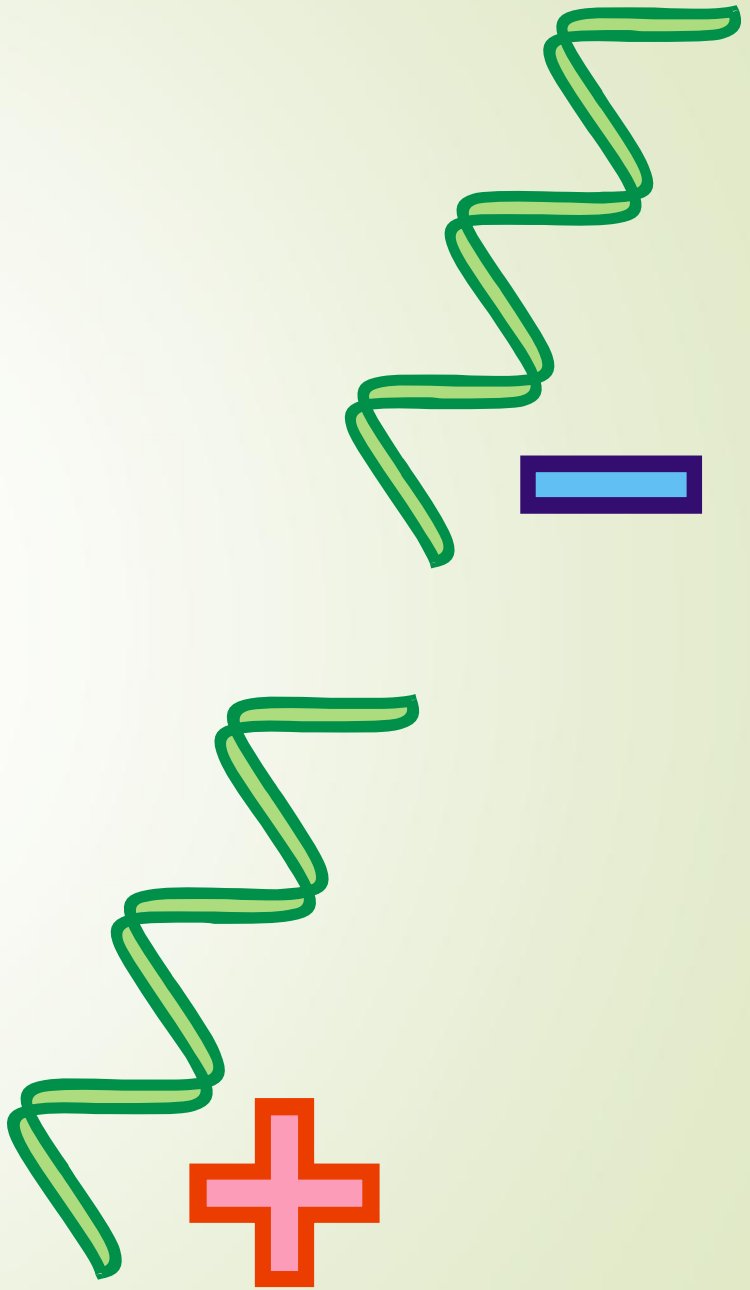
Nucleic acid (viral genome)

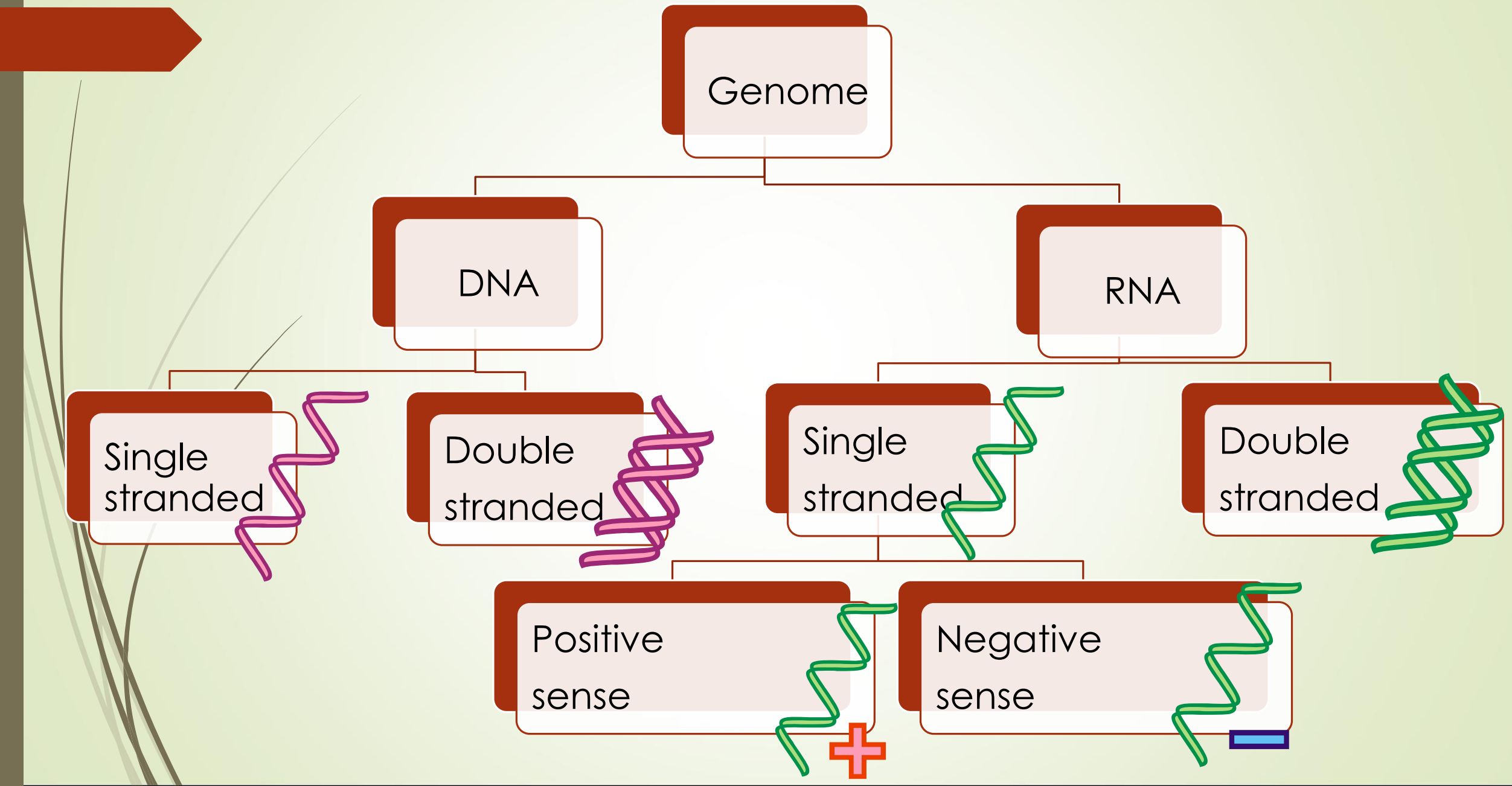
- It is either **DNA** or **RNA** but never both.
- It may be single-stranded (ss) or double-stranded (ds).

Polarity

Single stranded RNA genomes are further subdivided into:

- **Positive polarity**: has same polarity as messenger RNA → can be used for protein synthesis.
- **Negative polarity**: Complementary to messenger RNA → cannot be used directly for protein synthesis.

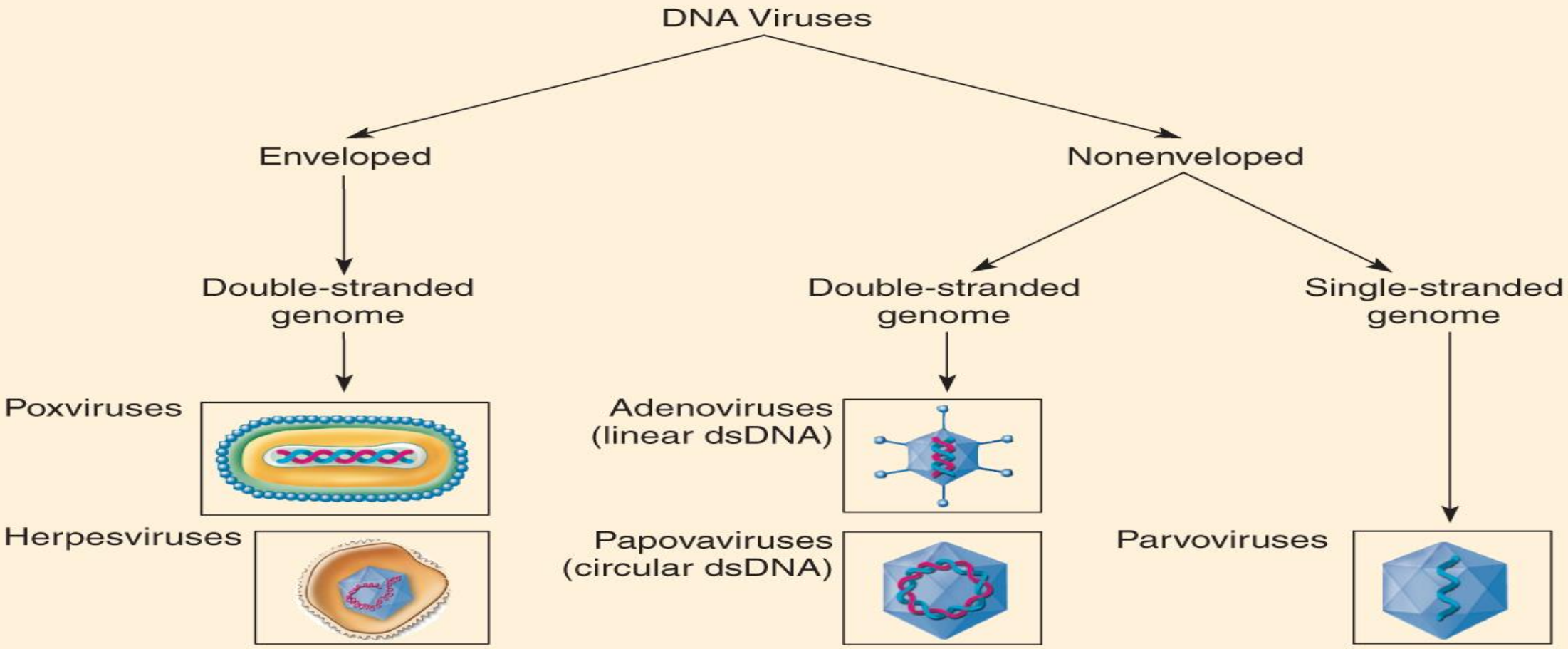



Genome
DNA
RNA
Single stranded
Double stranded
Single stranded
Double stranded
Positive sense
Negative sense

Functions of nucleic acid:

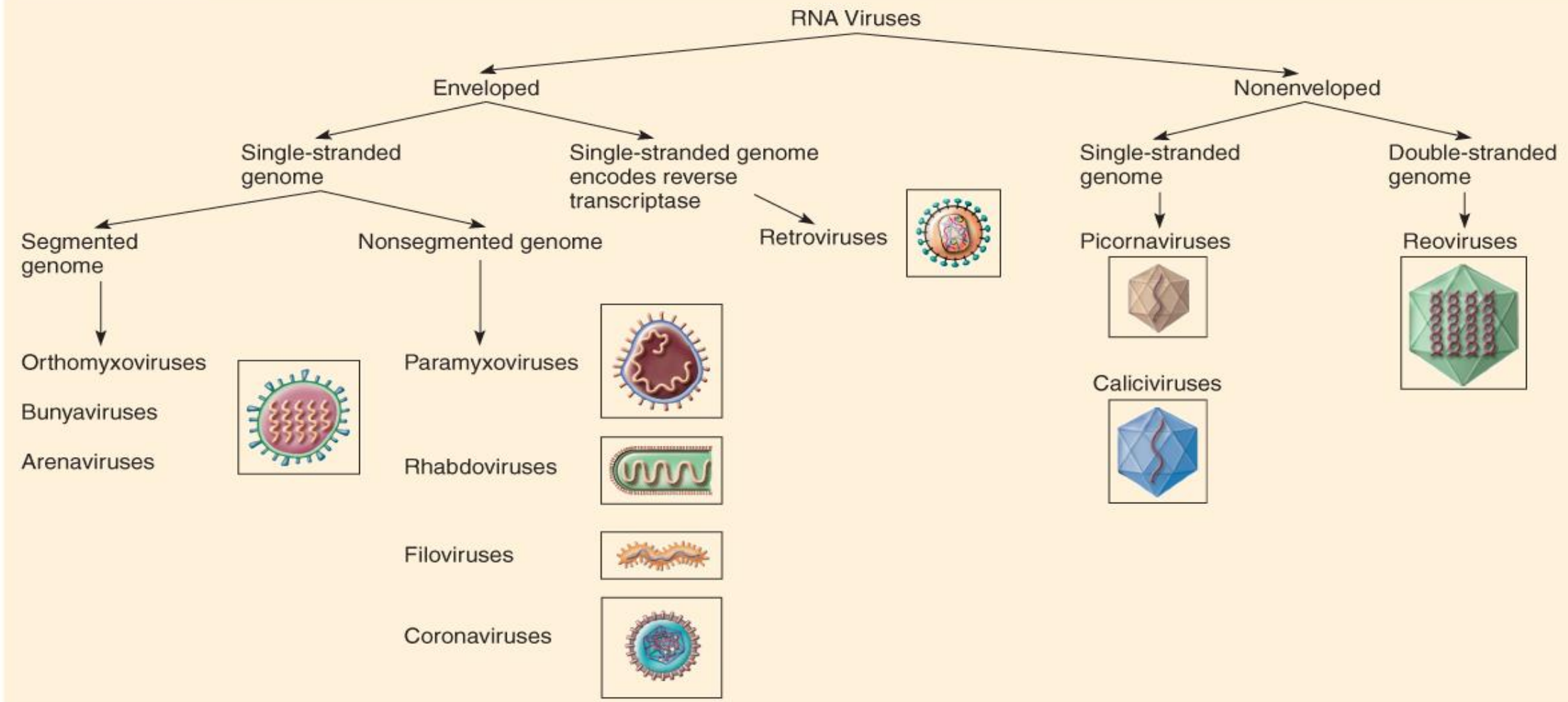
- It is the **infectious part** of the virus. Empty virus particles are none-infectious.
- It codes for the production of viral proteins.

TABLE 6.2 Medically Relevant DNA Virus Groups



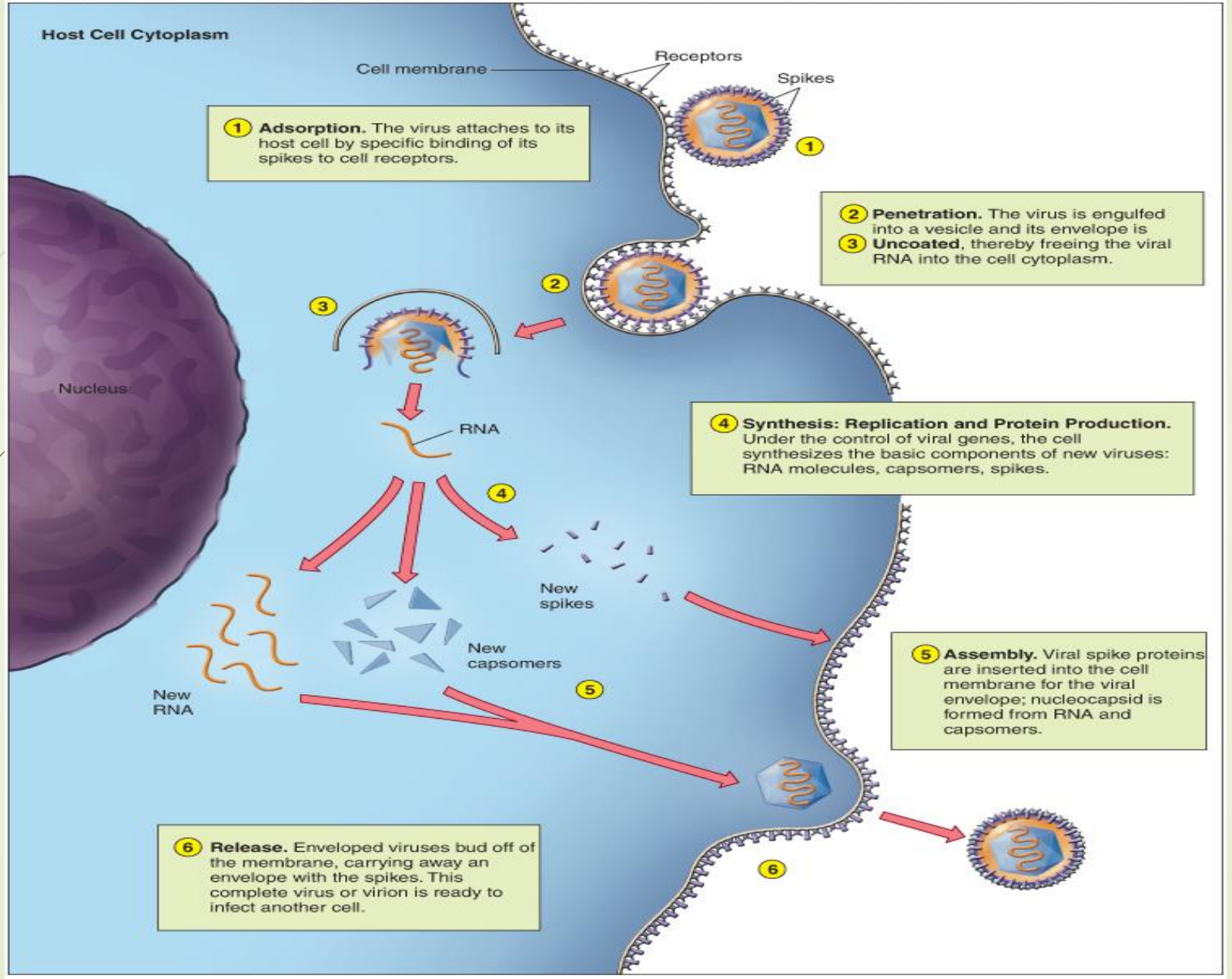
Source: Adapted from: *Poxviridae* from Buller et al., National Institute of Allergy & Infectious Disease, Department of Health & Human Services.

TABLE 6.3 **Medically Relevant RNA Viruses**



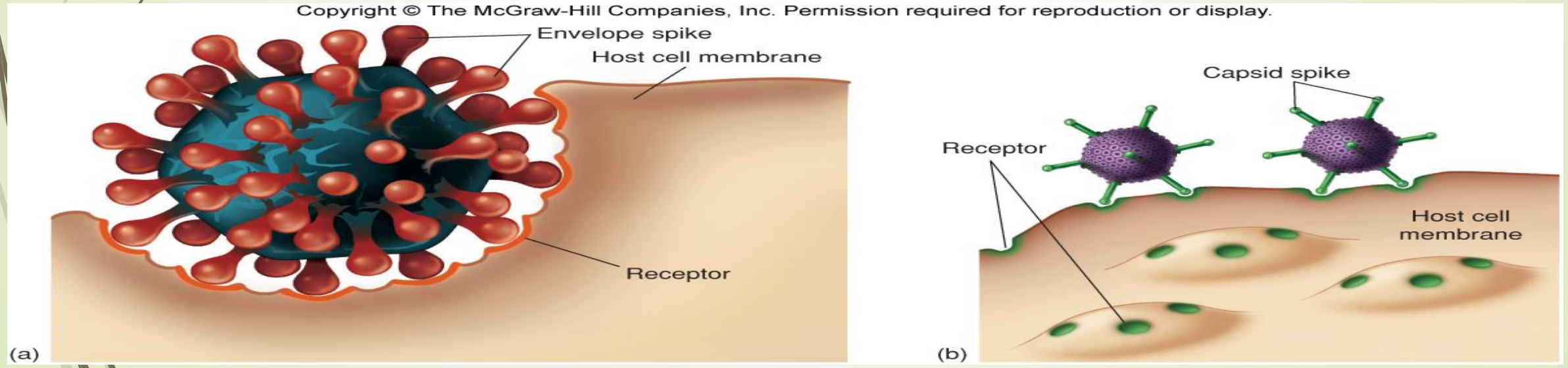
Viral Multiplication

- Adsorption
- Penetration
- Uncoating
- Synthesis
- Assembly
- Release



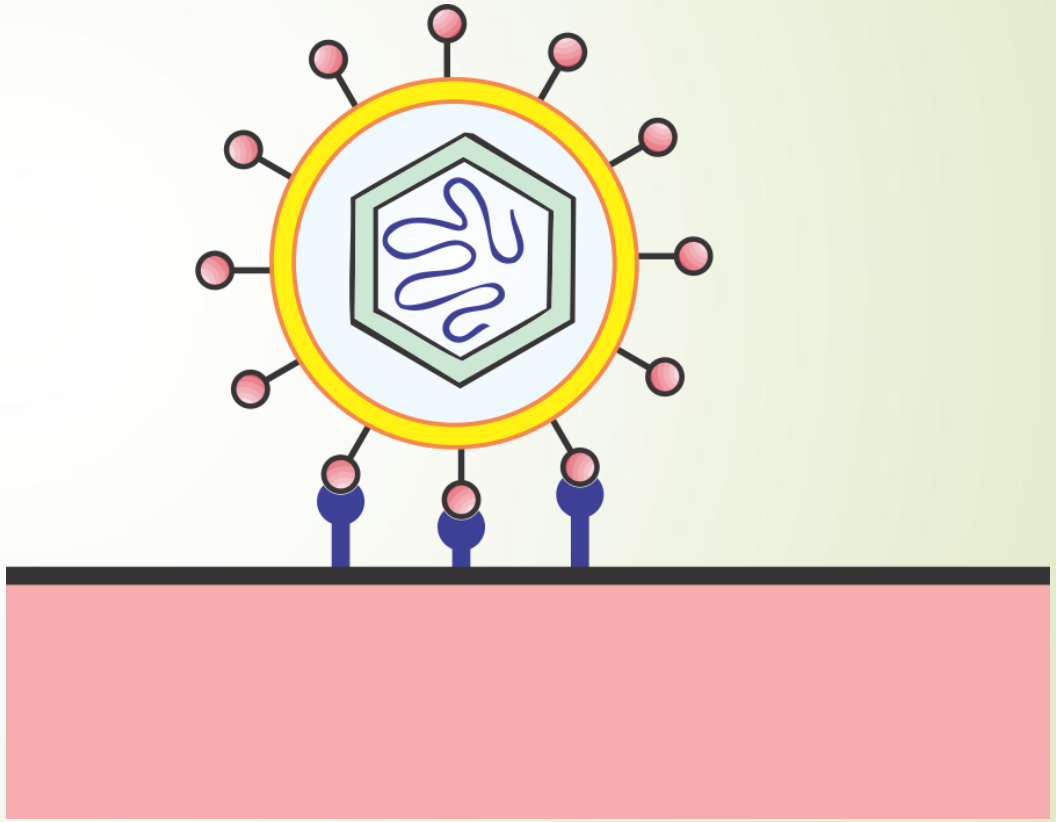
Adsorption

- Virus encounters susceptible host cells
- Adsorbs specifically to receptor sites on the cell membrane
- Because of the exact fit required, viruses have a limited **host range**



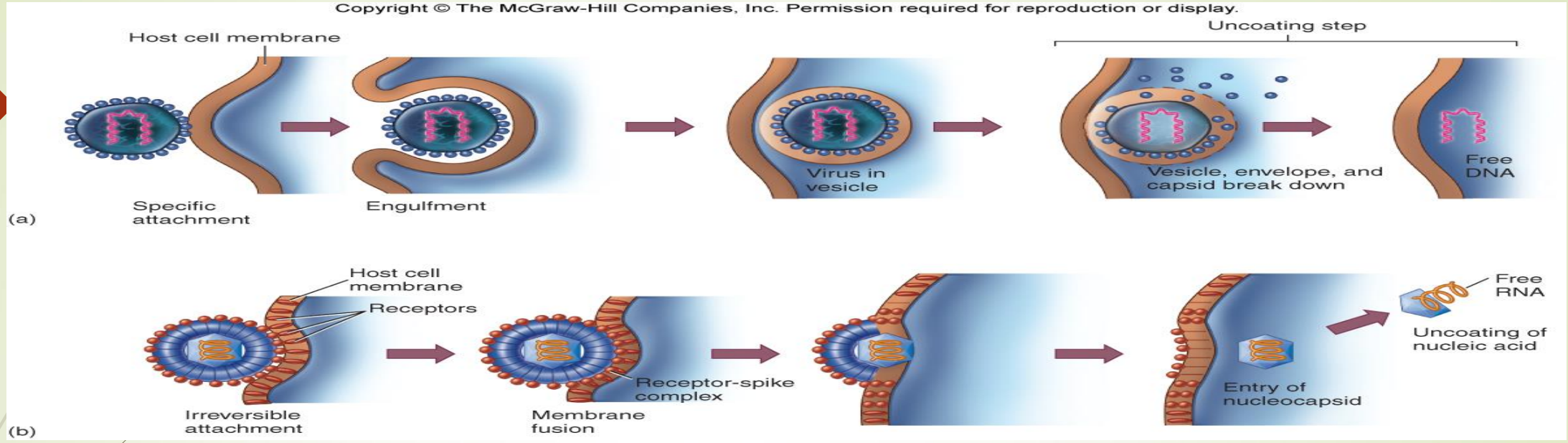
Adsorption (Attachment)

Specific binding between viral **surface proteins** and their **receptors** on the host cell surface.



Penetration

It is the passage of the virion from the surface of the cell, across the cell membrane and into the cytoplasm.



Penetration

Flexible cell membrane of the host is penetrated by the whole virus or its nucleic acid

The viral envelope can also directly fuse with the host cell membrane

Uncoating

- Enzymes in the vacuole dissolve the envelope and capsid and The virus is now **uncoated**

3. Uncoating

- It is the physical separation of the viral nucleic acid from the outer structural components of the virion.

Synthesis

- Free viral nucleic acid exerts control over the host's synthetic and metabolic machinery
- DNA viruses- enter host cell's nucleus where they are replicated and assembled
  - DNA enters the nucleus and is transcribed into RNA
  - The RNA becomes a message for synthesizing viral proteins (translation)
  - New DNA is synthesized using host nucleotides
- RNA viruses- replicated and assembled in the cytoplasm

Assembly

Mature virus particles are constructed from the growing pool of parts

5. Assembly

- It is the association of the new virus genomes and viral structural proteins to form new virus particles.

Synthesis of new viral components

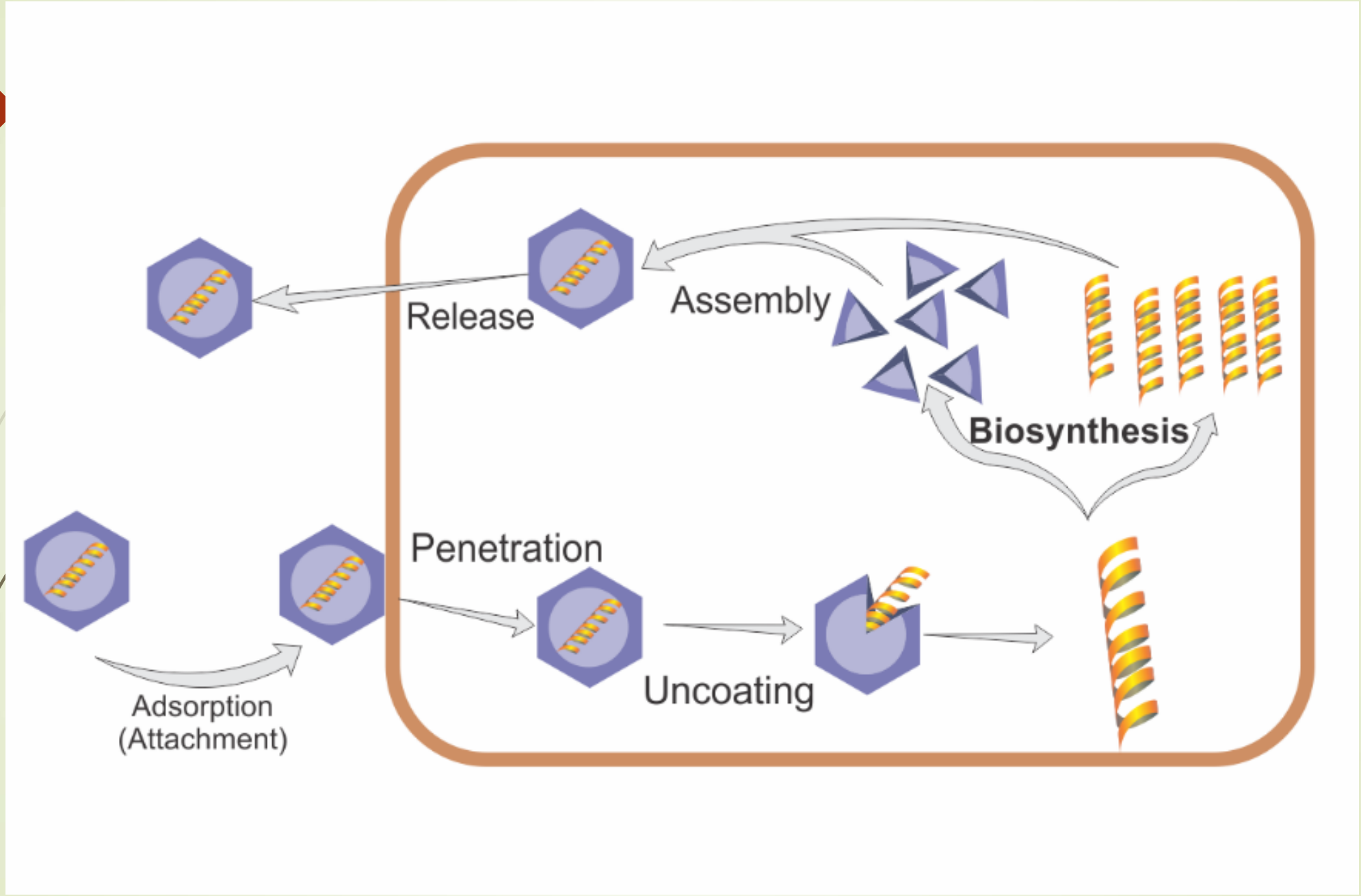
- Gene expression of viral genes (transcription and translation of viral genes).
- Replication of viral genome.

6. Release

- Some viruses may escape from the host cell by causing cell rupture (lysis).
- Enveloped viruses typically "bud" from the host cell.
- During budding, enveloped viruses acquire their envelope

Release

- Nonenveloped and complex viruses are released when the cell lyses or ruptures
- Enveloped viruses are liberated by **budding** or **exocytosis**
- Anywhere from 3,000 to 100,000 virions may be released, depending on the virus
- Entire length of cycle- anywhere from 8 to 36 hours


Release
Assembly
Biosynthesis
Penetration
Uncoating
Adsorption
(Attachment)

Damage to the Host Cell and Persistent Infections

- **Cytopathic effects**- virus-induced damage to the cell that alters its microscopic appearance
- Inclusion bodies- compacted masses of viruses or damaged cell organelles

Bacteriophage: Viruses that Infect Bacteria

- Most contain dsDNA
- Often make the bacteria they infect more pathogenic for humans
  - Adsorb to host bacteria
  - The nucleic acid penetrates the host after being injected through a rigid tube inserted through the bacterial membrane and wall
  - Entry of the nucleic acid causes the cessation of host cell DNA replication and protein synthesis
  - The host cell machinery is then used for viral replication and synthesis of viral proteins
  - As the host cell produces new parts, they spontaneously assemble

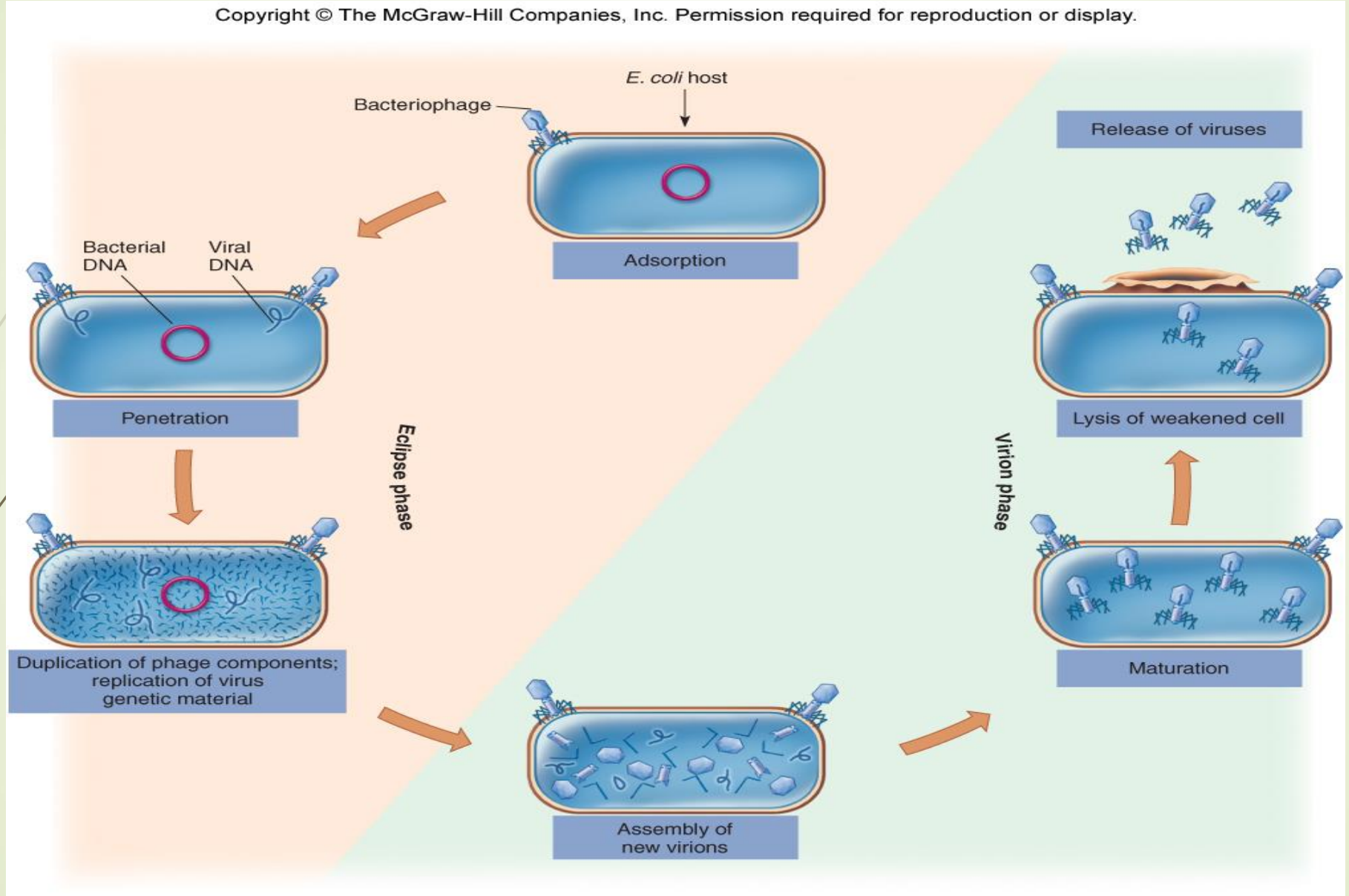
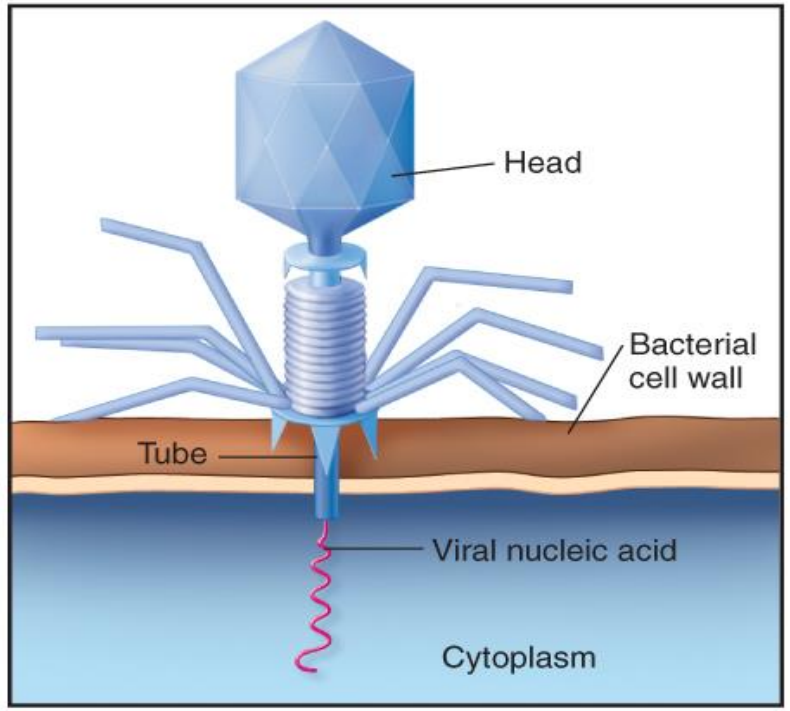


Figure 6.17



(a)

(b)

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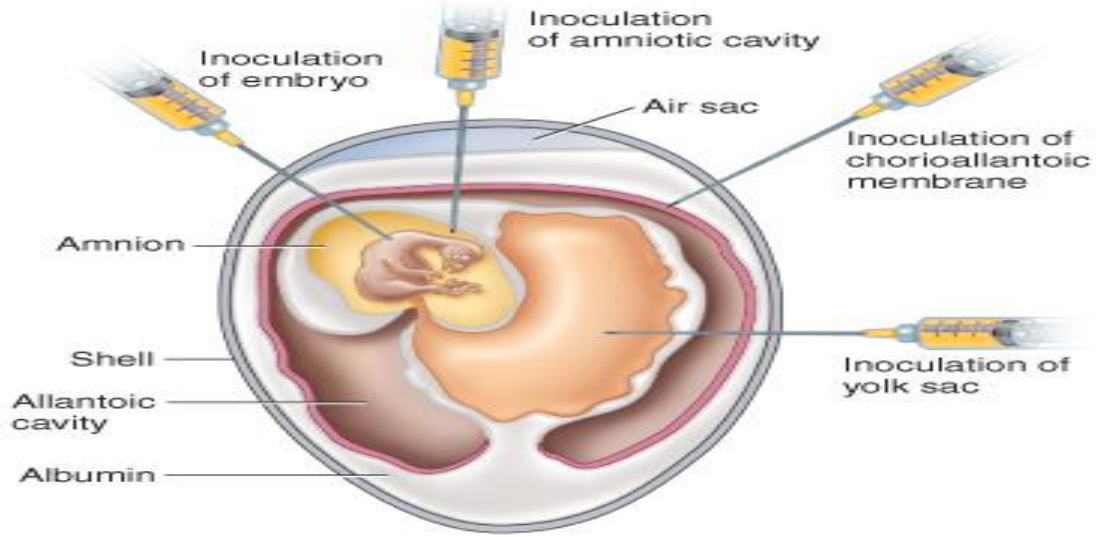
Techniques in Cultivating and Identifying Animal Viruses

- Primary purposes of viral cultivation
  - To isolate and identify viruses in clinical specimens
  - To prepare viruses for vaccines
  - To do detailed research on viral structure, multiplication cycles, genetics, and effects on host cells
- Using Live Animal Inoculation
  - Specially bred strains of white mice, rats, hamsters, guinea pigs, and rabbits
  - Occasionally invertebrates or nonhuman primates are used
  - Animal is exposed to the virus by injection
- Using Bird Embryos
  - Enclosed in an egg- nearly perfect conditions for viral propagation
  - Chicken, duck, and turkey are most common
  - Egg is injected through the shell using sterile techniques

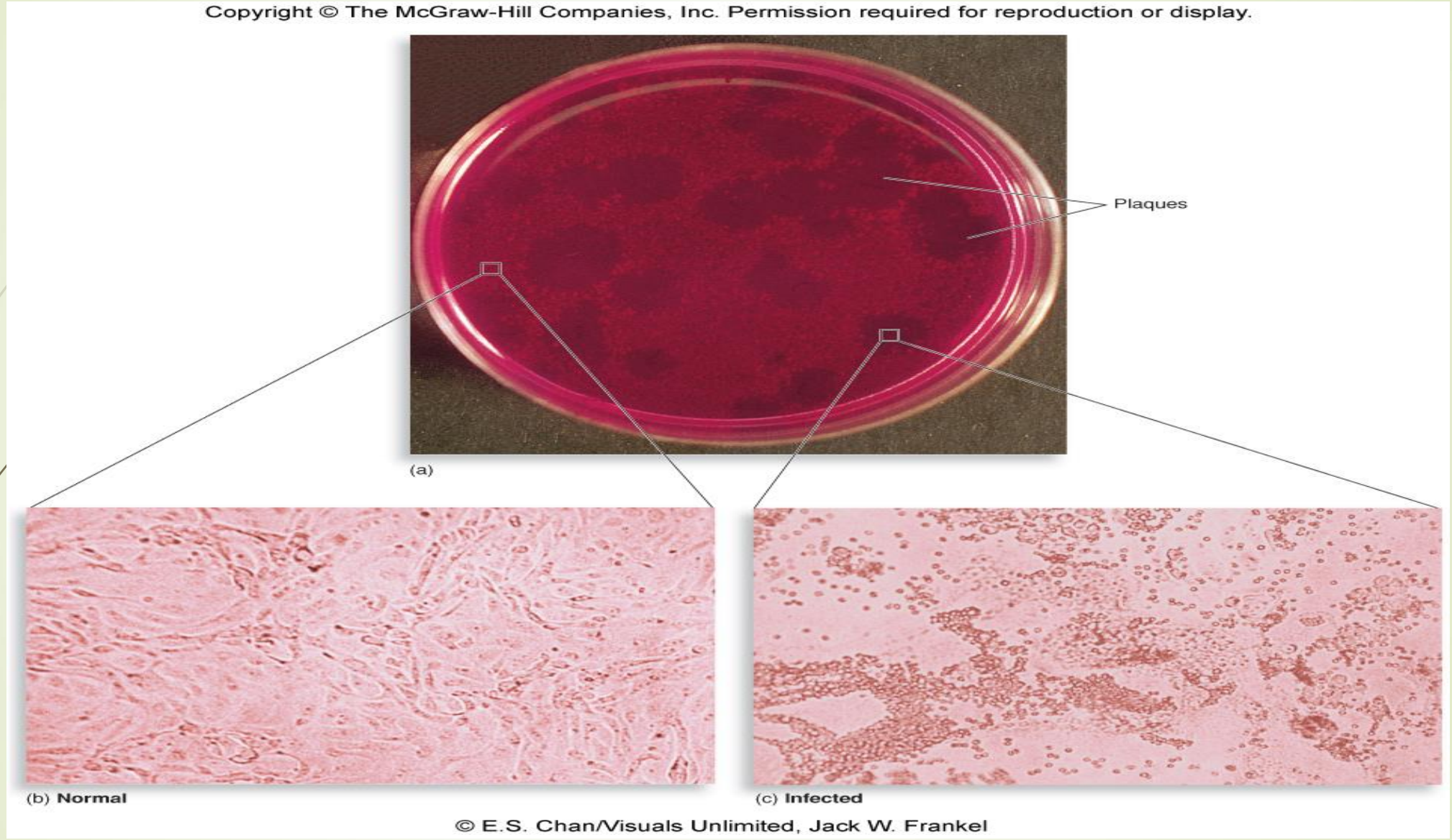
(a)



(b)

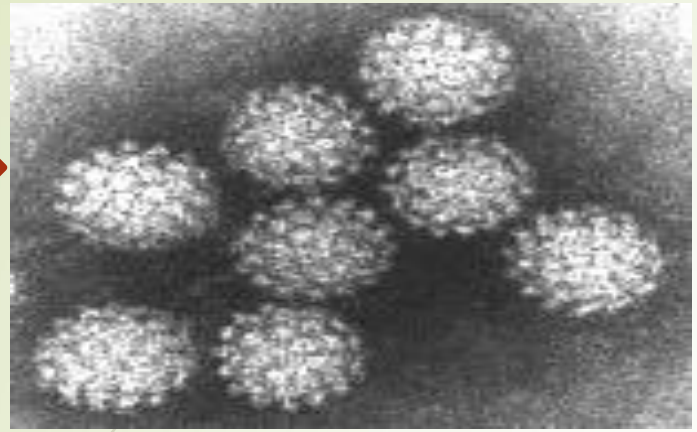
Using Cell (Tissue) Culture Techniques

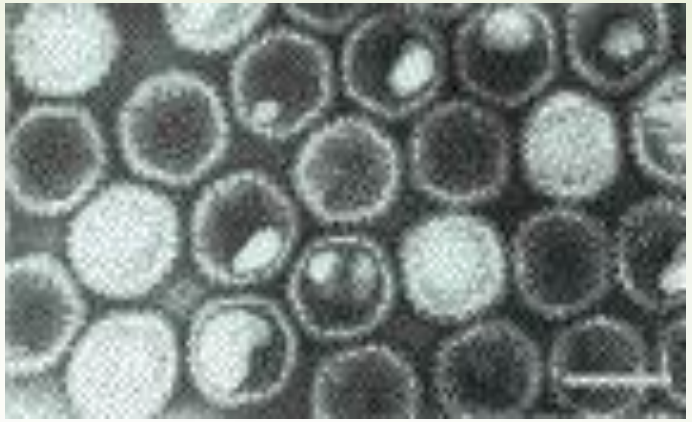
- Most viruses are propagated in some sort of cell culture
- The cultures must be developed and maintained
- Animal cell cultures are grown in sterile chambers with special media
- Cultured cells grow in the form of a monolayer
- Primary or continuous

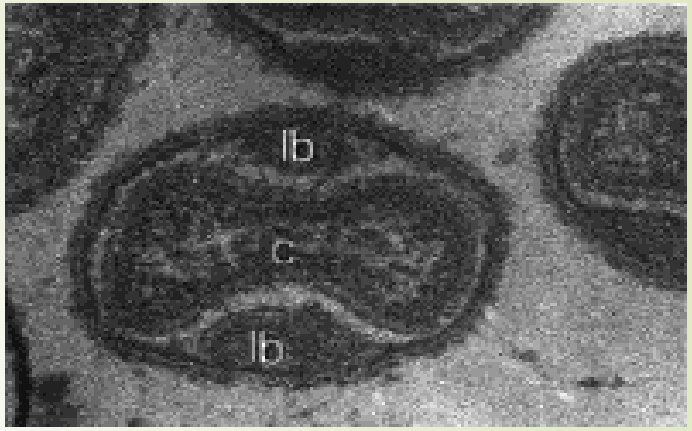


Treatment of Animal Viral Infections

- Because they are not bacteria, antibiotics are ineffective
- Antiviral drugs block virus replication by targeting one of the steps in the viral life cycle
- Interferon shows potential for treating and preventing viral infections
- Vaccines stimulate immunity



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