

Virus, Types, Structure, Classification, Examples, UPSC Notes

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Viruses are **parasitic entities lacking cells**, making them unclassifiable within any specific kingdom. They are sub-microscopic infectious agents that can only replicate inside host cells of living organisms. They range from **20 to 400 nm** and can infect all life forms - **humans, animals, plants, bacteria**. They are found in almost every ecosystem and environment on Earth. Though **not classified as living organisms**, viruses **exhibit biological properties** when inside a host cell.

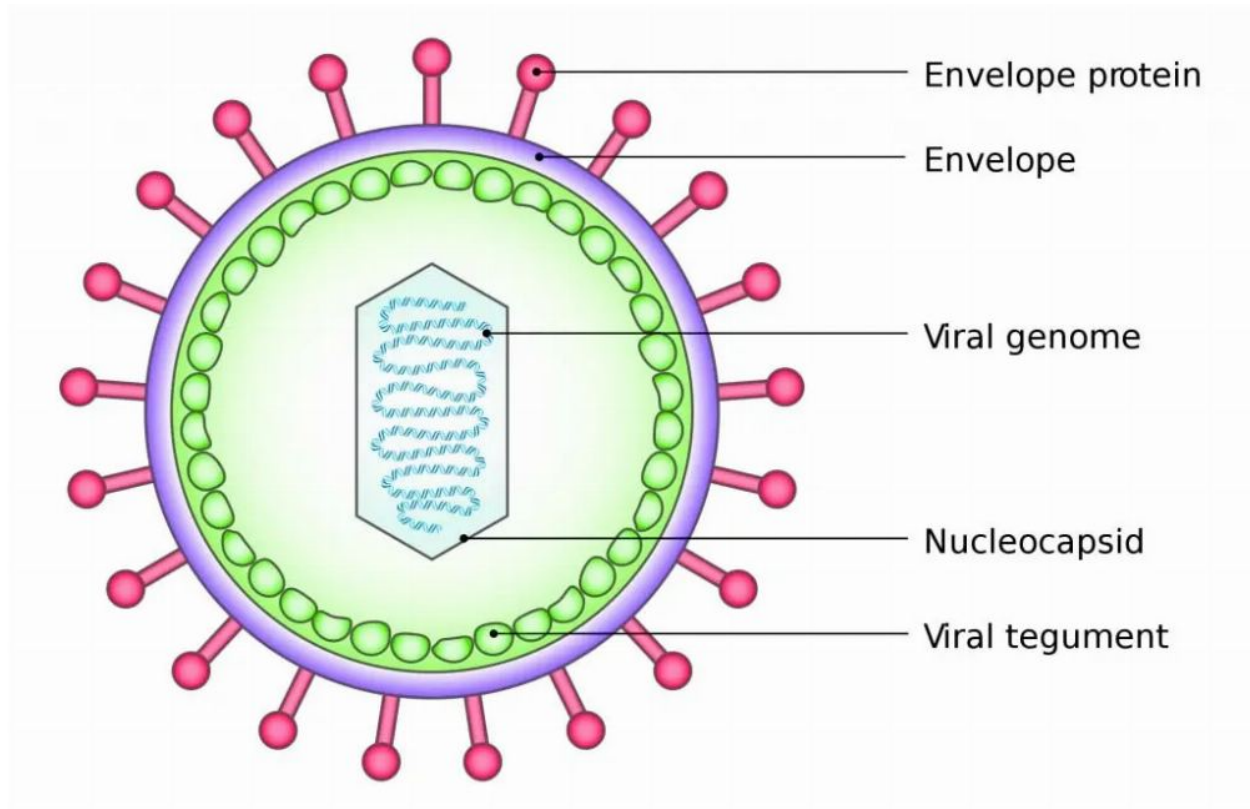
Many fatal epidemics throughout history like **smallpox, influenza, HIV/AIDS, Coronavirus**, etc. have been caused by viruses. Hence, understanding the nature, structure, and replication of viruses is essential for developing diagnostic tests, vaccines, and antiviral drugs.

About Viruses

Viruses are **non-cellular** entities with genetic material enclosed in a protein coat called **capsid**. The viral genome is usually either RNA or DNA. Outside the host, viruses remain **inert**. But once **inside host cells**, they utilise the cell machinery to make **copies of themselves**, often destroying the host cell. Viruses has following properties:

- Viruses, including human pathogens like enteroviruses and caliciviruses, survive in marine environments.
- Viruses can infect bacteria. Bacteriophages (phages) are viruses that specifically infect bacteria. They inject their genetic material into bacterial cells, hijack their machinery, and often lyse the host.

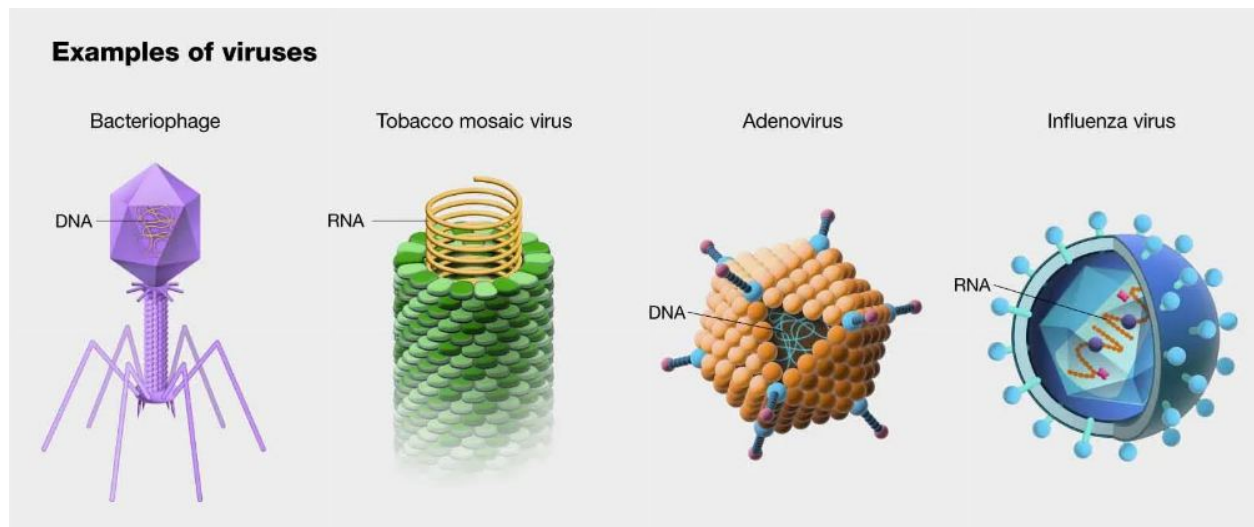
- Viruses like HIV, HBV, and EBV alter host transcriptional activity by modifying DNA methylation, recruiting chromatin-modifying enzymes, or disrupting transcription factors. These changes promote viral replication or disease progression.



Discovery of Virus

The concept of a disease-causing entity smaller than bacteria was first hypothesized in the 1890s.

- **Discovery of Mosaic Disease (1892):** Dmitri Ivanovsky demonstrates that sap from tobacco plants with mosaic disease remains infectious after bacterial filtration.
- **Term "Virus" (1898):** Martinus Beijerinck introduces the term "**virus**" to describe the newly identified soluble and filterable infectious agent.
- **Advancements in Virus Study:** Viruses grown in plants and animals for pathogenesis research.
- **Confirmation of Viral Particulate Nature:** Wendell Stanley crystallises the tobacco mosaic virus, confirming its particulate nature and persistent infectivity.
- **Technological Advancements:** The invention of the **electron microscope** enabled the visualisation of viruses. The biochemical analysis allowed the determination of viral chemical composition.
 - Improvements in **virus isolation** and **detection** methods resulted in the discovery of several important human viruses.



Structure of Viruses

Viruses are **unique parasites**, not classified as plants, animals, or bacteria. Despite their reproductive abilities, viruses aren't living organisms; they rely on host cells for survival. They lack ribosomes and energy-producing mechanisms, relying on host cells for protein synthesis and energy. Viruses exhibit tremendous diversity in size, shape, and composition, but some common structural elements are:

- **Genetic Material:** This can be single-stranded DNA, double-stranded DNA, single-stranded RNA, or double-stranded RNA. The size of the genome ranges from a few thousand bases for small viruses to over a million bases for giant viruses.
- **Capsid:** This is a **protective layer of protein** surrounding the genome. It consists of multiple copies of capsomere subunits tightly arranged to form a shell.
 - Based on symmetry, **capsids** can be **helical**, **icosahedral**, or **complex**.
- **Envelope:** Some groups of viruses have a membrane envelope made of **lipids**, **proteins**, and **glycoproteins**. Envelopes are acquired by budding from host cell membranes. They mediate viral entry and immune evasion.
- **Envelope Protein (Spikes):** **Glycoprotein** spikes protruding from the envelope help attach and enter host cells. **Influenza** and **HIV** viruses contain these spike structures.
- **Morphology:** Based on their morphology, viruses can be classified as naked icosahedral, enveloped icosahedral, naked helical, and enveloped helical.
- **Bacteriophages** infecting bacteria exhibit **head-tail** structures.

Difference between Virus and Bacteria

Parameter	Virus	Bacteria
Type	Acellular	Unicellular organism
Size	20 - 400 nm	0.2 - 10 μm
Structure	Capsid with genetic material	Cell wall, cell membrane, cytoplasm, DNA

Replication	Require host cells	Can replicate independently
Treatment	Antiviral drugs	Antibiotics
Diseases caused	COVID-19, influenza, HIV, smallpox	Tuberculosis, pneumonia, tetanus

Classification of Viruses

They contain only a few elements by which they can be classified: the viral genome, the type of capsid, and the envelope structure for the enveloped viruses.

- **Host Organism Infected:**

- Animal Viruses, Plant Viruses, Bacteriophages
- **Based on structure:** Viruses can be classified into four types:
- **Helical:** Long spiral capsids e.g. **Influenza**
- **Icosahedral:** Polygonal capsids with 20 faces e.g. **Poliovirus**
- **Enveloped:** Lipid bilayer covering capsid e.g. HIV, **Coronavirus**
- **Complex:** Intricate structures e.g. Bacteriophages (viruses that infect bacteria).

- The viral genome is tightly packed into a small volume within the capsid. Animal viruses have genome sizes ranging from **3,000 to 1,000,000** nucleotide bases.

- **Nature of Nucleic Acid:**

- **DNA Viruses:** Adenovirus, Herpesvirus, Hepadnavirus
- **RNA Viruses:** Picornavirus, Orthomyxovirus, Rhabdovirus

Viruses are classified by the **Baltimore system** based on their type of genetic material. There are seven groups:

Group	Nucleic Acid	Example Viruses
I	dsDNA*	Adenovirus, Herpesvirus, Poxvirus
II	ssDNA*	Parvovirus
III	dsRNA	Reovirus
IV	(+)ssRNA	Picornavirus, Togavirus
V	(-)ssRNA	Orthomyxovirus, Rhabdovirus
VI	ssRNA-RT*	Retrovirus - HIV
VII	dsDNA-RT	Hepadnavirus - Hepatitis B

(*ds - Double stranded, *ss - Single-stranded, *RT - Reverse transcribing)

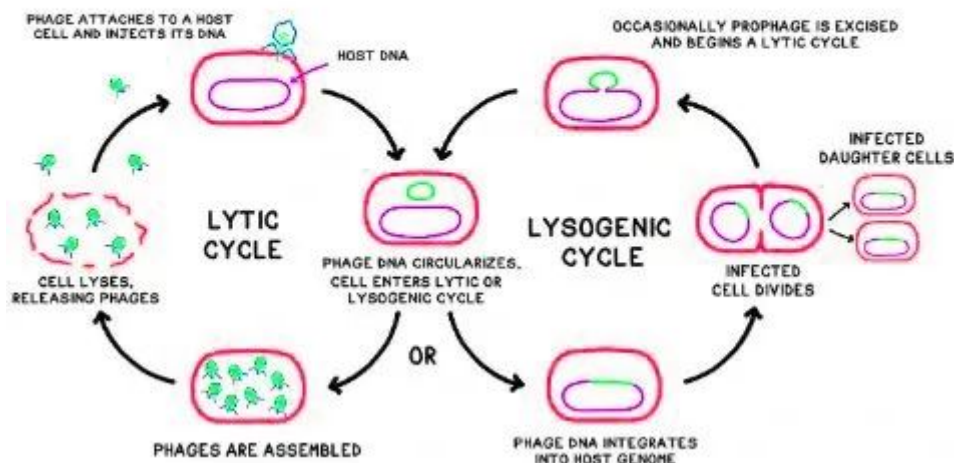
This genetic material of viruses encodes proteins and enzymes vital for viral replication inside host cells.

Reproduction in Viruses

They cannot replicate on their own but rather depend on their host cell's protein synthesis pathways to reproduce. There are two processes used by viruses to replicate:

- **Lytic Cycle:** This is the productive viral replication cycle exemplified by bacteriophages. It has the following stages:
 - **Attachment:** Viral spikes bind to specific receptors on the host cell surface
 - **Penetration:** The viral genome enters into the cell cytoplasm through endocytosis or membrane fusion.
 - **Replication:** Viral genes and genome hijack the cell machinery to produce viral proteins and nucleic acid.
 - **Assembly:** New viral particles are assembled using the replicated components.
 - **Release:** Cloned viruses break open the host cell by lysis and spread the infection.
 - Through this cycle, a virus can produce thousands of progenies from a single host cell in a matter of hours.
- **Lysogenic Cycle:** In this cycle, the viral genome gets incorporated into the host DNA. It persists in a dormant state as a **prophage without replication**.
 - The **prophage** later enters the **lytic cycle** in response to environmental triggers.
 - In latent infections like **herpes**, the viral genome is maintained in host cells in inactive form for later reactivation.
 - **Retroviruses** like HIV integrate their genome into the host DNA.

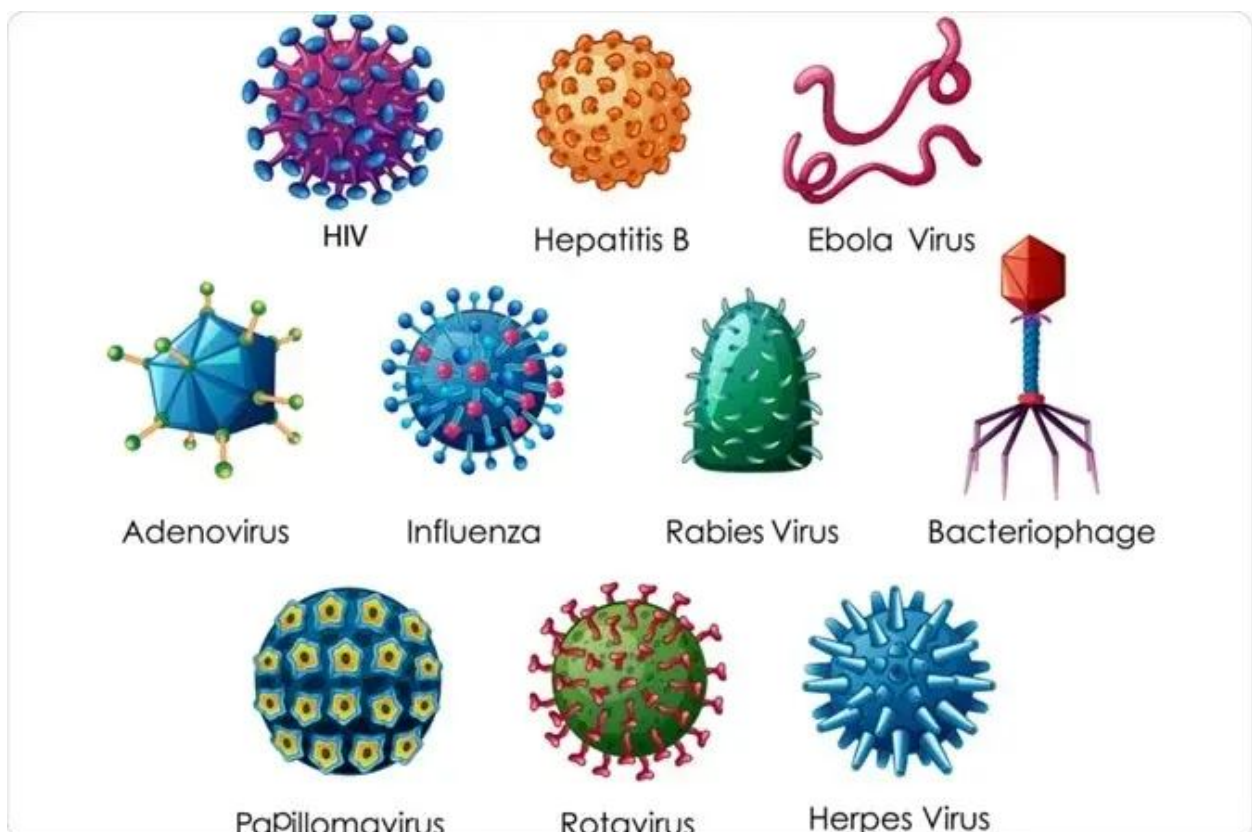
LYTIC AND LYSOGENIC CYCLES



Applications and Significance of Viruses

Scientists have harnessed the biology of viruses for the development of new tools and applications in molecular biology, medicine, and other streams. Despite the havoc they create, viruses also have some beneficial applications:

- **Vaccine development:** Attenuated or inactive viruses are used to produce vaccines and immunize against viral diseases.
 - For example, the **Oral polio vaccine (OPV) from attenuated poliovirus** led to the near eradication of **poliomyelitis**.
- **Gene therapy vectors:** Viruses can transfer genetic material into cells, enabling gene therapy.
 - For example, the **Adeno-associated virus (AAV)** has been used in clinical trials for treating **blindness, haemophilia, and neurodegenerative diseases**.
- **Cancer treatment:** Viruses specifically able to infect and kill cancer cells are being studied as oncolytic viruses for cancer treatment.
 - An example is the **herpesvirus T-Vec** which is FDA-approved for treating **melanoma**.
- **Bacteriophages:** Viruses infecting bacteria called bacteriophages have been utilised for killing strains of **pathogenic bacteria** like treating **antibiotic-resistant superbugs**.
 - **Phage therapy cocktails** are commercially produced and prescribed in Russia and parts of Europe.
- **Biological control:** Certain viruses attacking insect pest species can be formulated as biopesticides for controlling costly crop infestations.
 - An example is the use of baculoviruses against **gipsy moth infestations** in North America.
- **Molecular biology:** Due to their **structural simplicity**, viruses serve as excellent model systems and tools to examine fundamental cellular processes like **gene expression, genome replication, viral-host interactions**, etc. that provide wider biological insights.
 - Studies of **tobacco mosaic virus** led to the discovery of the **first virus genome enabling advances** in molecular biology.



Diseases Caused by Viruses

Viruses account for several troublesome diseases in humans ranging from mild ailments to severe life-threatening conditions.

Virus Families	Diseases	Mode of Transmission
Orthomyxoviridae	Influenza, bird flu	Airborne route
Picornaviridae	Poliomyelitis, common cold, hepatitis A	Faeco-oral route
Togaviridae	Rubella, chikungunya	Mosquito vectors
Flaviviridae	Dengue, yellow fever, hepatitis C	Mosquito vectors
Retroviridae	HIV/AIDS	Body fluids, blood
Herpesviridae	Herpes, chickenpox, shingles	Contact, sexual, saliva
Hepadnaviridae	Hepatitis B	Blood, body fluids
Paramyxoviridae	Measles, mumps	Airborne route
Rhabdoviridae	Rabies	The bite from an infected host
Poxviridae	Smallpox	Close Contact
Coronaviridae	SARS, MERS, COVID-19	Respiratory droplets

Viruses are unique microscopic infective agents that replicate only within host cells. Though tiny in size, they have an outsized impact on ecology, evolution, and human disease. Developing antiviral strategies is an ongoing battle due to the immense diversity and mutability of viruses as parasites dependent on hosts. Virology research on emerging viral threats, and developing new-generation vaccines and antiviral drugs will remain priorities for improving public health outcomes.

Virus UPSC PYQs

Q1: Consider the following statements: **(UPSC Prelims 2025)**

1. No virus can survive in ocean waters.
2. No virus can infect bacteria.
3. No virus can change the cellular transcriptional activity in host cells.

How many of the statements given above are correct?

- a) Only one
- b) Only two
- c) All three
- d) None

Ans: (d)

Source: <https://vajiramandravi.com/upsc-exam/virus/>

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