Course Title – Virology

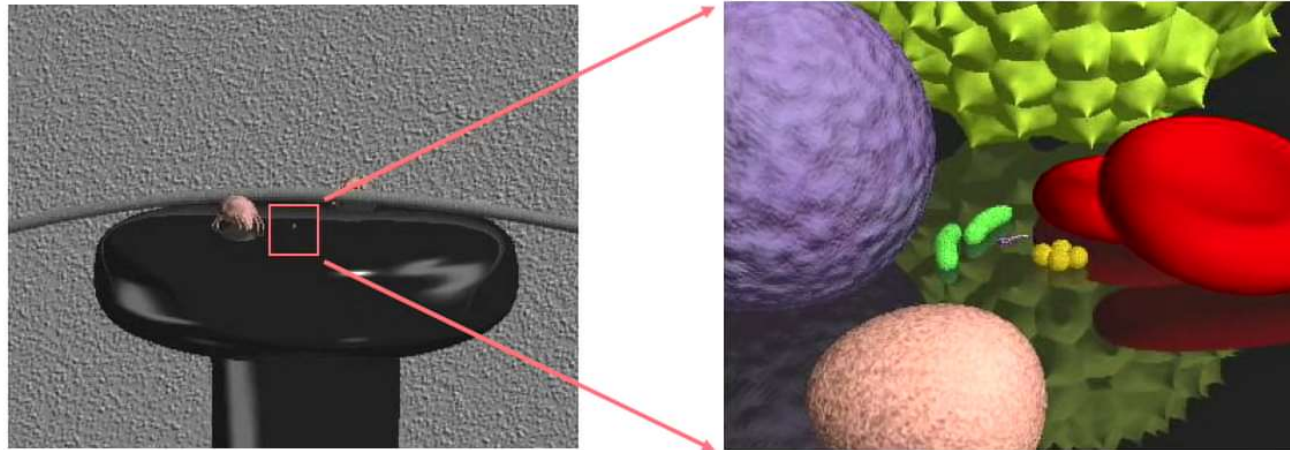| S. No.	Topic
1.	Origins of virology, viruses as a living system etc
2.	Classification of viruses
3.	Organization of viruses Protein structure and assembly, nucleic acid packaging, geometrical aspects, icosahedral and helical symmetry
4.	Virus attachment and entry in to host cells
5	Cellular and molecular biology of Host virus interaction
6.	Genome replication and mRNA production by RNA viruses
7	Reverse transcription and integration in to the host genome (retroviruses)
8.	DNA virus replication strategies
9	Unique features of viral gene expression
10.	Translational control of viral gene expression
11	Viral pathogenesis and cell transformation by viruses
12.	Viral Genetics, Viral vaccines, Antiviral chemotherapy, Persistence of viruses
13	Hepadnaviruses, HIV, Polyomaviruses (SV40), Baculovirus, Topsoviruses, Potyviruses
14	Virus evolution
15.	Viral vectors and gene therapy

Classification of Virus

A

NMR

X ray

CryO-EM

Electron microscope

Light microscope

(1 cm)	(1 mm)	10^{-4}		10^{-5}	(1 μm) 10^{-6}	10^{-7}	10^{-8}	(1 nm) 10^{-9}	(1 Å) 10^{-10}	
10^{-2}	10^{-3}									Meters

Plant cells   Animal cells   Bacteria   Viruses   Ribosomes   Proteins   Small molecules   Atoms

B

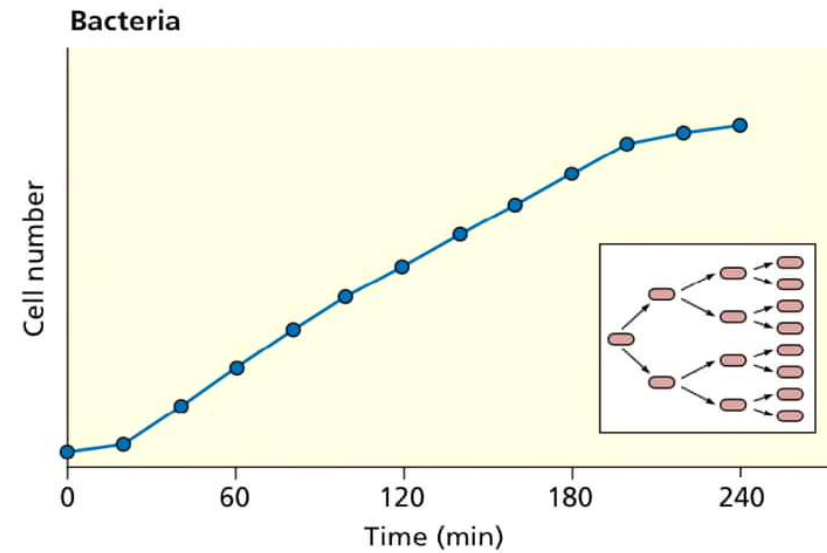Ribosomes (20 nm)

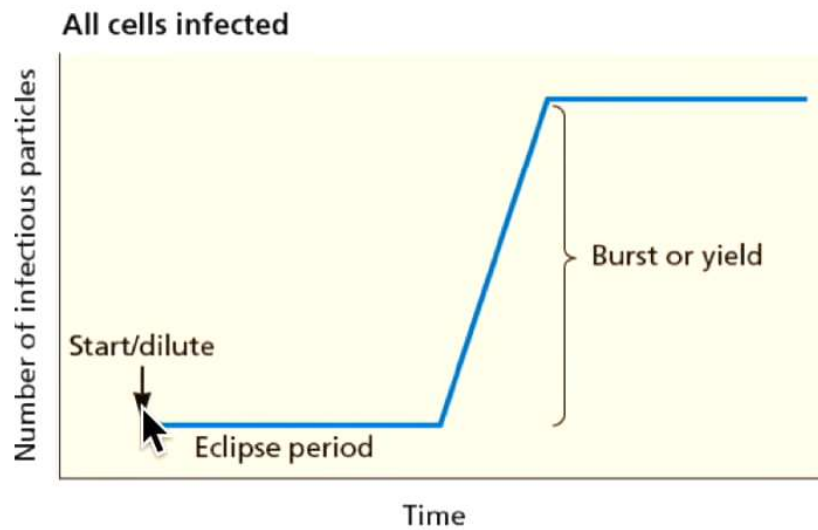Herpesvirus (200 nm)

Poliovirus (30 nm)
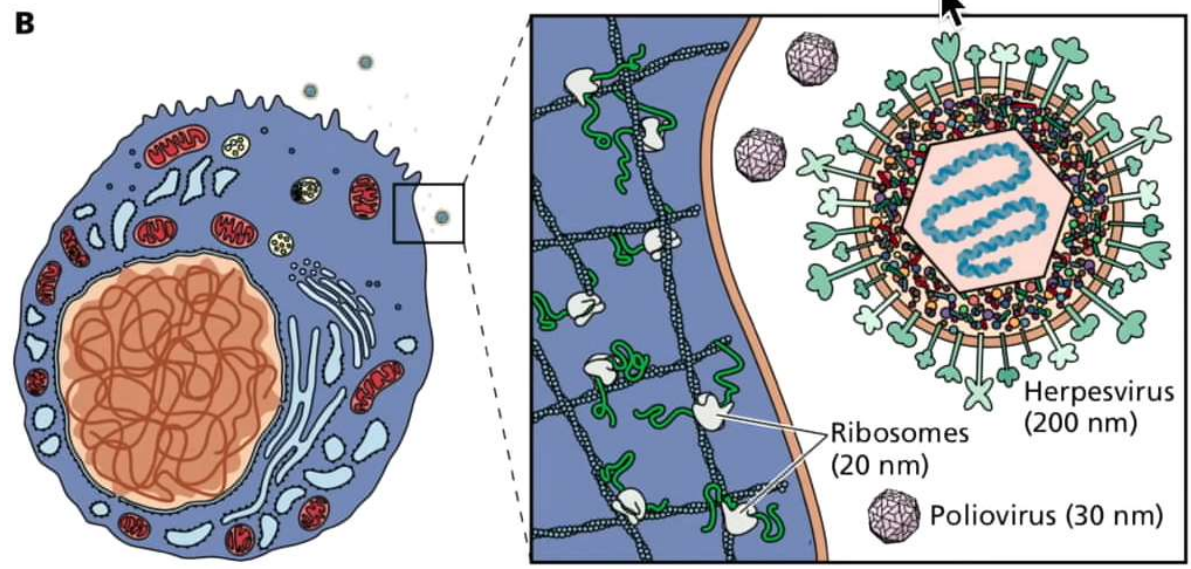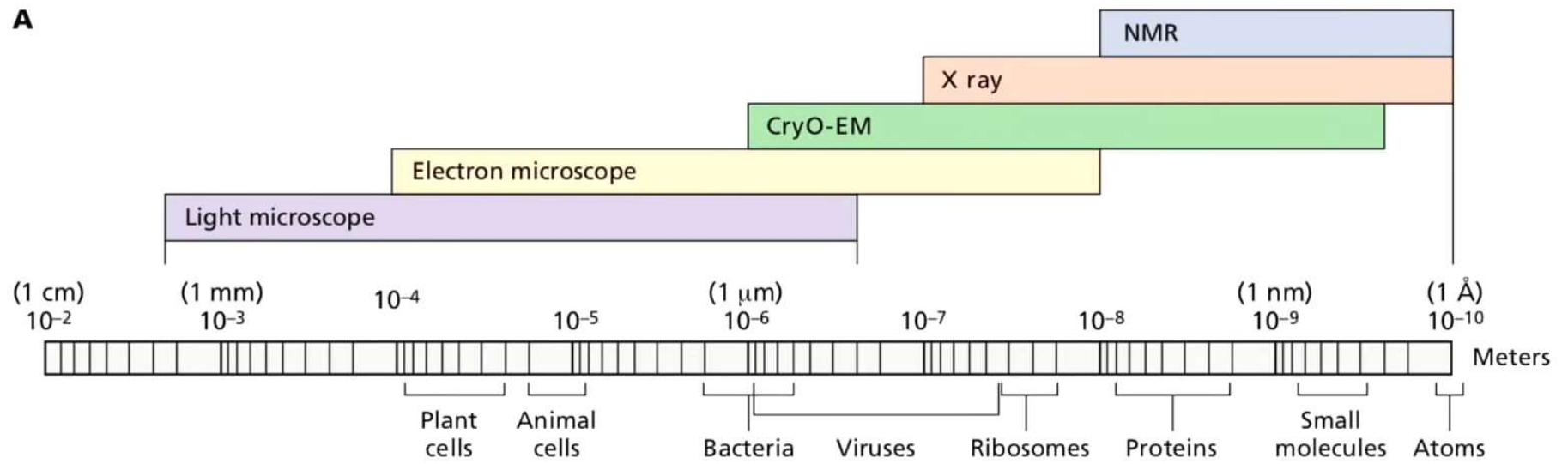
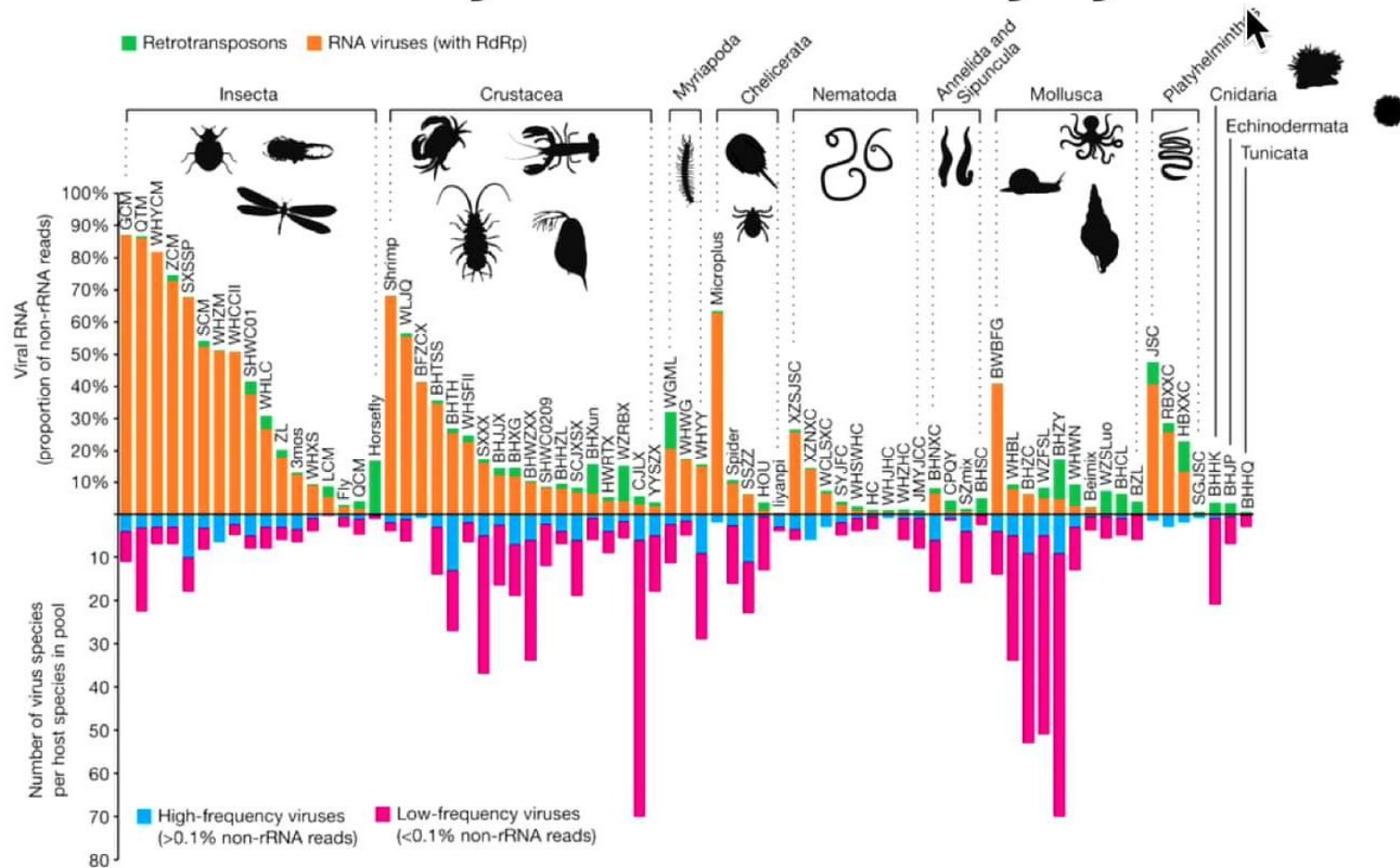# How many viruses can fit on the head of a pin?

2 mm = 2000 microns

- 500 million rhinoviruses

- When you sneeze, you fire an aerosol that contains enough viruses to infect thousands

Key 1939 experiment proved that viruses were not simply small bacteria

Virus discovery - Once driven only by disease

Analyzed RNA from 220 invertebrate species, found 1,445 new viruses

Classification of Virus:

❑ The classification of viruses is the subject of ongoing debate and proposals, due to their pseudo-living nature.

❑ Viruses are classified in categories based on different features.

❖ **Based on Viral Host**.

❖ Based on **Genetic Material Present**,

   Presence of envelop,

   Symmetry.

Classical Phase of Viral Taxonomy

Classification of Virus:

On the Basis of the Type of Host

Holmes classification (1948)

❖ **Phaginae (Bacteriophage):** Phi (φ) x 174 bacteriophages

❖ **Phytophaginae (Plant viruses):** TMV

❖ **Zoophaginae (Animal viruses):** Rabies virus, Polio virus

Classification of Virus:

On the Basis of Genetic Material Present

❖**DNA viruses:** Herpesvirus, Papillomavirus

❖**RNA viruses:** Corona virus, Polio virus, Ebola virus, HIV, Dengue virus

Classification of Virus:

On the Basis of the number of strands

❖**Double-stranded DNA:** Pox viruses, Herpes viruses

❖**Single-stranded DNA:** Phi (φ) x 174 bacteriophages

❖**Double-stranded RNA:** Reoviruses

❖**Single-stranded RNA:** Corona virus, TMV, Polio virus

Classification of Virus:

On the Basis of Presence of Envelope

❖**Enveloped Virus**

  ➢ **DNA viruses:** Pox virus

  ➢ **RNA viruses:** Corona virus

❖**Naked Virus:**

  ➢ **DNA viruses:** Adenovirus

  ➢ **RNA viruses:** Hepatitis A and E virus.

Baltimore Classification of Virus:

❑ **The most commonly used system of virus classification is Baltimore classification.**

❑ **This system was developed by David Baltimore in 1971.**

❑ Baltimore along with Howard Temin and Renato Dulbecco shared the Nobel Prize for Medicine in 1975 for the discovery of retroviruses and reverse transcriptase.

❑ **This system grouped the viruses into seven groups based on the relationship of the viral genome to its mRNA.**

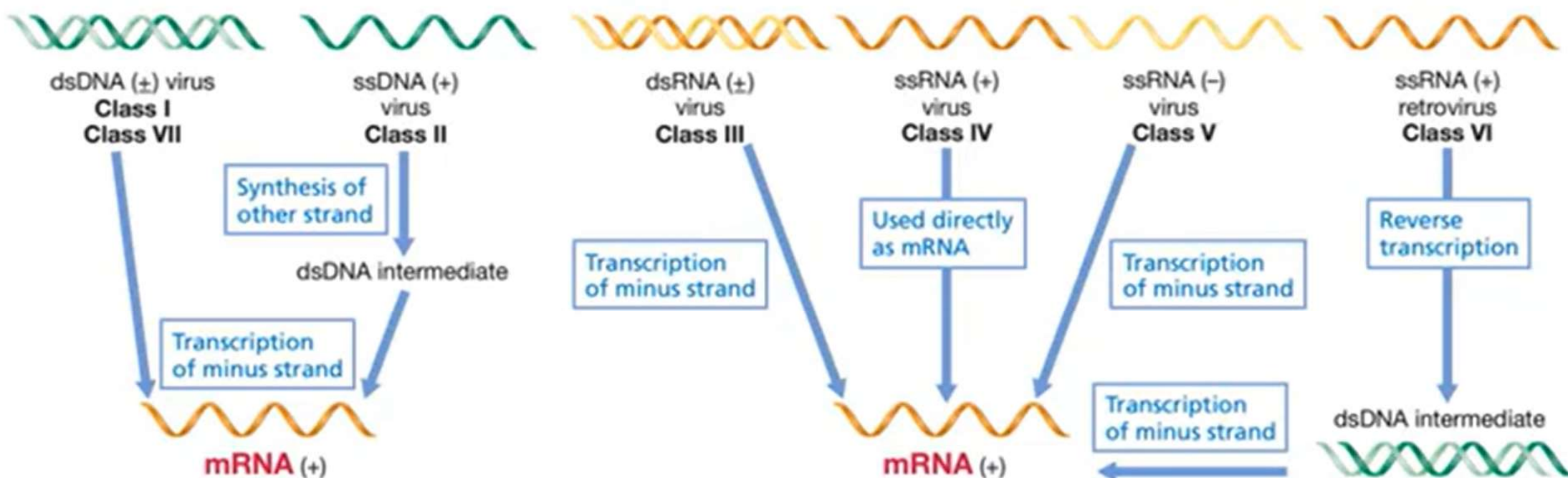# Overview

Genetic material present in the virion

Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII
DNA(+/-)	DNA (+)	RNA (+/-)	RNA(+)	RNA(-)	RNA(+)	DNA(+/-)

DNA(+/-)

RNA(-)

Reverse transcription

Reverse transcription

mRNA

proteins

Baltimore Classification of Virus:

dsDNA (±) virus
Class I
Class VII

ssDNA (+) virus
Class II

Synthesis of other strand

dsDNA intermediate

Transcription of minus strand

mRNA (+)

dsRNA (±) virus
Class III

ssRNA (+) virus
Class IV

ssRNA (−) virus
Class V

ssRNA (+) retrovirus
Class VI

Transcription of minus strand

Used directly as mRNA

Transcription of minus strand

Reverse transcription

Transcription of minus strand

mRNA (+)

dsDNA intermediate

Genome replication: **Class I**, classical semiconservative
Class II, classical semiconservative, discard (−) strand
Class VII, transcription followed by reverse transcription

DNA Viruses

Genome replication: **Class III**, make ssRNA (+) and transcribe from this to give ssRNA (−) partner
Class IV, make ssRNA (−) and transcribe from this to give ssRNA (+) genome
Class V, make ssRNA (+) and transcribe from this to give ssRNA (−) genome
Class VI, make ssRNA (+) genome by transcription of (−) strand of dsDNA

RNA Viruses

Image from: Madigan, Michael T., et al. *Brock biology of microorganisms 13th edition*. Benjamin Cummings, 2010.

Baltimore Classification of Virus:

- **Class I**: ds-DNA genome
- **Class II**: ss-DNA genome
- **Class III**: ds-RNA genome
- **Class IV**: ss-RNA genome of + strand or sense
- **Class V**: ss-RNA genome of − strand or antisense
- **Class VI**: ss-RNA genome that replicates with DNA intermediate
- **Class VII**: ds-DNA genome that replicates with RNA intermediate

Baltimore Classification of Virus:

❑ **Class I: Double stranded DNA (dsDNA) viruses**

➢ These viruses use the same mechanism for mRNA production and genome replication (using host cell polymerases) used by the host cell genome.

➢ Examples: *Herpesviridae* and *Adenoviridae*.

Baltimore Classification of Virus:

❏ **Class II: Single stranded DNA (ssDNA) viruses**

▸ These viruses convert their single-stranded genomes into a ds-DNA intermediate before transcription to mRNA can occur.

▸ RNA polymerase uses double-stranded DNA as a template.

▸ Examples: *Circoviridae*, and *Parvoviridae*.

Baltimore Classification of Virus:

❑ Class III: Double stranded RNA (dsRNA) viruses

- The two strands of the viral genome separate.

- One of them is used as a template for the generation of mRNA using the RNA-dependent RNA polymerase encoded by the virus.

- The genome of this class are mostly segmented, and each gene codes for only one protein.

- Examples: Rheoviridae.

Baltimore Classification of Virus:

☐ **Class IV: Single stranded RNA (ss-RNA) viruses of (+) strand**

▶ The positive-sense genomic RNA can serve directly as mRNA.

▶ Examples: *Coronaviridae* and *Picornaviridae*.

Baltimore Classification of Virus:

❑ **Class V: Single stranded RNA (ss-RNA) viruses of (-) strand**

➤ These viruses have to first transcribed the (-) strand into the (+) strand.

➤ Since, cells do not have RNA polymerase capable of this, these viruses must carry RNA-dependent RNA polymerase.

➤ Examples: *Orthomyxoviridae* and *Paramyxoviridae*.

Baltimore Classification of Virus:

❑ **Class VI: ss RNA viruses that replicate through a DNA intermediate**

- Retroviruses: a well-known family of viruses, have a positive sense, ss-RNA genome, but replicate through a DNA intermediate.

- The process is called reverse transcription, and the enzyme is known as reverse transcriptase (for which Baltimore received Nobel Prize).

Baltimore Classification of Virus:

☐ **Class VI: ds-DNA genome that replicates with RNA intermediate**

- These viruses have a ds DNA genome, but unlike Class I viruses, they replicate via a ss-RNA intermediate.

- Because, the genome is only partially double-stranded.

- Also, use reverse transcriptase.

- Example: Hepatitis B virus (*Hepadnaviridae* family)

Classification of Virus:

After 1990s, there is a formal and universal system for

classification of viruses:

International Committee on Taxonomy of Viruses (ICTV)

Order (-virales)

Family (-viridae)

Subfamily (-virinae)

Genus (-virus)

Species