19–2 Viruses *(continued)*

What Is a Virus?

In 1935, the American biochemist Wendell Stanley obtained crystals of tobacco mosaic virus. Living organisms do not crystallize, so Stanley inferred that viruses were not alive. **Viruses** are particles of nucleic acid, protein, and in some cases, lipids. Viruses can reproduce only by infecting living cells. Viruses differ widely in terms of size and structure. You can see examples of diverse viruses in the figure at right. As different as they are, all viruses have one thing in common: They enter living cells and, once inside, use the machinery of the infected cell to produce more viruses.

Virus Structures

Most viruses are so small they can be seen only with the aid of a powerful electron microscope. **A typical virus is composed of a core of DNA or RNA surrounded by a protein coat.** The simplest viruses contain only a few genes, whereas the most complex may have more than a hundred genes.

Virus Structures

A virus's protein coat is called its **capsid**. The capsid includes proteins that enable a virus to enter a host cell. The capsid proteins of a typical virus bind to receptors on the surface of a cell and "trick" the cell into allowing it inside. Once inside, the viral genes are expressed. The cell transcribes and translates the viral genetic information into viral capsid proteins. Sometimes that genetic program causes the host cell to make copies of the virus, and in the process the host cell is destroyed.

Because viruses must bind precisely to proteins on the cell surface and then use a host's genetic system, most viruses are highly specific to the cells they infect. Plant viruses infect plant cells; most animal viruses infect only certain related species of animals; and bacterial viruses infect only certain types of bacteria. Viruses that infect bacteria are called bacteriophages.

Viral Infection

Once the virus is inside the host cell, two different processes may occur. Some viruses replicate themselves immediately, killing the host cell. Other viruses replicate themselves in a way that doesn't kill the host cell immediately. These two processes are shown in the figure at right.

Lytic Infection Bacteriophage T4 is an example of a bacteriophage that causes a lytic infection. **In a lytic infection, a virus enters a cell, makes copies of itself, and causes the cell to burst.** Bacteriophage T4 has a DNA core inside an intricate protein capsid that is activated by contact with a host cell. It then injects its DNA directly into the cell. The host cell cannot tell the difference between its own DNA and the DNA of the virus. Consequently, the cell begins to make messenger RNA from the genes of the virus. This viral mRNA is translated into viral proteins that act like a molecular wrecking crew, chopping up the cell DNA, a process that shuts down the infected host cell.

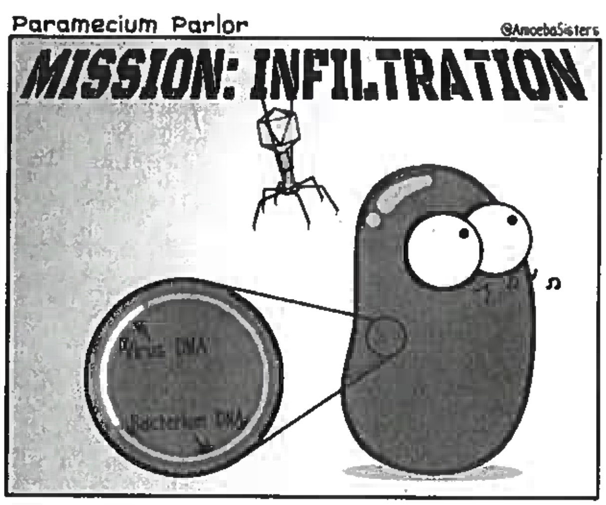
The virus then uses the materials of the host cell to make thousands of copies of its own DNA molecule. The viral DNA gets assembled into new virus particles. Before long, the infected cell lyses, or bursts, and releases hundreds of virus particles that may go on to infect other cells. Because the host cell is lysed and destroyed, this process is called a **lytic infection**.

In its own way, a lytic virus is similar to an outlaw in the American Old West. First, the outlaw eliminates the town's existing authority (host cell DNA). Then, the outlaw demands to be outfitted with new weapons, horses, and riding equipment by terrorizing the local people (using the host cell to make viral proteins and viral DNA). Finally, the outlaw forms a gang that leaves the town to attack new communities (the host cell bursts, releasing hundreds of virus particles).

Lysogenic Infection Other viruses, including the bacteriophage lambda, cause **lysogenic infections** in which a host cell makes copies of the virus indefinitely. **In a lysogenic infection, a virus integrates its DNA into the DNA of the host cell, and the viral genetic information replicates along with the host cell's DNA.** Unlike lytic viruses, lysogenic viruses do not lyse the host cell right away. Instead, a lysogenic virus remains inactive for a period of time.

The viral DNA that is embedded in the host's DNA is called a **prophage**. The prophage may remain part of the DNA of the host cell for many generations before becoming active. A virus may not stay in the prophage form indefinitely. Eventually, any one of a number of factors may activate the DNA of a prophage, which will then remove itself from the host cell DNA and direct the synthesis of new virus particles.

The steps of lytic and lysogenic infections may be different from those of other viruses when they attack eukaryotic cells. Most animal viruses, however, show patterns of infection similar to either the lytic or lysogenic patterns of infection of bacteria.

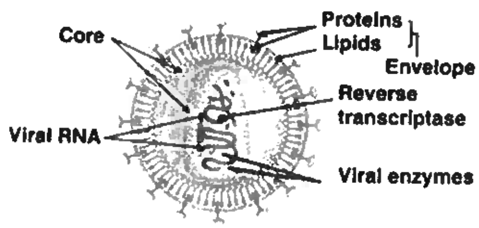


Retroviruses

Some viruses contain RNA as their genetic information and are called <u>retroviruses</u>. When retroviruses infect a cell, they produce a DNA copy of their RNA. This DNA, much like a prophage, is inserted into the DNA of the host cell. There the retroviruses may remain dormant for varying lengths of time before becoming active, directing the production of new viruses, and causing the death of the host cell.

Retroviruses get their name from the fact that their genetic information is copied backward—that is, from RNA to DNA instead of from DNA to RNA. (The prefix *retro-* means "backward.") Retroviruses are responsible for some types of cancer in animals, including humans. The virus that causes acquired immune deficiency syndrome (AIDS) is a retrovirus.

Structure of a retrovirus



Viruses and Living Cells

Viruses must infect a living cell in order to grow and reproduce. They also take advantage of the host's respiration, nutrition, and all the other functions that occur in living things. Therefore, viruses can be considered to be parasites. A parasite depends entirely upon another living organism for its existence, harming that organism in the process.

Are viruses alive? If we require that living things be made up of cells and be able to live independently, then viruses are not alive. Yet, viruses have many of the characteristics of living things. After infecting living cells, viruses can reproduce, regulate gene expression, and even evolve. Some of the main differences between cells and viruses are summarized in the table at right. Viruses are at the borderline of living and nonliving things.

Although viruses are smaller and simpler than the smallest cells, it is not likely that they could have been the first living things. Because viruses are completely dependent upon living things, it seems more likely that viruses developed after living cells. In fact, the first viruses may have evolved from the genetic material of living cells. Once established, however, viruses have continued to evolve, along with the cells they infect, over billions of years.