# 2.1.0 Viruses

## LOOKING AHEAD

- For **Lesson 2.1.1**, plan a field trip to see a working electron microscope.
- For **Lesson 2.1.2**, invite a doctor to speak about viral infections.
- For **Lesson 2.1.3**, obtain prepared slides of specific viruses. Invite a medical professional to speak about precautions used in the medical field to prevent the spread of viruses.

## SUPPLEMENTAL MATERIALS

- TM 2.1.1A Viruses
- Lab 2.1.3A Virus Infection
- WS 2.1.1A Virus Research
- WS 2.1.2A Virus Attack!
- WS 2.1.3A Viral Vocabulary
- Chapter 2.1 Test

## Chapter 2.1 Summary

Scientists continue to debate whether or not viruses are living things. This debate strikes at the foundational question of life science: What is life? Scientists are no closer to determining if viruses are alive today than they were when they first viewed viruses with the help of electron microscopes in the 1930s.

Viruses reproduce, assemble, and mutate; they possess genetic materials and proteins found only in living things. Despite these characteristics, many scientists do not consider them to be living things. Viruses are not made of cells, the basic unit of structure of all living things, and they are much smaller than even the tiniest cell. In addition, viruses cannot mutate or reproduce outside of host cells; in order to make more viruses they must seize control of the biological processes that direct the host cells' ribosomes. Viruses do not take in nutrition. They are inert particles by themselves; however, in the host cell they take over the host's metabolism, using the host's molecular parts and energy to replicate the virus DNA or RNA and the protein coat. These parts self-assemble, after which they leave the host cell through various means to repeat the process in other cells.

Viruses "grow" by replicating unit particles, which are all the same size. Once replicated, viruses do not increase in size. One of the amazing things about viruses is that once the component parts are made by host ribosomes and DNA polymerase enzymes, the parts self-assemble.

Although viruses may not be considered living things, no recent biology or life science textbook excludes them. If viruses were innocuous, they would be relegated to the status of biological anomalies. But because viruses cause some of the worst diseases that humanity has known, it is essential that the mysteries surrounding these tiny organisms or particles be solved.

## Background

### *Lesson 2.1.1 – The Structure of Viruses*

Viruses present biologists with a question that involves the very roots of the life sciences: Are viruses life-forms? Although viruses do not have long nucleic acids like other living things, some do contain DNA or RNA polymerase, enzymes that catalyze RNA or DNA production. Their DNA or RNA strands are sheathed in viral capsules, or capsids, shells of protective protein coatings ranging in size from 17 nm to 300 nm. In a host cell, viruses can reproduce and self-assemble. They can mutate into different forms. They utilize the enzyme processes and organelles of their host cells to replicate more DNA and RNA strands and to produce new protein coverings.

But many scientists do not consider viruses to be life-forms. Viruses cannot replicate by themselves. In order to reproduce, they must control and subvert the biological processes of the host cells, which then direct the production of new viral DNA or RNA. Only inside living cells can viruses replicate and self-assemble. Viruses lack complex nucleic acids that are characteristic of other organisms, and they have a structure made primarily of a protein with a chemical simplicity foreign to any other life-form. Viruses are much smaller than cells, which are the smallest recognized units of life. Viruses are able to survive in a crystallized, dormant form for years outside their host cells.

There are many different types of viruses, and each has unique features. Larger viruses made up of 180,000 nucleotides are more complex than small viruses made up of around 5,000 nucleotides. The simplest viruses are composed of single strands of DNA or RNA and a protein coat. The proteins making up viruses are acidic. Their one significant characteristic is their repeating subunits. For example, the tobacco mosaic virus (TMV) is composed of 2,100 identical peptide chains. DNA or RNA strands are located on the interior of virus particles.

Efforts to classify different strains of viruses have been only partially successful because viruses are often classified by the type of organism they infect. One broad classification system divides

viruses into bacterial, animal, and plant viruses. According to this system, families of animal viruses are further divided into strains that infect vertebrates and those that infect invertebrates. Many virus families, however, contain individual viruses that infect both vertebrates and invertebrates. The bacterial viruses are called *bacteriophages* or *phages*. Plant viruses are divided into major groups instead of families. Another classification system divides viruses into two separate groups according to the composition of their genetic material so one category includes all the DNA viruses and the other includes all the RNA viruses.

### *Lesson 2.1.2 – Virus Reproduction*

Viruses are incapable of reproduction unless they are in host cells. Once a virus penetrates a host cell, the virus's nucleic acid takes over the cell's biological process and redirects the cell's reproductive capabilities toward producing new viral parts. The virus then duplicates itself by directing the production of viral parts such as nucleic acid or protein coats. These parts are then assembled into new viruses. Depending on the virus, this duplication process occurs in the host cell's nucleus or cytoplasm. A few viruses, after assembly in the cells, are released by a budding process that involves the cell's membrane but does not destroy the host cell. Viruses use host cells' raw materials, metabolic machinery such as nucleotides and amino acids, and energy sources in the process of making new particles.

Retroviruses like HIV have a single strand of RNA. After a retrovirus penetrates a host cell, it employs a process that changes its single strand of RNA into a double strand of DNA. The virus then incorporates this DNA strand into the host's genetic material, making the virus's DNA message an inheritable feature of the host cell. Before any viral infection is detectable, the viral population must reach about $1 \times 10^9$ individuals, which takes about 30 generations or replicate cycles. All species of organisms undergo random mutations that slightly change their physical or chemical characteristics. Viruses, however, have a mutation rate 1 million times faster than organisms made of ordinary cells. Because viruses mutate so quickly, they adapt to infect new hosts.

### *Lesson 2.1.3 – Viruses and the World*

In the 1890s, the first virus was discovered, which was the tobacco mosaic virus (TMV), a plant virus that damages the leaves of the tobacco plant. Animal viruses are common both in the natural world and in domesticated animals. A well-known viral disease of mammals is rabies, which is caused by rhabdoviruses. The rabies virus moves from a saliva-infected wound to the central nervous system; the virus eventually enters the brain, where it destroys brain cells.

Viruses cause a wide range of human diseases. Some of these diseases are little more than a nuisance; others are fatal and can potentially reach epidemic proportions. The common cold, the most common human virus, is usually caused by rhinoviruses. Other human viral diseases include yellow fever, herpes, chicken pox, measles, hepatitis, and a host of respiratory and diarrheal infections. Viral infections account for up to 11 million deaths a year (not counting severe influenza epidemics).

Most life science subjects point directly to the goodness of God's creation. In later lessons of this unit, students will see that even bacteria are essential to life. Students may wonder if viruses are also part of the goodness of creation. Remind them, first of all, that all creation is infected with sin; God did not create viruses to wreak havoc. Also point out that as they learn more about creation, they will gain a new appreciation for things that once seemed useless or harmful (bacteria, for example). Researchers have discovered that viruses do play an important role in the world. Viruses are now being used in genetic engineering for crop improvements and in treatments for genetic diseases and cancer.

## WORLDVIEW

- The earth and everything in and on it was created with a purpose. All organisms were created with certain characteristics to exist within a specific environment. They were equipped by their Creator to have special survival skills that uniquely match the environments in which they live. These assertions are contrary to popular evolutionistic, adaptive theories. The Bible states that mankind was created with unique characteristics in order to have stewardship over all the earth. Viruses are just one area about which we still have very little knowledge. People are to use their God-given intelligence and mandate of stewardship to explore and care for all parts of the created Earth.

# 2.1.1 The Structure of Viruses



## OBJECTIVES

Students will be able to
- defend the arguments for and against considering viruses as life-forms.
- describe the basic characteristics of viruses.

## VOCABULARY

- **electron microscope** a microscope that uses a beam of electrons to produce magnified images
- **virus** a tiny particle that contains nucleic acid encased in protein

## MATERIALS

- Slips of paper with students' names, hat or box (*D*)
- TM 2.1.1A Viruses
- WS 2.1.1A Virus Research

## PREPARATION

- Obtain materials for *Try This* activities.
- Schedule a field trip to see an electron microscope. (*C*)

## TRY THIS

**Virus Model**
- *pipe cleaners, at least 4 per student*
- *plastic connecting bricks or other building materials*
- *construction paper*
- *tape*

**Virus Proportion**
- *meterstick*

## Introduction

Ask the class what it means to be alive. (**Possible answers: Something is alive when it is made of cells, eats, grows, reproduces, uses energy, and responds to its environment.**)

Display **TM 2.1.1A Viruses**. Ask questions on the basis of the images alone. Do viruses look alive? (**Answers will vary.**) Remark that viruses look a lot different from each other. What do they have in common? (**Possible answers: size, composition, behavior**)

## Discussion

- Discuss the basic characteristics of viruses.
  1. Virus sizes range from 17 nm to 300 nm, so they are much smaller than living cells. To give students a better idea of the size of viruses, measure something small, such as a pencil eraser or small fingernail. Then have students calculate how many 20 nm viruses could line up across that surface.
  2. They can only multiply inside living bacteria, animal, or plant cells.
  3. They lack the complex structures present inside living cells.
  4. Virus particles can remain dormant for years when outside a host cell.
  5. Their DNA or RNA is enclosed in a shell of protein.

- Explain the following information about electron microscopes: Electron microscopes serve two functions. They enable microbiologists to examine structures too small to be examined with light microscopes, and they can be used to study surfaces that emit electrons. Transmission electron microscopes supply a beam of electrons onto a condenser lens that concentrates the electrons on an image. Employing magnetic lenses, these microscopes yield the highest resolution and magnification. Electron microscopes have a magnification several hundred times greater than that of light microscopes. The highest useful magnification for light microscopes is about 1,000, but electron microscope's magnification can approach 1,000,000.

- Ask the following questions:
  1. What do you think scientists knew about viruses before electron microscopes? (**Possible answers: Viruses were a mystery. Scientists knew them by the effects they had on living things but not by their life functions or structure.**)
  2. How can electron microscopes help in the eradication of harmful viruses? (**Answers will vary but should include that by being able to see how viruses react in certain cells, scientists may understand how to prevent them from growing.**)

## Activities

A. Complete the *Try This* activities with students.

B. Assign **WS 2.1.1A Virus Research**. Have each student choose a virus that affects humans, animals, or plants. Encourage them to use the library or online resources. Students should begin by learning the shape and size of their chosen viruses. In their reports, students should draw the virus, label its parts, and include size information as well as identify what organism it affects and what kind of disease it causes.

C. Take a field trip to see a working electron microscope. Local universities or government laboratories, such as forensic labs, may offer tours for student groups.

D. Stage a short debate on whether or not viruses should be considered life-forms. Divide the class into two groups, Group 1 and Group 2. Arrange students' desks into two parallel lines with opposing sides facing each other. Provide time for students to list and develop the arguments supporting their side of the issue and to prepare specific rebuttals to the opposing side's

arguments. Before the debate, place slips of paper with students' names in a hat or box. Acting as moderator of the debate, draw a name of a student from Group 1 to present a specific argument for one side of the issue. Set a time limit. Score the student's argument on a scale of one to five. Allow Group 2 to choose a group member to give a rebuttal to the opening argument. Score the rebuttal from one to five. Then reverse the roles, drawing a name of a person from Group 2 to give its side's first argument. Next allow a team member from Group 1 time to give a rebuttal, closing the first round of the debate. Continue the debate for as many rounds as desired by drawing student names. Arguments should include the following:
**Arguments for considering viruses a life-form:** They have the ability to reproduce. They have the ability to survive off a host like a parasite. They contain proteins only found in living things. They have the ability to mutate into different forms. They have DNA or RNA.
**Arguments against considering viruses a life-form:** Viruses are not made of cells, which are the smallest recognized units of life. They have the ability to survive in crystallized form for years. They cannot reproduce, grow, or feed outside of a host. Viruses do not have both DNA and RNA. They lack cellular structures and cell membranes. Viruses are made primarily of protein.

E. Direct students to research the history of the development of the electron microscope.

F. Have students sketch a variety of viruses from electron micrograph images.

G. Challenge students to investigate infectious agents that are even smaller than viruses called *viroids* (strings of naked RNA) and *prions* (abnormally shaped proteins that are thought to be the infectious agents responsible for mad-cow disease or Creutzfeldt-Jakob disease).

**NOTES**

## 2.1.1 The Structure of Viruses

**OBJECTIVES**
- Defend the arguments for and against considering viruses as life-forms.
- Describe the basic characteristics of viruses.

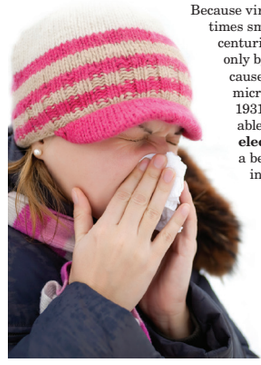
**VOCABULARY**
- **electron microscope** a microscope that uses a beam of electrons to produce magnified images
- **virus** a tiny particle that contains nucleic acid encased in protein

Have you ever had a virus? The answer must be yes because even if you have never had influenza or the chicken pox, you cannot have escaped the common cold. When people say they have a virus, they mean that they have an illness caused by a virus. Some of these illnesses are minor; others are serious. Today viruses can cause deadly diseases such as AIDS and hepatitis. Even though viruses are extremely small, they play a destructive role in the world.

What comes to mind when you hear the word *virus*? You probably think of feeling sick or of being vaccinated for measles or mumps, two illnesses caused by viruses. But what exactly are viruses? What are these things that can cause so much misery?

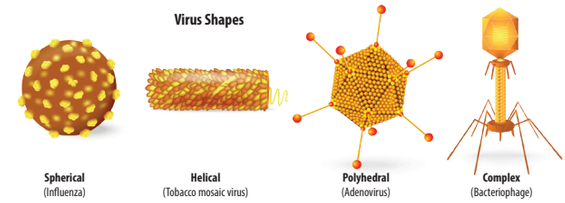
A **virus** is a tiny particle that contains nucleic acid—either DNA or RNA—encased in protein. Nucleic acids are organic compounds that contain genetic information and the information necessary for an organism to make the protein it needs. Some viruses are also surrounded by a membrane. Given all the trouble they cause, you might be surprised to learn how small viruses are. They are much smaller than the tiniest cell—only 17–300 nanometers. (A nanometer is one-billionth of a meter.) Tens of thousands of the largest viruses could line up in a centimeter.

**TRY THIS**
**Virus Model**
Construct a simple virus model. Twist two pipe cleaners to represent DNA or use single pipe cleaners to represent RNA strands of nucleic acid. Use plastic connecting bricks or other building materials to surround the virus and construction paper to surround the genetic material. Compare your virus to electron micrographs of actual viruses. In relation to the approximate size ratio of a virus to a cell, how large a cell would your virus infect?



Because viruses are about 300 times smaller than a cell, for centuries people knew them only by the diseases that they caused. But when the electron microscope was invented in 1931, microbiologists were able to look at viruses. An **electron microscope** uses a beam of electrons instead of light to detect objects, which allows objects as small as 0.5 nanometers in diameter to be seen. The electron microscope allowed scientists to see that just as each disease caused by a virus is different, so the size



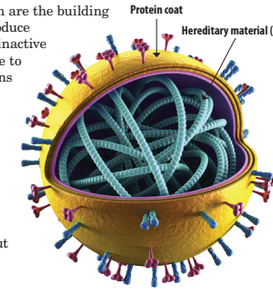



and shape of each virus is unique. In fact, a virus can be sphere-shaped, rod-shaped, spiral-shaped, or thread-shaped. Some viruses even look like tiny spaceships.

Despite everything that scientists know about viruses, they do not know the answer to one basic question: Are viruses living things? Viruses can reproduce and mutate, but only by infecting a living cell. They contain proteins that are found only in living things. Viruses also have genetic material—the RNA or DNA that a cell needs to reproduce itself. In these ways viruses are like living things.

**TRY THIS**
**Virus Proportion**
Imagine that your science room is a living cell. Using the approximate size ratio of a virus to a cell, make a square virus that infects this cell.

However, viruses are not made of cells, which are the building blocks of life. Viruses cannot mutate or reproduce outside of host cells. They can survive in an inactive form for years outside of host cells. They have to take control of cells to reproduce, which means they do not develop like other organisms do. A virus's genetic material resembles its host cell's genetic material more than it resembles the genetic material of other viruses. In these ways, viruses are not like living things.




The protein spikes that extend from the influenza virus mutate easily. That's why each flu season involves a different strain of influenza. People must build a new immunity with each mutation.

### LESSON REVIEW
1. How did the invention of the electron microscope help scientists learn more about viruses?
2. How are viruses like living things?
3. How are viruses not like living things?
4. Describe the basic characteristics of viruses.

NOTES

H. Ask students to research the etymology of the word *virus*. (**It's from the Latin *virus*, meaning "poison."**)

## Lesson Review

1. How did the invention of the electron microscope help scientists learn more about viruses? (**Viruses are too small to see under a regular microscope. The electron microscope allowed scientists to physically observe viruses.**)
2. How are viruses like living things? (**They have proteins; they reproduce and mutate; and they have genetic material.**)
3. How are viruses not like living things? (**They are able to reproduce and mutate only inside a host cell; they are not made up of cells; and they resemble their hosts more than each other.**)
4. Describe the basic characteristics of viruses. (**extremely small; can only multiply in living cells of bacteria, animals, or plants; lack structures found in living cells; can remain dormant for years outside a host cell; genetic material enclosed in a protein shell**)