6.2

Viruses

Viruses are infectious agents that can only replicate inside another living organism. All forms of life have been known to be susceptible to viral infection and viruses have been found in almost every ecosystem on earth. Viruses have one objective, take over a section of the DNA of a host cell by inserting new DNA that contains the instructions to make more virus. Once infected, the cell is “forced” to produce thousands of copies of the original virus which can then be released to infect new cells. Viruses that exist outside of host cells are called **virions**. Virions are composed of a protein coat called the **capsid** that surrounds genetic material. The genetic material exists as four different types: double stranded DNA (chicken pox), single stranded DNA (uncommon), double stranded RNA (uncommon) and single stranded RNA (most common, i.e., common cold). Virions are small, typically one-hundredth the size of a bacterial cell and over one hundred thousand bacteria can fit into the area of the period at the end of this sentence! Talk about small and simple bringing about great means! Capsids are often surrounded by a lipid bilayer called the **viral envelope**. Since the viral envelope is lipid based, like host cells, it is used to evade detection and to interact with cell recognition proteins, tricking the host cell into letting the virus enter. For example, the virus responsible for COVID19 enters cells through the ACE2 receptor, found primarily in lung, kidney, olfactory and taste cells, and placental tissues. Some viruses will even package necessary enzymes for replication inside their viral envelopes. There is still great debate as to whether viruses should be considered life and there is still debate on where viruses originated. Perhaps the best definition is that they are “organisms at the edge of life.”

Viruses can spread from host cell to host cell in many ways, but the most common seems to be through **vectors**. Vectors can be anything from insects to droplets from coughing and sneezing to food and water, to sexual contact. How well a virus infects a host is called its host range. Some viruses have very narrow host ranges and other much broader. Fortunately, viral infections lead to immune responses that are usually very effective at eliminating the virus, the exceptions being viruses that cause HIV/AIDS, HPV (human papillomavirus), and hepatitis.

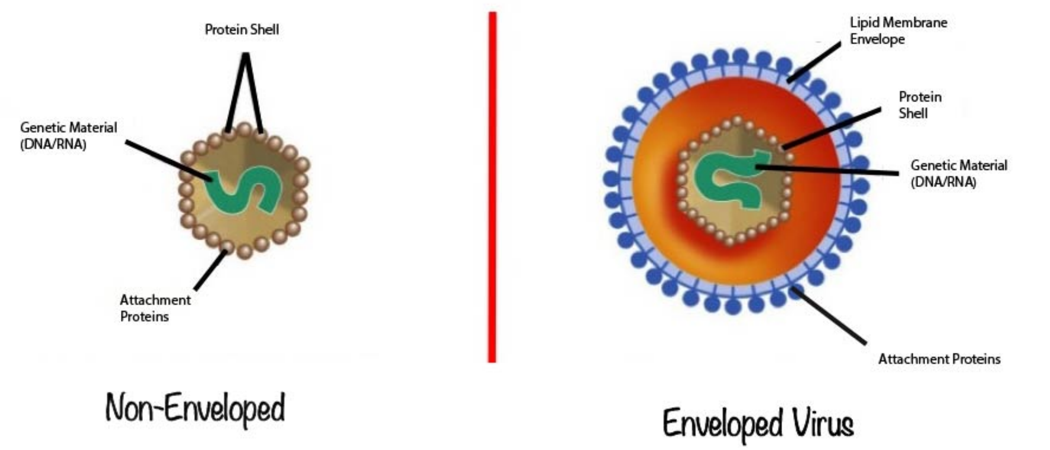
Viruses do not grow by cell division of binary fission, instead the use the host cell machinery to make thousands upon thousands of copies of themselves. Although some variation exists, there seems to some common stages in the “life” cycle of a virus.

Attachment. Attachment is the interaction between the viral capsid or envelope with specific receptors on the host cell. As stated previously, how specific this interaction determines the host range of the virus. Successful attachment allows the virus to enter the host cell.

Penetration. Penetration describes how a virus enters the host cell either though receptor mediated endocytosis or membrane fusion. Because plants have ridged cell walls, viruses typically can only penetrate if the cell wall has undergone some sort of damage. Still, some viruses have evolved a strategy to inject their DNA across the cell wall, leaving the capsule intact and stuck to the cell wall. The result of penetration is the releasing of the viral genetic material into the host cell.

Replication. With successful penetration, the viral nucleic acids are incorporated into the host cell DNA, and viral components are then produced and assembled. How the assembled virus is released is determined by whether the virus induces a lytic or lysogenic cycle. In the lysogenic cycle the viral DNA is spliced into the host DNA but then pauses before synthesis and assembly. This spliced DNA is called a provirus or prophage and the DNA is continually transferred each time the host cell replicates but the virus “waits” for a later time for synthesis and assembly. In the case of the HIV virus, in some humans the virus may lay dormant. The lytic cycle can be activated at any time due to sunlight, stress, etc. and this cycle results in the production of hundreds of thousands of viruses that end up lysing or rupturing the cell. The lytic cycle and the lysogenic cycle are not totally independent from each other. When a virus is synthesized, assembled, and released from the host immediately after the DNA incorporation, that is a purely lytic cycle. When there is a pause between the incorporation of DNA and the start of assembly (for host replication), that is a lysogenic cycle followed by the lytic cycle. Some viruses have even evolved the ability to make viral envelopes that can be released via exocytosis without rupturing the host cell membrane. Incorporation in the host DNA varies as to the type of viral genetic material that was introduced. The DNA viruses must make their way to the nucleus and use the host cells DNA and RNA machinery, or, in the case of very large viruses, they bring their own machinery. RNA viruses replicate in the cytoplasm, and they bring with them the necessary replicating enzymes. Of these enzymes, the best studied are called reverse transcribing enzymes or **reverse transcriptase**, which converts the RNA into DNA that can then be incorporated into the host DNA.

Since viruses become so integrated into the host cell, they can be difficult to eliminate using toxic drugs because the drug also destroys the host cells. The most effective approaches to viral disease have been vaccinations. Most vaccines contain live, but weakened forms of the virus in question, that do not cause the disease but still allow the body to recognize and build immunity. These viruses are called attenuated viruses. Although not perfect, their uses still have nearly eradicated viral diseases such as polio, measles, mumps, rubella, and smallpox. The COVID19 virus vaccine introduces an exciting discovery that has changed the effectiveness of vaccines. Instead of using an attenuated virus, the COVID19 vaccine used mRNA that was specifically designed for COVID19. In brief, once injected (and similar to natural viral infections), the engineered mRNA makes it way to the cells where it instructs the cell to make a harmless protein called a spike protein. The mRNA is quickly removed by the cells and the synthesized spike protein is placed at the surface of the cells. Our own immune system then recognizes the spike proteins and builds up an immunity. Thus, the body is prepped for any virus that displays the same spike protein (COVID19) and quickly eliminates the threat. This discovery allows for quick and precise vaccine immunity and will most likely prove extremely beneficial as new and more virulent viruses enter the population.



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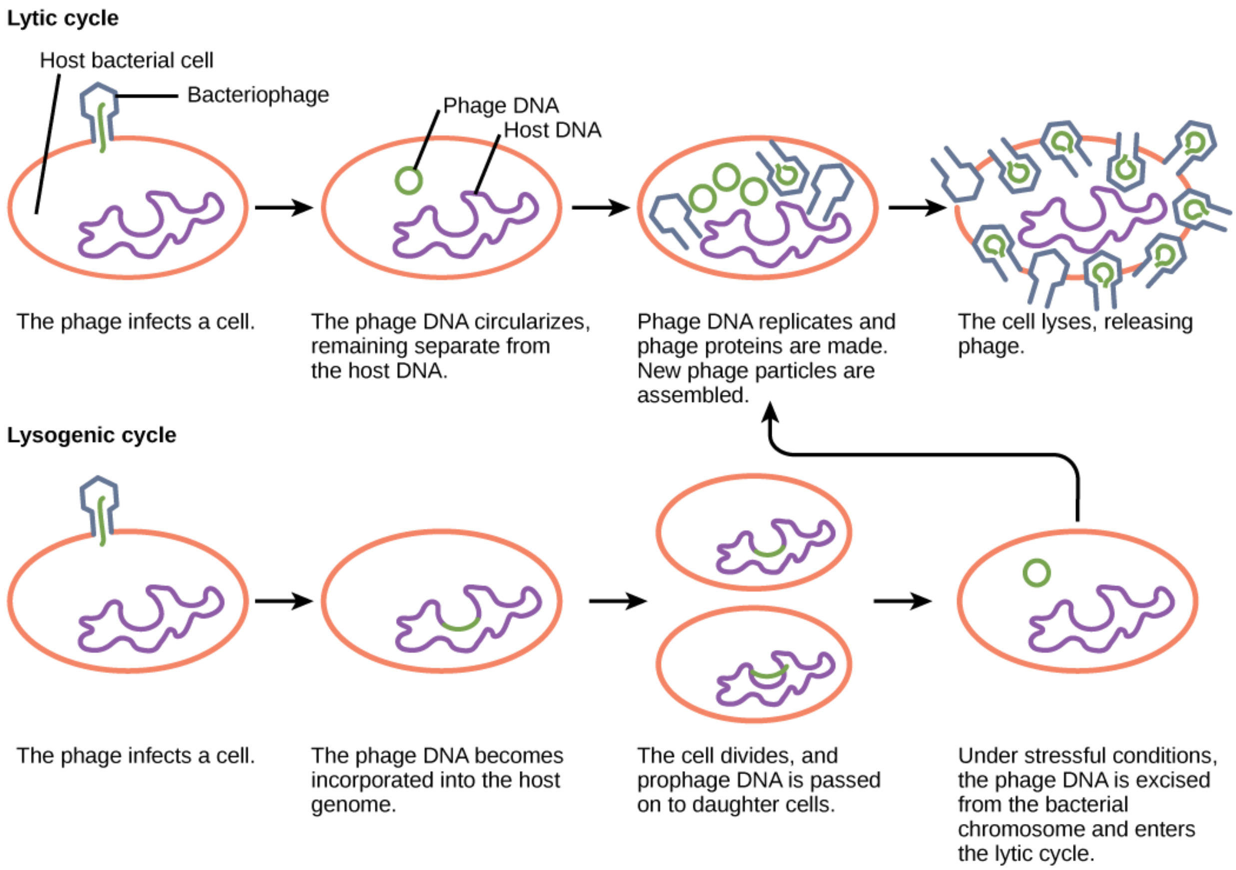
Lytic cycle
Host bacterial cell
Bacteriophage
Phage DNA
Host DNA
The phage infects a cell.
The phage DNA circularizes, remaining separate from the host DNA.
Phage DNA replicates and phage proteins are made. New phage particles are assembled.
The cell lyses, releasing phage.
Lysogenic cycle
The phage infects a cell.
The phage DNA becomes incorporated into the host genome.
The cell divides, and prophage DNA is passed on to daughter cells.
Under stressful conditions, the phage DNA is excised from the bacterial chromosome and enters the lytic cycle.