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## **Viruses: Structure, Replication Cycles, and HIV**

**Study Guide — Microbiology**

Pre-med/IB-style practice on virus structure, classification (DNA/RNA, enveloped/non-enveloped), replication strategies (lytic vs lysogenic), host range/tropism, and HIV as a key retrovirus example—focused on concept understanding and common traps.

**40 items — Study Guide with Answers**

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**1** A scientist isolates an infectious agent that contains nucleic acid and protein, but no ribosomes. It multiplies only inside living cells. Which statement BEST explains why this agent is an obligate intracellular parasite?

- A** It is too small to survive outside cells.
- B** It cannot synthesize proteins or generate enough resources independently, so it must use the host cell's machinery. ✓
- C** It lacks a cell wall, so it cannot replicate.
- D** It cannot mutate unless it is inside a cell.
- E** It can reproduce only by mitosis, which requires a host.

► **Explanation:** Viruses are acellular and lack ribosomes and many metabolic systems, so they must hijack host ribosomes/enzymes to make viral proteins and genomes. Small size doesn't logically force intracellular replication, and mitosis is a eukaryotic cell-division process (viruses assemble, they don't divide).



**2** Which option BEST defines a virion?

- A** A virus that is actively replicating inside a host cell
- B** A complete infectious virus particle outside a host cell, consisting of genome + protective structures ✓
- C** The bacterial chromosome after a virus inserts into it
- D** A host cell with viral genes turned on
- E** A membrane-bound organelle that makes viral proteins

► **Explanation:** A virion is the complete infectious particle (genome + capsid, sometimes envelope) when it's outside the cell. Terms like prophage/provirus describe integrated forms; organelles are cellular, not viral.





3 Which structure is found in ALL viruses (no exceptions among typical textbook viruses)?



- A A lipid envelope
- B A protein capsid ✓**
- C Ribosomes
- D A peptidoglycan cell wall
- E Mitochondria

► **Explanation:** All viruses have a protein coat (capsid) that packages/protects their genome. Envelopes are optional (only enveloped viruses). Ribosomes, peptidoglycan walls, and mitochondria are cellular features, not viral requirements.

4 A disinfectant that dissolves lipids (like soap) is especially effective at inactivating which type of virus?



- A Non-enveloped viruses, because their capsids are made of lipid
- B Enveloped viruses, because their outer envelope is a lipid bilayer that can be disrupted ✓**
- C Only bacteriophages, because they have tails
- D Only RNA viruses, because RNA dissolves in soap
- E Only lysogenic viruses, because they hide in DNA

► **Explanation:** Enveloped viruses depend on an intact lipid envelope (often carrying attachment/fusion proteins). Lipid-disrupting agents can destroy that envelope and prevent infection. Non-enveloped viruses are often more stable to detergents because they rely mainly on a protein capsid.

5 An enveloped virus leaves a host cell by budding. The virus obtains most of its envelope from:





- A New lipid synthesized by the viral capsid
- B The host cell membrane (or internal host membranes), which the virus buds through** ✓
- C The host cell wall
- D The bacterial nucleoid
- E The viral genome folding into a membrane

► **Explanation:** Envelopes are typically derived from host membranes during budding; the virus inserts its own proteins into that membrane. Viruses don't have cell walls or nucleoids, and genomes cannot "fold" into membranes.

**6** A single-stranded RNA virus enters a cell. Immediately after uncoating, host ribosomes begin translating the viral genome into protein without any viral enzymes being used first. Which genome type is MOST consistent with this?



- A Positive-sense (+) ssRNA** ✓
- B Negative-sense (–) ssRNA
- C Double-stranded RNA (dsRNA)
- D Double-stranded DNA (dsDNA)
- E Single-stranded DNA (ssDNA)

► **Explanation:** +ssRNA can act as mRNA and be translated immediately. –ssRNA and dsRNA must first be copied into a readable mRNA form using a viral RNA-dependent RNA polymerase. DNA genomes generally require transcription into RNA before translation.

**7** Which virus type MUST bring an RNA-dependent RNA polymerase inside the virion to start infection (basic rule)?



- A Positive-sense (+) ssRNA virus





- B Negative-sense (–) ssRNA virus ✓**
- C dsDNA virus
- D ssDNA virus
- E A temperate bacteriophage in lysogeny

► **Explanation:** A –ssRNA genome is the “reverse-complement” of mRNA, so it cannot be translated directly. The virus must carry an RNA-dependent RNA polymerase to make +RNA (mRNA) soon after entry. Many +ssRNA viruses can translate first and make the polymerase after.

**8 Which sequence correctly represents the classic bacteriophage lytic cycle?**



- A Attachment → DNA integration → cell division → induction → lysis
- B Attachment → genome entry → synthesis of viral parts → assembly → release (often by lysis) ✓**
- C Endocytosis → fusion → reverse transcription → integration → budding
- D Mitosis → cytokinesis → translation → transcription → budding
- E Spore formation → germination → replication → transformation → release

► **Explanation:** In the lytic cycle, the virus attaches, delivers its genome, hijacks the host to synthesize viral components, assembles new virions, and releases them (often by lysing the cell). Integration is lysogenic, and reverse transcription/integration is retroviral, not typical phage lytic replication.

**9 A bacterial culture infected by a bacteriophage suddenly becomes clear (turbidity drops sharply). Which event MOST directly causes the culture to clear?**



- A Viral attachment to bacterial receptors
- B Assembly of virions inside the bacterium
- C Lysis of many bacteria releasing new phage particles ✓**





- D Integration of viral DNA into the bacterial chromosome
- E Transcription of bacterial genes

► **Explanation:** A clear culture means many bacteria were destroyed. Lysis ruptures bacterial cells, reducing the number of intact cells scattering light (turbidity). Attachment/assembly happen earlier but don't directly cause the sudden clearing.

**10** A temperate bacteriophage infects a bacterium and integrates its DNA into the bacterial chromosome without immediately killing the cell. The integrated viral DNA is called a:



- A Capsid
- B Prophage ✓
- C Prion
- D Plasmid
- E Virion

► **Explanation:** In bacteria, integrated phage DNA is a prophage (lysogeny). A virion is the complete particle outside the cell. A plasmid is bacterial extra-chromosomal DNA (not necessarily viral). A prion is an infectious protein.

**11** A bacterium carrying a prophage is exposed to UV light. Soon after, many bacteria lyse and release phages. Which explanation BEST fits this observation?



- A UV causes the virus to lose its capsid
- B UV induces the prophage to excise and enter the lytic cycle (induction) ✓
- C UV converts the prophage into a plasmid that cannot replicate
- D UV makes bacteria divide faster, so more viruses appear
- E UV blocks translation, so viruses are released





► **Explanation:** Stress/DNA damage can trigger induction: prophage excision followed by lytic replication and lysis. The key concept is the switch from lysogenic “silent” replication with the host to active lytic production.

**12** A harmless bacterial strain becomes toxin-producing after infection by a temperate phage that carries a toxin gene. This is an example of:



- A Binary fission
- B Lysogenic conversion ✓**
- C Fermentation
- D Translation coupling
- E Osmosis

► **Explanation:** Lysogenic conversion occurs when a prophage introduces new genes that change the host bacterium’s phenotype (e.g., toxin production). It’s a major reason temperate phages can alter bacterial traits.

**13** A bacteriophage accidentally packages bacterial DNA and transfers it to a new bacterium. The recipient gains a new gene. This mechanism of horizontal gene transfer is called:



- A Conjugation
- B Transformation
- C Transduction ✓**
- D Translation
- E Meiosis





► **Explanation:** Transduction is phage-mediated gene transfer. Conjugation is cell-to-cell DNA transfer (often via pilus). Transformation is uptake of free DNA from the environment. Meiosis is eukaryotic gamete formation.

**14** Which type of transduction can potentially transfer ANY bacterial gene because it results from random packaging errors during the lytic cycle?



- A Specialized transduction
- B Generalized transduction ✓
- C Conjugation
- D Transformation
- E Lysogenic conversion

► **Explanation:** Generalized transduction happens when lytic phages mistakenly package random fragments of bacterial DNA, so many genes could be moved. Specialized transduction is limited to genes near the prophage integration site (due to faulty excision).

**15** A phage integrates into a specific site in the bacterial genome. Later, it excises incorrectly and carries nearby bacterial genes into new hosts. This is MOST consistent with:



- A Generalized transduction
- B Specialized transduction ✓
- C Transformation
- D Conjugation
- E Mitosis

► **Explanation:** Specialized transduction occurs when a prophage excises with adjacent bacterial DNA due to an excision error. Because integration is site-specific, only nearby genes are typically transferred.





**16** Why don't antibiotics that inhibit peptidoglycan synthesis (bacterial cell wall) directly stop viruses from replicating?



- A Viruses have a thicker peptidoglycan wall than bacteria.
- B **Viruses do not build peptidoglycan cell walls; they use capsids/envelopes instead.**
- C Viruses are made of cellulose, not peptidoglycan.
- D Viruses synthesize their own ribosomes, so antibiotics cannot bind.
- E Antibiotics only work on RNA, not on DNA.

► **Explanation:** Antibiotics target bacterial-specific structures or processes (like peptidoglycan synthesis or bacterial ribosomes). Viruses are acellular and don't have peptidoglycan walls (or their own ribosomes).

**17** Two strains of the same virus differ only in a surface protein. Strain 1 infects human respiratory cells; strain 2 cannot. The MOST direct explanation is that the surface protein determines:



- A The virus's ability to perform glycolysis
- B **Which host cell receptor the virus can bind (tropism/host range)** ✓
- C Whether the virus uses mitosis or meiosis
- D Whether the host cell has mitochondria
- E How many ribosomes the virus contains

► **Explanation:** Attachment proteins control receptor binding, which strongly determines host range and tissue tropism. Viruses don't do glycolysis, don't undergo mitosis/meiosis, and don't contain their own ribosomes.





**18** Plant viruses are often transmitted by insects or through mechanical damage. Why is this especially important for plant viruses compared with many animal viruses?

- A** Plant cells lack genetic material, so viruses must be injected.
- B** Plant cell walls act as a physical barrier that prevents easy membrane fusion/endocytosis-based entry. ✓
- C** Plant viruses are always enveloped and dissolve in water.
- D** Plants do not have ribosomes, so viruses need insects to supply them.
- E** Plant viruses replicate only in chloroplasts, which insects deliver.

► **Explanation:** The rigid plant cell wall makes direct entry harder. Many plant viruses enter through wounds or via vectors (like insects) and then spread cell-to-cell through plasmodesmata. Plants do have DNA and ribosomes.



**19** A typical bacteriophage infects a bacterium. Which statement BEST describes how it delivers its genome?

- A** The entire virion enters the bacterium by endocytosis.
- B** The phage injects its nucleic acid through its tail; the capsid usually remains outside. ✓
- C** The bacterium actively imports the genome through nuclear pores.
- D** The phage fuses with the bacterial mitochondrion.
- E** The bacterium translates the capsid first, then builds the genome.

► **Explanation:** Many bacteriophages attach and inject their genome into the bacterial cytoplasm. Bacteria do not do endocytosis like eukaryotic cells and do not have nuclei/mitochondria.





20 Which statement BEST describes how viruses increase in number (compared with cellular reproduction)?



- A They grow larger and then split by binary fission.
- B They are assembled from newly made parts (genomes + proteins) inside a host cell. ✓**
- C They replicate by mitosis.
- D They replicate by meiosis to make gametes.
- E They reproduce only by conjugation.

► **Explanation:** Viruses replicate by hijacking host processes to make viral nucleic acids and proteins, then assembling new virions. Binary fission is bacterial; mitosis/meiosis are eukaryotic; conjugation is bacterial gene transfer.

21 Which pairing of virus “shape class” with example is MOST accurate at a basic level?



- A Icosahedral — head-tail bacteriophage
- B Helical — rod-like plant virus nucleocapsid (classic example) ✓**
- C Complex — spherical influenza virion because it is round
- D Helical — always naked (non-enveloped) viruses only
- E Icosahedral — requires a lipid envelope by definition

► **Explanation:** A classic helical example is a rod-like plant virus (helical capsid). Complex viruses include many bacteriophages with head-tail structures. Helical nucleocapsids can be enveloped (e.g., influenza), and icosahedral viruses can be enveloped or non-enveloped.

22 Many DNA viruses replicate in the nucleus of eukaryotic cells. The BEST basic reason is that they often rely on:





- A Host ribosomes, which are found only in the nucleus
- B Host DNA/RNA-processing machinery that is concentrated in the nucleus (general rule) ✓**
- C Chloroplast enzymes that copy DNA
- D Peptidoglycan synthesis enzymes located in the nucleus
- E The bacterial nucleoid inside eukaryotic cells

► **Explanation:** A common pattern is that DNA viruses use nuclear enzymes for replication/transcription. Ribosomes are mainly cytosolic (or on rough ER), chloroplasts are plant organelles, and peptidoglycan/nucleoids are bacterial features.

**23 Why do many RNA viruses evolve rapidly (show high genetic variability) compared with many DNA viruses?**



- A RNA viruses always replicate more slowly, increasing errors.
- B RNA-dependent RNA polymerases often lack strong proofreading, so mutations occur more frequently. ✓**
- C RNA viruses are protected by peptidoglycan, which causes mutation.
- D RNA viruses do not have genomes, so they must constantly change.
- E Mutations happen only in RNA, never in DNA.

► **Explanation:** A key reason is enzyme accuracy: many RNA polymerases used to copy viral RNA are more error-prone than DNA polymerases. Peptidoglycan is unrelated, and both DNA and RNA can mutate.

**24 Two different strains of a segmented RNA virus infect the same cell. Some new virions contain a mixture of genome segments from both strains. This process is called:**



- A Reassortment ✓**





- B Binary fission
- C Transformation
- D Translation
- E Mendelian segregation

► **Explanation:** Reassortment occurs when segmented genomes mix during co-infection, producing offspring with new combinations of segments. This is not cell division or bacterial DNA uptake, and it's different from Mendelian segregation (which refers to allele separation in meiosis).

**25** HIV is classified as a retrovirus. Which statement BEST matches what makes a retrovirus “retro” in information flow?



- A It converts protein into RNA.
- B **It uses reverse transcription: RNA is copied into DNA. ✓**
- C It converts DNA into protein directly without RNA.
- D It replicates only in bacteria.
- E It is a bacteriophage that inserts into a plasmid.

► **Explanation:** Retroviruses reverse-transcribe their RNA into DNA. That DNA can integrate into the host genome. Protein→RNA doesn't occur, and HIV is an animal virus, not a bacteriophage.

**26** Which enzyme allows HIV to convert its RNA genome into DNA inside the host cell?



- A DNA polymerase I
- B **Reverse transcriptase ✓**
- C RNA polymerase II
- D Ligase





E Pepsin

► **Explanation:** Reverse transcriptase is the viral enzyme that synthesizes DNA from an RNA template. Host RNA polymerase II transcribes DNA into RNA, not RNA into DNA.

27 After HIV makes a DNA copy of its genome, which viral enzyme MOST directly inserts that DNA into the host chromosome?



A Protease

B **Integrase** ✓

C Helicase

D Catalase

E Trypsin

► **Explanation:** Integrase inserts viral DNA into the host genome, forming a provirus. Protease cuts viral polyproteins (maturation). The other enzymes listed are unrelated or digestive enzymes.

28 HIV produces large polyproteins that must be cut into functional proteins to form mature infectious virions. Which viral enzyme performs this cutting step?



A Reverse transcriptase

B Integrase

C **Protease** ✓

D Ribosome

E ATP synthase

► **Explanation:** HIV protease cleaves polyproteins into the separate functional proteins needed for an infectious particle. Ribosomes synthesize proteins but do not perform HIV's specific maturation cleavage.





29 Entry of HIV into many immune cells requires binding to CD4 and also to a co-receptor. Which co-receptor is commonly involved (basic concept)?



- A Aquaporin
- B CCR5 (or in some cases CXCR4) ✓
- C Insulin receptor
- D SGLT1
- E Na<sup>+</sup>/K<sup>+</sup> ATPase

► **Explanation:** HIV commonly binds CD4 plus a chemokine co-receptor such as CCR5 (and sometimes CXCR4). The other choices are transporters/receptors unrelated to HIV entry.

30 In HIV, which statement about envelope proteins is MOST accurate at a basic level?



- A gp120 is mainly responsible for binding CD4/co-receptor; gp41 helps fuse viral and host membranes. ✓
- B gp120 is the viral genome; gp41 is the viral capsid.
- C gp120 is a bacterial cell wall protein.
- D gp41 binds DNA inside the nucleus.
- E gp120 and gp41 are only present in non-enveloped viruses.

► **Explanation:** gp120 mediates attachment (receptor binding) and gp41 mediates membrane fusion—both are envelope glycoproteins. They are not the genome/capsid, and they exist specifically because HIV is enveloped.





31 Which statement **BEST** explains why HIV can persist for years in a host even when immune responses reduce active virus levels?

- A HIV can survive by photosynthesis in the blood.
- B HIV can integrate into host DNA as a provirus and remain latent in infected cells.** ✓
- C HIV is protected by a peptidoglycan cell wall.
- D HIV forms bacterial endospores.
- E HIV replicates only outside cells where antibodies cannot reach it.

► **Explanation:** Integration into the host genome creates a provirus that can be transcriptionally silent (latent). Latency is a major reason complete eradication is difficult. The other options describe non-viral or incorrect survival strategies.



32 A virus is released from a living cell without immediately bursting it. Which type of virus is **MOST** consistent with this release strategy?

- A A non-enveloped virus that must exit by cell lysis
- B An enveloped virus that buds from the host membrane** ✓
- C A prion, which buds from membranes
- D A bacterial endospore
- E A plasmid

► **Explanation:** Budding is typical of enveloped viruses and can allow release without immediate cell lysis (though it can still damage the cell). Non-enveloped viruses commonly exit by lysis.



33 Which is **NOT** a typical function of a viral capsid?

- A Protect the viral genome from damage





- B Help attach to host cells (directly or indirectly via spikes)
- C Deliver the genome into the host cell during infection
- D **Generate ATP to power viral replication** ✓
- E Package the viral genome into a stable particle

► **Explanation:** Capsids protect and deliver the genome and help make stable infectious particles. Viruses do not generate ATP; they depend on host energy and resources.

34 HIV mutates rapidly partly because its reverse transcriptase:



- A Has very strong proofreading and corrects most errors
- B **Lacks effective proofreading, so copying errors are common** ✓
- C Is a ribosome that translates RNA into DNA
- D Works only in the lysosome, which causes mutation
- E Does not copy nucleic acids at all

► **Explanation:** Reverse transcriptase is relatively error-prone, creating many mutations. This variability helps HIV escape immune recognition and makes long-term control/vaccines harder (conceptually).

35 Which sequence BEST represents the information flow for a retrovirus from entry to producing viral proteins?



- A DNA → RNA → DNA → protein
- B **RNA → DNA → RNA → protein** ✓
- C Protein → RNA → DNA → protein
- D RNA → protein → DNA → RNA
- E DNA → protein (no RNA step)





► **Explanation:** Retroviruses reverse-transcribe RNA into DNA, which can integrate. The integrated DNA is then transcribed back into RNA, which is translated into proteins.

**36** In eukaryotic cells, integrated retroviral DNA is called a:



- A Prophage
- B **Provirus** ✓
- C Capsomer
- D Viroid
- E Ribosome

► **Explanation:** A prophage is integrated bacteriophage DNA in bacteria. A provirus is integrated viral DNA (classically retroviral) in a eukaryotic host genome.

**37** Which statement about viral genomes is correct?



- A All viruses use DNA as their genetic material.
- B **Viruses may use DNA or RNA (single- or double-stranded), depending on the virus.** ✓
- C Viruses store genetic information only as proteins.
- D Viruses have no genomes because they are not alive.
- E All viruses have both DNA and RNA genomes simultaneously.

► **Explanation:** A key feature of viruses is genome diversity: some use DNA, others RNA, and either can be single- or double-stranded. They do have genomes even though they're acellular.





**38** A newly discovered virus has an RNA genome that cannot be directly translated by host ribosomes. Early viral protein production occurs only if the infecting particle provides a polymerase. Which genome type is MOST consistent with this clue?

- A Positive-sense (+) ssRNA
- B Negative-sense (–) ssRNA ✓**
- C A host mRNA molecule
- D A bacterial plasmid
- E A protein-only infectious particle

► **Explanation:** A –ssRNA genome must be copied into +RNA (mRNA) before translation, requiring a viral RNA-dependent RNA polymerase. +ssRNA could be translated immediately, so it wouldn't fit the “needs polymerase first” clue.



**39** A double-stranded RNA (dsRNA) virus enters a cell. What MUST happen before host ribosomes can make viral proteins?

- A The dsRNA must be reverse-transcribed into DNA and integrated.
- B The dsRNA must be transcribed into single-stranded mRNA using a viral RNA-dependent RNA polymerase. ✓**
- C The dsRNA must be converted into peptidoglycan.
- D The dsRNA must be imported into the nucleus through nuclear pores as intact dsRNA and directly translated.
- E The dsRNA must be copied by host ribosomes into DNA.

► **Explanation:** Ribosomes translate single-stranded mRNA. dsRNA must be used as a template to produce mRNA, typically by a viral RNA-dependent RNA polymerase (hosts don't normally provide an enzyme to make RNA from RNA for the virus).





40 Which comparison between viruses and bacteria is MOST accurate?

- A Viruses and bacteria both have ribosomes and reproduce by binary fission.
- B Bacteria are cells with metabolism and ribosomes; viruses are acellular and are assembled using host machinery. ✓**
- C Viruses are always larger than bacteria and have mitochondria.
- D Bacteria need host cells to reproduce, but viruses do not.
- E Viruses have peptidoglycan cell walls; bacteria have capsids.

► **Explanation:** Bacteria are living cells with their own ribosomes and metabolism and can divide independently. Viruses are not cells; they replicate only by hijacking host cells and assembling new particles. The other options swap or invent key features.

