2.3 Viruses

virus a microscopic particle capable of reproducing only within living cells

Did you notice that viruses do not appear in the six-kingdom classification system presented in section 2.1? Taxonomy provides a framework for examining existing living systems and comparing modern organisms with extinct forms. Viruses (Latin for "poison") do not display the essential characteristics of living cells. A **virus** is a lifeless particle that carries out no metabolic functions on its own and cannot reproduce on its own; however, once it invades a living cell, it is capable of reproduction. On this basis, viruses occupy a position between nonliving and living matter.

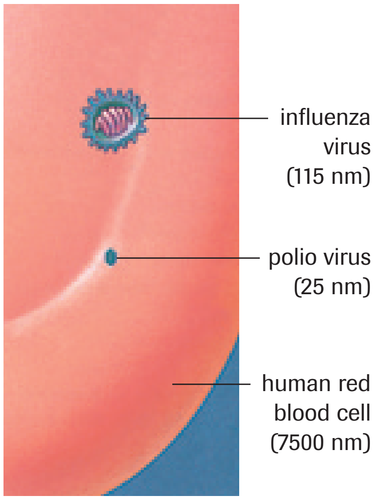

Figure 1
Comparative sizes of viruses and the human blood cell. Each virus is composed of hundreds of thousands of large protein molecules, which surround a core of nucleic acids.

It was not until the 1950s that an early electron microscope enabled scientists to view viruses (**Figure 1**). A virus is so small that it must be measured in units called nanometres (nm). One nanometre equals one-billionth of a metre (10^{-9} m). Viruses range in size from about 20 nm to 400 nm in diameter. Because it is difficult to visualize such small measurements, imagine more than 5000 influenza viruses fitting on the head of a pin.

A virus is far less complex than the simplest living organism. It consists of an inner nucleic acid (DNA or RNA) core or strand, surrounded by an outer protective protein coat called a **capsid**. The capsid accounts for 95% of the total virus and gives the virus its particular shape (**Figure 2**). **Bacteriophages**, also referred to as phages, are a category of viruses known as "eaters of bacteria" that have a unique tadpole shape with a distinct head and tail region.

capsid the protective protein coat of viruses

bacteriophage a category of viruses that infect and destroy bacterial cells

host range the limited number of host species, tissues, or cells that a virus or other parasite can infect

While viruses must enter cells to carry out life processes, not every virus is a killer. The tobacco mosaic virus, which infects the leaves of the tobacco plant, does not appear to destroy plant tissue on any large scale. Generally, viruses are selective; specific viruses enter only specific cells. This is called the **host range**, the number of host species, tissues, or cells that can be infected by a virus or other parasite. Some animal viruses have a broad host range. For example, the swine flu virus can infect hogs and humans; the rabies virus can infect many mammals including rodents, dogs, and humans. Other viruses have a very narrow host range. For example, the human cold virus usually infects only the cells of the upper respiratory tract, and HIV affects the immune system because it attaches only to a specific site on the surface of certain types of white blood cells.

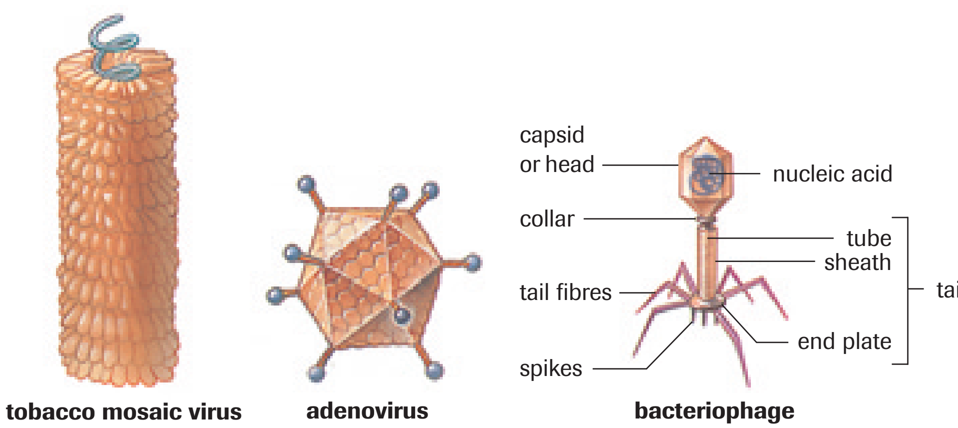

Figure 2
The protein coat, or capsid, of a virus may display various geometric shapes.

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Viral Replication

Replication, the process by which the virus and its genetic material are duplicated before a cell divides, occurs in a variety of ways, but there are generally four basic steps:

1. Attachment and entrance: The virus chemically recognizes a host cell, attaches to it, and enters it (**Figure 3**). Either the whole virus or only its genetic material (for certain viruses, this can be DNA or RNA) enters the cell's cytoplasm.
2. Synthesis of protein and nucleic acids: Molecular information in the viral DNA or RNA directs the host cell in replicating viral components (nucleic acids, enzymes, capsid proteins, and other viral proteins).
3. Assembly of the units: The viral nucleic acids, enzymes, and proteins are brought together and assembled into new virus particles.
4. Release of new virus particles: The newly formed virus particles are released from the infected cell, and the host cell dies. This is called **lysis**.

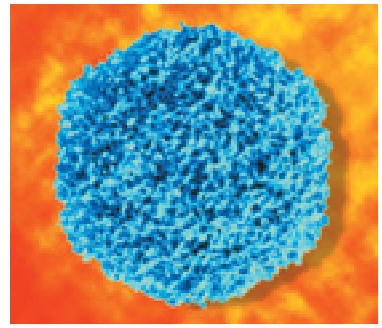

Figure 3
The common cold virus, rhinovirus, contains 60 sites capable of connecting to a receptor on human cells.

lysis the destruction or bursting open of a cell. An example is when an invading virus replicates in a bacterium and many viruses are released.

The entire process, known as the lytic cycle, may be completed in as little as 25 to 45 min and produces hundreds of new virus particles under laboratory conditions.

Certain types of viruses, such as those that cause cancer or those that infect bacteria, have a lysogenic cycle. The virus does not kill the cell outright. It may coexist with the cell and be carried through many generations without apparent harm to the host. As above, the virus enters the host cell. Instead of taking control, its nucleic acid becomes integrated into the bacterium's DNA and acts as an additional set of genes on the host chromosome. Then it is replicated along with the host DNA and passed along to all daughter cells. During this period of normal replication, the virus appears to be in a dormant state, called **lysogeny**. Often the dormant virus may be activated by a stimulus, such as an environmental change to a bacterium (e.g., temperature or pH), or some other event such as changes in available nutrients. This triggers the lytic cycle, and once again new virus particles are formed and released. **Figure 4** shows both the lytic and the lysogenic cycles.

lysogeny the dormant state of a virus

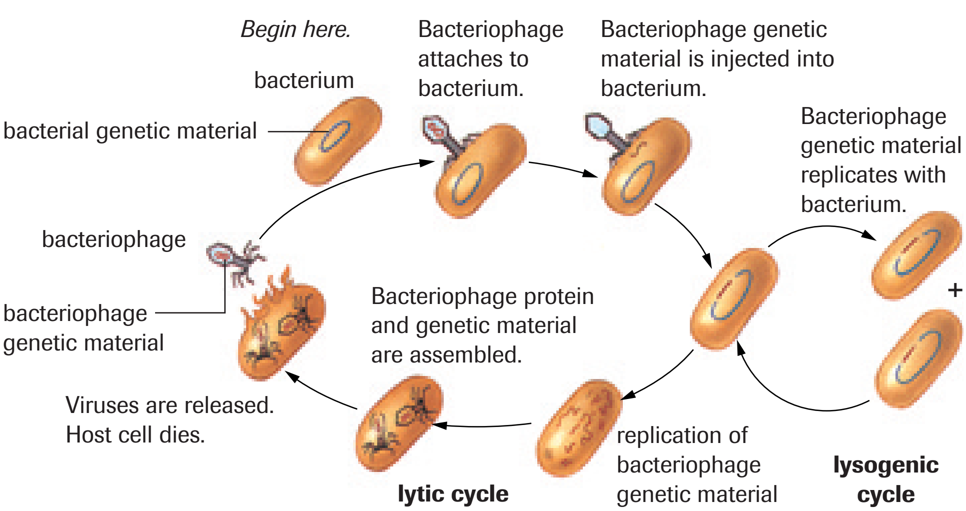

Figure 4
Viral replication

Viruses and Human Health

In many diseases caused by viruses (**Table 1**), the virus attacks cells as it reproduces. The destruction of these cells causes symptoms of the disease. Unfortunately, most viral infections are difficult to treat, as they are not destroyed by **antibiotics**, the substances that inhibit the growth of microorganisms. As well, some viruses remain dormant in the body for years before disease symptoms appear. Certain viruses cause cancer by adding specific genes to an infected cell, thereby turning it into a cancer cell. **Vaccines** are liquid preparations of dead or weakened viral or bacterial cells that stimulate the body's immune system to fight back. Some viral (and bacterial) diseases can be prevented with vaccines (e.g., polio, smallpox, hepatitis B). Vaccines are given orally or by injection (inoculation).

antibiotic a chemical produced synthetically or by microorganisms that inhibits the growth of or destroys certain other microorganisms

vaccine a suspension prepared from dead or weakened viral or bacterial cells

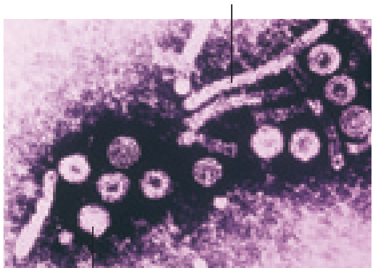

Figure 5
An electron micrograph of two forms of the hepatitis B virus, isolated from the blood of an infected patient. Only the polyhedral forms are infectious.

Table 1 Examples of Human Viral Diseases

Organism	Disease(s)	Transmission
DNA viruses		
Epstein-Barr	infectious mononucleosis	direct contact, airborne droplets
poxviruses	smallpox	direct contact, airborne droplets
varicella-zoster	chicken pox	direct contact, airborne droplets
RNA viruses		
enteroviruses	polio, infectious hepatitis (**Figure 5**)	direct contact, fecal contamination
rhinoviruses	common cold	direct contact, airborne droplets
paramyxoviruses	measles, mumps	direct contact
rhabdoviruses	rabies	bite by infected animal
orthomyxoviruses	influenza	direct contact, airborne droplets
retroviruses (HIV)	AIDS, some cancers	direct contact
flaviviruses (West Nile)	encephalitis	mosquito vector
caliciviruses (Norwalk)	gastroenteritis	direct contact, fecal contamination
coronavirus	SARS (severe acute respiratory syndrome)	direct contact, airborne droplets

Influenza—A Representative Virus

Influenza, or "flu" for short, has affected humans for centuries. Derived from the Italian word for "influence," the flu was originally thought to be caused by a bad influence from the heavens. Although this viral infection is usually considered to be more annoying than dangerous, flu, accompanied by pneumonia, is the sixth leading cause of death in North America.

The influenza virus was identified in the 1930s, and its structure was seen with the electron microscope in 1943. Like all viruses, the influenza virus consists of a nucleic acid core, with single-stranded RNA, inside a capsid (**Figure 6**). Rigid protein spikes radiate from a spherelike body about 20 nm in diameter. Physical and chemical differences result in three flu types: A, B, and C. Strains of influenza are described by the protein coat, the year of isolation, and the geographic location.

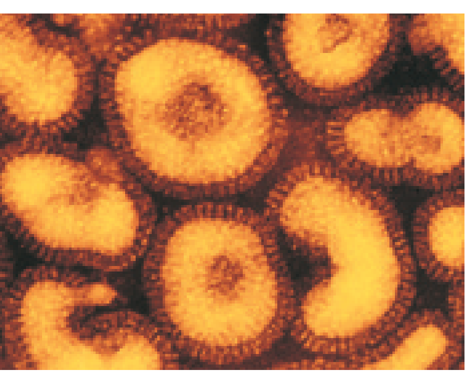

Figure 6
Micrograph of the influenza virus, magnified about 150 000 times

The influenza virus is spread by direct contact and can live for hours in dry mucus. Respiratory tissues of the lungs and the throat are the first hosts for the flu virus (**Figure 7**). If ciliated cells in the upper respiratory passages are destroyed, the lining can no longer sweep mucus and foreign particles out of the body. A sore throat and congested lungs may be the first signs of the infection. Accompanying symptoms may include chills, fever (up to 40°C), muscle aches and pains, sweating, fatigue, and nausea and vomiting. Pneumonia, bronchitis, and sinus or ear infections are three examples of complications from the flu.

The flu is highly contagious from one day before symptoms appear to up to seven days later. Symptoms start one to four days after the virus enters the body and may persist for up to two weeks. Treatment for the flu is rest, liquids, and medication to relieve symptoms. Remember: Antibiotics are ineffective against viruses.

The influenza vaccine can be up to 90% effective in preventing illness from a specific influenza virus. The influenza vaccine is highly recommended for the young, the elderly, health and child-care workers, and people of any age with chronic medical conditions. Because the protein in the viral coat evolves as the virus moves from country to country, the vaccine can become less and less effective. New vaccines must be developed and administered each year.

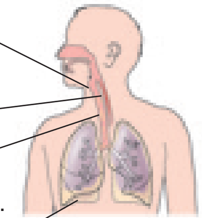

Figure 7
How a flu virus affects the body

Section 2.3 Questions

Understanding Concepts

1. Why aren't viruses placed within the normal classification system?
2. Name two human diseases caused by (a) RNA viruses and (b) DNA viruses. How is each transmitted?
3. The symptoms of many viruses come and go within 24 h. Use viral replication information to explain why this is the case.
4. What is the difference between a nanometre and micrometre? Draw a scale to illustrate this difference.
5. Label the capsid, the core, and the location of DNA in the diagram of the hepatitis B virus (**Figure 8**). Describe the shape and appearance of each.

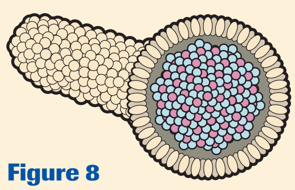

Figure 8

Applying Inquiry Skills

6. During the summer and fall of 2002, the West Nile virus advanced north into Canada. This virus replicates in birds, is transmitted by mosquitoes, and can be spread to humans. Canadian Blood Services impounded all blood supplies collected during this time. Hypothesize on why this action was taken.
7. The numbers of deaths attributed to AIDS in various countries in 1999 are listed in **Table 2**. What conclusions can you draw from these figures? What accounts for the difference in numbers? What additional information would help you analyze these data?

Table 2

Country	Number of deaths attributed to AIDS in 1999
Brazil	18 000
Canada	400
China	17 000
India	310 000
Nigeria	250 000
Russia	850
United Kingdom	450
U.S.A.	20 000

Making Connections

8. "Five million Canadians get sick with the flu every year, resulting in 1.5 million workdays lost. The flu costs the Canadian health care system about $1 billion a year." Interpret these statements by identifying the costs and suggesting solutions to this problem.
9. Current research indicates that multiple sclerosis (MS) may be caused by a slow-acting virus. If this is the case, why might environmental factors (e.g., sunlight, stress) have an effect on the severity of MS symptoms?
10. The hepatitis B virus (HBV) is transmitted through activities that involve contact with blood or body fluids. Research this disease to prepare a fact sheet. Cover the following topics: signs and symptoms; risk and occurrence; prevention; treatment; trends and statistics; connection between HBV and HIV.

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