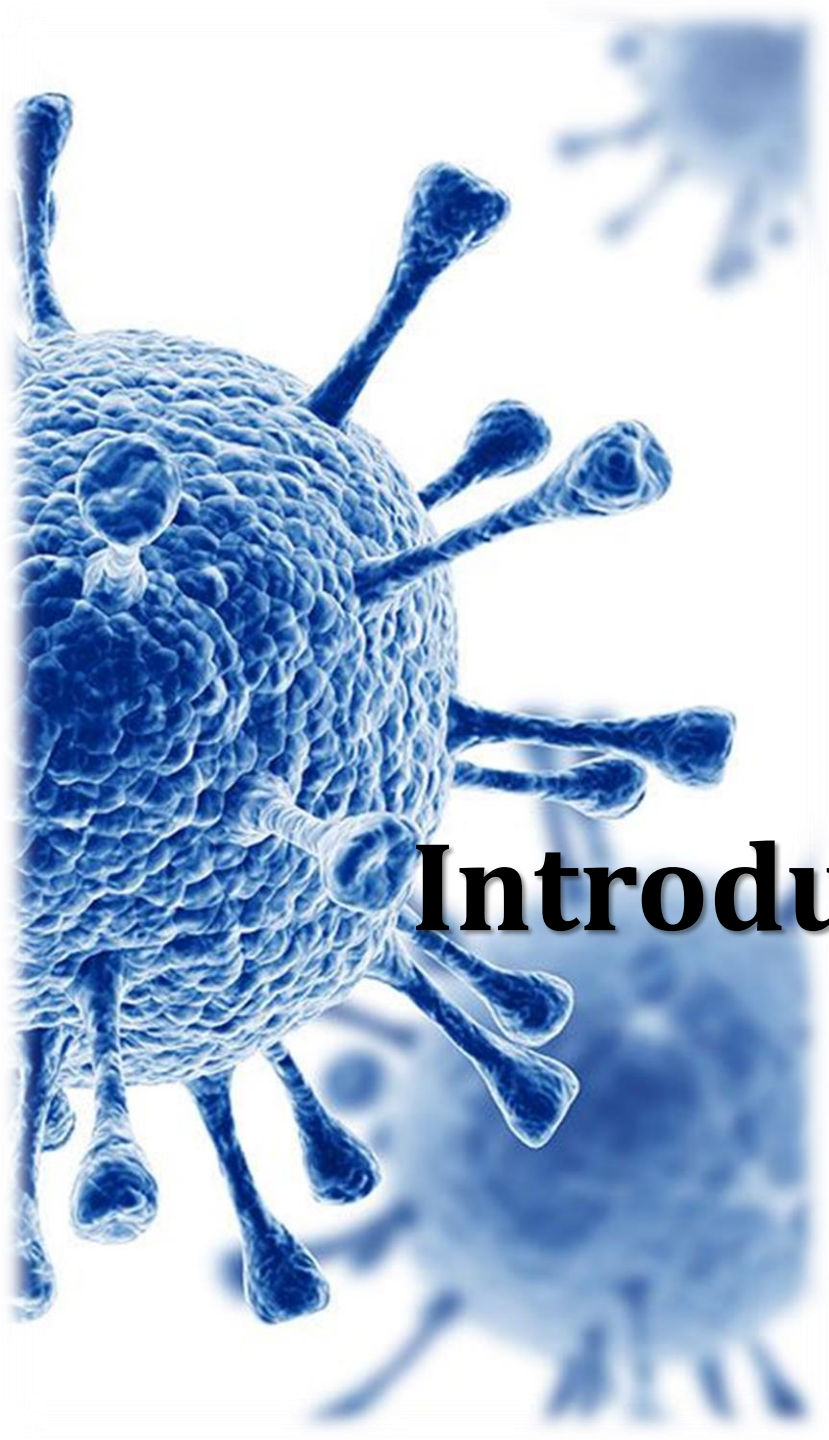

Introduction to Medical Virology

Summer Term
Lecture no.1

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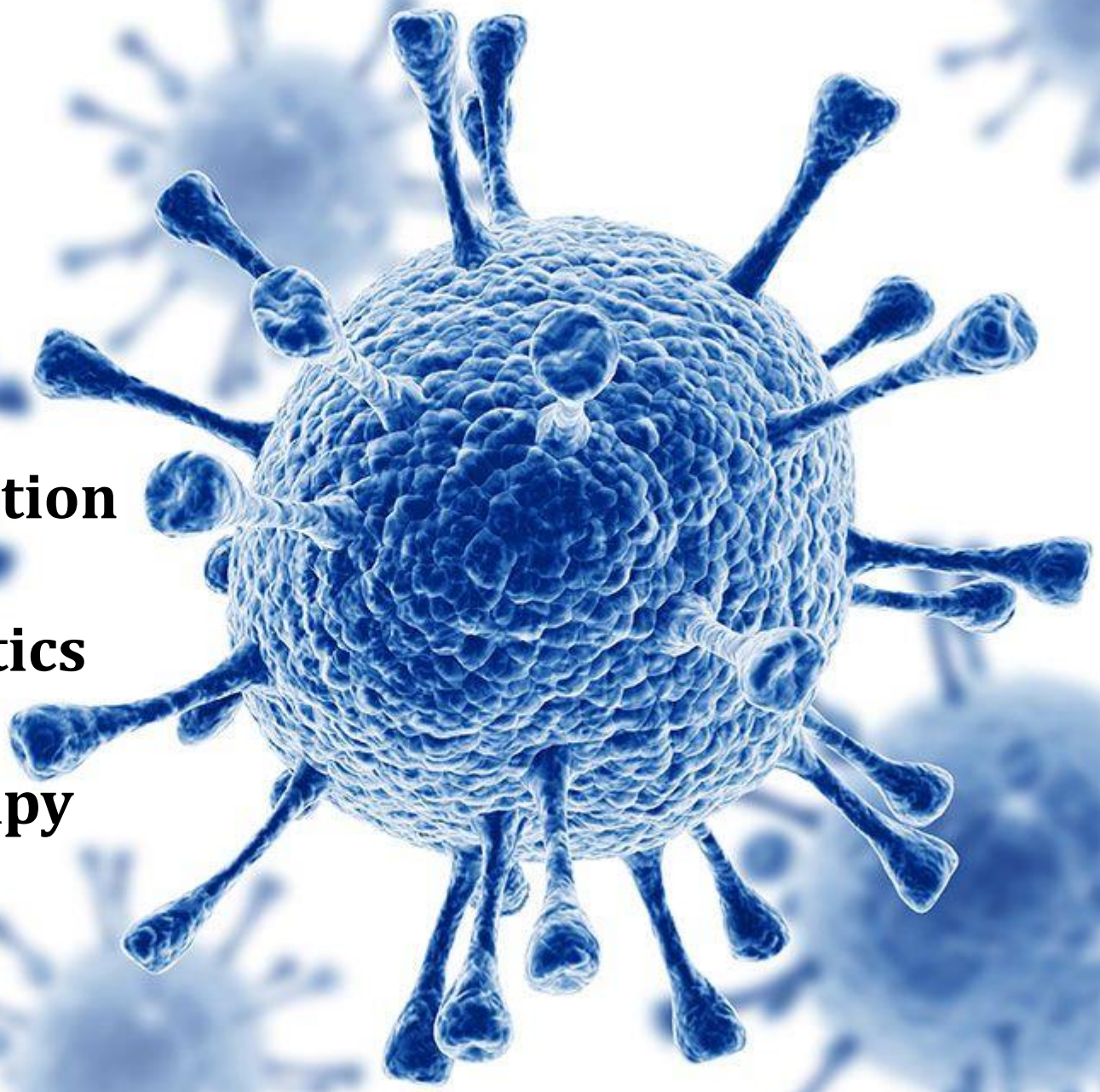
Syllabus

1. Introduction to **Virology**
2. Viral **Structure** and **Classification**
3. Viral **Replication**
4. **Pathogenesis** and Viral **Genetics**
5. Viruses and **Cancer**
6. Viral **Vectors** and **Gene Therapy**
7. Antiviral **Drugs** and **Vaccines**



1. Introduction to Virology

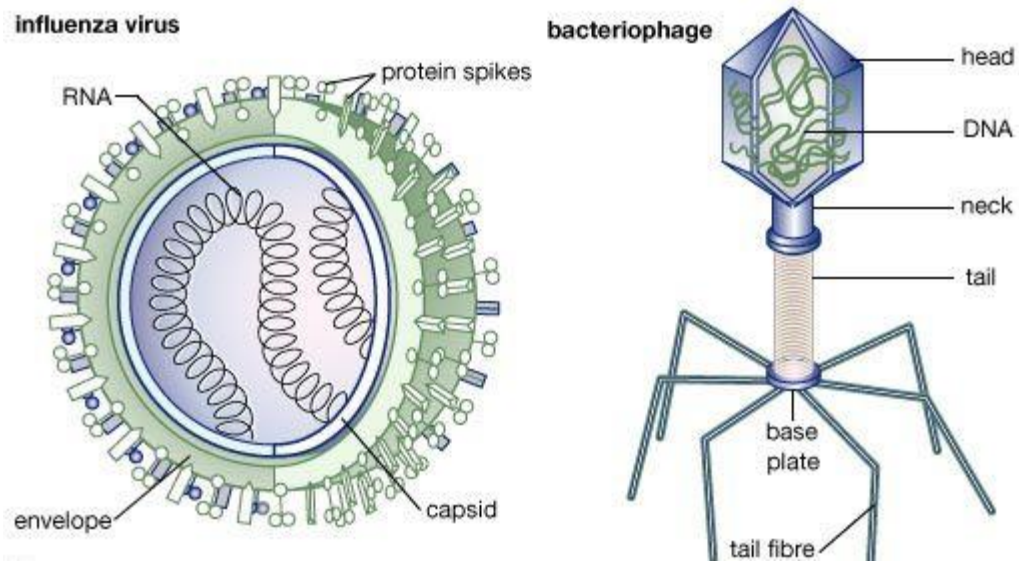
- **Virology** is the scientific study of viruses_ tiny, sub-cellular, obligate intracellular parasites that consist of **genetic material** (DNA or RNA) protected by a **protein coat** called a **capsid**. They *cannot reproduce or generate energy on their own and must use a living host cell to multiply.

- **Viruses** are acellular (or sub-cellular) because they are not made of cells. They **lack** a cell membrane, cytoplasm, and cellular organelles like ribosomes or mitochondria.

2. Viral Structure and Classification

Basic Structure of a Virus

- ❑ **Genome:** Either DNA or RNA (single-stranded or double-stranded), but never both.
- ❑ **Capsid:** A protein shell made of subunits (capsomeres) that protects the viral genome.
- ❑ **Envelope:** A lipid membrane stolen from the host cell, often studded with viral glycoproteins for attachment (naked viruses lack this).



Why Do They Need a Host?

- ❑ **No independent metabolism:** They cannot generate energy or make proteins on their own.
- ❑ **Obligate intracellular parasites:** They must hijack [steal] a living host cell's machinery to replicate and make new viral particles.

- A **bacteriophage**, also known informally as a phage, is a virus that infects and replicates within bacteria. The term is derived from Ancient Greek 'to devour' [ingest] and bacteria. Bacteriophages are composed of proteins that encapsulate a DNA or RNA genome, and may have structures that are either simple or complex.

Viral Classification

- The two main frameworks used are the ICTV [International Committee on Taxonomy of Viruses] taxonomic hierarchy and the Baltimore classification system.

- **ICTV Taxonomic Classification_**

Managed by the International Committee on Taxonomy of Viruses (ICTV), this system groups viruses into hierarchical ranks **based on evolutionary and structural features**:

Realm: Ribo**viria**
Kingdom: Pararna**virae**
Phylum: Artver**viricota**
Class: Revtra**viricetes**
Order: Orter**virales**
Family: Retro**viridae**
Subfamily: Orthoretro**virinae**
Genus: *Lentivirus*
Species: *Human immunodeficiency virus 1 [HIV]*

✔ Baltimore Classification System_

Created by Nobel laureate David Baltimore, this system categorizes viruses into **seven distinct groups based on how they generate messenger RNA (mRNA)** and replicate:

- ❑ **Group I:** Double-stranded DNA (dsDNA) _ e.g., *Herpesviruses*, *Poxviruses*
- ❑ **Group II:** Single-stranded DNA (ssDNA) _ e.g., *Parvoviruses*
- ❑ **Group III:** Double-stranded RNA (dsRNA) _ e.g., *Reoviruses*
- ❑ **Group IV:** Positive-sense single-stranded RNA (+ssRNA) _ e.g., *Coronaviruses*, *Flaviviruses*
- ❑ **Group V:** Negative-sense single-stranded RNA (-ssRNA) _ e.g., *Orthomyxoviruses*, *Rhabdoviruses*
- ❑ **Group VI:** Single-stranded RNA viruses with a DNA intermediate (ssRNA -RT) _ e.g., *Retroviruses* (HIV)
- ❑ **Group VII:** Double-stranded DNA viruses with a RNA intermediate (dsDNA-RT) _ e.g., *Hepadnaviruses* (Hepatitis B)

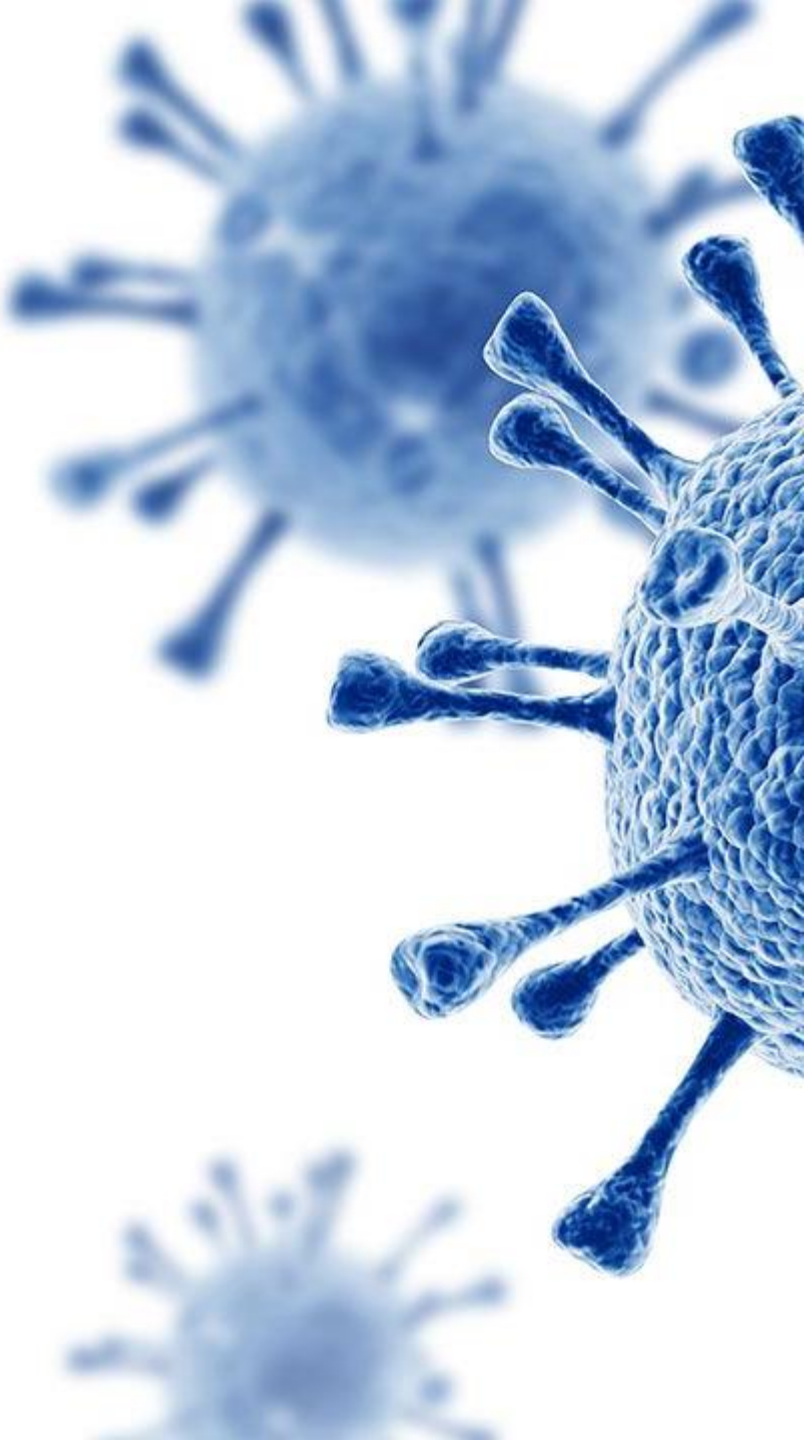
3. Viral Replication

- **Attachment (Adsorption):** Virus binds to specific receptor sites on the host cell surface.
- **Entry (Penetration):** The virus or its genetic material enters the cell.
- **Uncoating:** The viral capsid degrades, releasing the nucleic acid inside the host cell.
- **Biosynthesis:** The host machinery is hijacked to copy viral genes and make viral proteins.
- **Assembly:** New viral particles are put together from the manufactured parts.
- **Release:** New virions exit the cell by bursting the cell (lysis) or budding off the membrane.

4. Pathogenesis and Viral Genetics

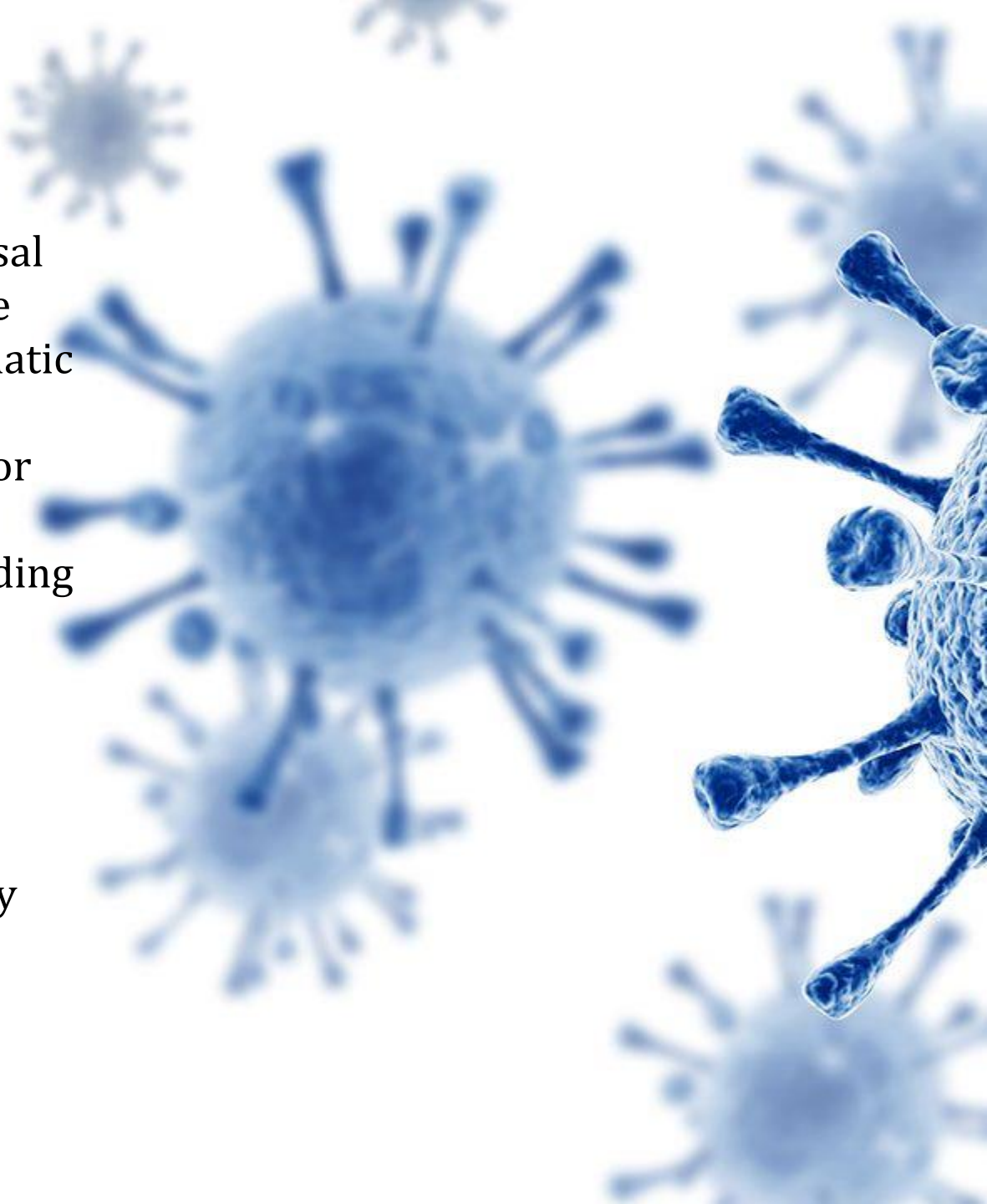
- **Viral pathogenesis_** is the process by which a virus infection causes disease, driven by viral entry, tissue tropism, and host immune responses.

- **Tissue tropism** is the specific preference of a pathogen (like a virus, bacterium, or parasite) to infect and grow in certain types of host cells or tissues instead of others. For example, the **rabies** virus targets nerve tissue, while the **hepatitis** virus targets liver tissue.



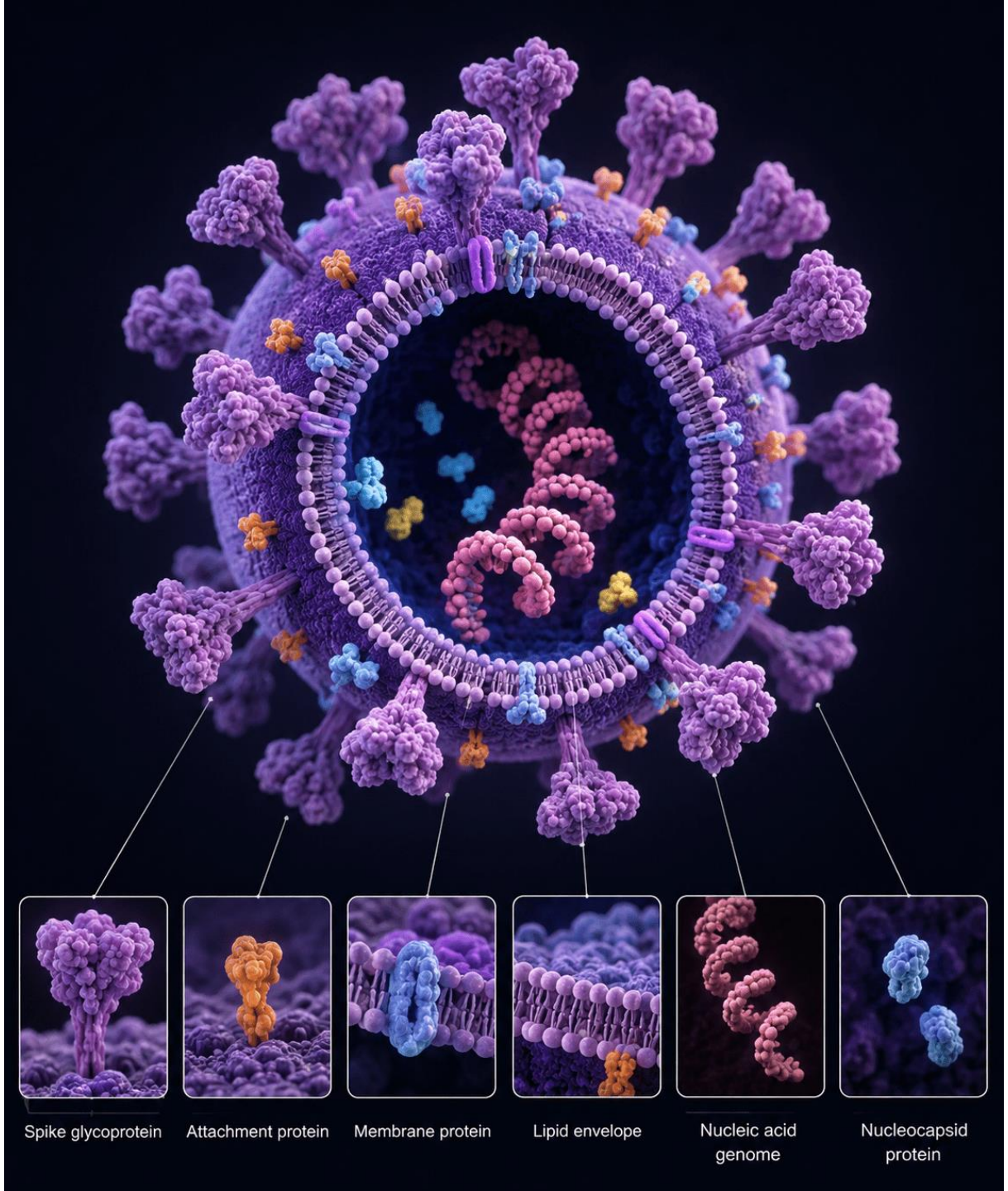
Key Concepts of Viral Pathogenesis

- **Entry and Spread:** Viruses enter through mucosal surfaces or skin breaks, replicating locally before spreading via the bloodstream (**viremia**), lymphatic system, or nerves.
- **Tissue Tropism:** Viruses target specific organs or cells because their surface proteins must match precise host cell receptors (e.g., SARS-CoV-2 binding to ACE2_ **receptor**).
- **Cellular Injury:** Disease occurs either through direct cell destruction (cytopathic effects) or indirect damage caused by severe host inflammation and immune responses.
- **Infection Outcomes:** Infections can clear rapidly (acute), persist over time (chronic/latent or hidden), or trigger uncontrolled cell growth (oncogenesis_ the development of a tumour).



- **Viral genetics_** studies how viral genomes change through high mutation rates and recombination, directly shaping how pathogens evolve, evade immune systems, and alter disease severity.

- *Viral **genomes** are the total genetic material of a virus, composed of either DNA or RNA.*



Core Mechanisms of Viral Genetics

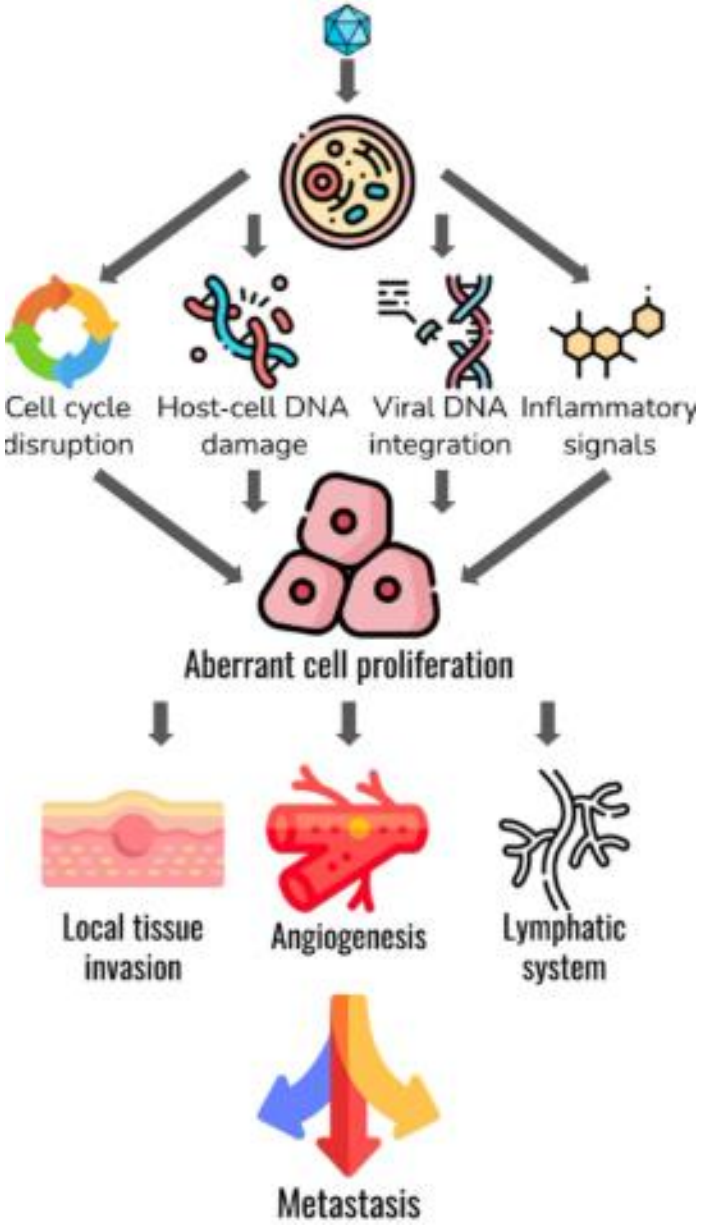
- **Mutation Rates:** RNA viruses mutate much faster than DNA viruses because their **replication enzymes lack proofreading ability**, leading to rapid evolutionary **shifts** [changes].
- **Antigenic Drift [relocation]:** Minor point mutations in viral surface proteins gradually alter how the immune system recognizes the virus.
- **Recombination and Assortment:** Co-infecting viruses swap large genetic segments, occasionally producing **novel strains** with entirely new pandemic [disease] potential (antigenic shift).

  Virus A + Virus B [infect the same cell] → reassortment → new Virus C

- **Reverse Genetics:** Laboratory techniques that rebuild viruses from cDNA to study how specific genetic changes alter virulence and transmission.

5. Viruses and Cancer

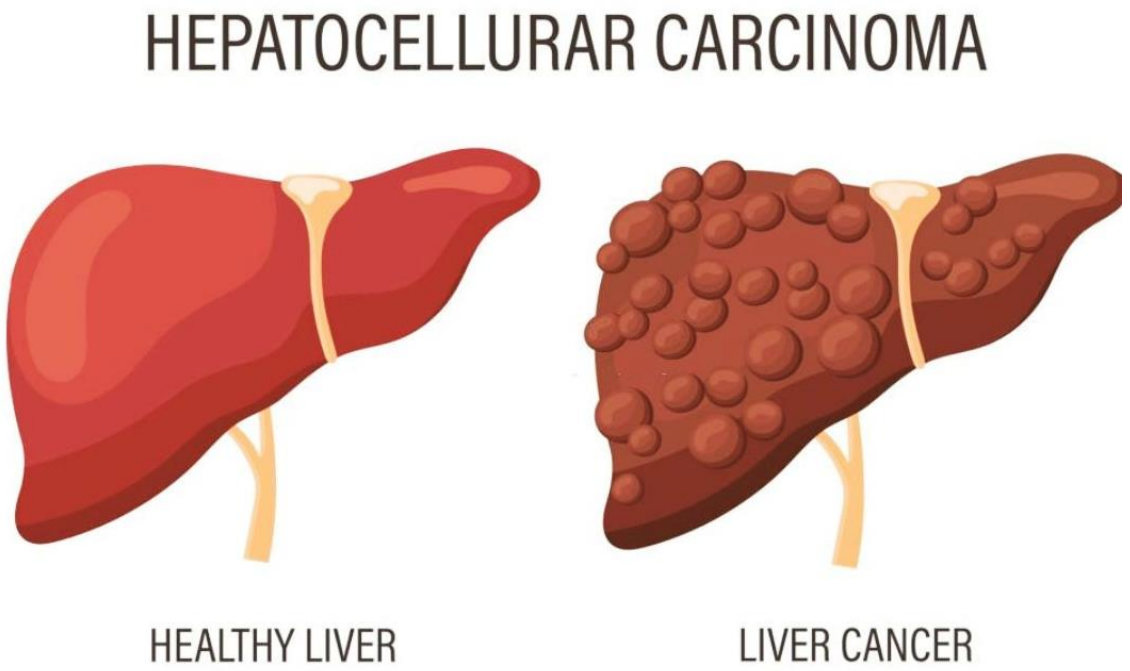
- ❑ Certain viruses (called oncoviruses) cause about 10% to 20% of all human cancers.
- ❑ They trigger cancer by putting their own genes into human cells, causing long-term swelling and damage, or weakening the body's immune defense so abnormal cells grow without stopping.



- ***Oncoviruses*** *(oncogenic viruses) are viruses that can cause or-drive cancer in humans and animals.*

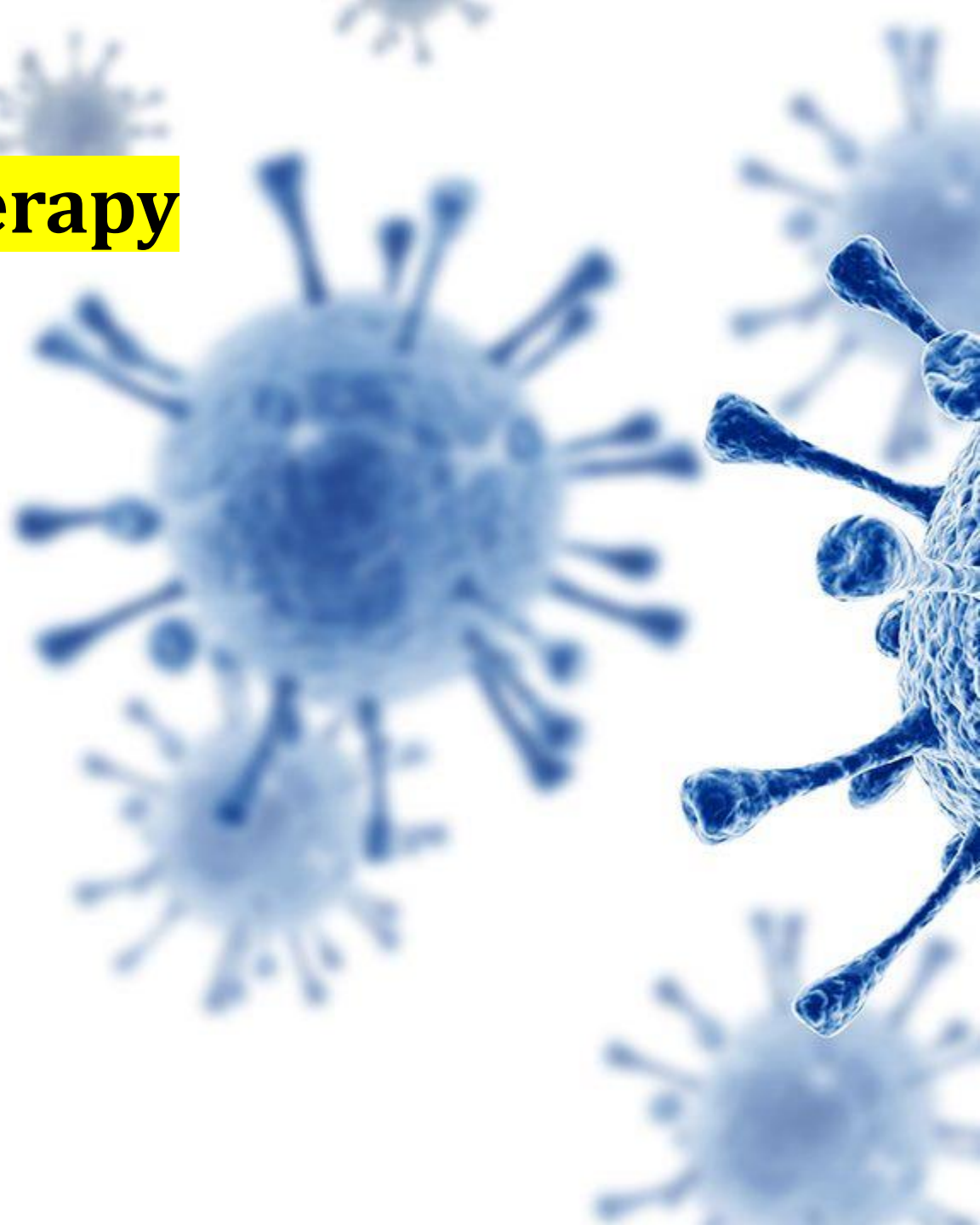
Viruses Linked to Cancer

- **Human Papillomavirus (HPV):** Causes cervical, throat, and anal cancers.
- **Hepatitis B and C (HBV, HCV):** Cause long-term liver damage that can lead to liver cancer.
- **Epstein-Barr Virus (EBV):** Linked to types of lymphomas and nasopharyngeal cancer.
- **Human Immunodeficiency Virus (HIV):** Does not make cancer directly, but weakens the immune system so other cancer-causing viruses take over.



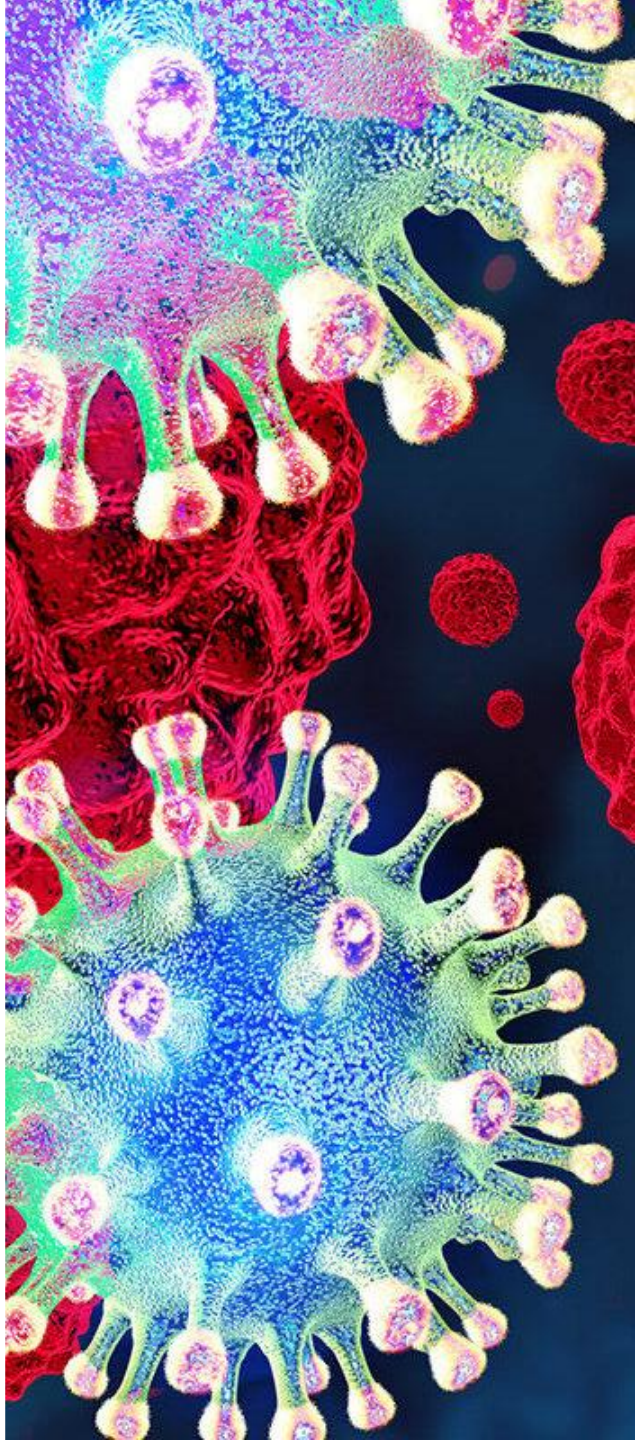
6. Viral **Vectors** and **Gene Therapy**

- A viral vector is a **modified, safe version of a virus** used as a tool to deliver new or working genes into cells.
- Scientists remove harmful disease-causing and replication genes from the virus and replace them with a therapeutic genetic payload.
- They are widely used in medicine for gene therapy and vaccines.



Common Applications of Viral Vectors

- **Gene Replacement Therapy:** Delivering a healthy, working copy of a gene to fix single-gene inherited disorders.
- **Vaccines:** Instructing immune cells to safely produce specific viral proteins to build immunity against infectious diseases.
- **Cancer Treatment:** Using targeted or oncolytic vectors to destroy tumor cells or stimulate an anti-cancer immune response.
- **Laboratory Research:** Overexpressing or knocking down specific genes to study cellular mechanisms at a molecular level.



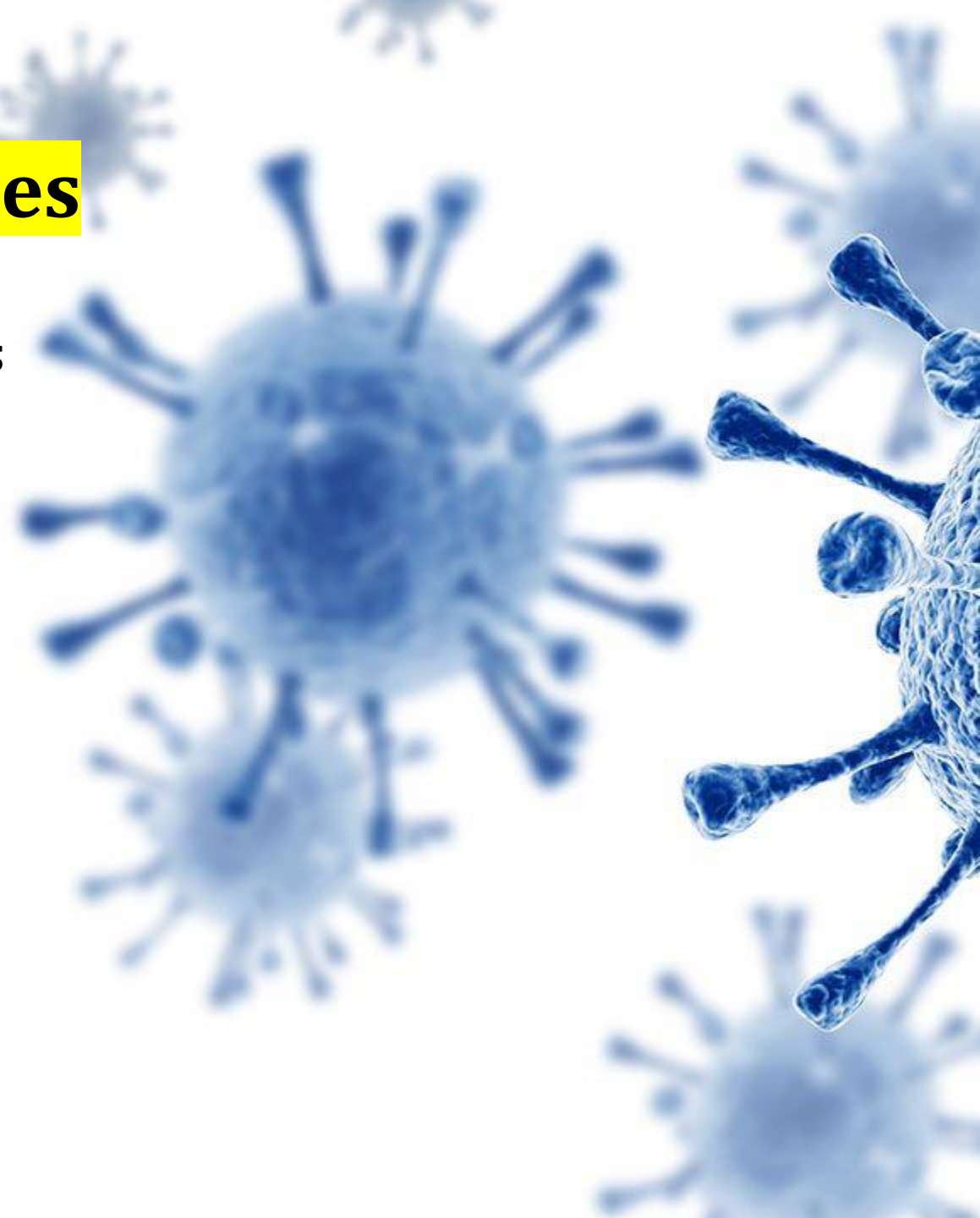
- **Viral gene therapy**_ uses modified, harmless viruses as delivery trucks (vectors) to carry healthy working genes into human cells. This fixes or replaces broken genes that cause rare inherited diseases, blindness, and specific blood cancers.

How It Works

- **Strip the Virus:** Scientists take out the harmful parts of a virus so it cannot cause sickness.
- **Add the Good Gene:** A healthy human gene is placed inside the empty viral shell.
- **Deliver to Cells:** The engineered virus enters the patient's target cells and unloads the healthy DNA or RNA.
- **Make Proteins:** The cell reads the new instructions and starts making the correct proteins to heal the body.

7. Antiviral **Drugs** and **Vaccines**

- Antiviral drugs are prescription medicines that *stop viruses from multiplying in the body. They *ease symptoms, *shorten illness, and *treat long-term infections like flu, herpes, HIV, and hepatitis.

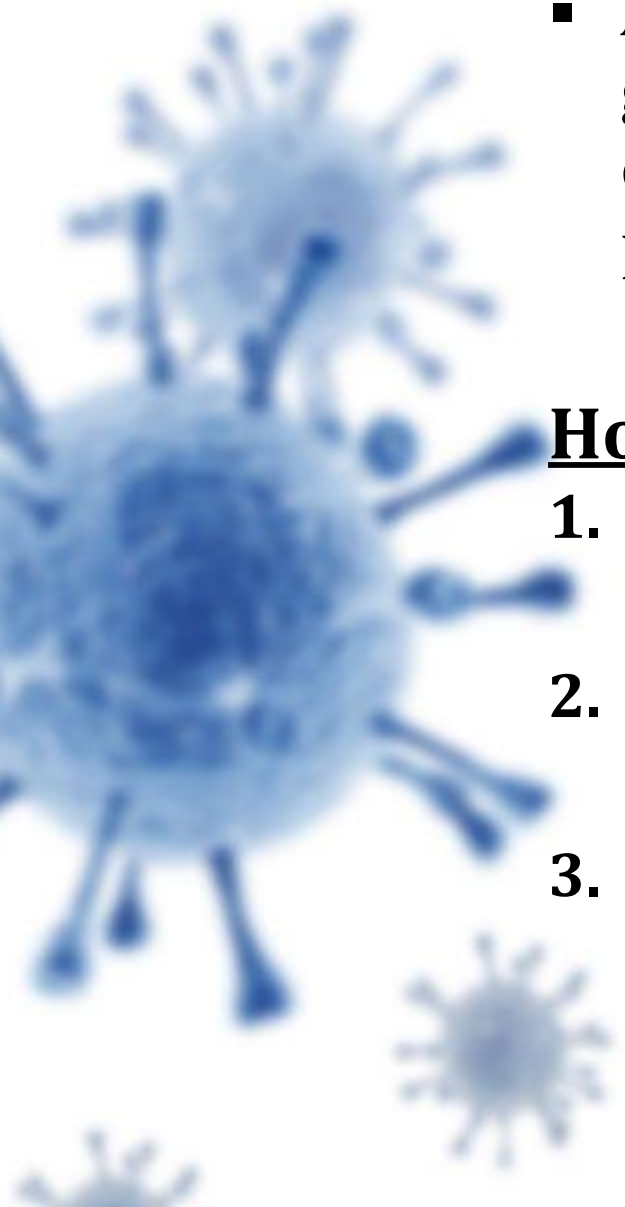


How Antivirals Work

- ❑ Block entry: Stop the virus from attaching to healthy cells.
- ❑ Stop copying: Trick viral DNA or RNA so the virus cannot grow.
- ❑ Prevent release: Keep new virus cells from leaving infected cells.

Common Drug Classes & Targets

- ❑ **Nucleoside Analogs:** Trick the virus into using a fake building block to halt [stop] genetic replication.
- ❑ **Neuraminidase Inhibitors:** Stop the flu virus from leaving infected cells to spread.
- ❑ **Protease Inhibitors:** Block vital enzymes the virus needs to assemble functional parts.
- ❑ **Entry/Uncoating Inhibitors:** Keep the virus from attaching to, entering, or opening inside host cells



- A **virus** is a tiny germ that invades cells and makes people sick.
- A **vaccine** is a safe medical tool that trains the body to fight that germ without causing the actual illness.

How Vaccines Work

1. **Safe training:** Vaccines put a weak, dead, or partial piece of a virus into the body.
2. **Guard cells:** The body sees the piece as a threat and makes special fighter tools called antibodies.
3. **Memory boost:** The body keeps a memory of the virus. If the real virus shows up later, the body kills it fast before it causes harm.

Assessment

1. Which statement best describes a virus?
A. A unicellular organism capable of independent metabolism
B. An obligate intracellular parasite that requires a living host cell for replication
C. A bacterium without a cell wall
D. A eukaryotic cell lacking mitochondria

2. Which of the following is NOT normally found in a virus?
A. Genetic material
B. Capsid
C. Ribosomes
D. Viral proteins

3. The viral genome consists of:
A. Both DNA and RNA
B. DNA only
C. RNA only
D. Either DNA or RNA, but not both

4. What is the main function of the viral capsid?
A. Production of ATP
B. Protection of the viral genome
C. Protein synthesis
D. Viral genome replication

5. A viral envelope is primarily derived from:
A. The bacterial cell wall
B. The viral capsid
C. The host cell membrane
D. The host cell nucleus

6. A bacteriophage is a virus that infects:
A. Fungi
B. Bacteria
C. Human cells only
D. Protozoa

7. Which virus is associated with cervical, throat, and anal cancers?
A. HIV
B. HPV
C. Influenza virus
D. Rabies virus

8. What is a viral vector?
A. A naturally occurring bacterial toxin
B. A modified virus used to deliver genetic material into cells
C. A type of antibody
D. A viral enzyme that destroys DNA

9. A positive-sense single-stranded RNA viral genome can:
A. Act directly as mRNA
B. Never be translated
C. Only function after conversion to DNA
D. Function only after conversion to negative-sense RNA

10. What is the first major step in the viral replication cycle?
A. Uncoating
B. Assembly
C. Attachment
D. Release

11. During which stage of viral replication is the viral capsid degraded and the nucleic acid released?
A. Attachment
B. Entry
C. Uncoating
D. Assembly

12. New viral particles can leave an infected cell through:
A. Lysis or budding
B. Phagocytosis only
C. Mitosis
D. Endocytosis only

13. Tissue tropism refers to:
A. The ability of viruses to mutate
B. The preference of a virus to infect specific cells or tissues
C. The ability of viruses to produce toxins
D. The movement of viruses between countries

14. SARS-CoV-2 uses which receptor to enter human cells?
A. CD4
B. ACE2
C. CD8
D. TLR4

15. Which mechanism can contribute to rapid genetic change in RNA viruses?
A. High mutation rates
B. Formation of mitochondria
C. Cell division
D. Protein folding

16. Antigenic drift is primarily caused by:
A. Large-scale exchange of complete chromosomes
B. Minor point mutations in viral surface proteins
C. Integration of bacterial DNA
D. Loss of the viral capsid

17. The main purpose of vaccination is to:
A. Cause the actual viral disease
B. Destroy all viruses immediately after administration
C. Train the immune system to recognize and respond to a pathogen
D. Prevent the production of antibodies

18. Which antiviral drug class prevents influenza virus from leaving infected cells?
A. Protease inhibitors
B. Nucleoside analogs
C. Neuraminidase inhibitors
D. Entry inhibitors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