CHAPTER PREVIEW

Main Ideas

In this chapter, you will learn about the structure of viruses and how they replicate inside cells. You will also explore the world of bacteria, including their classification, growth and reproduction, and importance to other organisms. You will learn about several diseases caused by viruses and bacteria.

Reading Strategies

Sequencing Events As you read about viruses, list the steps of viral replication. Write a few sentences to describe each stage.

Outlining Information As you read about bacteria, write down all the titles of the blue headings. Then, under each heading, write down the key points.

Journal Activity

Biology and Your World Chances are, you have been sick at least once in your life, thanks to the effects of viruses or bacteria! What was the most memorable time you were sick, and why? What were your symptoms? How was your illness treated? Describe your recollections in your journal.

17–1 Viruses

Guide For Reading

- What is a virus?
- How do viral life cycles differ?
- What is the relationship between viruses and their hosts?

Imagine for a moment that you have been presented with a great challenge. A disease has begun to destroy certain crops. The leaves of diseased plants are covered with large bleached spots that form a pattern that farmers call a mosaic. As the disease progresses, the leaves turn yellow, wither, and fall off, killing the plants.

To determine what is causing the disease, you take some leaves from a diseased plant and crush them until a juice is extracted. You then place a few drops of the juice on the surfaces of the leaves of healthy plants. A few days later, you discover that, wherever you have placed the juice on the healthy leaves, a mosaic pattern has appeared. You reason that the cause of the disease must be in the juice of the infected plant.

You then search for a microorganism that might be responsible for the disease, but none can be found. In fact, even when the juice is passed through a filter with pores so fine that not even cells can pass through, the juice still causes the disease. When you look at a small amount of the filtered juice under the light microscope, you see no evidence of cells. The juice, which is capable of transferring the disease from one plant to another, must contain disease-causing particles so

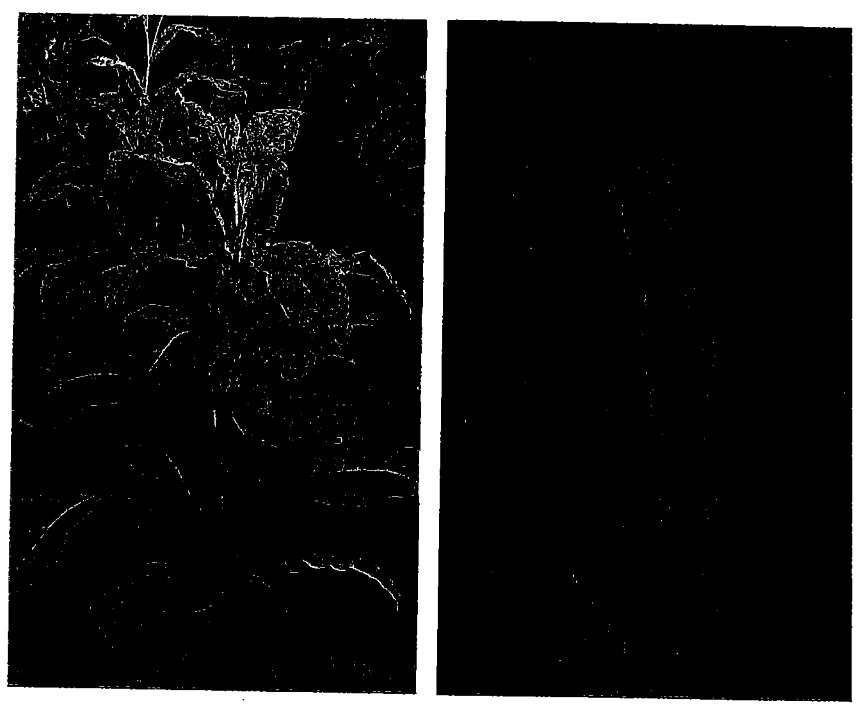
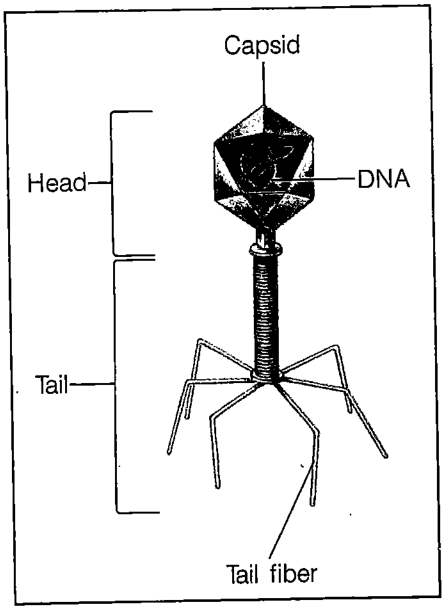


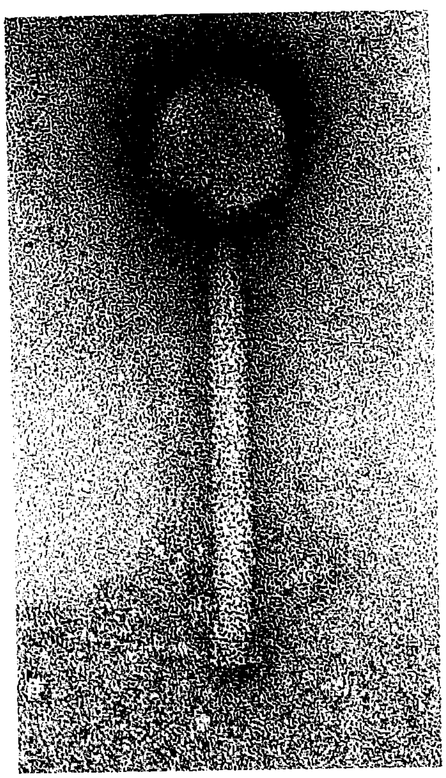
Figure 17–1 *Tobacco mosaic virus (TMV) causes the leaves of tobacco plants to develop a pattern of spots called a mosaic (left). A TMV particle, magnified approximately 41,800 times (right), appears as a thin purple tube in the color-enhanced micrograph.*

small that they are not visible under the light microscope. Although you cannot see the disease-causing particles, you decide to give them the name viruses, from the Latin word meaning poison.

With a few exceptions, most of these events actually took place. About 100 years ago in what is now Ukraine, an epidemic of tobacco mosaic disease occurred that seriously threatened the tobacco crop. The disease-causing nature of the juice from infected tobacco leaves was discovered by the Russian biologist Dimitri Iwanowski. A few years later, the Dutch scientist Martinus Beijerinck determined that tiny particles in the juice caused the disease. He named these particles **viruses.**

Figure 17–2 A bacteriophage is a virus that infects bacteria. Compare the structures shown in the diagram of the bacteriophage to those in an actual bacteriophage.





What Is a Virus?

You have just read how scientists hypothesized the existence of viruses, which they thought were cells even smaller than one-celled bacteria. This idea persisted until 1935 when the nature of a virus was discovered by the American biochemist Wendell Stanley. He had set out to chemically isolate the particle responsible for the tobacco mosaic disease. Stanley identified the particle as the tobacco mosaic virus (TMV).

Since Stanley's discovery, many viruses have been identified, largely through the use of the electron microscope, which was invented in the 1930s. We now appreciate the fact that viruses have distinct structures that are complex and fascinating. **A virus is a noncellular particle made up of genetic material and protein that can invade living cells.**

STRUCTURE OF A VIRUS A typical virus is composed of a core of nucleic acid surrounded by a protein coat called a capsid. The capsid protects the nucleic acid core. Depending on the virus, the nucleic acid core is either DNA or RNA but never both. The core may contain several genes to several hundred genes.

A more complex structure occurs in certain viruses known as **bacteriophages**. You may recall from Chapter 7 that bacteriophages are viruses that invade bacteria. A bacteriophage has a head region, composed of a capsid (protein coat), a nucleic acid core, and a tail. Bacteriophages are interesting and relatively easy to study because their hosts (bacteria) multiply quickly.

One well-studied bacteriophage, known as T4, has a core of DNA contained within a protein coat. A number of other proteins (about 30 in all) form the other parts of the virus, including the tail fibers. The tail fibers are the structures by which the virus attaches itself to a bacterium.

Viruses come in a variety of shapes. Some, such as the tobacco mosaic virus, are rod-shaped. Others, such as the bacteriophages, are tadpole-shaped. Still others are many-sided, helical, or cubelike. Figure 17–3 shows some of these shapes.

Viruses vary in size from approximately 10 to 400 nanometers. A nanometer is one billionth of a meter. The tobacco mosaic virus is about 300 nanometers long, whereas the virus that causes polio is about 20 nanometers in diameter.

SPECIFICITY OF A VIRUS Usually, specific viruses will infect specific organisms. For example, a plant virus cannot infect an animal. There are some viruses that will infect only humans. Others, such as the virus that causes rabies, infect all mammals and some birds. Still others infect only coldblooded animals (animals with body temperatures that change with the surrounding air). There are even some viruses that will infect species of animals that are closely related. For example, viruses that infect mice may infect rats. So you can see that viruses are capable of infecting virtually every kind of organism, including mammals, birds, insects, and plants.

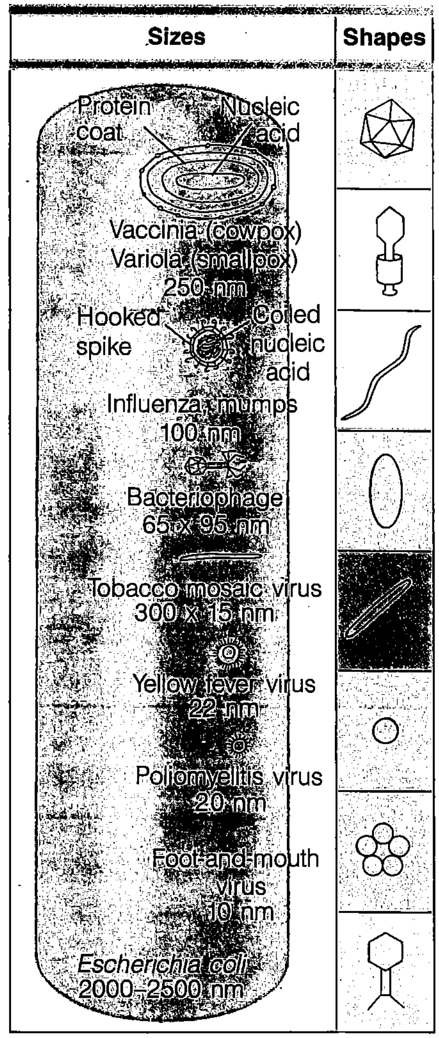


Figure 17–3 *Viruses come in a variety of sizes and shapes. Notice the size of the bacterium* E. coli *as compared to the sizes of the viruses.*

Life Cycle of a Lytic Virus

In order to reproduce, viruses must invade, or infect, a living host cell. However, not all viruses invade living cells in exactly the same way. When T4 bacteriophages invade living cells, they cause the cells to lyse, or burst. Thus T4 viruses are known as lytic (LIHT-ihk) viruses.

INFECTION A virus is activated by chance contact with the right kind of host cell. In the case of T4, molecules on its tail fibers attach to the surface of a bacterium. The virus then injects its DNA into the cell. In most cases, the complete virus particle itself never enters the cell.

GROWTH Soon after entering the host cell, the DNA of the virus goes into action. In most cases, the host cell cannot tell the difference between its own DNA and the DNA of the virus. Consequently, the very same enzyme RNA polymerase that makes messenger RNA from the cell's own DNA begins to make messenger RNA from the genes of the virus. This viral messenger RNA now acts like a molecular wrecking crew, shutting down and taking over the infected host cell. Some of these viral genes turn off the synthesis of molecules that are important to the infected cell. One viral gene actually produces an enzyme that destroys the host cell's own DNA but does not harm the viral DNA!

REPLICATION As the virus takes over, it uses the materials of the host cell to make thousands of copies of its own protein coat and DNA. Soon the host cell becomes filled with hundreds of viral DNA molecules. When *Escherichia coli,* or *E. coli,* the bacterium found in the human intestine, is infected by a T4 bacteriophage, this sequence of infection, growth, and replication can happen in as brief a time as 25 minutes!

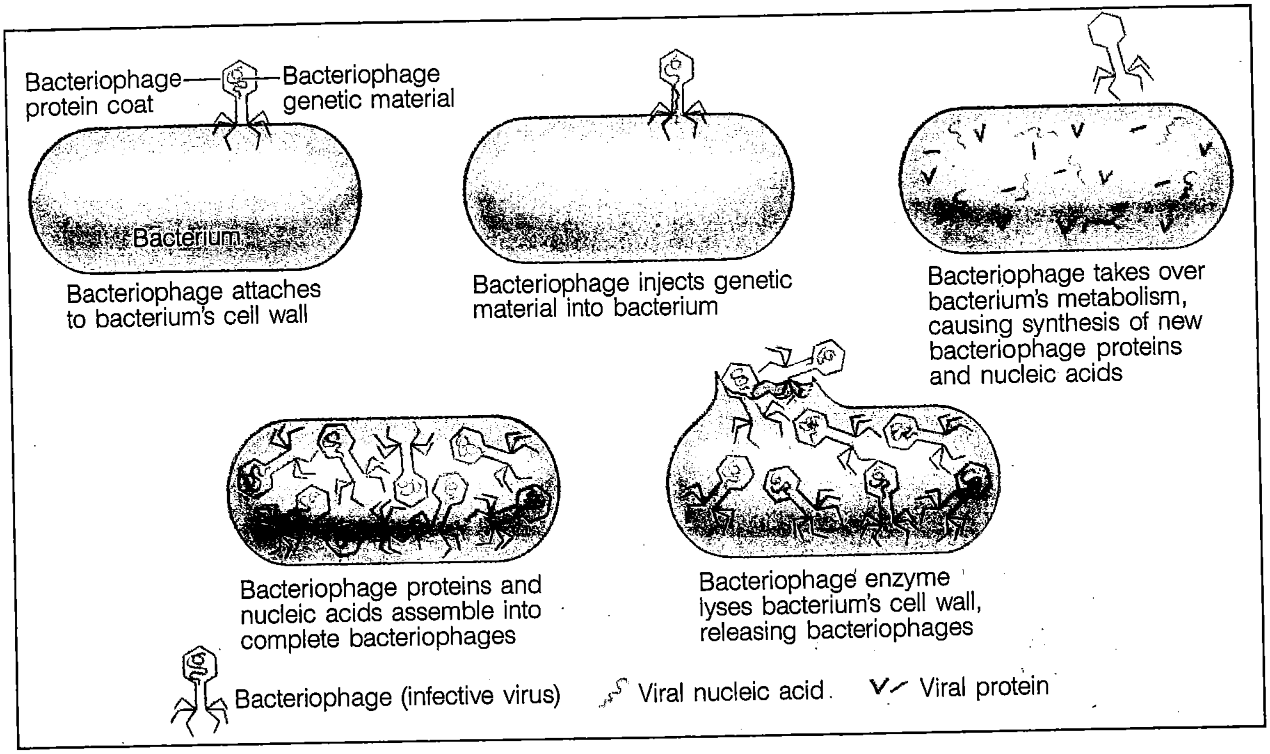
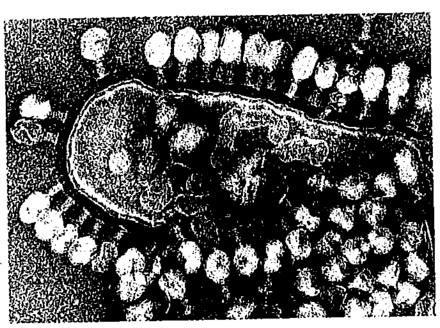


Figure 17–4 *In the life cycle of a lytic virus, the virus invades a bacterium, reproduces, and is scattered when the bacterium lyses, or breaks.*

During the final stage of reproduction, the DNA molecules serve as the starting points around which new virus particles are assembled. Before long, the infected cell lyses (bursts) and releases hundreds of virus particles that may now infect other cells. Because the host cell is lysed and destroyed, this process is called a **lytic infection**. Lytic infections are one way in which viruses can infect host cells.

The life cycle of a lytic virus such as T4 consists of repeated acts of infection, growth, and cell lysis. We may imagine the virus as a desperado moving into a town in the Old West. First, the desperado eliminates the town's existing authority (host cell DNA). Then the desperado demands to be outfitted with new weapons, horses, and riding equipment by terrorizing the local merchants and businesspeople (using the machinery of the host cell to make proteins). Finally, the desperado recruits more outlaws and forms a gang that leaves the town and attacks new communities (the host cell bursts, releasing hundreds of virus particles).

Figure 17–5 *This electron micrograph shows bacteriophages attacking the bacterium* E. coli. *How do viruses attach themselves to the bacterium?*



Lysogenic Infection

Another way in which a virus infects a cell is known as a **lysogenic** (ligh-soh-JEHN-ihk) **infection**. In a lysogenic infection, the virus does not reproduce and lyse its host cell—at least not right away! Instead, the DNA of the virus enters the cell and is inserted into the DNA of the host cell. Once inserted into the host cell's DNA, the viral DNA is known as a **prophage**.

The prophage may remain part of the DNA of the host cell for many generations. An example of a lysogenic virus is the bacteriophage *lambda*, which infects *E. coli.*

PROPHAGE ACTIVITY The presence of the prophage can block the entry of other viruses into the cell and may even add useful DNA to the host cell's DNA. For example, a lambda virus can insert the DNA necessary for the synthesis of important amino acids into the DNA of *E. coli.* As long as the lambda virus remains in the prophage state, *E. coli* can use the viral genes to make these amino acids.

A virus may not stay in the prophage form indefinitely. Eventually, the DNA of the prophage will become active, remove itself from the DNA of the host cell, and direct the synthesis of new virus particles. A series of genes in the prophage itself maintains the lysogenic state. Factors such as sudden changes in temperature and availability of nutrients can turn on these genes and activate the virus.

RETROVIRUSES One important class of viruses are the **retroviruses.** Retroviruses contain RNA as their genetic information. When retroviruses infect a cell, they produce a DNA copy of their RNA genes. This DNA, much like a prophage, is inserted into the DNA of the host cell. Retroviruses received 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 and humans. One type of retrovirus produces a disease called AIDS.

Viruses and Living Cells

As you have just learned, viruses must infect living cells in order to carry out their functions of growth and reproduction. They also depend upon their hosts for respiration, nutrition, and all of the other functions that occur in living things. Thus viruses are **parasites**. A parasite is an organism that depends entirely upon another living organism for its existence in such a way that it harms that organism.

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. However, when they are able to infect living cells, viruses can grow, reproduce, regulate gene expression, and even evolve. Viruses have so many of the characteristics of living things that it seems only fair to consider them as part of the system of life on Earth.

Because it is possible to study the genes that viruses bring into cells when they infect them, viruses have been extremely valuable in genetic research. And, as we saw in Chapter 12, some viruses are now being used in gene therapy. It is possible that modified viruses may one day be routine medical tools.

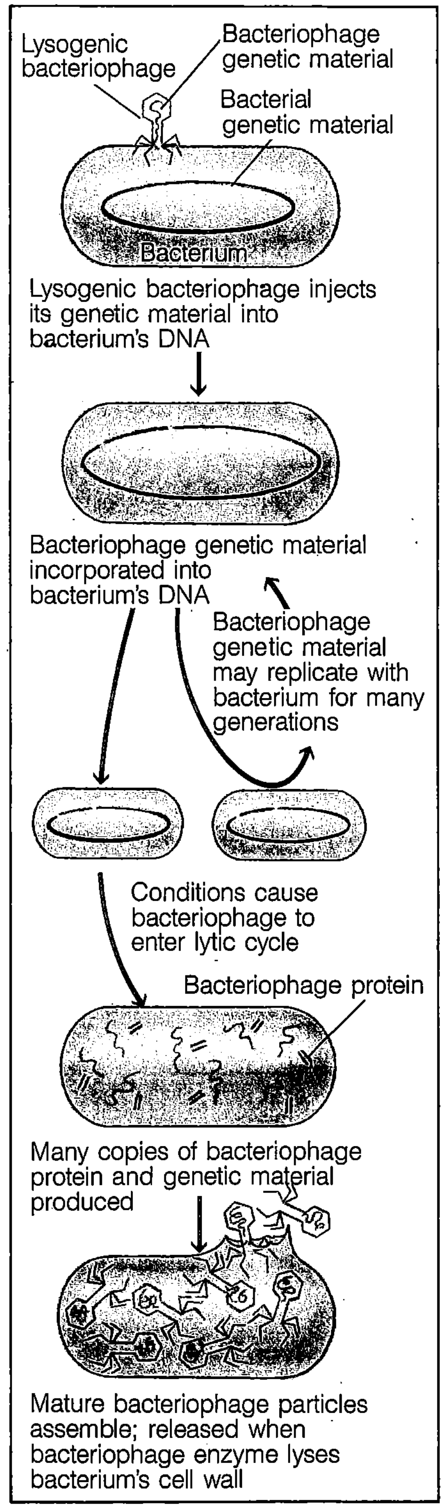


Figure 17–6 *In a lysogenic infection, the DNA of the bacteriophage enters the host cell and is inserted into its DNA.*