Chapter 26 : *Viruses*

Note : In this chapter the important points are in **bold** font and the less important are in normal font . so if you don't have an enough time ; study only **important points .**

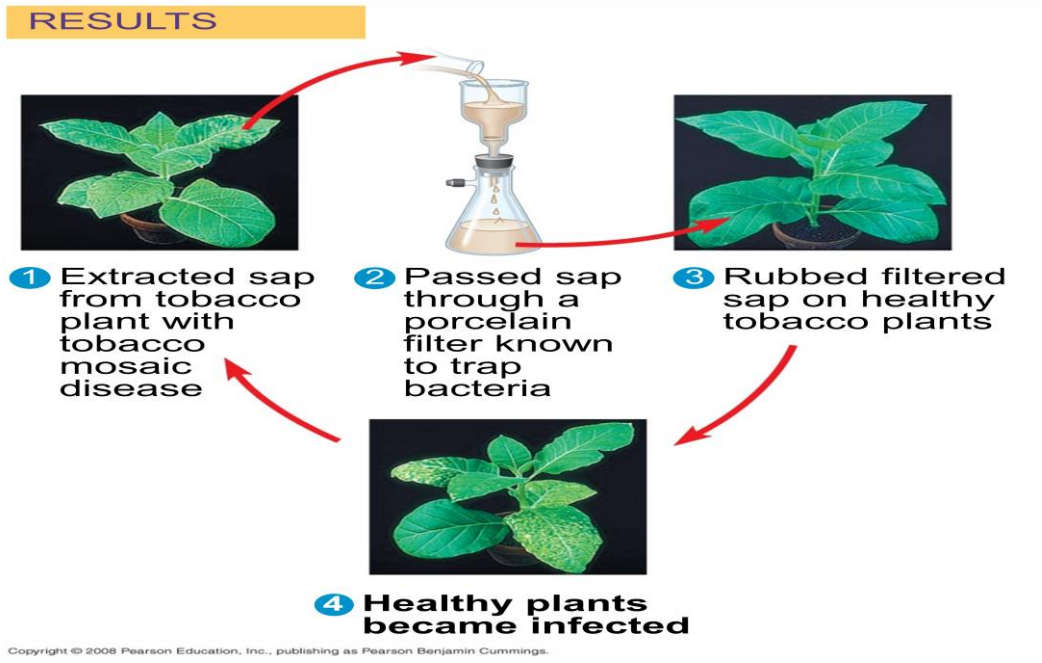
Concept 26.1: **A virus consists of a nucleic acid surrounded by a protein coat**

- **The story of how viruses were discovered begins near the end of 19th century .**

❖ The Discovery of Viruses:

- **the beginning was with Tobacco mosaic diseases >>**
  - **Tobacco mosaic diseases stunts(يعيق) the growth of tobacco plants and gives their leaves a mosaic coloration .**
    - At the beginning scientist thought the disease transmit from plant to another by microbe and then they said that was wrong !
    - they suggest it caused by an invisible bacteria , they tested this suggestion by the next inquiry …

Figure 26.2 : What causes Tobacco mosaic disease by (Dimitri Ivanowsky)



Scientist knew that if the sap of infected plant transferred to another healthy plant that will transfer the disease , by this experiment they want to Know if bacteria is responsible for this transferring of disease !

Result : although they isolate bacteria from the sap in step #2 the disease was transferred . that mean bacteria wasn't responsible !
but after this inquiry scientist said bacteria is too small , so it may still in the filtered sap (filter passed it with the sap) .

- all of these arguments had finished when Martinus Beijerink found by his experiences that the infectious agent in the filtered sap could reproduce. so agent is not bacteria !

- **In the late 1800s, Martinus Beijerink hypothesized that a particle smaller than bacteria caused the disease . and this particle can reproduce itself within the host it infected .**

- **In 1935, Wendell Stanley confirmed this hypothesis by crystallizing the infectious particle, now known as tobacco mosaic virus (TMV) .**

❖ Structure of Viruses

- **Viruses are not cells**
- **Viruses are very small infectious particles consisting of nucleic acid enclosed in a protein coat and, in some cases, a membranous envelope**
  - Smallest viruses are only 20nm in diameter (smaller than a ribosome) even largest viruses are a hundreds of nm !

a) viral Genome

- **Viral genomes may consist of either**
  - **Double- or single-stranded DNA, or**
  - **Double- or single-stranded RNA**

➲ **Depending on its type of nucleic acid, a virus is called a *DNA virus* or an *RNA virus***

- **Genome is usually organized as a single linear or circular molecule of nucleic acid , sometimes it consists of multiple molecules of nucleic acid .**

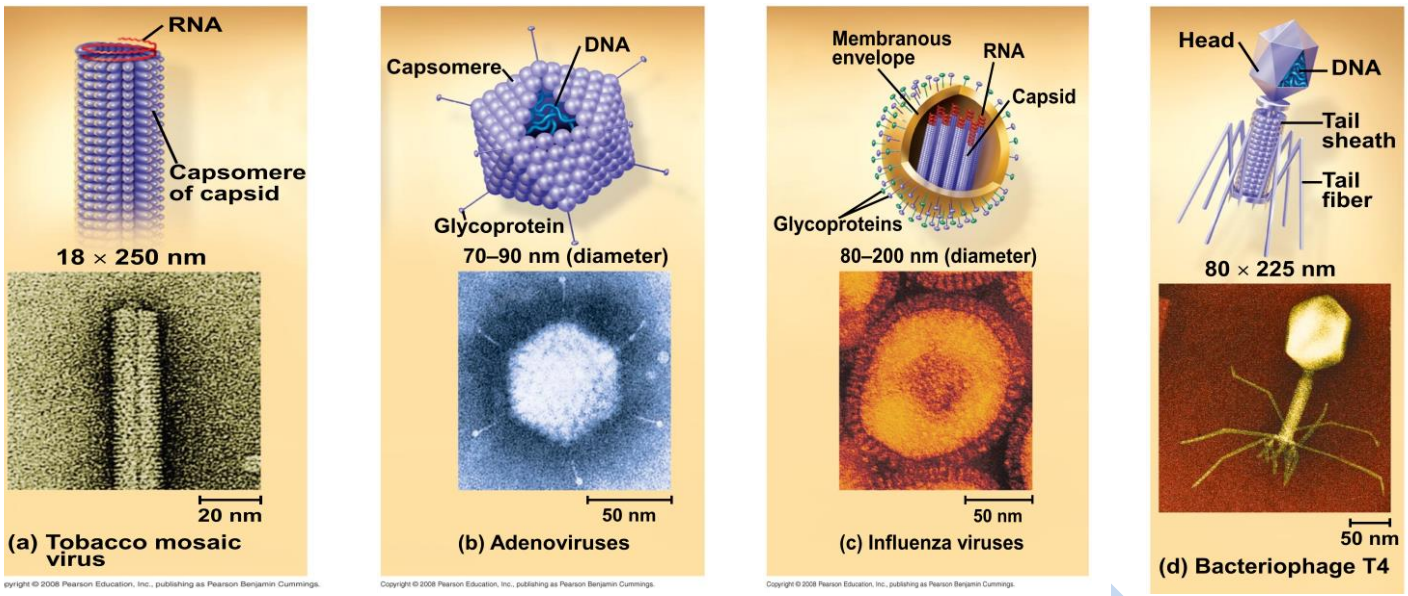
- Smallest viruses have only 4 genes in their genome while the largest have several hundred to a thousand .

b) *Capsids and Envelopes*

- **capsid : is the protein shell that encloses the viral genome**
  - **it is built from protein subunits called *capsomeres***

- **capsids can have various structures look to figure 26.3 to Know them ..**

Figure 26.3 Viral structure



a) **Tobaco mosaic virus : it has a rigid rod-shaped capsid made from a thousand molecules of one type of protein arranged in a helix (rod-shaped usually called helical viruses).**

b) **Adenovirus : this virus infect the respiratory system of animals , it is shaped in polyhedral capsid with a glycoprotein spike at each vertex .**
Its Caspid consists of 252 identical protein with 20 triangular facets (because of that it is called (icosahedrons : ذو العشرون وجه) and all similarly shaped viruses has the same name "icosahedrons" .

c) **Influenza virus : it has an outer envelope studded with glycoprotein spikes , the genome consists of 8 different RNA molecules .**

- **Some viruses have membranous envelopes that help them infect hosts**
- **These viral envelopes surround the capsids of influenza viruses and many other viruses found in animals**
- **Viral envelopes, which are derived from the host cell's membrane, contain a combination of viral molecules (proteins and Glycoprotein) and host cell molecules (phospholipids and membrane proteins) .**

d) **Bacteriophages "phages" : are viruses that infect bacteria , They have the most complex capsids found among viruses T-even phages Have <u>elongated icosahedral heads</u> (contain their DNA) and a protein tail piece with fibers to attach with bacterium and inject the phage DNA inside it .**

Concept 26.2: **Viruses reproduce only in host cells**

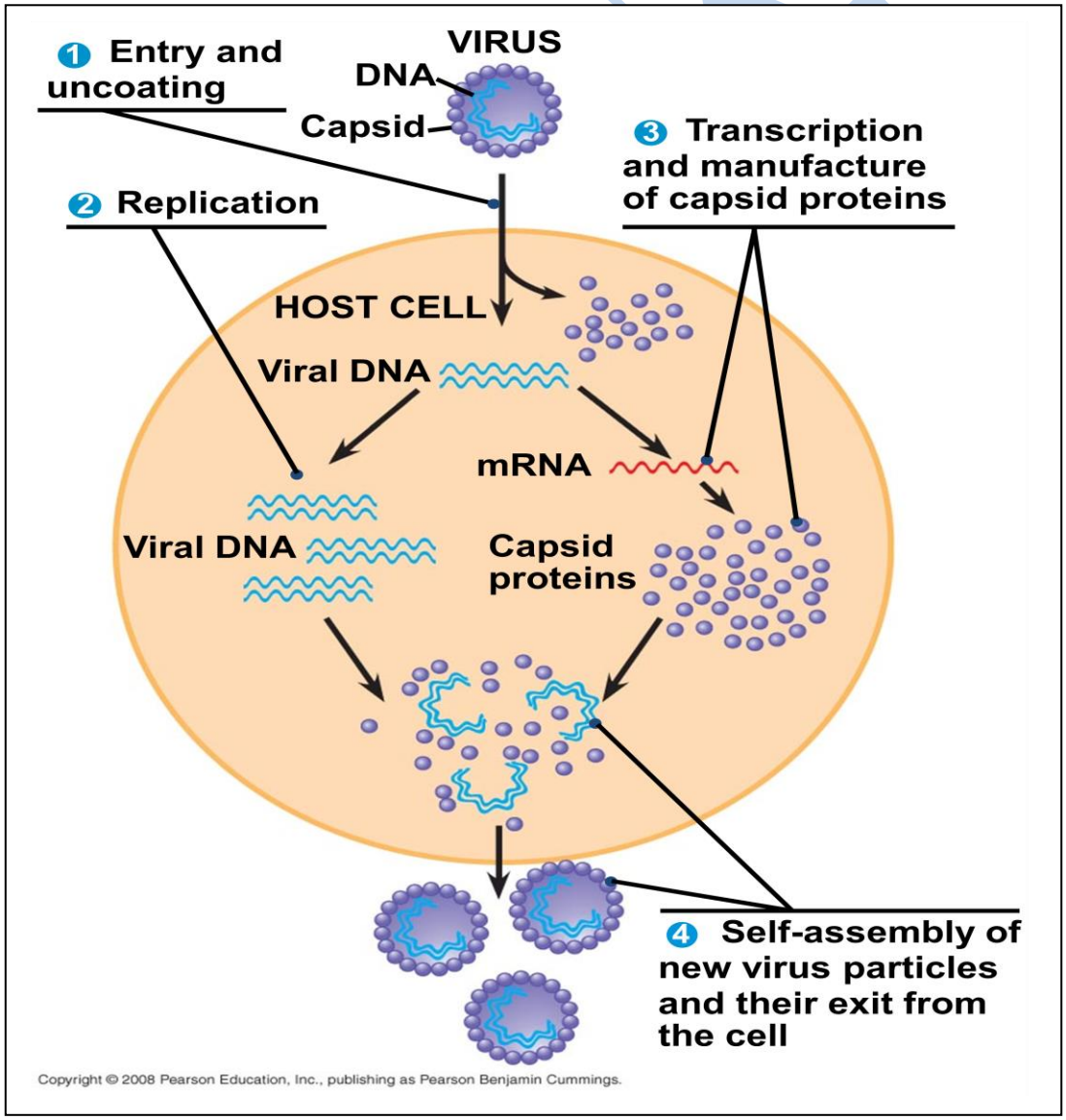
- **Viruses are obligate intracellular parasites, which means they can reproduce only within a host cell**
  - They lack metabolic enzymes and equipments for making proteins **.**
- **Each virus has a host range, a limited variety of host cells that it can infect. (thus because of the evolution of recognition systems by the virus) .**

➲ **Virus identify host cells by a "lock and Key "** Fit between viral surface proteins and specific receptor molecules on the outside of cells .

- So viruses may affects a specific type of organism or a particular tissues in many organisms .

❖ **General Features of Viral Reproductive Cycles**

Figure 26.4 A simplified viral reproductive cycle



Notes for figure 26.4 :

1) **The mechanism of genome entry depends on the type of virus and type of host cell.**
   T-even phages use their elaborate tail apparatus , other viruses depend on endocytosis , or by fusion of viral envelope with plasma membrane .

- **Once a viral genome has entered a cell, the cell begins copying the viral nucleic acid and manufacture viral proteins**

2) **Most DNA-viruses use DNA polymerase of host cell to synthesize new genomes along the templates of Viral DNA .**
   In contrast to replicate their genomes, RNA viruses use virally encoded polymerase that can use RNA as a template .

3) **The virus uses host enzymes, ribosomes, tRNAs, amino acids, ATP, and other molecules needed to produce the viral proteins (capsid proteins)**

4) The simplest type of viral reproductive cycle ends with the exit of hundreds or thousands of viruses from the infected host cell .

❖ Reproductive Cycles of Phages

- Phages are the best understood of all viruses
- **Phages have two reproductive mechanisms: the lytic cycle and the lysogenic cycle .**

a) ***The Lytic Cycle***

- **The lytic cycle is a phage reproductive cycle that culminates in the death of the host cell**
- **The Word "lytic" refers to the last stage of infection ..**
- **The lytic cycle produces new phages and digests the host's cell wall, releasing the progeny viruses**
- **A phage that reproduces only by the lytic cycle is called a *virulent phage***

Stages of lytic cycle : look to the figure in next page

1) **Attachment : the T4 phage uses its tail fibers to bind to specific receptor sites on the outer surface of an E.coil cell .**

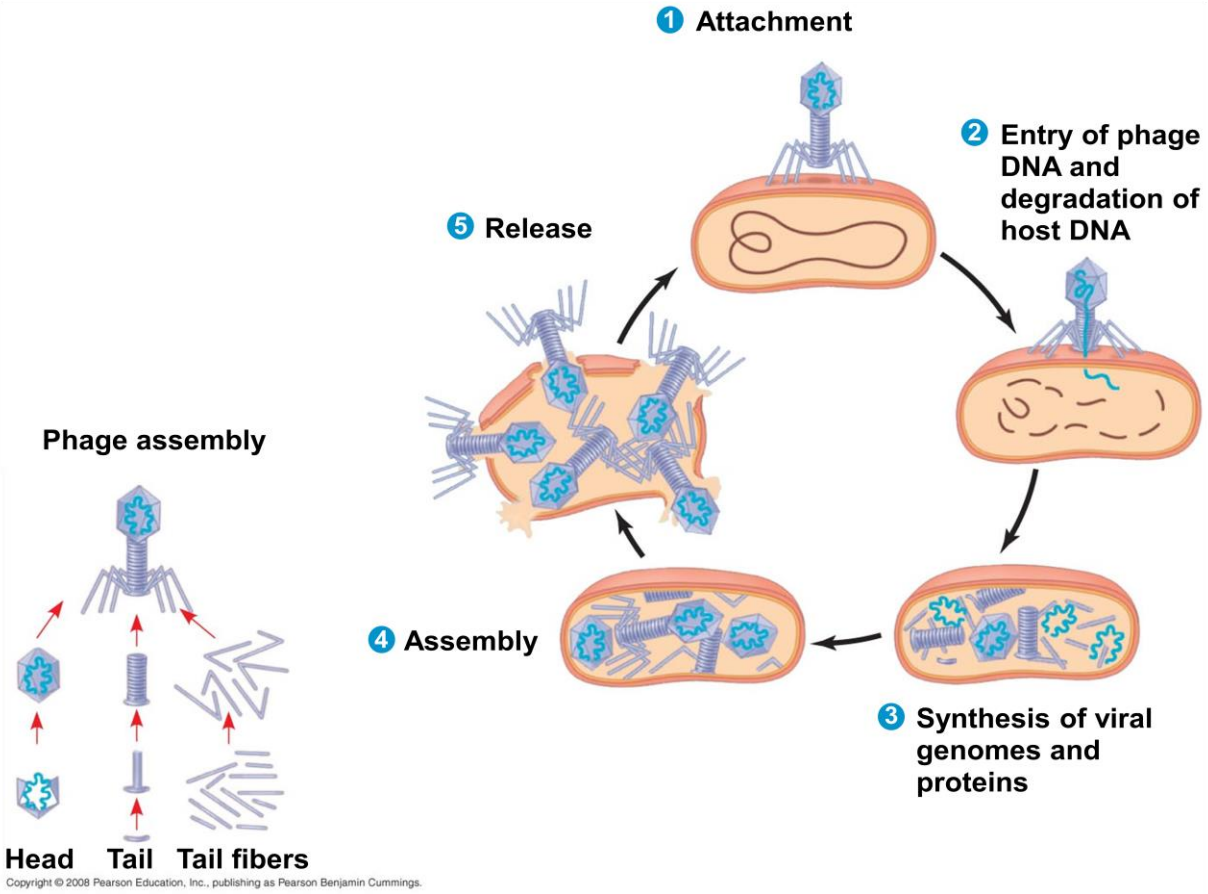
2) **Entry of phage DNA and degradation of host DNA : the sheath of the tail contracts , injecting the phage DNA into the cell and leaving an empty capsid outside . the cell's DNA is hydrolyzed .**

3) **Synthesis of viral genomes and proteins : the phage DNA directs production of phage proteins and copies of the phage genome by host enzymes , using components within the cell .**

4) **Assembly : Three separate sets of proteins self-assemble to form phage heads , tails , and tail fibers .The phage genome is packaged inside the capsid as the head forms .**

5) Release : the phage directs production of an enzyme that damages the bacterial cell wall, allowing fluid to enter . The cell swells and finally bursts releasing 100 to 200 phage particles .

Figure 26.5 The lytic cycle of phage T4, a virulent phage



Notes :

- The phage DNA is protected from breakdown because it contains a modified form of cytosine that isn't recognized by enzymes .

- lytic cycle takes only 20-30 minutes at 37 C .

- **Bacteria have defenses against phages,**
  1) **By restriction enzymes that recognize and cut up certain phage DNA**
  2) **Some mutant bacteria have difficult recognizing receptors for a particular types of phages .**
     **** but sometimes there are mutant phages that can bind to more than one type of receptors or resistant to particular types of restriction enzymes ..**

b) *The Lysogenic Cycle*

- **The lysogenic cycle replicates the phage genome without destroying the host cell .**
  - **Steps of reproduction :**

    1. The viral DNA molecule is incorporated into the host cell's chromosome , This integrated viral DNA is known as a *prophage* .

    2. A one prophage gene codes for protein , this protein prevents transcription of most of the other prophage genes .

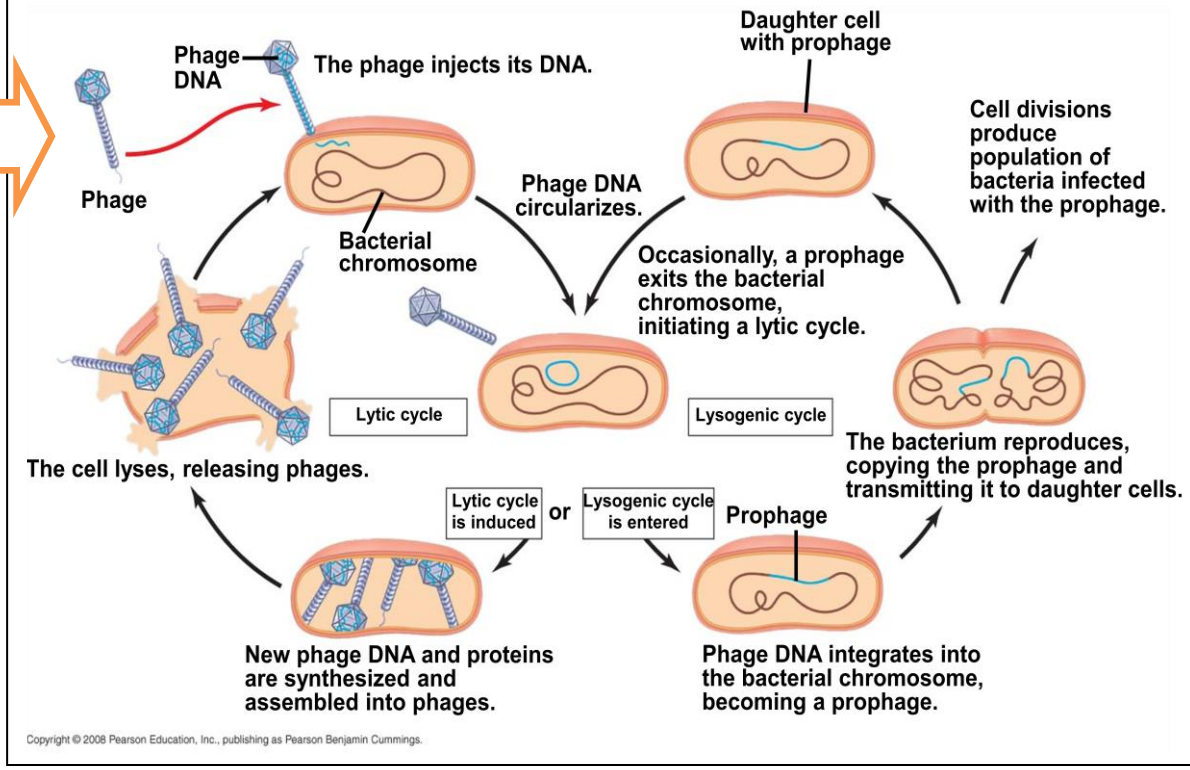
    3. this phage genome will still silent within the bacterium .

    4. when bacterium prepare to divide it replicates the phage DNA with its own and passes the copies (in prophage form) to its daughter cells .

  <<This mechanism enables viruses to propagate without killing the host cell >>
- **Phages that use both the lytic and lysogenic cycles are called temperate phages or (lambda ʎ)**
  - **for example: T4 and it is called (*phage ʎ*) , (**but phage ʎ differs from original T4 ; it has only a short tail fiber)

    when it infects any E.coil cell it begins with binds to the surface of the cell and injects its linear DNA genome , then ʎ DNa molecule forms a circle, what happens next depends on the reproductive cycle …
    look to figure 26.6 and study it carefully ☺

Figure 26.6 The lytic and lysogenic cycles of phage λ, a temperate phage



- **Lysogenic term means prophages are capable of generating active phages that lyse their host cells , that happens when :**

  1- **environmental signal (**chemical / high energy radiation **)can trigger the virus genome to exit the bacterial chromosome and switch to the lytic mode .**
  2- **there are in addition to the main prophage other types of prophage genes expressed and alter the hosts phenotype .**

❖ Reproductive Cycles of Animal Viruses

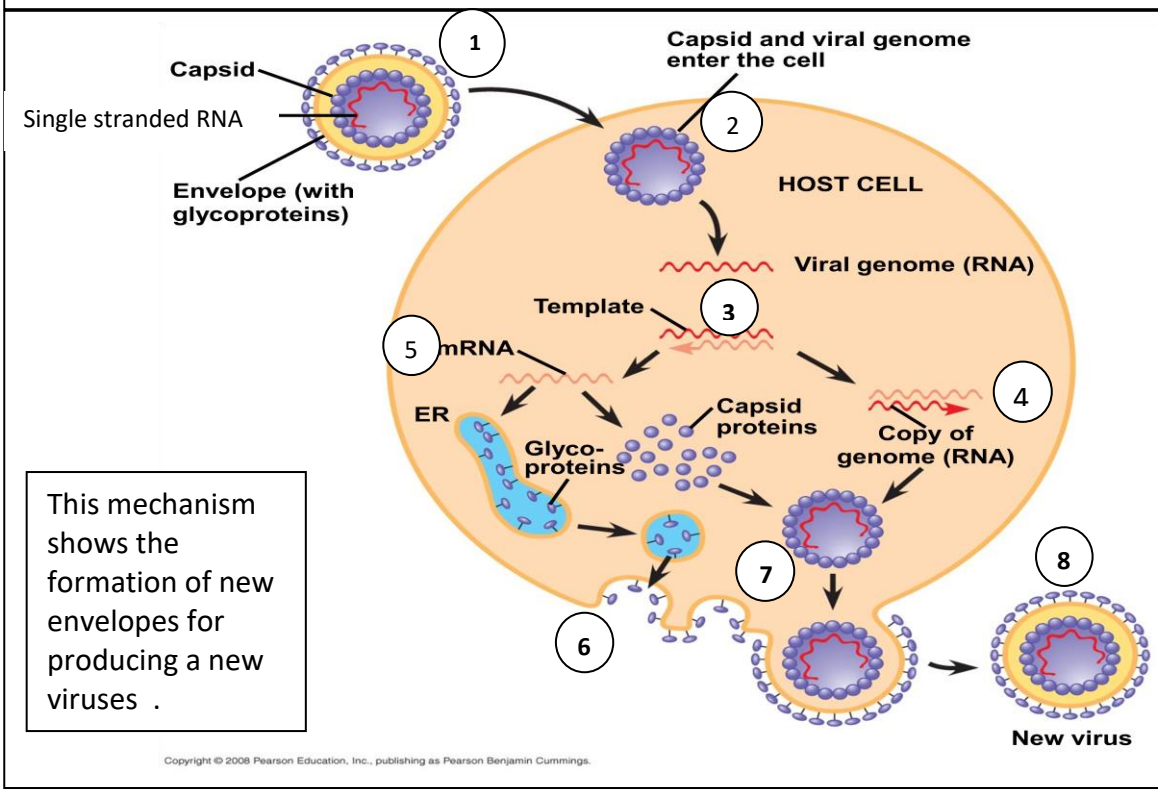
- **There are two key variables used to classify viruses that infect animals:**
  - **DNA or RNA?**
  - **Single-stranded or double-stranded?**

➲ **We will talk about *Viral Envelope* and viral genetic material roles :**

a) Viral Envelopes

- **The viral Envelope is derived from the host cell plasma membrane with molecules specified by viral gene .**

Figure 26.7 The reproductive cycle of an enveloped RNA virus



This mechanism shows the formation of new envelopes for producing a new viruses .

Figure illustration :

1) **Glycoproteins on the viral envelope bind to specific receptor molecules on the host cell (prompting viral entry into the host cell).**

2) **The capsid and viral genome enter the cell . digestion of the capsid by cellular enzymes releases the viral genome .**

3) **The viral genome functions as a template for synthesis of complementary RNA strands by a viral enzyme .**

4) **New copies of viral genome RNA are made using complementary RNA strands as template .**

5) **Complementary RNA strands also function as mRNA , which is translated into both capsid proteins (in the cytosol) and glycoproteins for the viral envelope in the ER and Golgi apparatus .**

6) **Vesicles transport envelope glycoproteins to the plasma membrane (exocytosis)**

7) **A capsid assembles around each viral genome molecule**

8) **Each new virus buds from the cell , its envelope studded with viral glycoproteins embedded in membrane derived from the host cell .**

- **This reproductive cycle doesn't necessarily kill the host cell .**

- **Other viral membranes form from the host's nuclear envelope and are then replaced by an envelope made from Golgi apparatus membrane such as" herpesviruses"**
- **These viruses have double –stranded DNA genome and reproduce within the host cell nucleus .**

b) RNA as Viral Genetic Material

- **The broadest variety of RNA genomes is found in viruses that infect animals**
- **Remember that >**
- **In figure 26.7 the virus was from class IV ,**
  In step 3 RNA genome uses viral enzymes for RNA synthesis to produce mRNA for the next steps .
  - Here we will talk about another RNA animal viruses with the most complicated reproductive cycle >>
- **Retroviruses use Reverse transcriptase (enzyme) to copy their RNA genome into DNA .**
- *Retro* means backward ; it is an unusual phenomenon !!

- **These viruses are enveloped viruses and contain 2 identical molecules of single stranded RNA and 2 molecules of reverse transcriptase .**
- **One of them is >>**
  HIV (human immunodeficiency virus) that causes AIDS (acquired immunodeficiency syndrome) .

  Look to figure 26.8 to know its reproductive cycle >>

Figure 26.8 The reproductive cycle of HIV, the retrovirus that causes AIDS

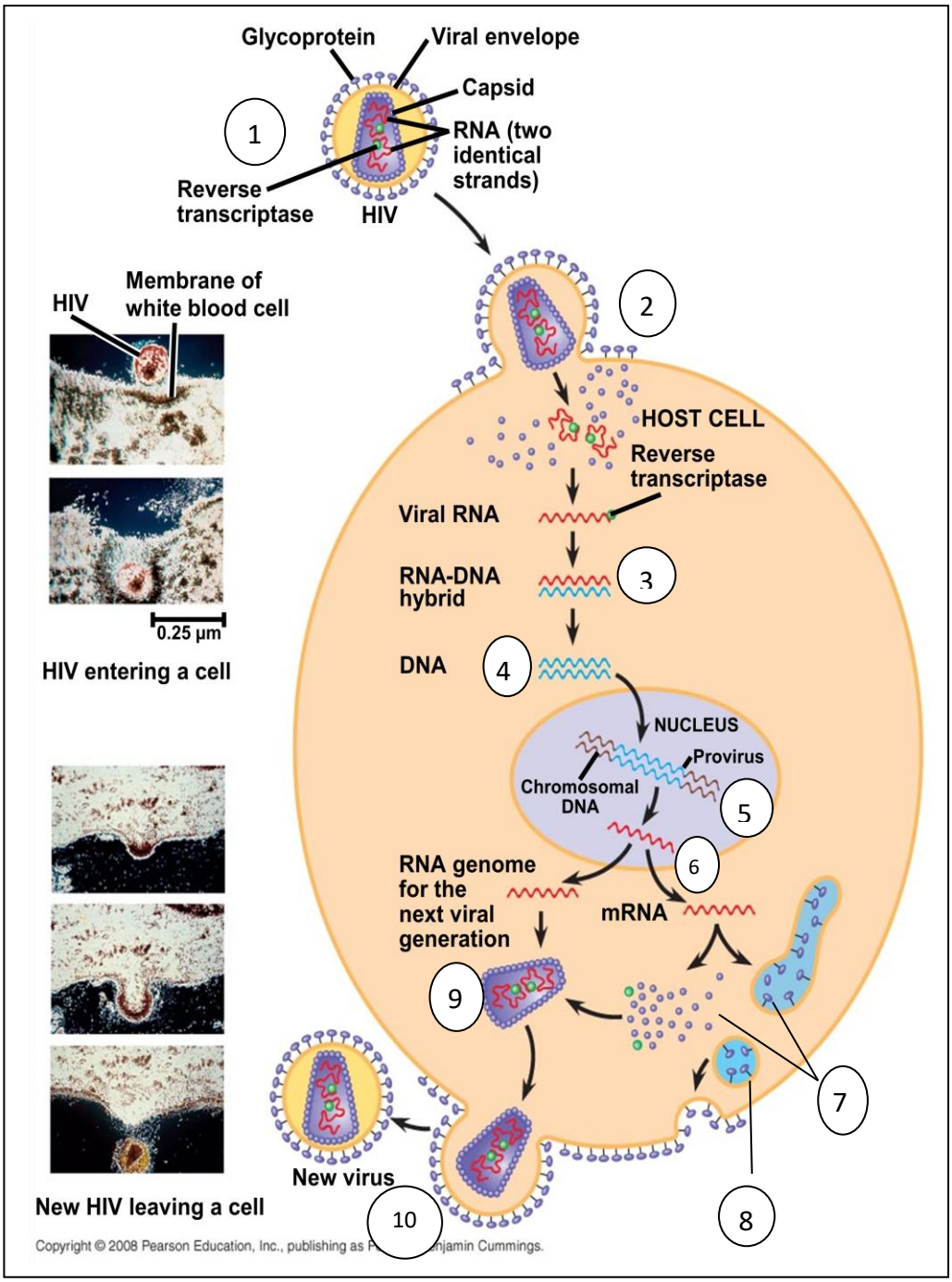


Figure Illustration >>

1) **The envelope glycoproteins enable the virus to bind to specific receptors on certain white blood cells .**

2) **The virus fuses with the cells plasma membrane . The capsid proteins are removed , releasing the viral proteins and RNA .**

3) ***Reverse transcriptase* catalyzes the synthesis f a DNA strand complementary to the viral RNA .**

4) ***Reverse transcriptase* catalyzes the synthesis of a second DNA strand complementary to the first .**

5) **<u>The double stranded DNA is incorporated as a provirus into the cell's DNA</u>**

6) **Proviral genes are transcribed into RNA molecules , which serve as genomes for the next viral generation and as mRNAs for translation into viral protein .**

7) **The viral proteins include capsid proteins and reverse transcriptase (made in the cytosol) and envelope glycoproteins (made in the ER).**

8) **Vesicles transport the glycoproteins to the cell‘s plasma membrane .**

9) **Capsids are assembled around viral genomes and reverse transcriptase molecules.**

10) **New viruses bud off from the host cell .**

Note :

- **(In step 5) Provirus is the integrated viral DNA ,**
- **Provirus is Unlike a prophage , it remains a permanent resident of the host cell**

The End of Chapter 26

وأخيراً , استودع الله ما حفظت وما فهمت ☺

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