TIU - Faculty of Science
Medical Analysis Department

Introduction to Medical Virology

Dr. Shatha S. Jumaah/ Lecturer

Virology – Four /1st Semester

shatha.saadi@tiu.edu.iq

https://tiu.edu.iq/

2020 - 2021

VIROLOGY

- VIROLOGY study of viruses and virus-like agents, their taxonomy, disease-producing properties, cultivation and genetics. It is often considered a part of microbiology or pathology.

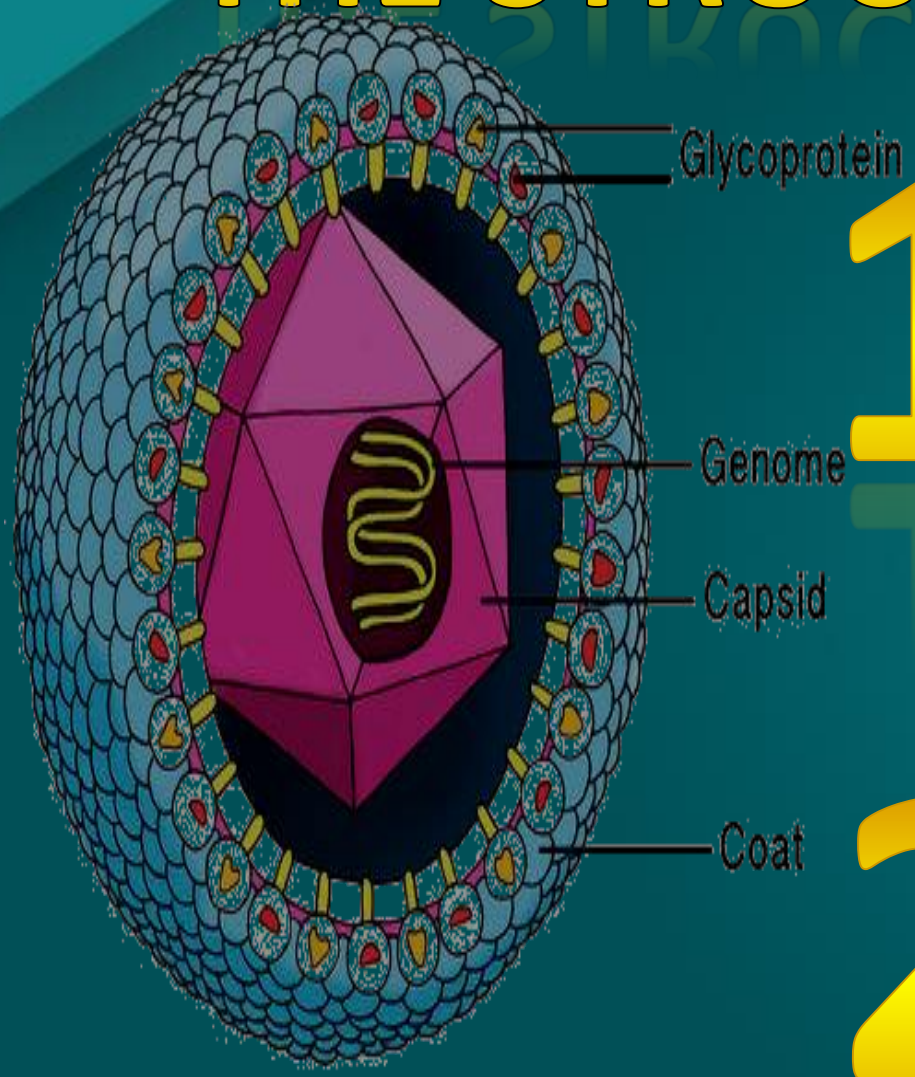
- MARTINUS BEIJERINCK (Father of Virology) He considered one of the founders of virology. In 1898, he published results on the filtration experiments demonstrating that tobacco mosaic disease is caused by an infectious agent smaller than a bacterium.

A VIRUS is an tiny, infectious particle that can reproduce only by infecting a host cell. Viruses "commander" the host cell and use its resources to make more viruses, basically reprogramming it to become a virus factory.

What are Viruses

- Viruses show property of living things only inside a living cell. Out side the cell they behave like a nonliving thing
- They have no cell nucleus, organelles, or cytoplasm.
- They are called obligate intracellular parasites
- Virus particles contain only one kind of nucleic acid—either DNA or RNA but never both viruses are not considered living.
- They're very small, much smaller than the cells of living things, and are basically just packages of nucleic acid and protein.

THE STRUCTURE OF A VIRUS



1 GENOME

A core of DNA or RNA May be single-stranded (ss) or double stranded (ds) or May be circular or linear

2 CAPSID

protein coat surrounds the genome, provides structural symmetry & participates in attachment to susceptible host Facilitates transfer of viral nucleic acid in to]host cell Protects the viral genome from nucleases in blood stream &

structural units making up capsid is the **Capsomeres** consist of one or several ..proteins encoded by the virus genome

ENVELOPE

3

In addition to the capsid, some viruses also have a lipid membrane known as an envelope. Virus envelopes can be external, surrounding the entire capsid, or internal, found beneath the capsid.

- **Typical bilayer**
- Naked or non-enveloped viruses have only a capsid and no envelope. nonenveloped, viruses.
- **projections referred to as spikes may or may not extend from the viral envelope.**
- These surface projections are glycoproteins that serve to attach virions to specific receptor sites on host cell surfaces.

Enveloped Viruses	Non-enveloped Viruses
Sensitive to heat, drying, detergents and alcohols	Not sensitive to heat, drying, detergents and alcohols
Transmitted by direct contact as by blood, sexual) contact (HIV	transmitted by feco-oral route like poliovirus

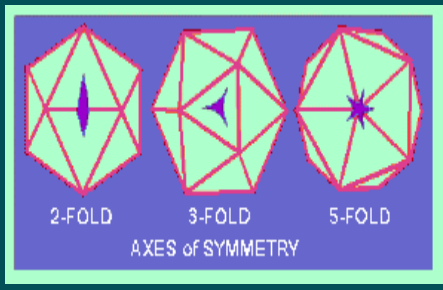
Nucleocapsid :- The protein-nucleic acid complex

Virion The complete infective virus particle

VIRUSES: SYMMETRY (SHAPES)

Cubic Symmetry (Icosahedral)

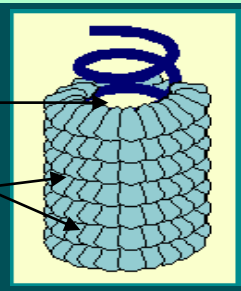
Have exactly 60 subunits on the surface of an icosahedronHave fivefold, threefold and twofold rotational symmetry



Helical Symmetry

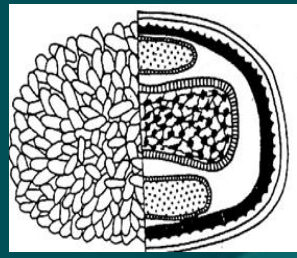
The virion contains an elongated nucleocapsid.

The capsomeres are arranged round the spiral of nucleic acid. **Most helical viruses are enveloped**



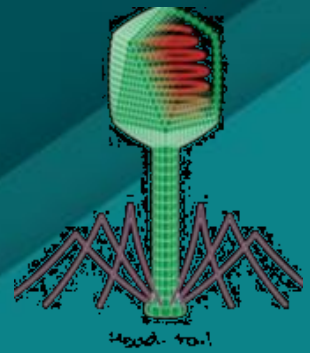
Complex symmetry

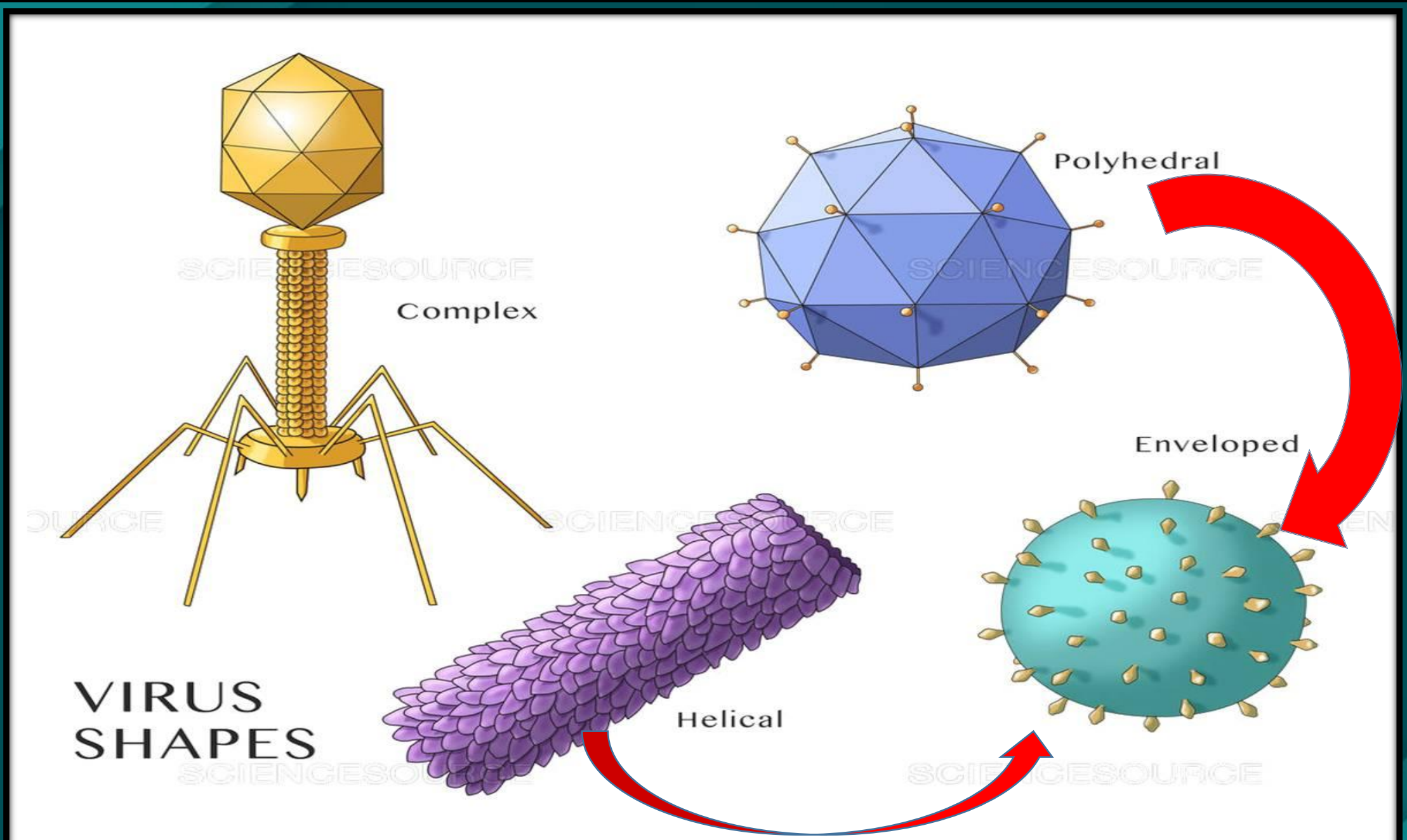
Does not conform to cubic or helical symmetry **(POX VIRUS)**



Head-tail

capsids are kind of a hybrid between the Helical and icosahedral shapes.
They basically consist of an icosahedral head attached to a filamentous or helical tail.




Complex
Polyhedral
Enveloped
Helical
VIRUS
SHAPES

ATYPICAL VIRUS-LIKE AGENTS

1. Defective Viruses

- Are composed of viral nucleic acid and proteins but cannot replicate without a 'helper' virus
- During growth many defective viruses are produced in addition to infectious viruses

2. Pseudovirions

- Contain host cell DNA instead of viral DNA within the capsid
- Can infect cells but do not replicate

3. Viroids

- Consist solely of a single molecule of circular RNA without a protein coat or envelope
- RNA is small and does not code for any protein.
- Cause several plant diseases but are not implicated in human diseases

4. Prions

Are infectious particles that are composed solely of protein and no detectable nucleic acid

Are cause of certain slow diseases like Creutzfeldt-Jacob Disease (CJD) in human and scrapie in sheep

WHAT IS A VIRAL INFECTION?

A viral infection means that many viruses are using your cells to make more copies of themselves.

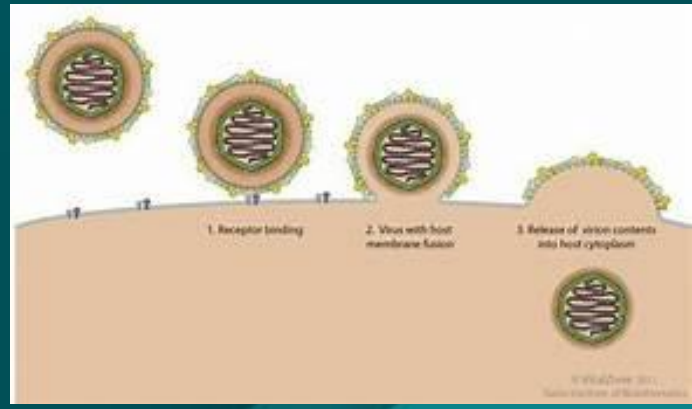
The viral lifecycle is the set of steps in which a virus recognizes and enters a host cell, "reprograms" the host by providing instructions in the form of viral DNA or RNA, and uses the host's resources to make more virus particles.

Attachment

Aspecific protein on the capsid of the virus physically "sticks" to a specific molecule on the membrane of the host cell.
This molecule, called a receptor, is usually a protein. A virus recognizes its host cells based on the receptors they carry, and a cell without receptors for a virus can't be infected by that virus.

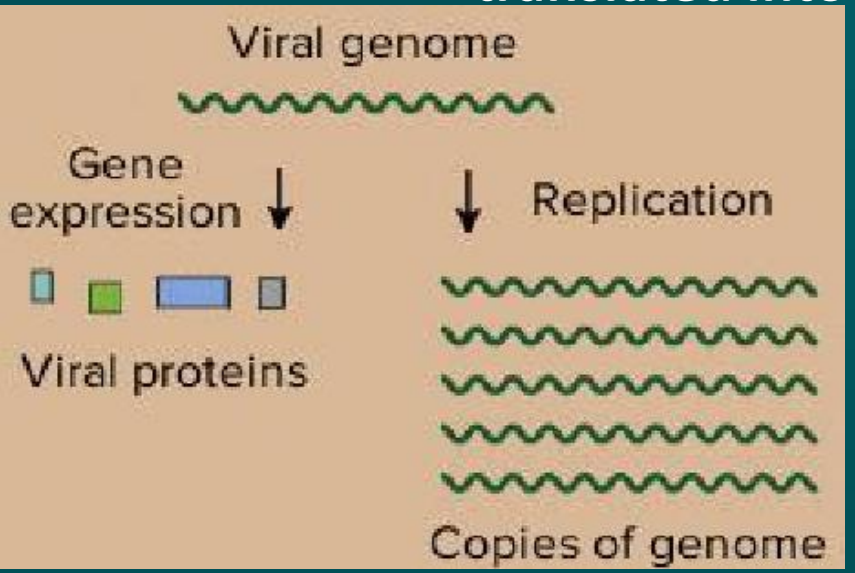
Entry

One typical route for viral entry is fusion with the membrane, which is most common in viruses with envelopes. Viruses may also trick the cell into taking them in by a bulk transport process called endocytosis. Some even inject their DNA into the cell



Genome replication and gene expression

- Involves copying the viral genome and making more viral proteins, so that new virus particles can be assembled.
- The materials for these processes (such as nucleotides) come from the host cell, not the virus.
- Most of the "machinery" for replication and gene expression is also provided by the host cell.
- For instance, the messenger RNAs (mRNAs) encoding viral genes are translated into viral proteins using the host cell's ribosomes.

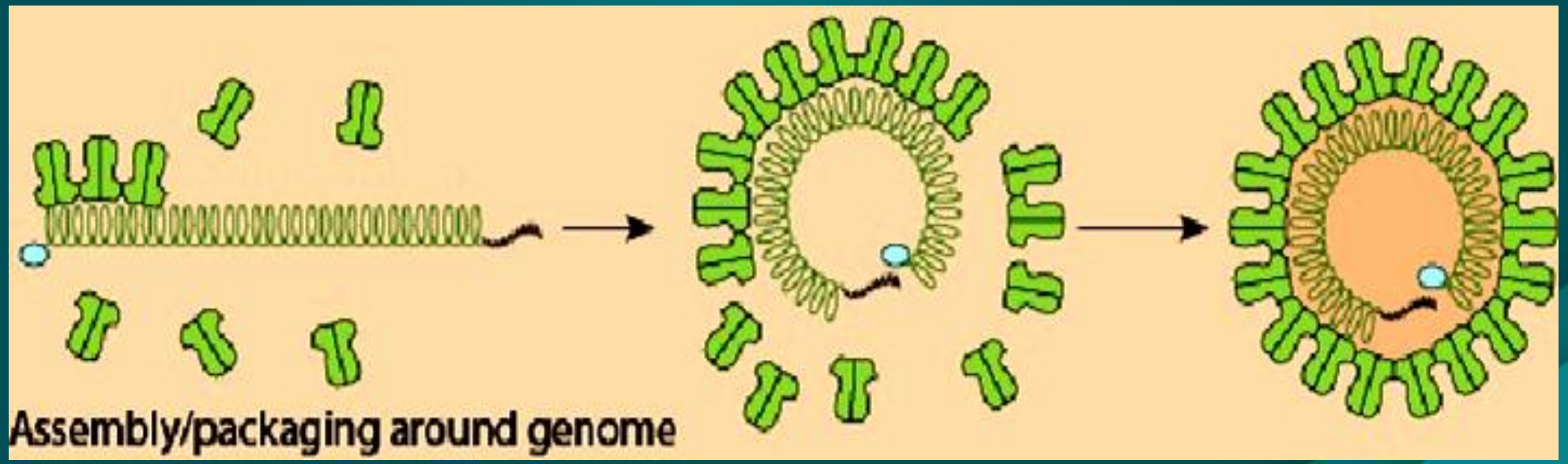


- However, certain steps, such as the copying of an RNA virus's genome, cannot be performed by host cell enzymes. In such cases, the viruses must encode their own enzymes.
- All viruses must encode capsid proteins, and enveloped viruses typically also encode envelope proteins (which often aid in host recognition).

- Viruses may also encode proteins that manipulate the host genome (e.g., by blocking host defenses or driving expression of genes to benefit the virus), help with viral genome replication, or play a role in other parts of the viral lifecycle.

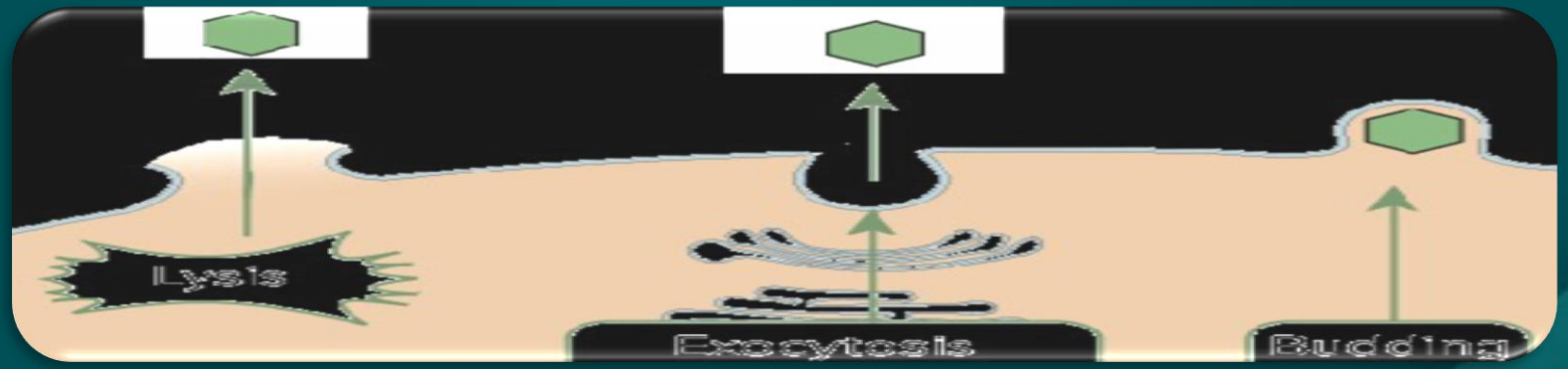
Assembly

- Newly synthesized capsid proteins come together to form capsomers, which interact with other capsomers to form the full-sized capsid.
- Some viruses, like head-tail viruses, first assemble an "empty" capsid and then stuff the viral genome inside.
- Other viruses build the capsid around the viral genome, as shown below.



Release

- The last step in the virus lifecycle is the release of newly made viruses from the host cell.
- Different types of viruses exit the cell by different routes: some make the host cell burst (a process called lysis), while others exit through the cell's own export pathways (exocytosis), and others yet bud from the plasma membrane, taking a patch of it with them as they go.
- In some cases, the release of the new viruses kills the host cell. (For instance, a host cell that bursts will not survive.) In other cases, the exiting viruses leave the host cell intact so it can continue cranking out more virus particles.



CLASSIFICATION OF VIRUSES

Viruses are mainly classified by phenotypic characteristics, such as morphology, nucleic acid type, mode of replication, host organisms, and the type of disease they cause.
Currently there are **two** main schemes used for the classification of viruses

1 The International Committee on Taxonomy of Viruses (ICTV) system

2 The Baltimore classification system

1

✓ Family names are typically derived from special characteristics of viruses within the family or from the name of an important member of the family eg. Picornaviridae, Hepadnaviridae, Herpesviridae.

✓Viruses are assigned to certain genera within families.

✓Viral classification starts at the level of order and follows as thus, with the taxon suffixes given in italics:

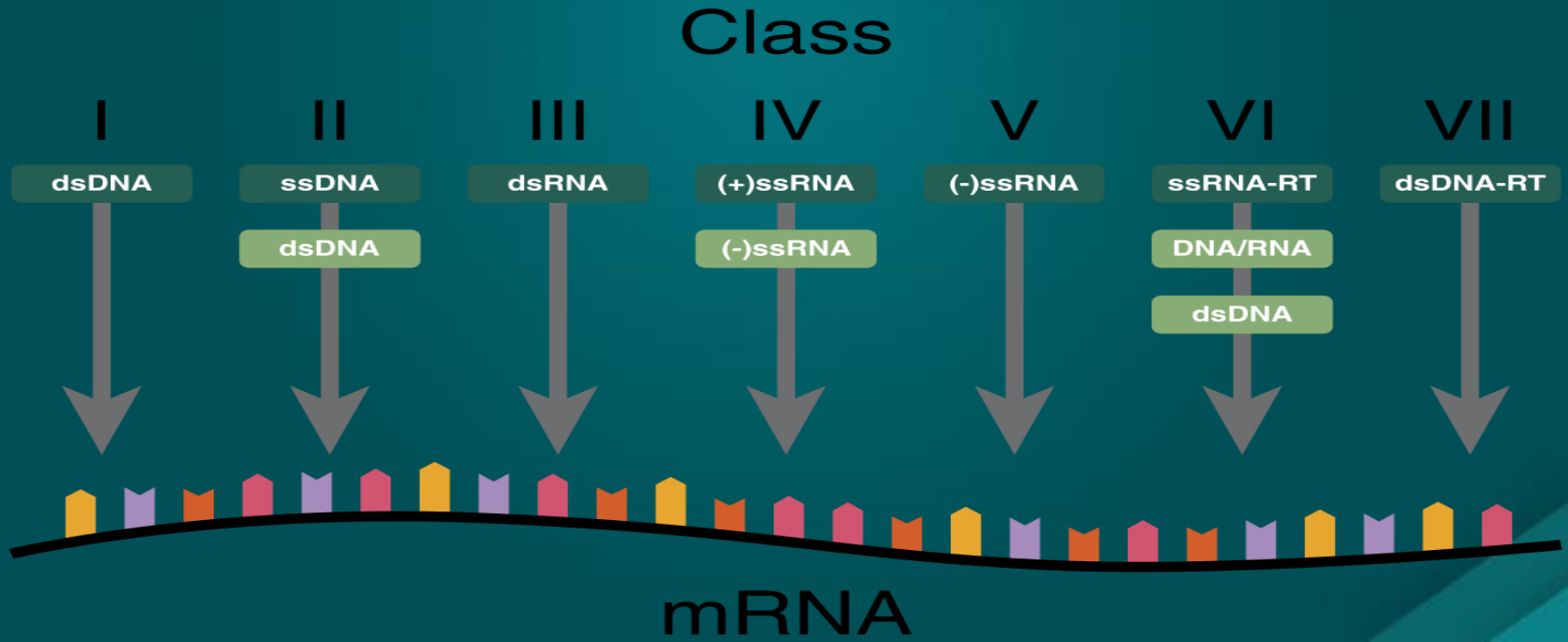
- Order (-virales)
- Family (-viridae)
- Subfamily (-virinae)
- Genus (-virus)
- Species

- So far, six orders have been established by the ICTV: the Caudovirales, Herpesvirales, Mononegavirales, Nidovirales, Picornavirales, and Tymovirales.
- These orders span viruses with varying host ranges. Ex.

1. Herpesvirales contains large eukaryotic dsDNA viruses.
2. Picornavirales contains small (+) strand ssRNA viruses that infect a variety of plant, insect, and animal host.

2 BALTIMORE CLASSIFICATION

- first defined in 1971
- A classification system that places viruses into one of seven groups depending on a combination of their nucleic acid (DNA or RNA), strandedness (single-stranded or double-stranded), Sense and method of replication
- these groups are designated by Roman numerals and discriminate viruses depending on their mode of replication, and genome type.



BALTIMORE CLASSIFICATION

VIRUSES CAN BE PLACED IN ONE OF THE SEVEN FOLLOWING GROUPS:

I. dsDNA viruses (e.g. Adenoviruses, Herpesviruses, Poxviruses)

II. ssDNA viruses (+) sense DNA (e.g. Parvoviruses)

III. dsRNA viruses (e.g. Reoviruses)

IV. (+)ssRNA viruses (+) sense RNA (e.g. Picornaviruses Togaviruses)

V. (–)ssRNA viruses (–) sense RN (e.g. Orthomyxoviruses Rhabdoviruses)

VI: ssRNA-RT viruses (+) sense RNA with DNA intermediate in life-cycle (e.g. Retroviruses)

VII: dsDNA-RT viruses (e.g. Hepadnaviruses)

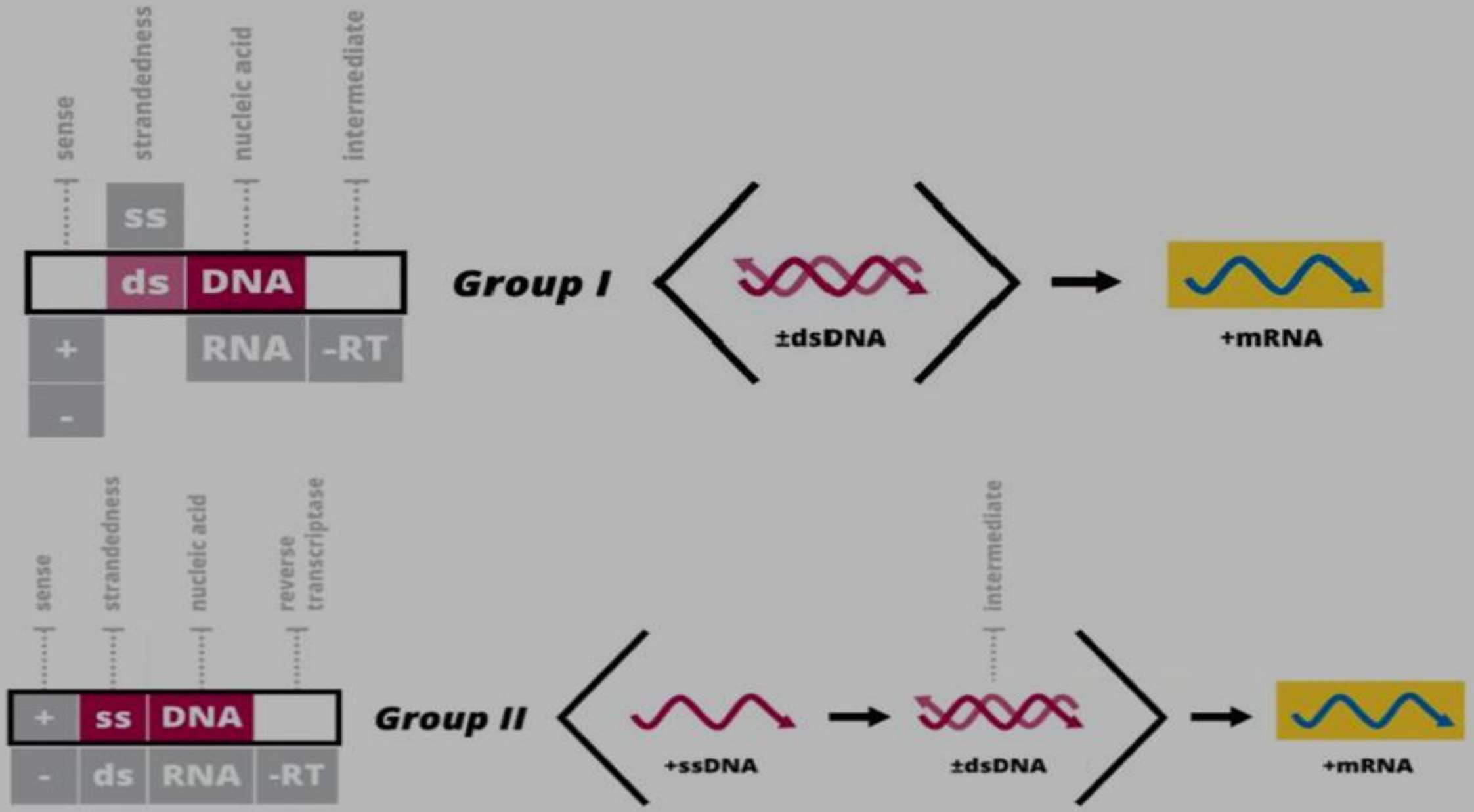
DNA VIRUSES VERSUS RNA VIRUSES

DNA VIRUSES	RNA VIRUSES
DNA viruses refer to viruses whose genetic information is stored in the form of DNA	RNA viruses refer to viruses whose genetic information is stored in the form of RNA
Contain DNA as their genetic material	Contain RNA as their genetic material
Most are double-stranded	Most are single-stranded
Replicated inside the nucleus of the host cell	First transcribed and then replicated in the cytoplasm
Viral DNA is first transcribed into RNA, and then mRNA is translated into viral proteins	Can bypass transcription during protein synthesis since they already contain RNA in the genome
Stable due to the lower mutation rate	Unstable due to the higher mutation rate
Shows an accurate replication	Shows an error-prone replication
Contain a large genome	Contain a small genome
Newly-synthesized viral DNA is packed into a pre-formed capsid called procapsid	Newly-synthesized viral RNA is not packed in a procaspid
Include Class I, II, and VII of the Baltimore classification of viruses	Include Class III, IV, V, and VI of the Baltimore classification of viruses
Ex: Adenoviruses, Herpesviruses, Poxviruses, Parvoviruses, and Hepadnaviruses	Ex: Reoviruses, Picornaviruses, Togaviruses, Rhabdoviruses, and Retroviruses
Smallpox, herpes, and chickenpox are diseases of DNA viruses	Aids, Ebola hemorrhagic fever, SARS, common cold, etc. are some diseases of RNA viruses

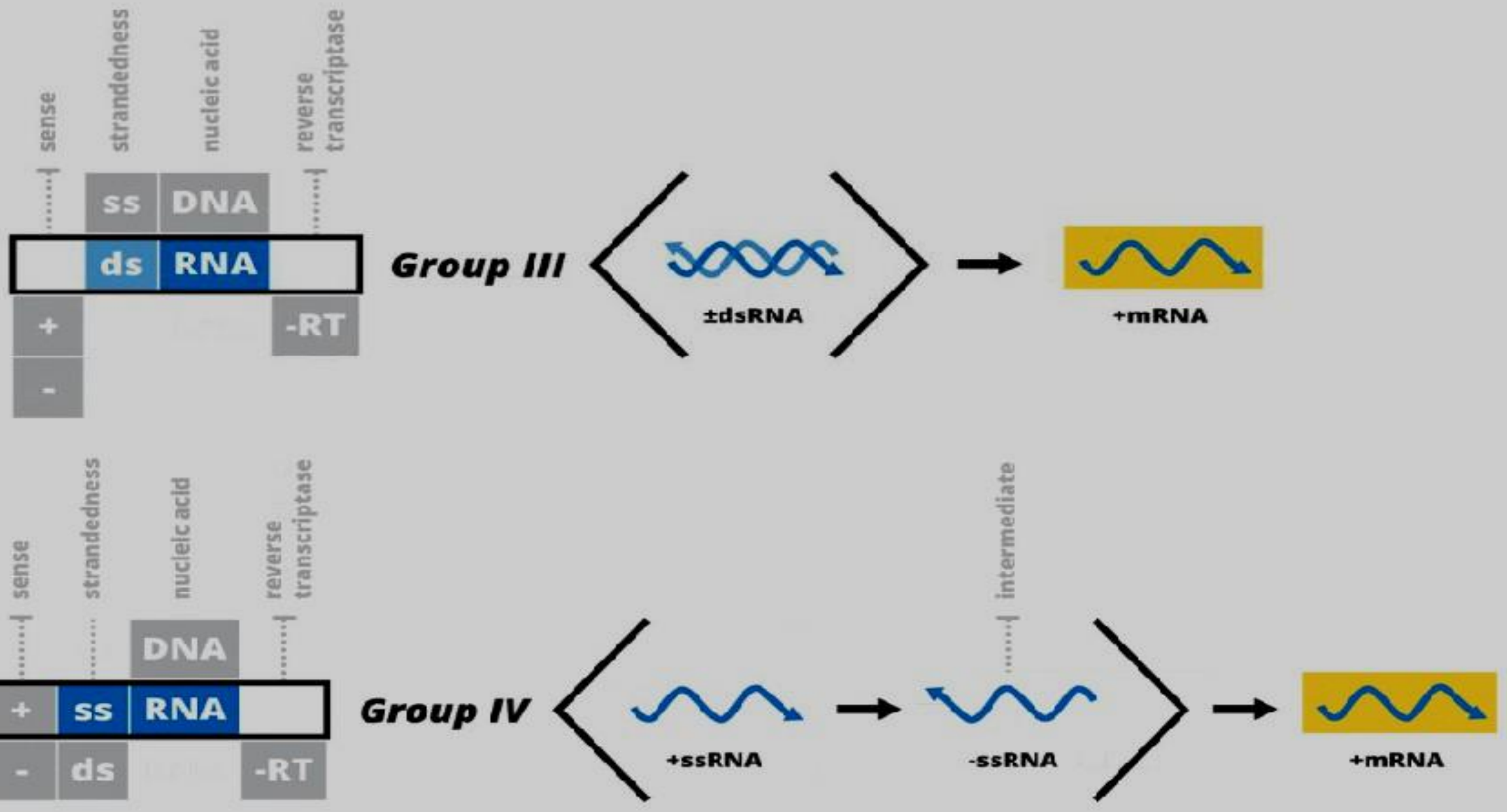
POSITIVE SENSE RNA VIRUS VERSUS NEGATIVE SENSE RNA VIRUS

POSITIVE SENSE RNA VIRUS	NEGATIVE SENSE RNA VIRUS
Positive sense RNA virus is a type of single-stranded RNA viruses whose genetic material is viral mRNA that encodes for proteins	Negative sense RNA virus is a type of single-stranded RNA viruses whose genetic material is the antisense strand of the viral mRNA
Known to have a positive sense (5' to 3') RNA genome	Known to have a negative sense (3' to 5') RNA genome
Called the plus-strand or sense strand	Called the minus-strand or antisense strand
Consists of viral mRNA that can be readily translated into proteins	Consists of viral mRNA complementary to the mRNA
Needs not be transcribed	Should be transcribed into positive sense RNA before the translation
Do not require RNA polymerase	Require RNA-dependent RNA polymerase for the transcription of the genome into positive sense RNA
Replicate via a double-stranded RNA intermediate	Replication occurs with the aid of RNA-dependent RNA polymerase
Polio virus, echovirus, and Coxsackie virus are examples	Ebola virus, Rabies virus, mumps virus, influenza virus, and hepatitis D virus are examples

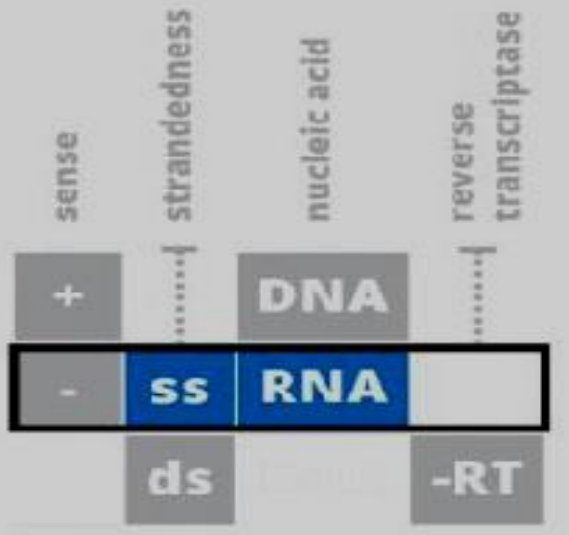
Baltimore classification

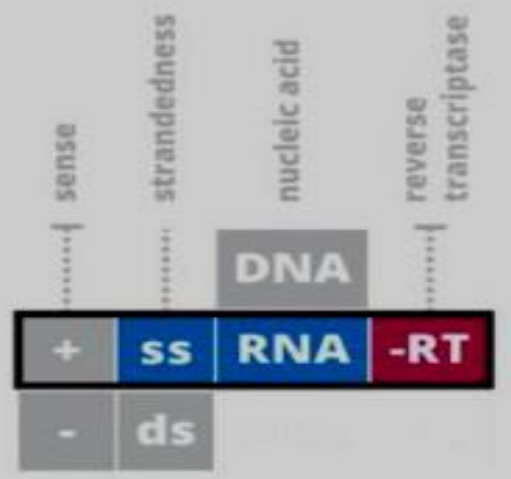


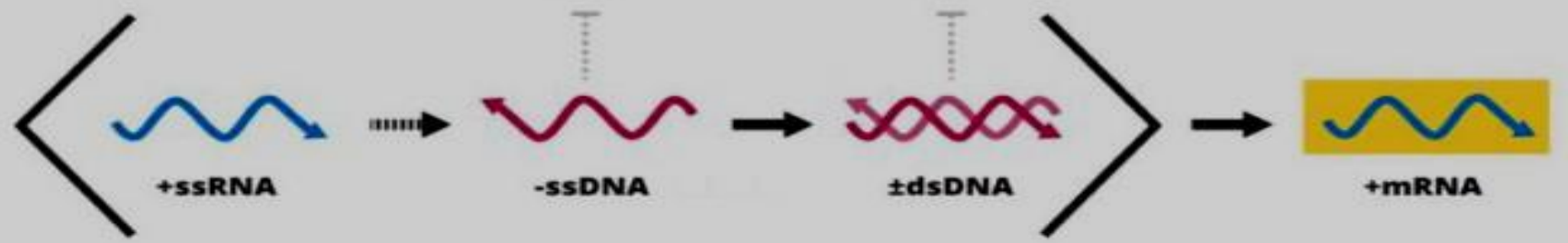
Baltimore classification



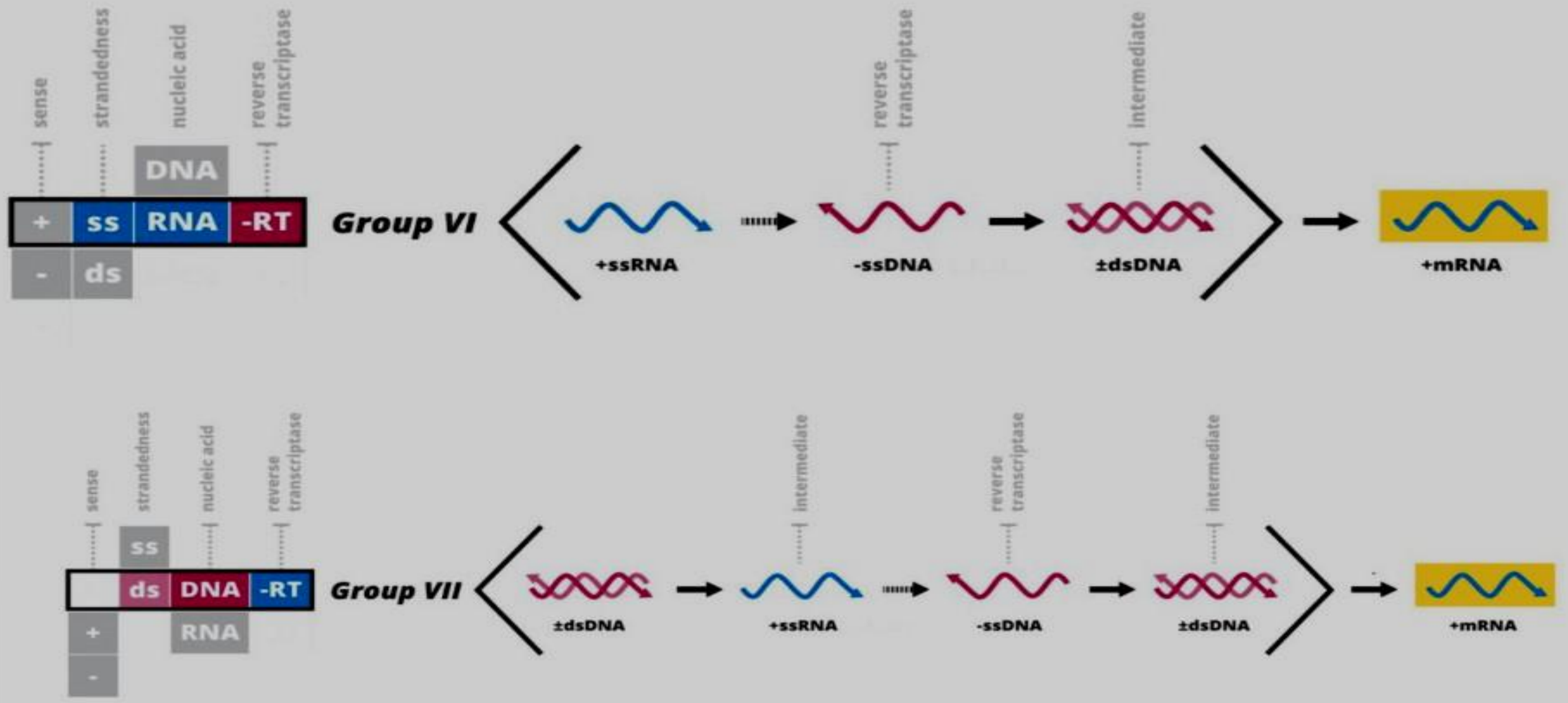
Baltimore classification

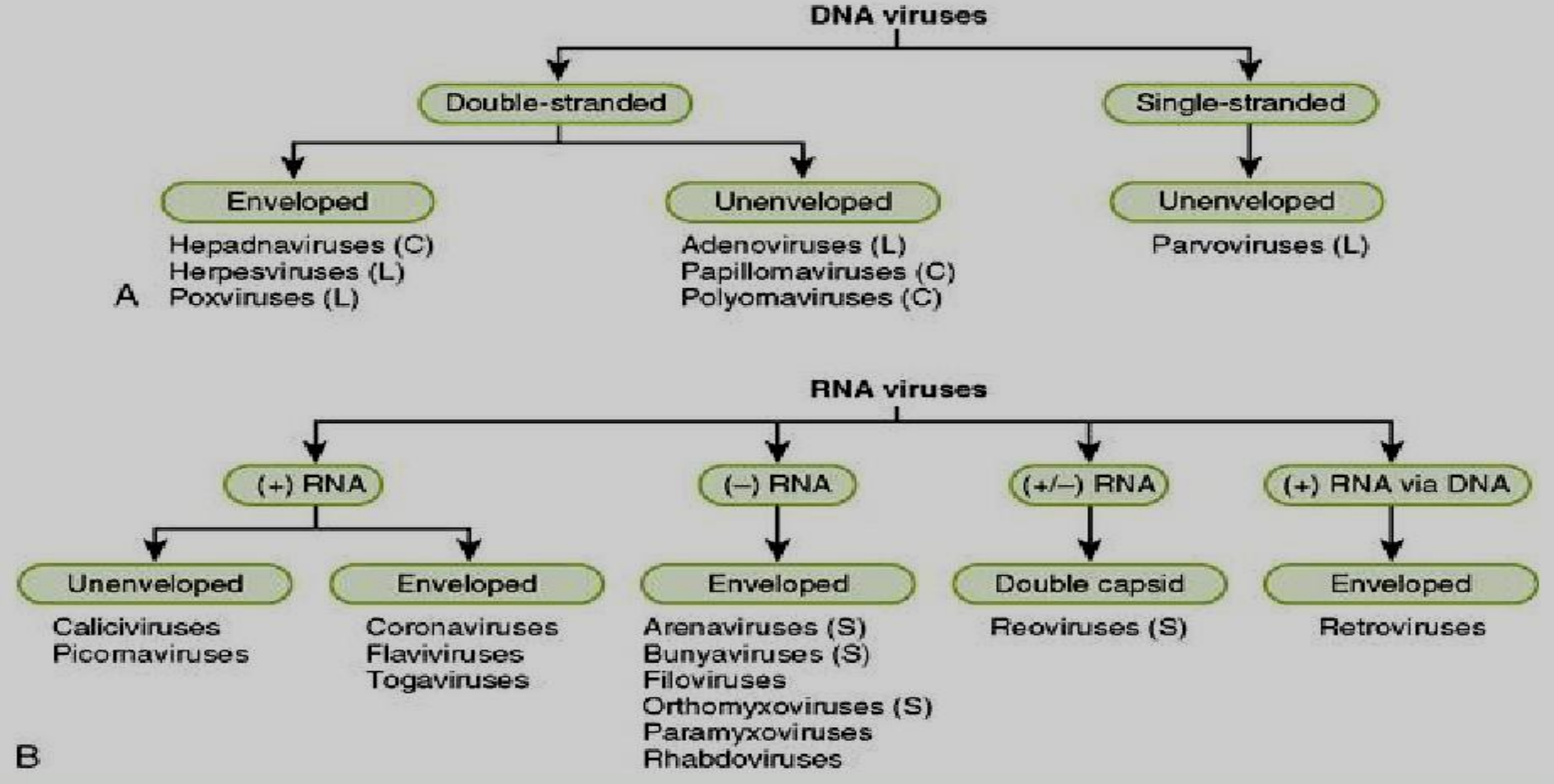






Baltimore classification




DNA viruses
Double-stranded
Single-stranded
Enveloped
Unenveloped
Unenveloped
Hepadnaviruses (C)
Herpesviruses (L)
Poxviruses (L)
Adenoviruses (L)
Papillomaviruses (C)
Polyomaviruses (C)
Parvoviruses (L)
A
RNA viruses
(+) RNA
(–) RNA
(+/–) RNA
(+) RNA via DNA
Unenveloped
Enveloped
Enveloped
Double capsid
Enveloped
Caliciviruses
Picornaviruses
Coronaviruses
Flaviviruses
Togaviruses
Arenaviruses (S)
Bunyaviruses (S)
Filoviruses
Orthomyxoviruses (S)
Paramyxoviruses
Rhabdoviruses
Reoviruses (S)
Retroviruses
B

CLASSIFICATION OF VIRUS ON THE BASIS OFHOST RANGE:

1. **Bacteriophage**: virus infecting bacteria. Eg, λ phage, T2, T4, ϕ174, MV-11

2. **Plant virus**: virus that infects plants. Eg. TMV, cauliflower mosaic virus.

3. **Animal virus** Those virus that infects animals. Eg. Polio virus, Retro virus, Herpes virus, Adeno virus.

4. **Insect virus** Virus that infects insects. Eg. Baculovirus, Sacbrood virus, Entomopox virus, Granulosis virus.

Thanks for your attention

shatha.saadi@tiu.edu.iq