General Biology Lecture - 7

Kidney Dialysis Techniques Department

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Viruses: Characteristic Properties, Classification, Nature and Structure

Learning Objectives

Understand viruses as non-cellular biological entities

Differentiate physical and chemical characteristics of viruses

Master two major classification systems (Baltimore & ICTV 2024)

Analyze viral structural components (capsid, envelope, genome)

Connect virology knowledge to clinical applications in hemodialysis units

What are Viruses? Modern Definition

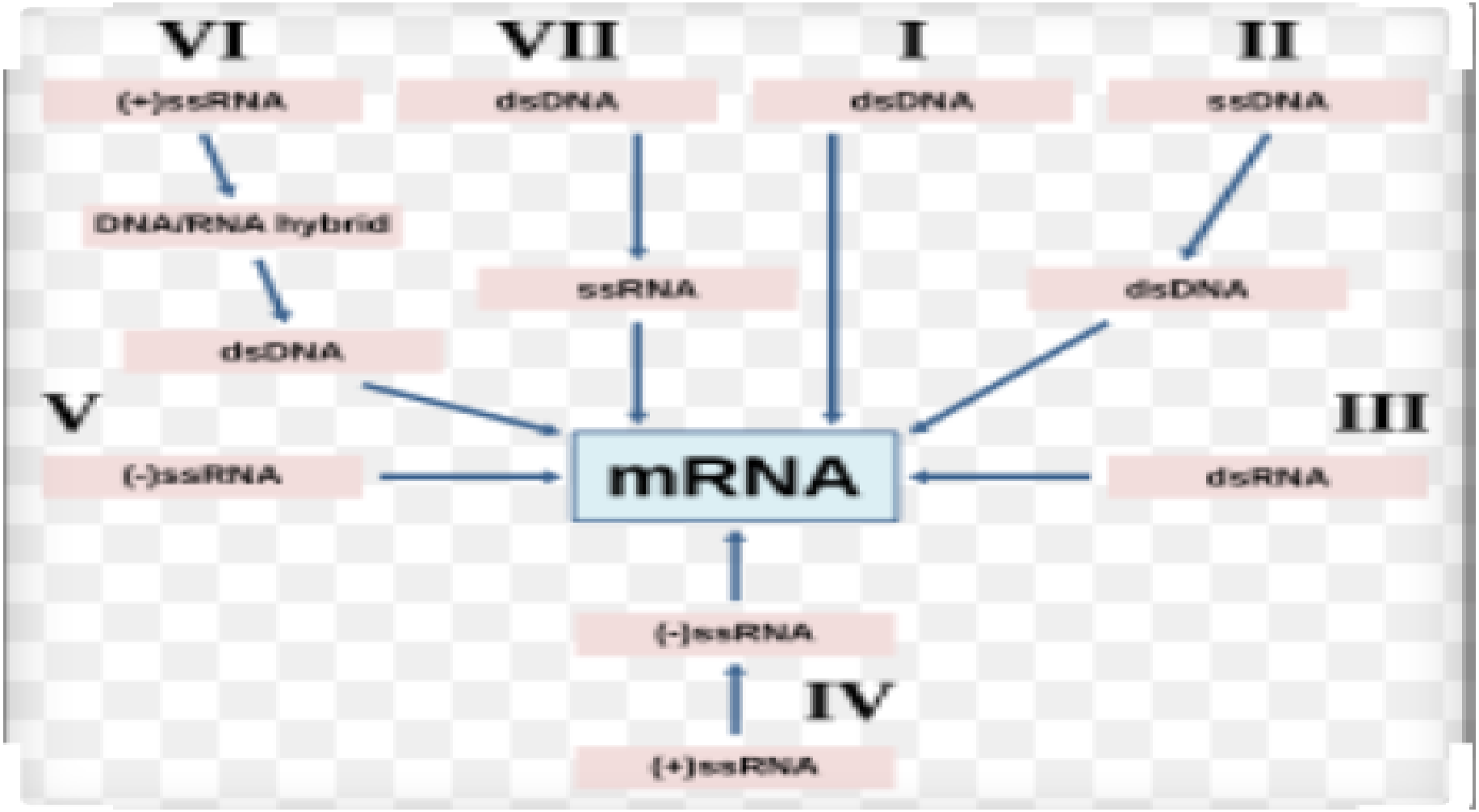
- **Non-cellular entities completely dependent on host cells for replication**
- **Lack independent metabolic machinery (no respiration, no ATP production)**
- **Basic composition:**
  - **Genetic material (DNA or RNA – single or double-stranded)**
  - **Structural proteins (capsid)**
  - **Optional lipid envelope (in enveloped viruses)**
- **Size range: 20-300 nanometers (10-100x smaller than bacteria)**

Clinical Note: **Understanding viral nature is critical for infection control in hemodialysis units where patients face elevated risk of HBV, HCV, and HIV exposure**

Characteristic Properties of Viruses

Property	Scientific Description	Clinical Relevance
Absolute dependence	Cannot replicate outside host cells	Explains difficulty in laboratory cultivation
Cellular tropism	Bind to specific cellular receptors	Determines target tissues (e.g., hepatocytes for hepatitis viruses)
Environmental stability	Varies based on presence/absence of lipid envelope	Non-enveloped viruses (e.g., norovirus) more resistant to disinfection
High mutation rate	Especially in RNA viruses	Challenges long-term vaccine development (e.g., influenza)

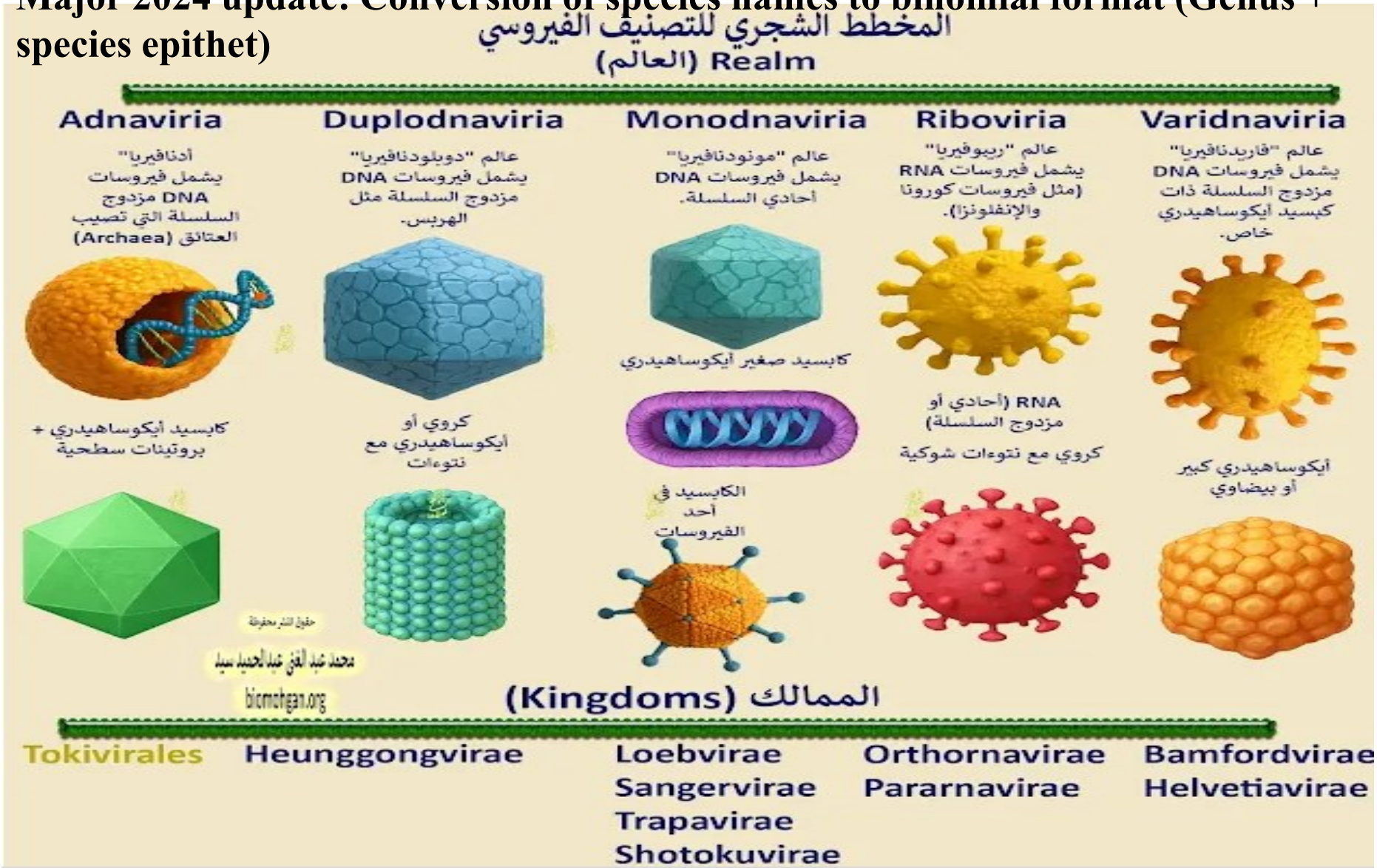
♣ A. Baltimore Classification System – 7 Groups



B. International Committee on Taxonomy of Viruses (ICTV 2024)

Hierarchical structure: Realm → Phylum → Class → Order → Family → Genus Species النوع ← الجنس ← الفصيلة ← الرتبة ← الطائفة ← الشعبة ← المملكة :الهيكل الهرمي

Major 2024 update: Conversion of species names to binomial format (Genus + species epithet)



♠ **Structural Anatomy of Viruses**

Core Components:

♠ **Viral Genome**

- **DNA or RNA (never both simultaneously)**
- **May be segmented (e.g., influenza with 8 segments) or non-segmented**

♠ **Capsid**

- **Protein shell protecting genetic material**
- **Symmetry types:**
  - **Icosahedral symmetry (20 triangular faces) → common viruses**
  - **Helical symmetry → long filamentous viruses**
  - **Complex symmetry → bacteriophages**
  -

♠ **Lipid Envelope (Optional)**

- **Derived from host cell membrane during budding**
- **Contains spike glycoproteins for cell attachment**
- **Enveloped viruses more susceptible to disinfectants (e.g., alcohol)**

Viral replication involves six essential steps:
1- attachment,
2- penetration,
3- uncoating,
4- replication,
5- assembly, and
6- release.

Clinical Application: Understanding these stages guides disinfection protocols in hemodialysis units to prevent viral transmission through shared equipment

Viruses and Kidney Disease – Critical Clinical Connection
A. Common Viruses in Hemodialysis Patients
scientific websites

Virus	Baltimore Group	Risks in Hemodialysis
Hepatitis B Virus (HBV)	Group VII (dsDNA with RT)	Bloodborne transmission; chronic hepatitis affects drug dosing
Hepatitis C Virus (HCV)	Group IV (+ssRNA)	High prevalence in dialysis units; causes liver cirrhosis
Human Immunodeficiency Virus (HIV)	Group VI (Retrovirus)	Immunosuppression → increased bacterial/fungal infections
BK Polyomavirus (BKPyV)	Group I (dsDNA)	Causes BK virus nephropathy (BKVN) → graft loss in 10-50% of cases

B. Prevention Guidelines (KDIGO 2022)

Routine screening for HBV/HCV/HIV in all dialysis patients

Dedicated dialysis machines for infected patients

HBV vaccination for all susceptible patients upon dialysis admission

Key Takeaways & Practical Recommendations

☑ **Viruses are non-cellular entities dependent on host cells**

☑ **Baltimore system (7 groups) and ICTV 2024 form modern classification framework**

☑ **Tripartite structure (genome + capsid ± envelope) determines viral properties**

☑ **Virology knowledge is essential for:**

► **Preventing nosocomial transmission in dialysis units**

► **Selecting appropriate disinfection protocols based on virus type**

► **Understanding viral complications on kidney and liver function**

Updated Scientific References

1- Simmonds P, et al. Changes to virus taxonomy and the ICTV Statutes ratified by the ICTV (2024). Arch Virol. 2024.

link.springer.com

2- ICTV Virus Taxonomy: 2024 Release. https://ictv.global/taxonomy

ictv.global

3- Alkhalifah RH, et al. Prevalence of HBV, HCV, and HIV among hemodialysis patients. Saudi J Kidney Dis Transpl. 2023.

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4- Kotton CN, et al. Second International Consensus Guidelines on BK Polyomavirus. Transplantation. 2024.

journals.lww.com

5- KDIGO Clinical Practice Guideline on Hepatitis C in Chronic Kidney Disease. 2022.

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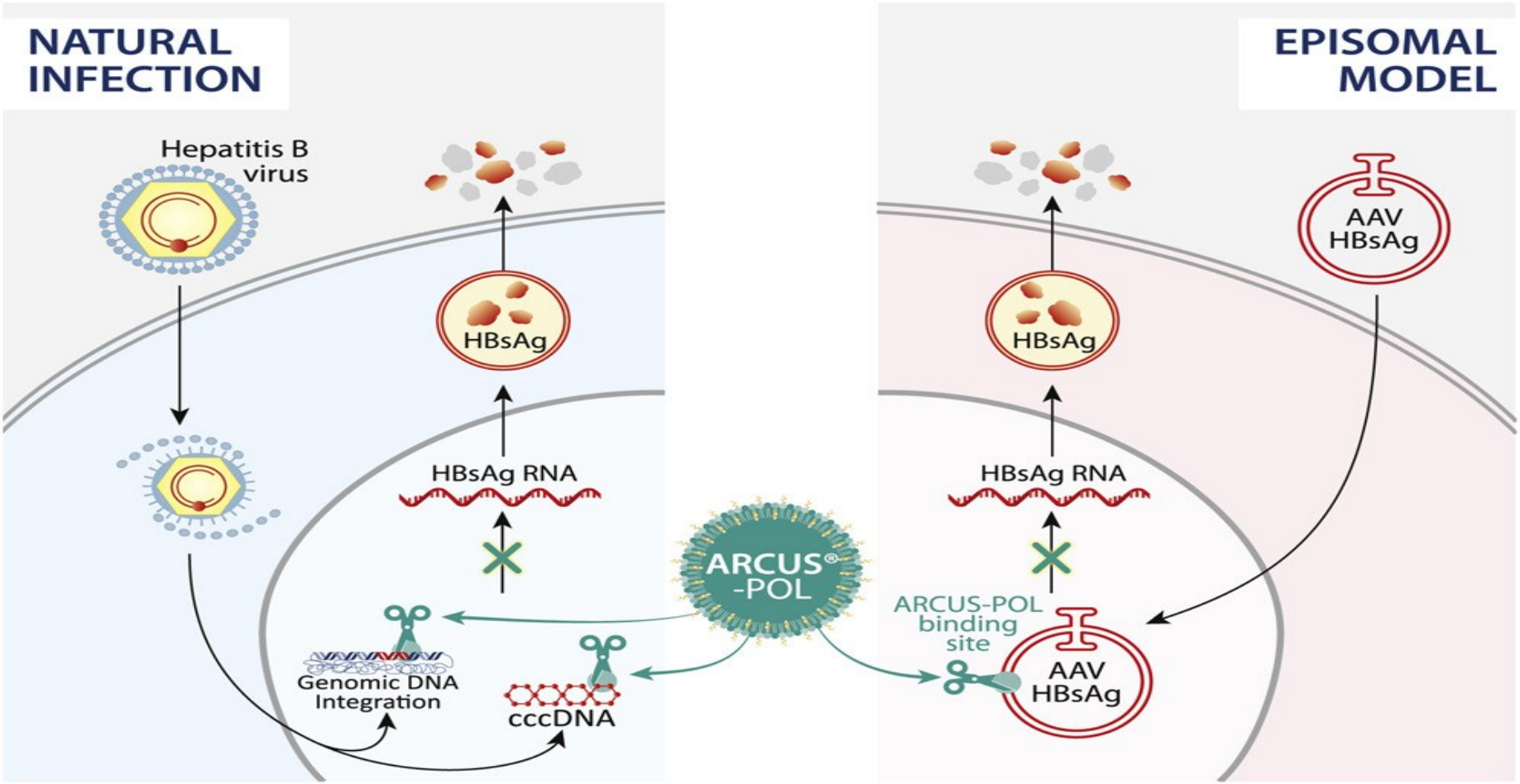
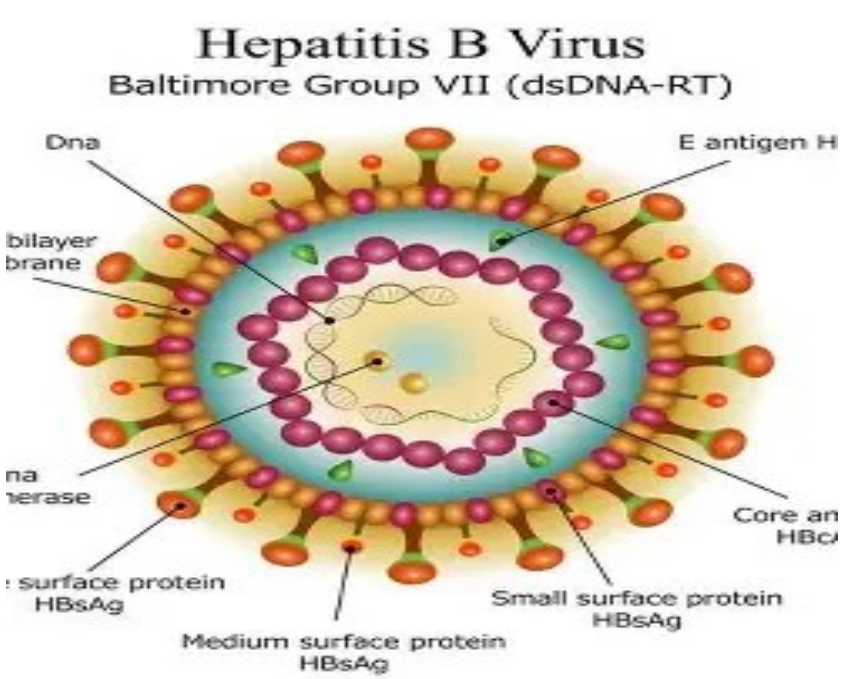
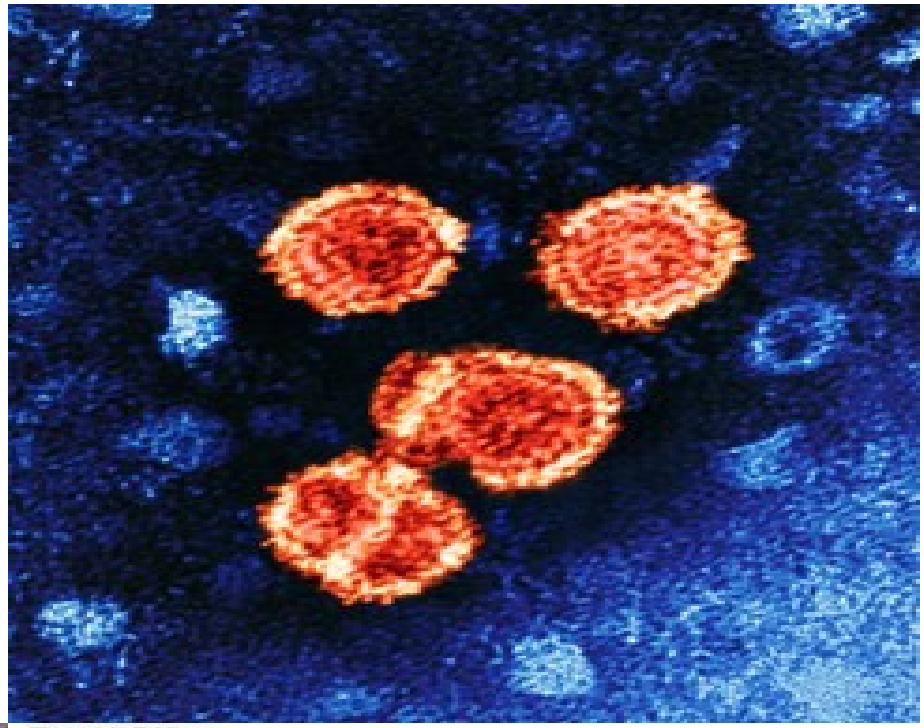
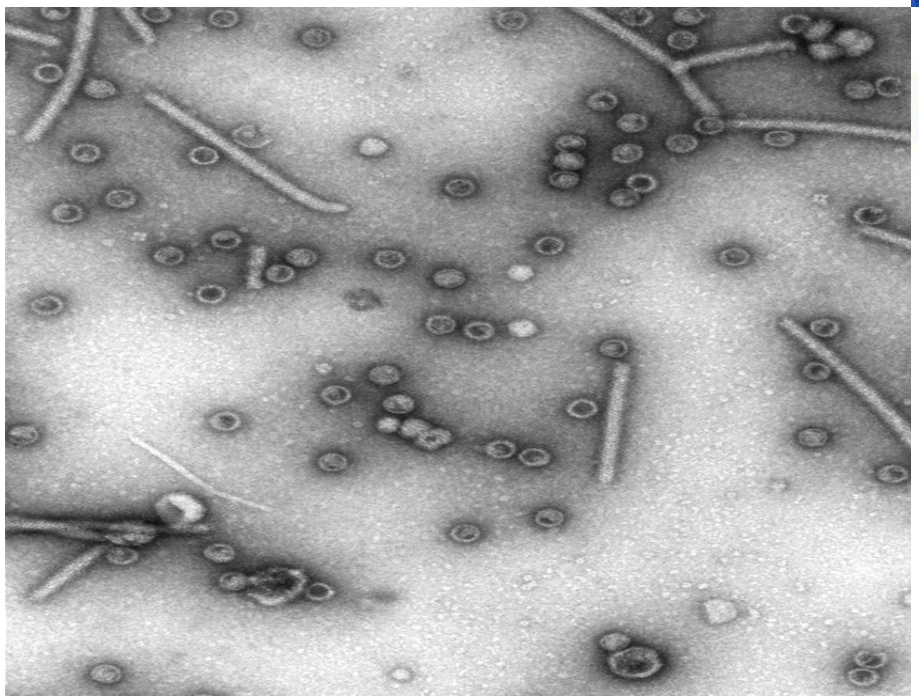
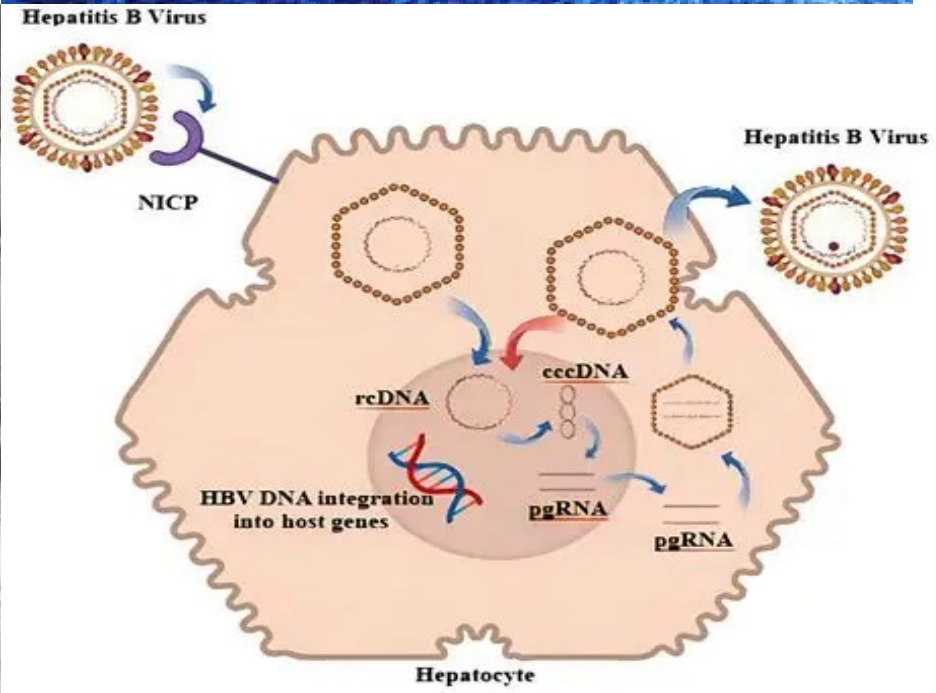

NATURAL INFECTION
Hepatitis B virus
HBsAg
HBsAg RNA
Genomic DNA Integration
cccDNA
ARCUS® -POL
EPISOMAL MODEL
AAV HBsAg
HBsAg
HBsAg RNA
ARCUS-POL binding site
AAV HBsAg

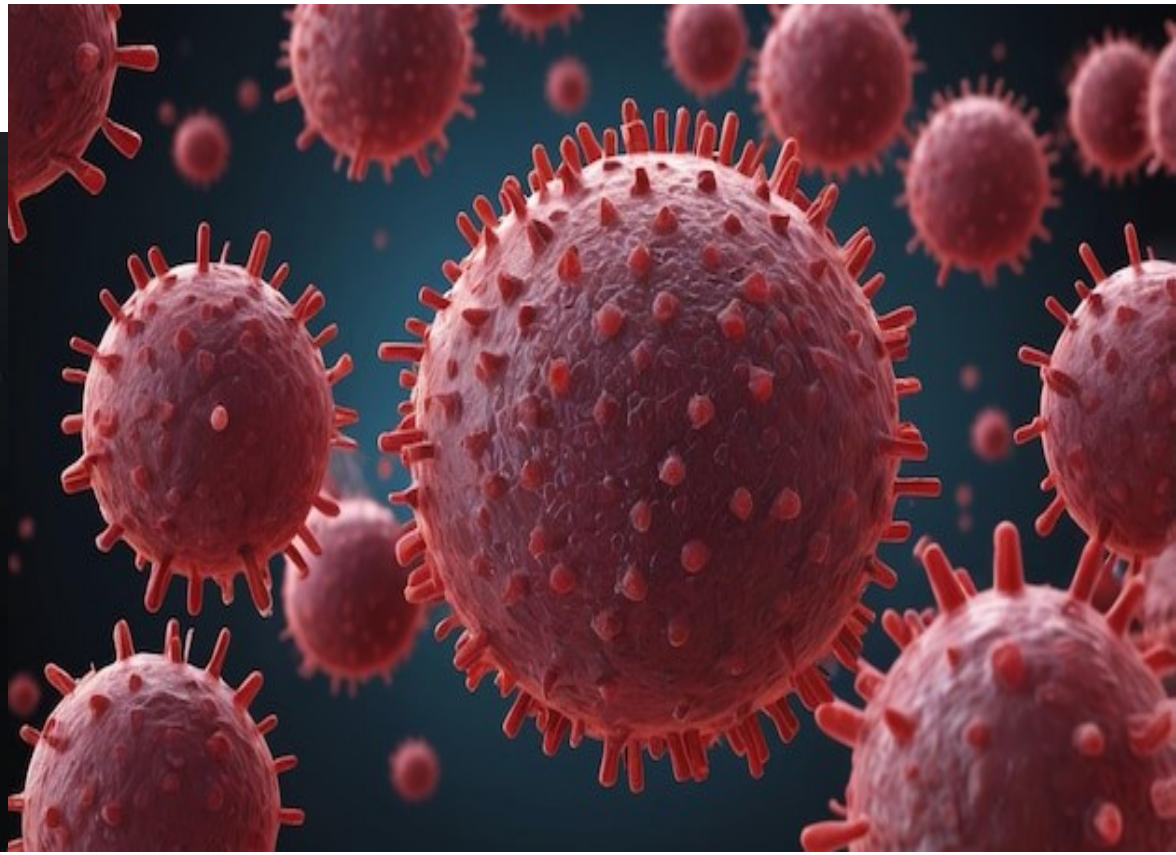

Hepatitis B Virus
Baltimore Group VII (dsDNA-RT)
Dna
E antigen H
bilayer
brane
na
erase
Core an
HBc
surface protein
HBsAg
Small surface protein
HBsAg
Medium surface protein
HBsAg

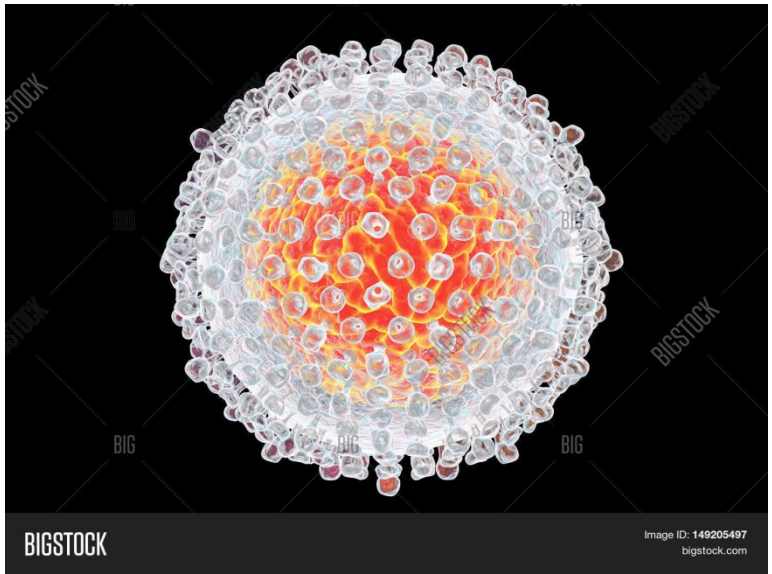


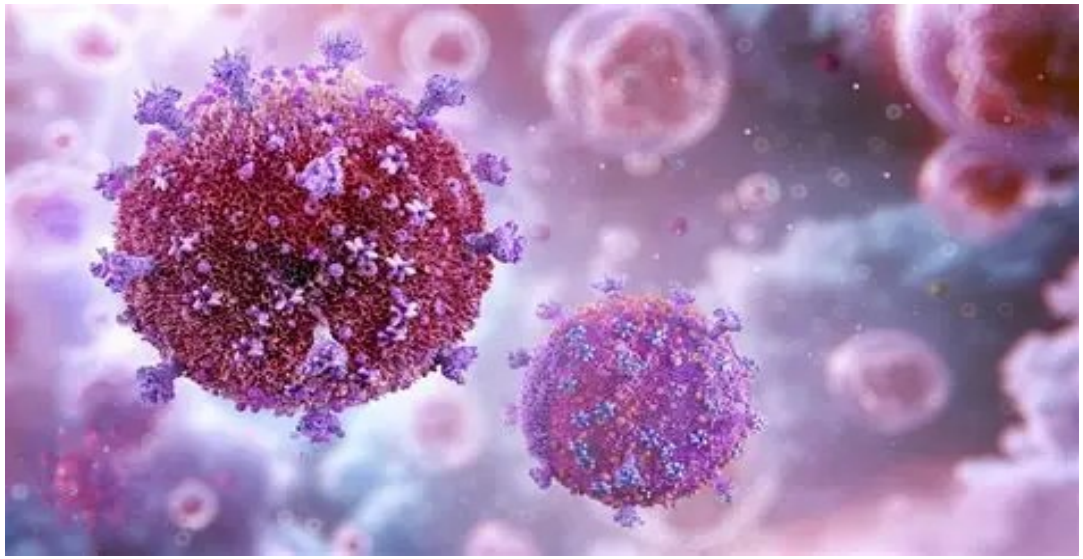


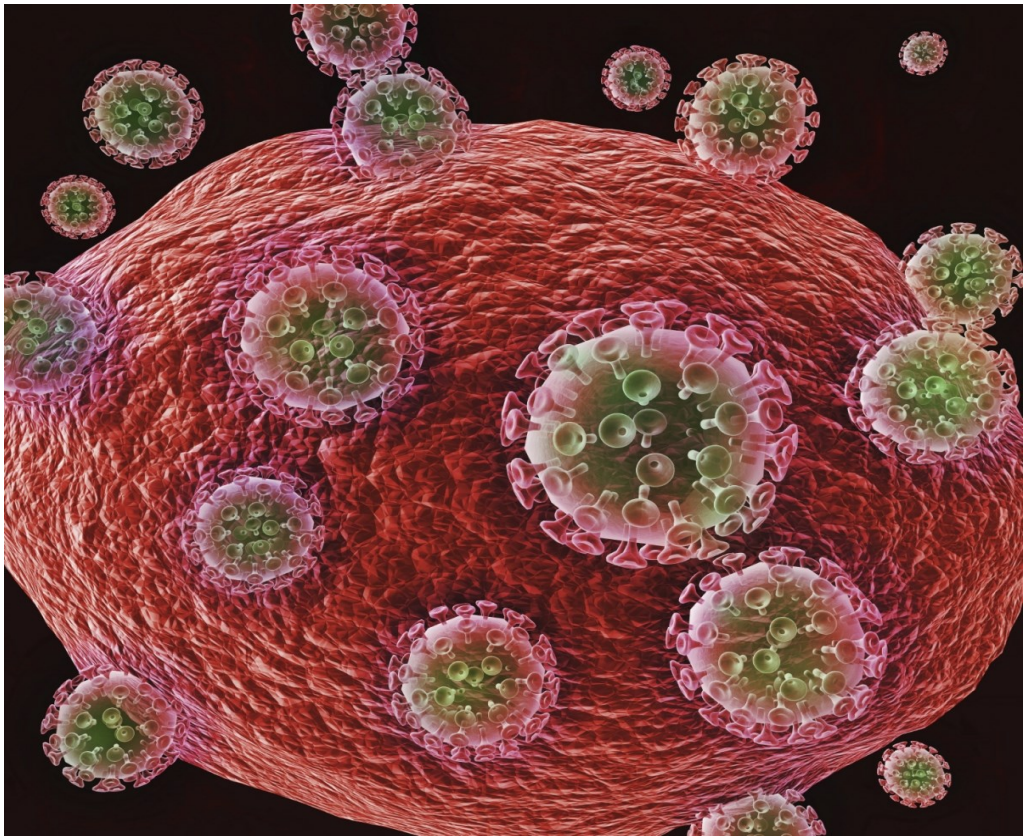

Hepatitis B Virus
NICP
Hepatitis B Virus
cccDNA
rcDNA
HBV DNA integration
into host genes
pgRNA
pgRNA
Hepatocyte

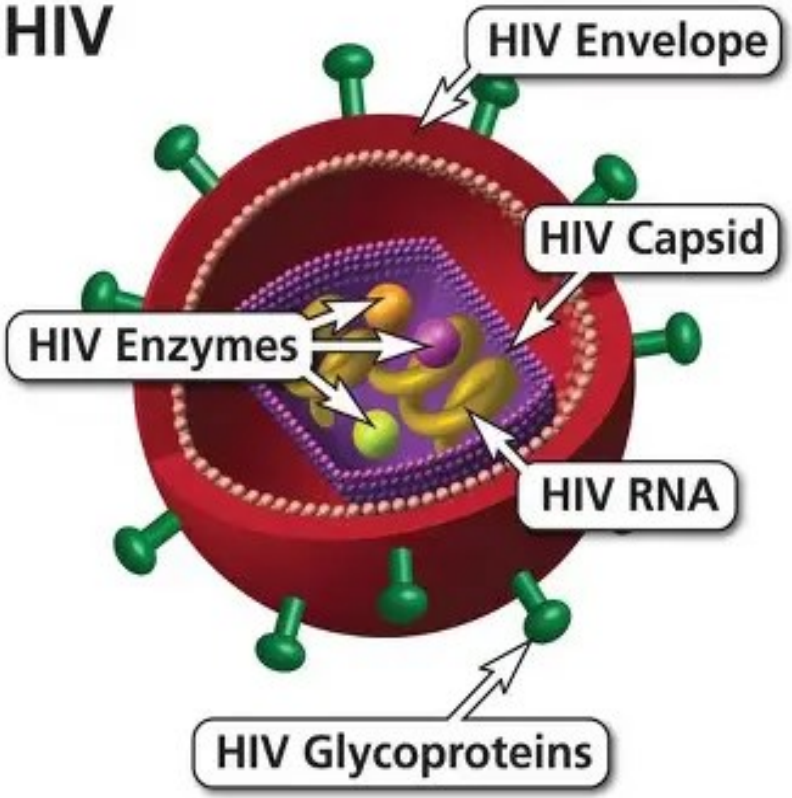
Hepatitis C Virus










HIV
HIV Envelope
HIV Capsid
HIV Enzymes
HIV RNA
HIV Glycoproteins