Virology for 2nd Year MD Students

(01) Introduction to Medical Virology

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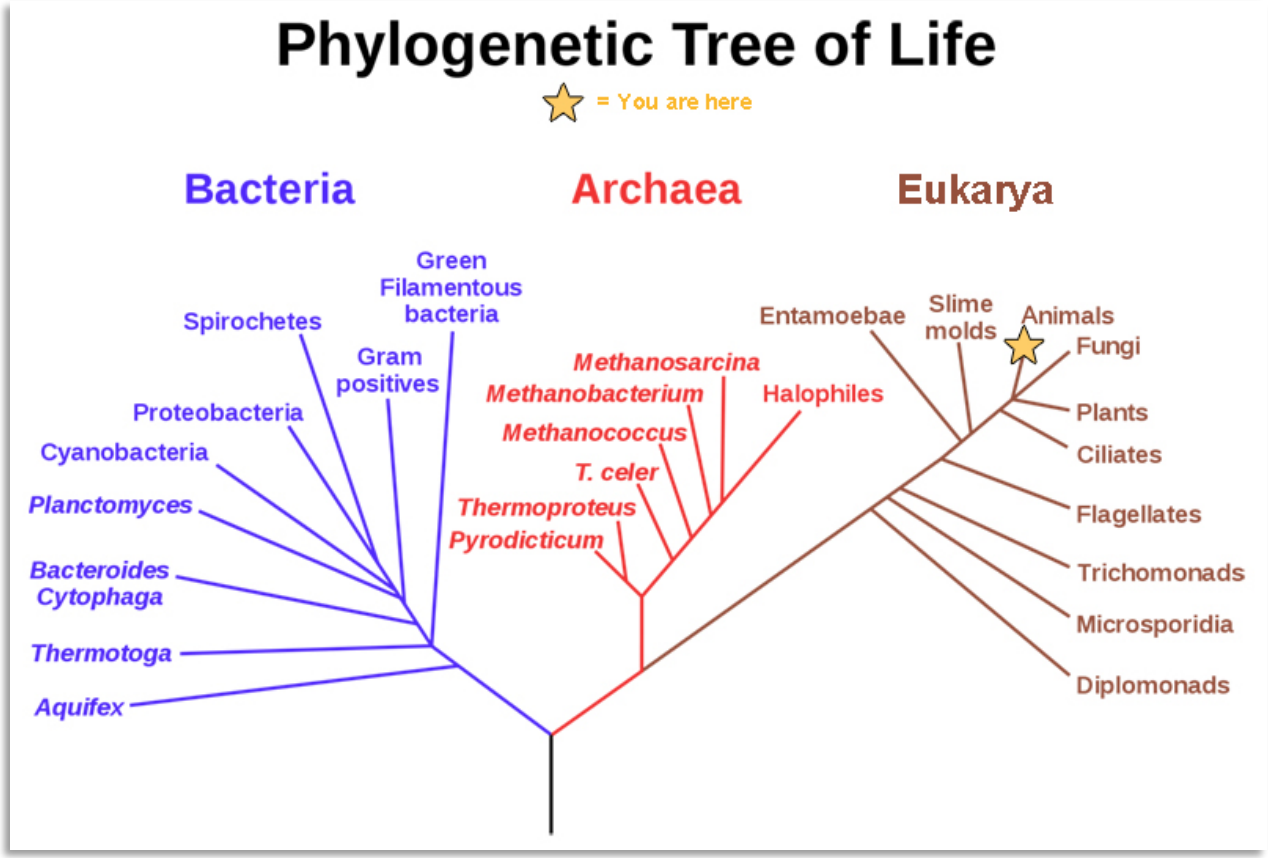
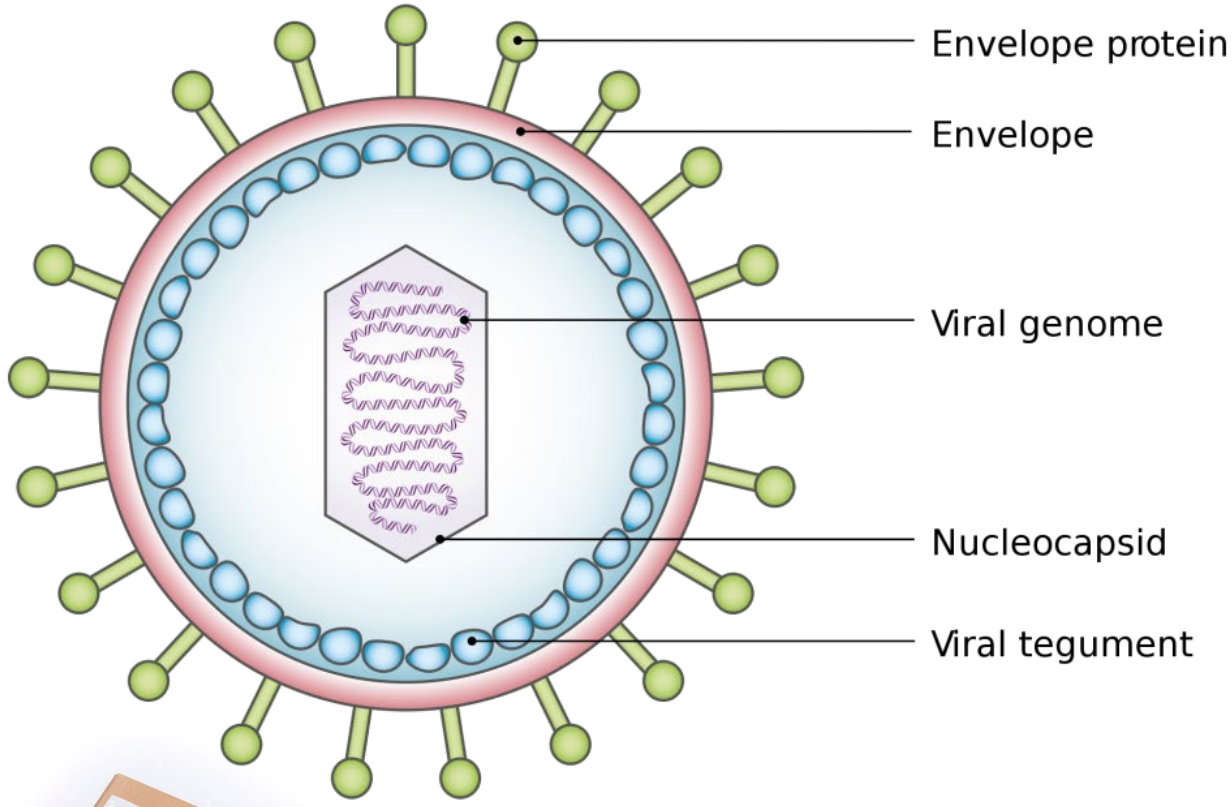
What is a Virus?

- Viruses are obligate intracellular parasites containing either DNA or RNA, but not both.
- They lack metabolic machinery for energy production and protein synthesis.
- Replication occurs only within living host cells.
- Structurally simpler than any prokaryotic or eukaryotic cell.



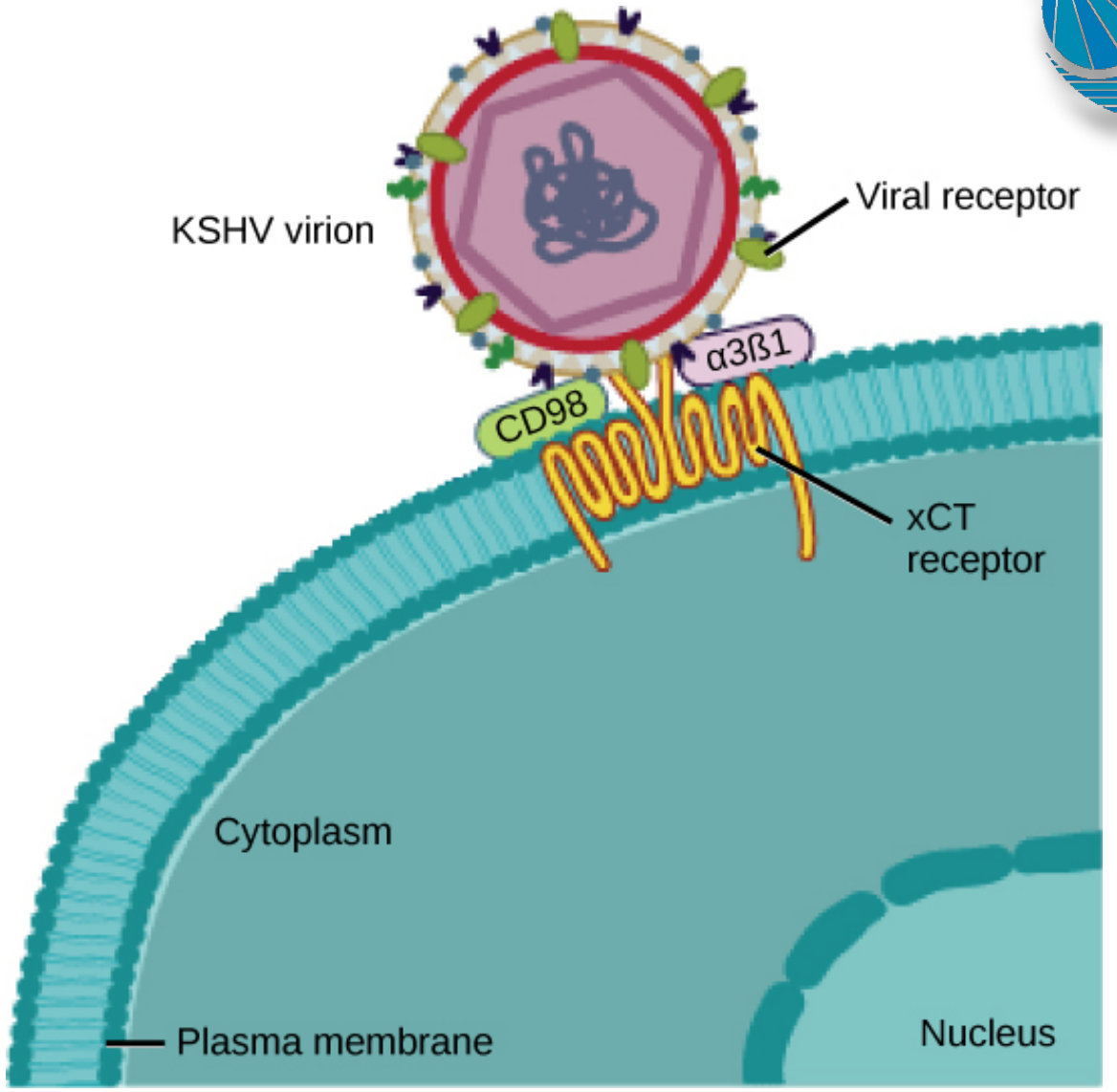
Basic Virus Structure

- Composed of a nucleic acid core (DNA or RNA) enclosed by a protein coat (capsid).
- The combination of nucleic acid and capsid is termed the nucleocapsid.
- Some viruses possess a lipid envelope derived from host membranes.
- Surface projections (spikes/peplomers) mediate attachment to host receptors.



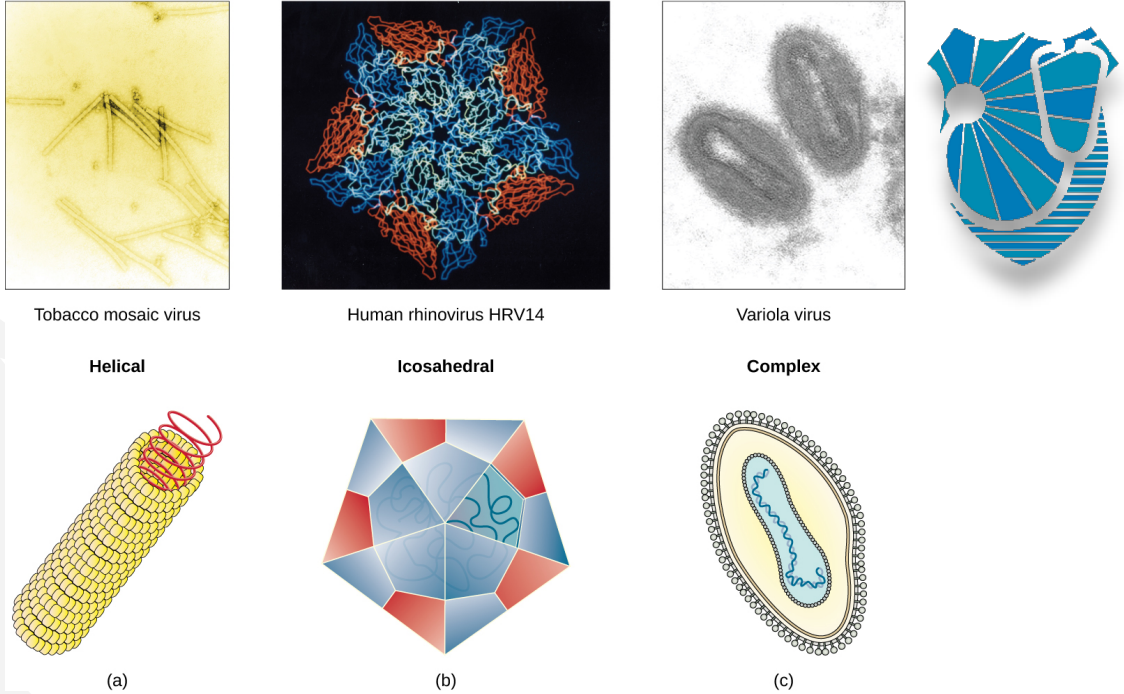
The Virion

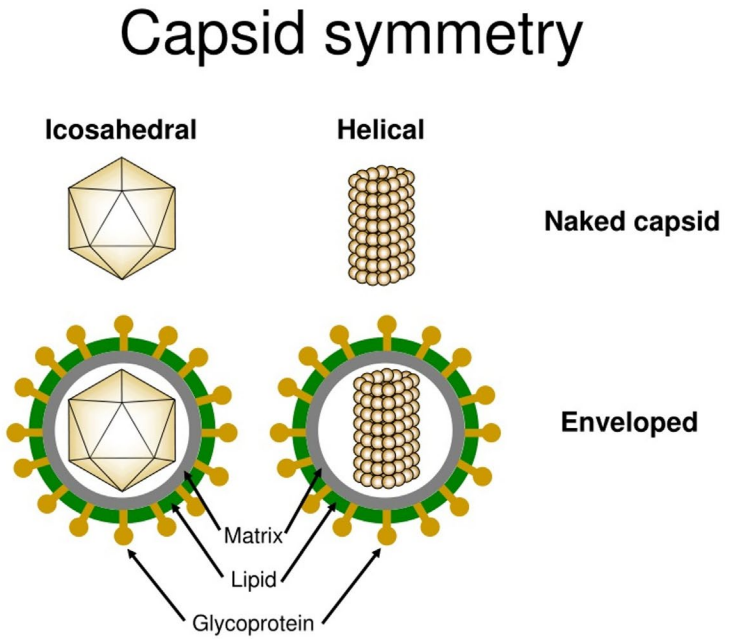
- A virion is the complete, infectious viral particle.
- Contains all structural components necessary for host cell infection.
- Can exist extracellularly but cannot replicate outside a host.
- Responsible for transmission between hosts.



The Capsid and its Symmetry

- The capsid is composed of subunits called capsomeres.
- Provides protection for the viral genome against nucleases and harsh conditions.
- Determines the virus's morphology: icosahedral (20-faced geometric shape that is very stable and space-efficient), helical, or complex.
- Plays a key role in antigenicity and host immune recognition.





Host Range and Tropism

- Viruses infect all forms of life: humans, animals, plants, fungi, bacteria, and archaea.
- Host range is determined by specific viral receptor-host receptor interactions.
- Tropism refers to virus preference for certain cell types or tissues. Example: HIV infects CD4+ T cells; Rabies virus targets neurons.

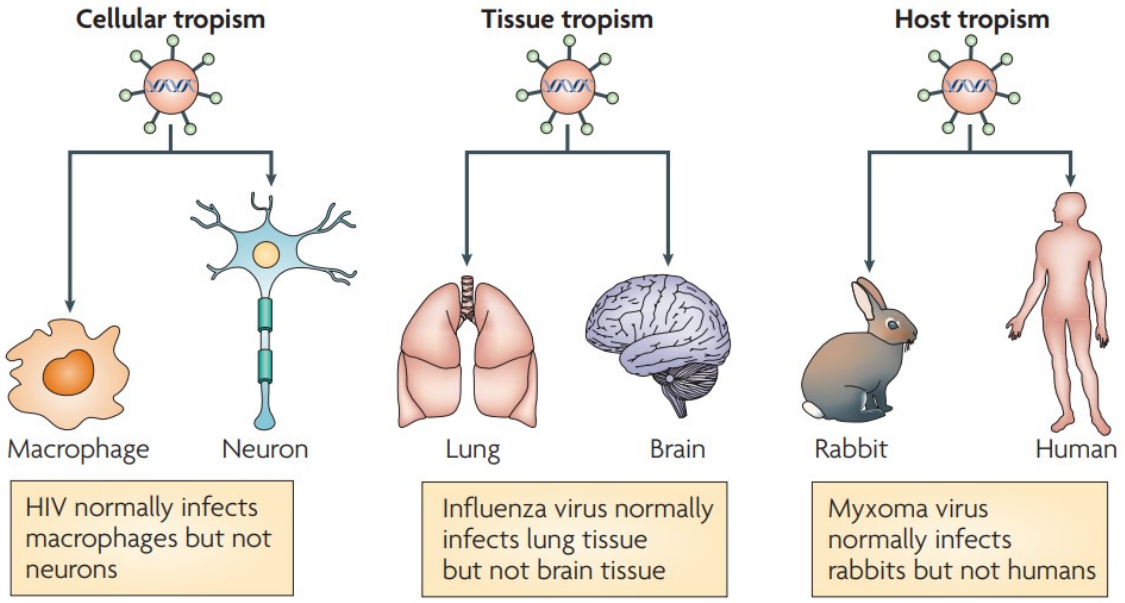
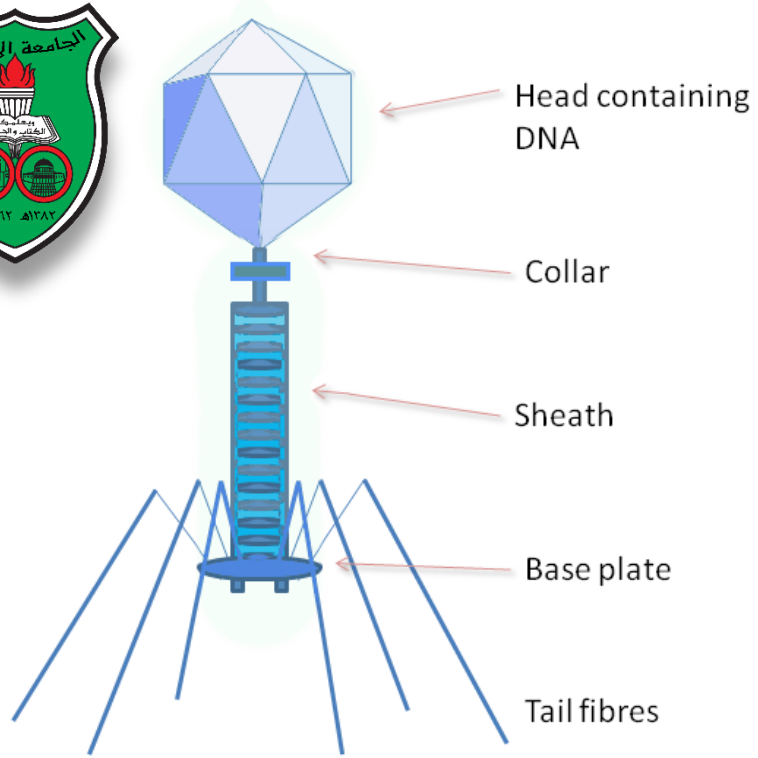


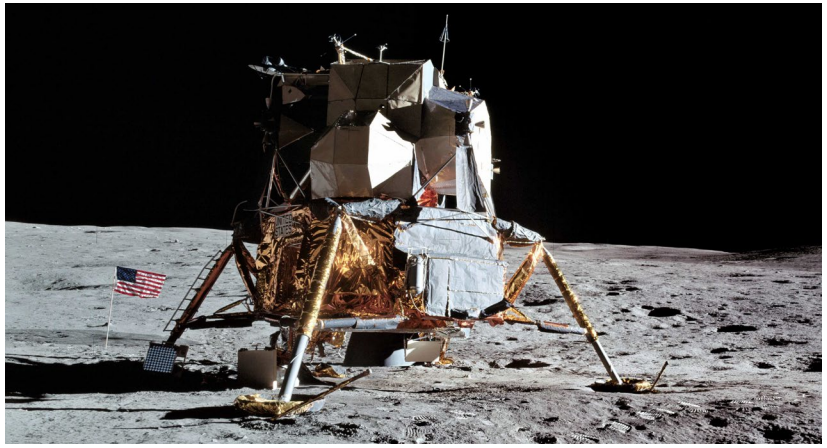
Figure 1 | **Levels of viral tropism.** Viral tropism can be divided into three distinct categories depending on the physiological level at which it is measured. Tropism in which the virus replicates in one cell type but not another is known as cellular tropism , tropism in which the virus replicates in a particular tissue or organ but not another is known as tissue tropism, and tropism in which the virus replicates in one host species but not another is known as host tropism .

Source: McFadden, G., Mohamed, M., Rahman, M. et al. Cytokine determinants of viral tropism. Nat Rev Immunol 9, 645–655 (2009). https://doi.org/10.1038/nri2623



Bacteriophages (Phages)

- Phages are viruses that infect bacteria.
- They may exhibit lytic (host lysis) or lysogenic (genome integration) cycles.
- Play major roles in bacterial genetics and horizontal gene transfer.
- Basis for phage therapy and molecular cloning vectors.



Key Virus Characteristics

- Each virus contains a single nucleic acid species (DNA or RNA).
- Lacks independent metabolic enzymes for ATP or protein synthesis.
- Replication depends on host cell ribosomes and enzymes.
- Evolutionary origin remains uncertain with possible cellular or pre-cellular ancestry.

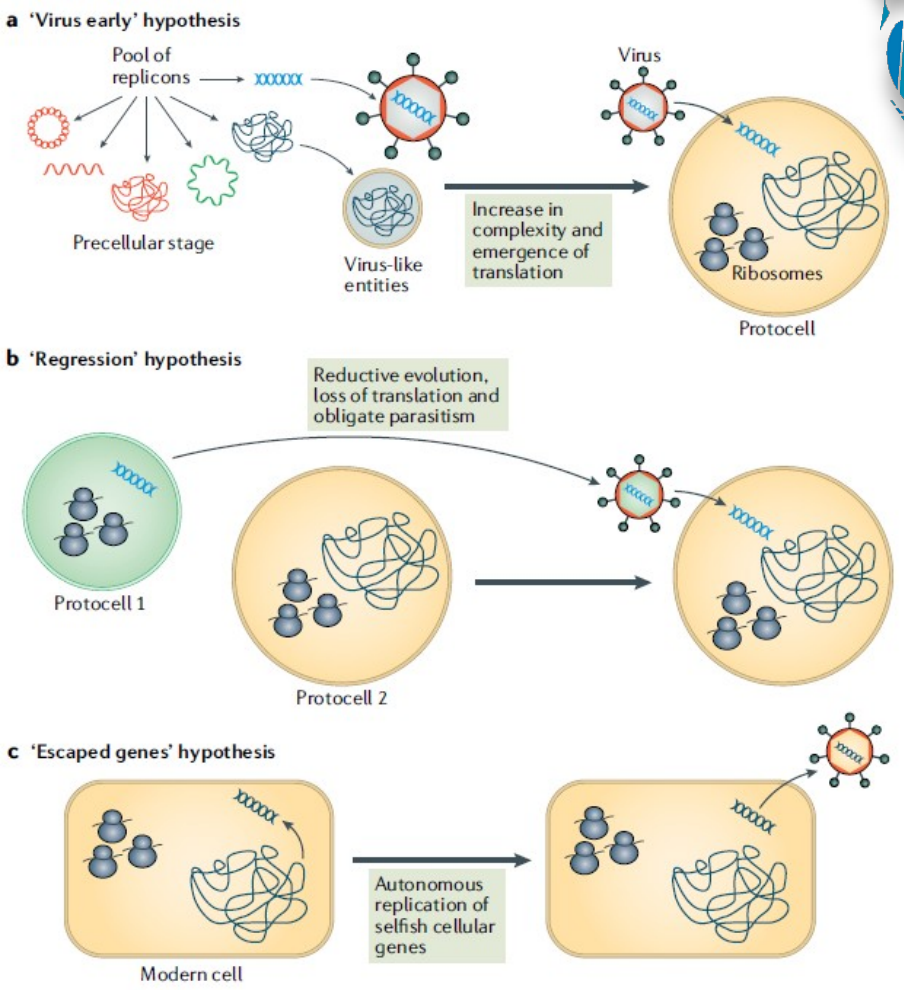


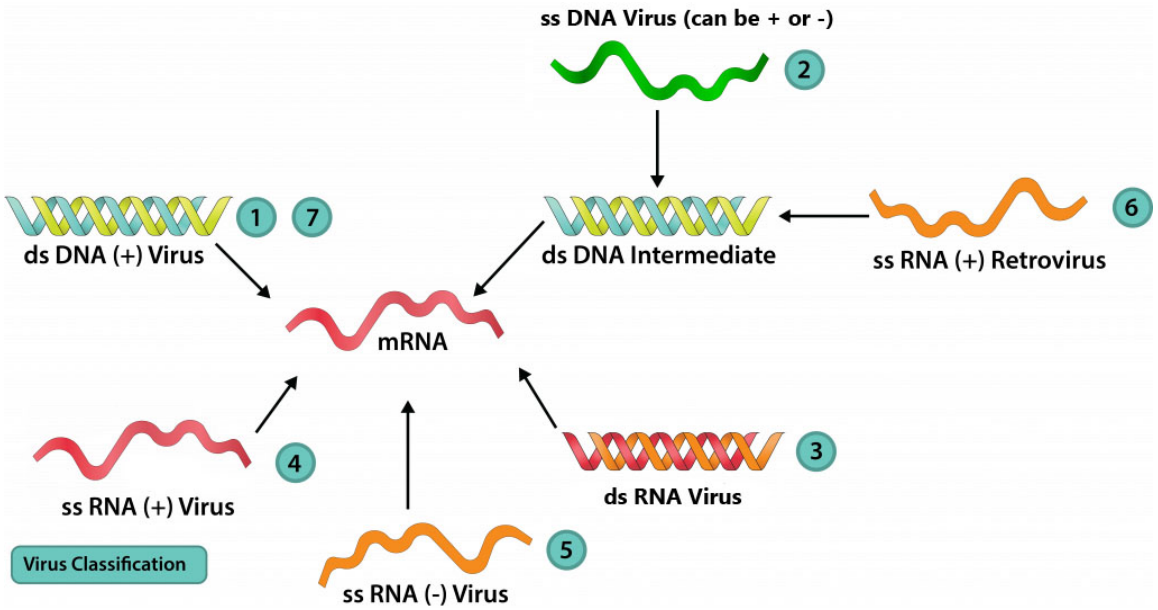
Fig. 1 | **The three major scenarios for the origin of viruses. a** | The 'virus early' hypothesis assumes that viruses evolved from early replicative elements that preceded the first cellular life forms. **b** | The 'regression' hypothesis suggests that viruses emerged through the degeneration of cells that then assumed a parasitic lifestyle. **c** | Finally, the 'escaped genes' hypothesis proposes that cellular genes acquired the ability for 'selfish' replication and spread.

Source: Krupovic, M., Dolja, V.V. & Koonin, E.V. Origin of viruses: primordial replicators recruiting capsids from hosts. Nat Rev Microbiol 17, 449–458 (2019). https://doi.org/10.1038/s41579-019-0205-6

Viruses: Living vs. Nonliving Controversy

- Viruses are nonliving when extracellular (metabolically inert).
- Exhibit living properties only during intracellular replication.
- Reproduce by assembly, not by binary fission.
- Represent the “gray zone” between living and nonliving entities.

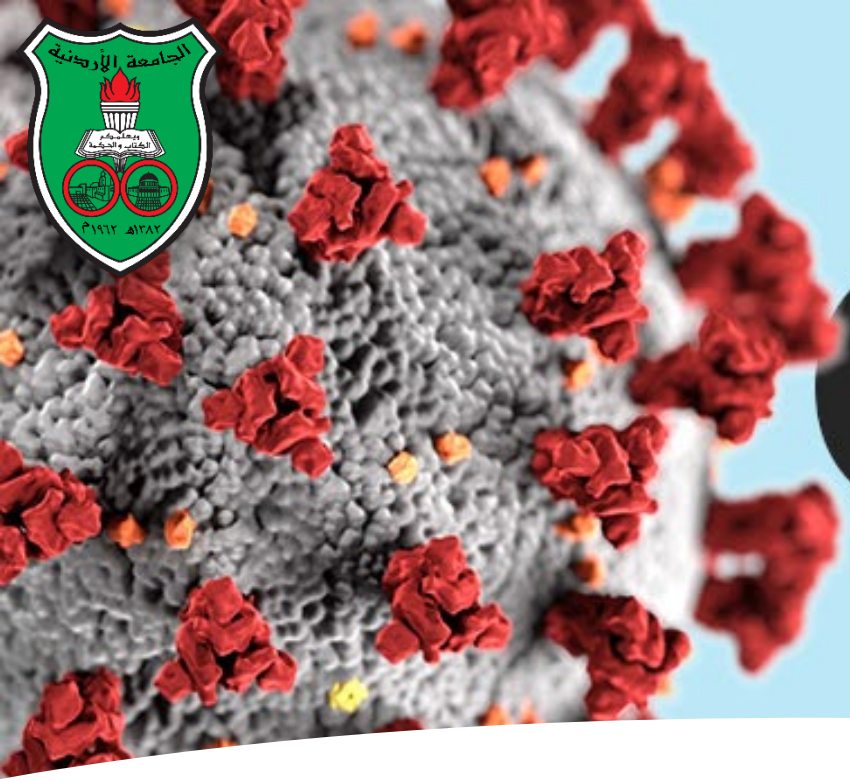
Viral Genome Diversity



- Viral genomes may be DNA or RNA, single- or double-stranded.
- May exist as linear, circular, segmented, or continuous molecules.
- The Baltimore classification groups viruses into seven classes based on replication.
- Genome type dictates replication site (nucleus vs. cytoplasm).

DNA Viruses

- Can be single-stranded (ssDNA) or double-stranded (dsDNA).
- Replicate primarily in the nucleus, using host DNA polymerases.
- Generally, exhibit genetic stability due to proofreading enzymes. Examples: *Herpesviridae, Adenoviridae, Poxviridae*.

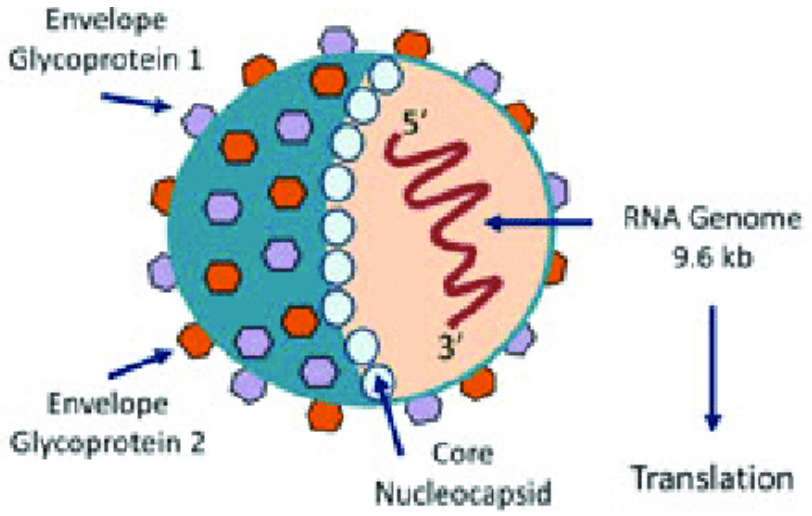


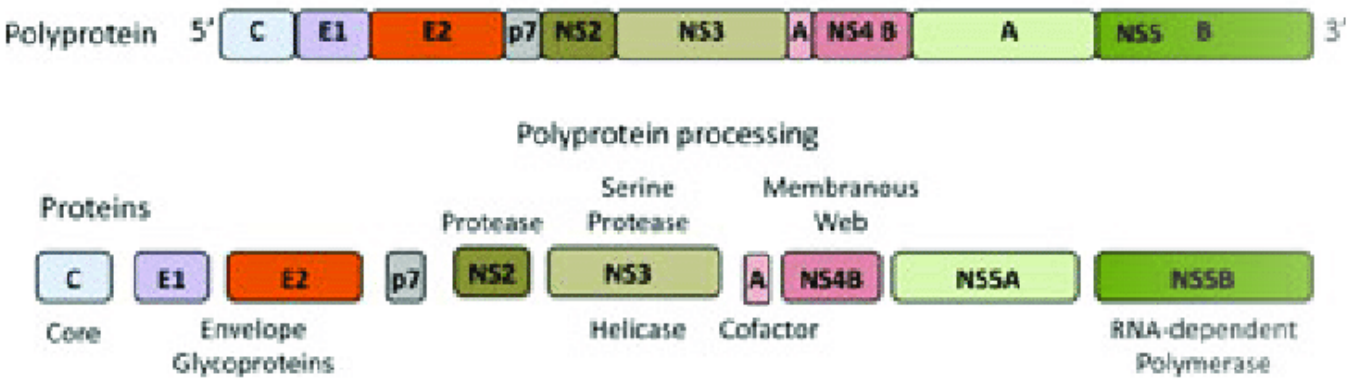
COVID-19
CORONAVIRUS PANDEMIC

RNA Viruses

- RNA viruses may be ssRNA or dsRNA.
- Most replicate in the cytoplasm via virus-encoded RNA polymerases.
- Exhibit high mutation rates, promoting antigenic variation. Examples: *Orthomyxoviridae* (Influenza), *Picornaviridae* (Polio).

Positive-Sense RNA Viruses





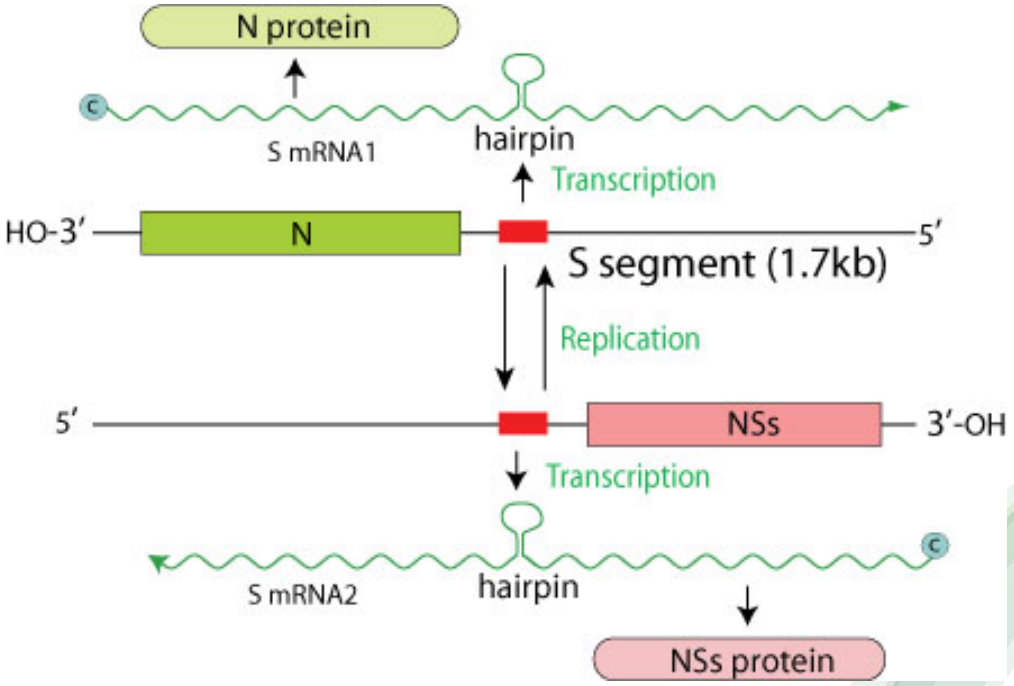
- The viral RNA acts directly as messenger RNA (mRNA).
- Translation into viral proteins occurs immediately upon entry.
- Replication requires synthesis of a negative-sense intermediate. Examples: *Flavivirus, Coronavirus, Picornavirus*.

Negative-Sense RNA Viruses

- The genome is complementary to mRNA and must be transcribed by viral RNA polymerase.
- Carry their own RNA-dependent RNA polymerase within the virion.
- Newly synthesized positive-sense RNA serves as mRNA and replication template. Examples: *Rhabdovirus* (Rabies), *Filovirus* (Ebola), *Orthomyxovirus* (Influenza).

Ambisense RNA Viruses

- Contain both positive- and negative-sense regions within the same strand.
- Permit differential expression of early and late viral genes.
- Replication strategy combines features of both RNA types. Examples: *Arenaviridae* and some *Bunyaviridae*.



Key Messages

Viruses are non-cellular, obligate intracellular parasites.

Genome diversity determines replication mechanism and host range.

Classification based on nucleic acid type, symmetry, and envelope.

Understanding viral structure aids in diagnosis, treatment, and prevention.

Thank You…
Wishing you all the best!