**Essential Questions**

- What is the general structure of a virus?
- What are similarities and differences in the lytic cycle, the lysogenic cycle, and retroviral replication?
- What is the relationship between a prion's structure, replication, and action and its ability to cause disease?

**Review Vocabulary**

- protein: large, complex polymer composed of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur

**New Vocabulary**

- virus
- capsid
- lytic cycle
- lysogenic cycle
- retrovirus
- prion

**Viruses and Prions**

**MAIN IDEA**  Viruses and prions are smaller and less complex than bacteria; they invade cells and can alter cellular functions.

**Real-World Reading Link**  "It’s Cold and Flu Season," "1918 Spanish Flu Epidemic Kills Millions," "New Cases of SARS Reported," "Number of H1N1 Cases Increases"—headlines tell many stories about diseases that spread worldwide. What do colds, severe acute respiratory syndrome (SARS), and types of flu have in common? They all are caused by viruses.

**Viruses**

Although some viruses are not harmful, other viruses are known to infect and harm all types of living organisms. A **virus** is a nonliving strand of genetic material within a protein coat. Most biologists don’t consider viruses to be living because they do not exhibit all of the characteristics of life. Viruses have no organelles to take in nutrients or use energy, they cannot make proteins, they cannot move, and they cannot replicate on their own. In humans, some diseases, such as those listed in **Table 2**, are caused by viruses. Just as there are some bacteria that cause sexually transmitted disease, some viruses can cause sexually transmitted diseases—such as genital herpes and AIDS. These viruses can be spread through sexual contact. Diseases caused by these viruses have no cure or vaccine to prevent them.

**Virus size**  Viruses are some of the smallest disease-causing structures that are known. They are so small that powerful electron microscopes are needed to study them. Most viruses range in size from 5 to 300 nanometers (a nanometer is one billionth of a meter). It would take about 10,000 cold viruses to span the period at the end of this sentence.

**Table 2**  **Human Viral Diseases**

<table>
<thead>
<tr>
<th>Category</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sexually transmitted diseases</td>
<td>AIDS (HIV), genital herpes</td>
</tr>
<tr>
<td>Childhood diseases</td>
<td>Measles, mumps, chicken pox</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>Common cold, influenza</td>
</tr>
<tr>
<td>Skin diseases</td>
<td>Warts, shingles</td>
</tr>
<tr>
<td>Digestive tract diseases</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Nervous system diseases</td>
<td>Polio, viral meningitis, rabies</td>
</tr>
<tr>
<td>Other diseases</td>
<td>Smallpox, hepatitis</td>
</tr>
</tbody>
</table>

**Multilingual eGlossary**

- protein: large, complex polymer composed of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur
Viruses have several different types of arrangements, but all viruses have at least two parts: an outer capsid portion made of proteins, and genetic material.

**Virologist**

Virologists study the natural history of viruses and the diseases they cause. Most virologists spend many hours in the laboratory conducting experiments.

**Virus origin**

Although the origin of viruses is not known, scientists have several theories about how viruses evolved. One theory, now considered to be most likely, is that viruses came from parts of cells. Scientists have found that the genetic material of viruses is similar to cellular genes. These genes somehow developed the ability to exist outside of the cell.

**Virus structure**

Figure 11 shows the structures of adenovirus, influenza virus, bacteriophage, and tobacco mosaic virus. Adenovirus infection causes the common cold, and influenza virus is responsible for causing the flu. A virus that infects bacteria is called a bacteriophage (bak TIHR ee uh fayj). Tobacco mosaic virus causes disease in tobacco leaves. The outer layer of all viruses is made of proteins and is called a capsid. Inside the capsid is the genetic material, which could be DNA or RNA, but never both. Viruses generally are classified by the type of nucleic acid they contain.

**Reading Check** Sketch the general structure of a virus.

**The History of Smallpox**

Though it has been eradicated, smallpox has been an important and deadly disease throughout history.

- **243 B.C.** A terrible epidemic ravages China. Invading Huns bring smallpox to China, where the disease is called "Hun-pox."
- **1519** Hernando Cortes and his crew spread smallpox to Mexico, which decimates the Aztec population.
- **1157 B.C.** Smallpox kills Egyptian Pharaoh Ramses V. Two centuries earlier, Egyptian prisoners caused the first known smallpox epidemic when they were captured by the Hittites in Syria.
- **1017** A hermit in China introduces mild cases of smallpox into humans to build immunity (variolation).
The virus that causes smallpox is a DNA virus. Outbreaks of smallpox have occurred in the human population for thousands of years. A successful program of worldwide vaccination eliminated the disease, and routine vaccination was stopped. For a closer look at the history of the discovery of the virus that causes smallpox and smallpox vaccination, examine Figure 12.

**Viral Infection**

To replicate, a virus must enter a host cell. The virus attaches to the host cell using specific receptors on the plasma membrane of the host. Different types of organisms have receptors for different types of viruses, which explains why many viruses cannot be transmitted between different species.

Once the virus successfully attaches to a host cell, the genetic material of the virus enters the cytoplasm of the host. In some cases, the entire virus enters the cell and the capsid is broken down quickly, exposing the genetic material. The virus then uses the host cell to replicate by either the lytic cycle or the lysogenic cycle.
**Lytic cycle** In the lytic cycle, illustrated in Figure 13, the host cell makes many copies of the viral RNA or DNA. The viral genes instruct the host cell to make more viral protein capsids and enzymes needed for viral replication. The protein coat forms around the nucleic acid of new viruses. These new viruses leave the cell by exocytosis or by causing the cell to burst, or lyse, releasing new viruses that are free to infect other cells. Viruses that replicate by the lytic cycle often produce active infections. Active infections usually are immediate, meaning that symptoms of the illness caused by the virus start to appear one to four days after exposure. The common cold and influenza are two examples of widespread viral diseases that are active infections.

**Lysogenic cycle** In some cases, the viral DNA might enter the nucleus of the host cell. In the lysogenic cycle, also illustrated in Figure 13, the viral DNA inserts, or integrates, into a chromosome in a host cell. Once integrated, the infected cell will have the viral genes permanently. The viral genes might remain dormant for months or years. Then, at some future time, the viral genes might be activated by many different factors. Activation results in the lytic cycle. The viral genes instruct the host cell to manufacture more viruses. The new viruses will leave the cell by exocytosis or by causing the cell to lyse.

Many disease-causing viruses have lysogenic cycles. Herpes simplex I is an example of a virus that causes a latent infection. This virus is transmitted orally, and a symptom of this infection is cold sores. When the viral DNA enters the nucleus, it is inactive. It is thought that during times of stress, whether physical, emotional, or environmental, the herpes genes become activated and the production of viruses occurs.

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**DATA ANALYSIS LAB 1**

**Model Viral Infection**

Is protein or DNA the genetic material?  
In 1952, Alfred Hershey and Martha Chase designed experiments to find out whether protein or DNA provides genetic information. Hershey and Chase labeled the DNA of bacteriophages—viruses that infect bacteria—with a phosphorus isotope and the protein in the capsid with a sulfur isotope. The bacteriophages were allowed to infect the bacteria E. coli.

**Think Critically**

1. **Analyze and Conclude** Do the results of these experiments support the idea that proteins are the genetic material or DNA is the genetic material? Explain.

2. **Infer** If proteins and DNA had entered the cell, would these data be useful to answer Hershey and Chase’s question?

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**Data and Observations**

- At least 80 percent of the sulfur-containing proteins stayed on the surface of the host cell.
- Most of the viral DNA entered the host cell upon infection.
- After replication inside the host cell, 30 percent or more of the copies of the virus contained radioactive phosphorus.

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**Based on Real Data**  
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Visualizing Viral Replication

Figure 13
In the lytic cycle, the entire replication process occurs in the cytoplasm. The viruses’ genetic material enters the cell, and the cell replicates the viral RNA or DNA. The viral genes instruct the host cell to manufacture capsids and assemble new viral particles. The new viruses then leave the cells.

In the lysogenic cycle, the viral DNA inserts into a chromosome of the host cell. Many times, the genes are not activated until later. Then the viral DNA instructs the host cell to make more viruses.

- **Attachment:** Virus attaches to bacterial cell.
- **Entry:** Viral DNA enters bacterial cell.
- **Provirus formation:** Viral DNA becomes part of the bacterial chromosome.
- **Replication:** The bacterial cell makes more viral DNA and proteins.
- **Assembly:** New viral particles assemble.
- **Release:** New viruses leave host cell.
- **Lytic Cycle**
- **Lysogenic Cycle**
- **Cell division**

**Concepts in Motion** Animation