VIRAL LYSIS AND BUDDING

OVERVIEW

This activity is part of a series of activities and demonstrations focusing on various aspects of the human immunodeficiency virus (HIV) life cycle. In this activity, students learn how viruses leave a host cell by either lysis or budding.

Viruses, a type of infectious agent, can cause disease in eukaryotic and prokaryotic organisms, including animals, plants, fungi, or bacteria. Some viruses (adenovirus, Norwalk virus, or papillomavirus) are characterized as "nonenveloped" or "naked." These viruses have a typical viral structure of a nucleic acid core surrounded by a protein coat (capsid). Other viruses (influenza, hepatitis A, Ebola, or HIV) are characterized as "enveloped." These viruses have the typical viral structure, but they have an additional coat comprised of proteins and lipids derived from the membrane of the infected host cell.

Students will explore an interactive that discusses some of the characteristics of viruses. They will then observe two demonstrations that illustrate how viruses exit cells. Enveloped viruses exit a cell by budding, taking the host cell membrane with them. In the first demonstration, this process is shown using a plastic bag filled with Styrofoam balls or Ping Pong balls. Nonenveloped viruses exit an infected cell by lysis, or by bursting out of and destroying the infected cell. In the second demonstration, this process is shown using a balloon filled with bits of paper.

This activity can be done on its own or following some of the other activities in the series, such as the integration activity or the reverse transcription activity.

KEY CONCEPTS AND LEARNING OBJECTIVES

- Viruses exit host cells by either lysis or budding.
- Through budding, part of the host cell membrane becomes part of the virus.
- Lysis destroys the host cell.

Students will be able to:

- explain the difference between nonenveloped viruses and enveloped viruses.
- describe two strategies that viruses use to exit infected cells.
- evaluate the limitations of models to illustrate biological processes.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (2013)	HS.LS1-1
AP Biology (2013)	2.B.3; 2.D.3; 3.A.1; 3.C.3; 4.A.1

KEY TERMS

Virus, enveloped, nonenveloped, protein, genome, capsid, lysis, budding, host, eukaryotic

TIME REQUIREMENT

This activity is designed to be completed in a 50-minute class period.

SUGGESTED AUDIENCE

This activity is appropriate for all levels of high school biology (Honors, AP, and IB).

PRIOR KNOWLEDGE

Students should know that viruses infect cells and replicate within host cells to produce more viruses. It would be helpful for students to be familiar with the basic structure of cells, including knowing that animal cells are surrounded by a lipid membrane embedded with proteins.

MATERIALS

Demonstration 1: Budding by Enveloped Virus

- Large Ziploc bag (1 gallon) to represent the host cell
- 4 to 8 Styrofoam balls (or Ping Pong balls) to represent virus particles
- 4 to 8 rubber bands to wrap at intervals around the individual Styrofoam balls inside the bag
- Scissors

Demonstration 2: Lysis by Nonenveloped Virus

- Large balloon (8" to 12") to represent the host cell
- Cut-up pieces of paper to represent virus particles. The pieces of paper must be small enough to insert into the balloon. You can also use confetti.
- Funnel (optional) to insert the pieces of paper in the balloon. If a funnel is used, be sure that the neck is wide enough for the small pieces of paper to fit through but small enough to fit into the mouth of the balloon.
- Pin to pop the balloon

PROCEDURE

1. Review students' answers to questions 1 to 6 in their worksheet.

2. Explain that you will model how an enveloped virus exits a cell. Carry out steps *a* to *d* below as shown in Figure 1.

Demonstration 1: Budding by Enveloped Virus

a. Place a single Styrofoam ball in a plastic bag. This step models a virus like HIV infecting a cell.
b. Inside the cell, the virus will replicate. Add three to seven additional balls to illustrate this step.
c. Once HIV has replicated and new virus particles form, they will bud from the cell surface, taking bits of the host cell membrane with them. To illustrate this step, wrap the plastic around each ball and keep it in place with a rubber band. Make sure the rubber band is tight.
d. Cut the bag below the rubber bands and release the balls. Call attention to the fact that each ball is covered with a section of the plastic bag.

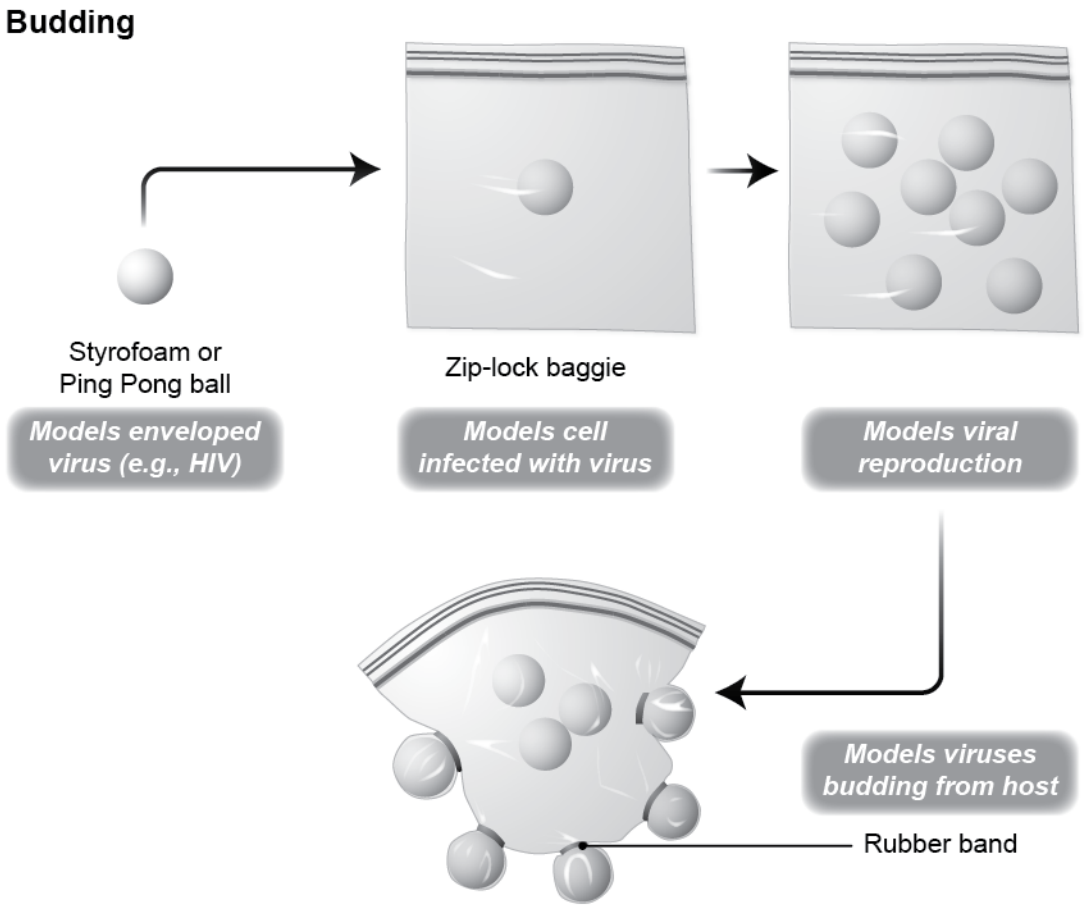

Figure 1. Model of how an enveloped virus budding from a host cell.

3. Watch the animation of the HIV life cycle at https://www.hhmi.org/biointeractive/hiv-life-cycle. Discuss with students the differences between this model and how HIV actually exits from a cell. Show students that there are holes in the Ziploc bag where the scissors were used to cut off the budding virus. When viruses bud from cells, the cell membrane closes around where the virus was, so there isn't a hole in the cell membrane (at least not at first; once thousands of viruses have bud, then a lot of the membrane gets used up and may develop holes as the cell dies).

4. Tell students that you will now model how a nonenveloped or naked virus exits from a cell by a process known as lysis. Carry out steps *a* to *d* below as shown in **Figure 2**.

Demonstration 2: Lysis by Nonenveloped Virus

a. Cut up pieces of paper. You will need about 100 pieces of paper for a good effect. Be sure to cut the paper small enough to easily slip through the neck of the balloon. This should be done before class. (Note that you can also use confetti for this demonstration.) Static electricity may cause the small pieces of paper to become attracted to the balloon (both inside and out). Position the pile of cut pieces away from the balloon so that they do not become attracted

but close enough for you to gather several at a time.
b. Insert the pieces of paper in the balloon. After inserting a few, gently blow into the balloon to move the pieces out of the neck before adding more.
c. After adding at least 100 pieces of paper, finish blowing up the balloon and knot it shut. Then, give it a couple of shakes.
d. Hold the balloon high up over students' heads and pop it using the pin. Make certain to get everyone's attention when you are ready to pop the balloon. It happens very quickly and the pieces scatter quite a distance.

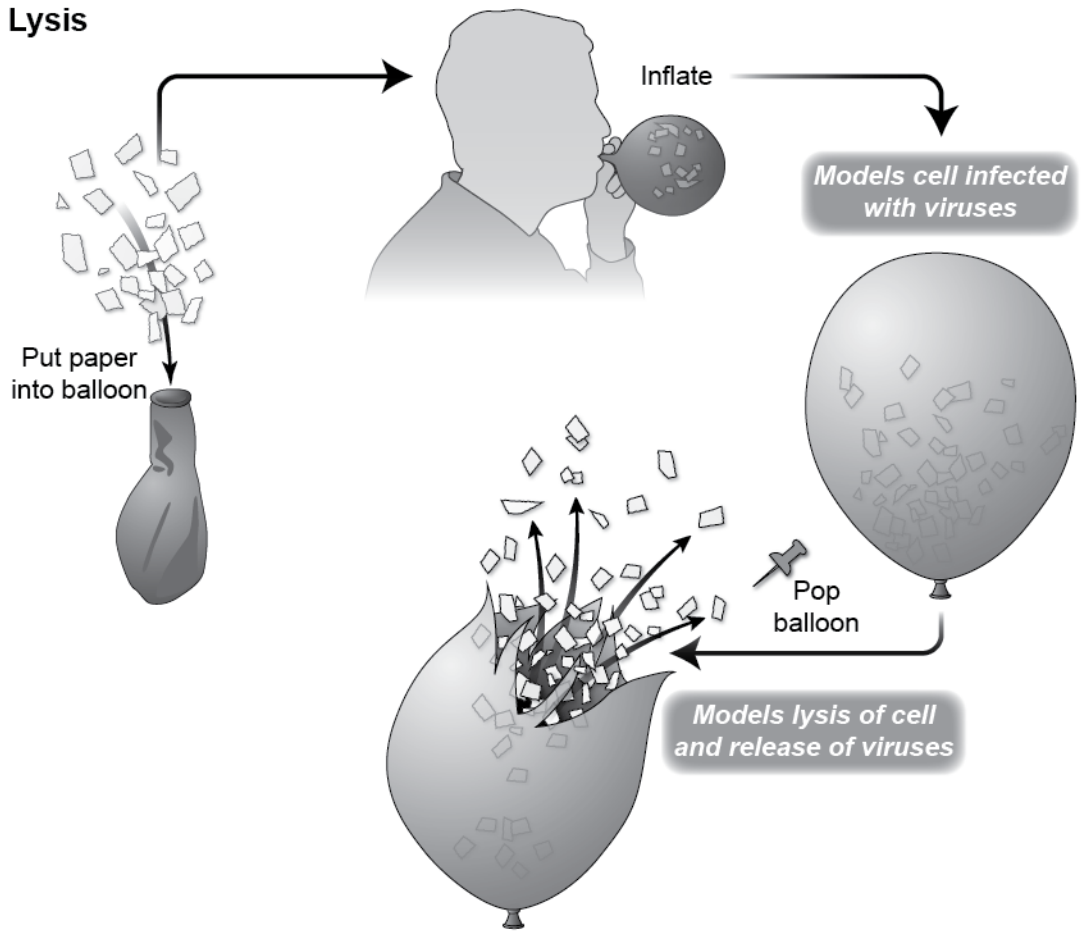

Figure 2. Model of how a nonenveloped virus exits a cell by lysis.

TEACHING TIPS

- Students can complete the *student handout questions 1-6* for homework before class or in class. Students should explore different types of viral structure and how viruses cause disease by using the HHMI interactive "Virus Explorer" (https://www.hhmi.org/biointeractive/virus-explorer) to investigate the different types of viruses. *Student handout questions 4-6* are based on this online resource.
- Question 9 in the handout requires students to calculate relative size. Depending on the level of your students, you may want to have them work on the question as a class exercise.
- After the first demonstration, students are asked to watch an animation of the virus life cycle. If students have done any other activities in this series, they will have already seen this animation and you may just skip to the section at the end where HIV buds from the cell. Explain that the membrane is made primarily of lipids and closes back up when the virus is released.
- This activity provides an opportunity to discuss the limitations of models. One limitation in the first model is that the budding seems to imply that holes are left in the cell membrane as the virions exit, which is not accurate. Also the relative sizes of the virus particles and cells are not accurate. Models are however useful in illustrating general concepts, such as the key differences between lysis and budding.
- Review with students the differences between lysis and budding. Budding does not cause complete destruction of the host cell, meaning it continues to produce more viruses. Each newly synthesized virus now has part of the host cell's membrane around it, forming an envelope. Because the virus is enveloped in the host's cell membrane, it is more difficult for immune cells to recognize the virus and eliminate it (although the host's antibodies can bind to viral proteins embedded in the envelope). On the other hand, because nonenveloped viruses do not have a cell membrane around them they are more resistant to heat, acids, and drying. Nonenveloped viruses can persist on surfaces, for example, for a longer time.

ANSWER KEY

1. List three to five distinguishing characteristics of viruses.

Answers will vary, but students may say that viruses are tiny, are not composed of cells, can cause disease, infect cells, and are parasites. Students in more advanced classes may say that viruses consist of genetic material (DNA or RNA) and proteins and that they replicate using host cell proteins. Students may also say that viruses are not considered to be living organisms. Some may also mention that infections causes by viruses cannot be treated with antibiotics.

2. List three to five distinguishing characteristics of living organisms.

Answers will vary, but students may say that living organisms possess a cell membrane and genetic material, have the capacity to convert and use energy (ATP), and are able to reproduce on their own (which is good for further discussion, as not all living organisms can successfully reproduce). A living organism undergoes birth and death. While alive, it carries out metabolic activities and generates the molecules necessary for life. They can grow by increasing in size and/or number. Students may also mention that living organisms excrete excess substances and the waste products of metabolism.

3. Provide evidence from your answers above to support a claim that

a. viruses are living organisms.

Students may mention that viruses are able to reproduce and some viruses have a cell membrane. They contain genetic material

b. viruses are not living organisms.

Viruses are not able to reproduce on their own. They are also unable to collect and use energy on their own.

4. List three characteristics used to classify different types of viruses.

Students should mention structure, type of genetic material, the organisms it infects, and whether it has an envelope.

5. What is a viral envelope? Where does it come from?

The viral envelope is a membrane that surrounds some types of viruses. It comes from the host cell's membrane.

6. Select one enveloped and one nonenveloped (naked) virus and then complete the chart below.

Virus name	Shape	Enveloped (Yes or No)	Genome (DNA or RNA)	Which organism(s) does it infect?	Does it cause disease?
Influenza A	spherical	Yes	RNA	Humans, pigs, other mammals, and birds	Yes
papillomavirus	icosahedral	No	DNA	Many different organisms	Some types yes, including cancer

7. a. In this demonstration, what represents the virus particles?

The Styrofoam balls are the virus particles.

b. What represents the host cell?

The plastic bag represents the host cell.

8. When a new virus particle is released from the cell, what does it have surrounding it? Be specific.

A piece of host cell membrane.

9. a. A human blood cell, which is the type of cell infected by HIV, is about 10 micrometers (µm) in size. HIV is about 120 nanometers (nm) in size, or 0.12 micrometers. About how many times smaller is the virus compared to the blood cell?

It's about 100 times smaller.

b. Is the demonstration an accurate representation of the relative size of the virus versus host cell? Explain your answer.

No. The Styrofoam balls are not 100 times smaller than the plastic bag.

10. Identify one important difference between how the virus was shown to exit the cell in the demonstration and how the virus is actually released from the infected cell.

Students should mention that in the demonstration, the plastic bag (cell) is left with holes. In reality, when HIV buds from a cell it does not cause holes to form.

11. a. In this demonstration, what represents the virus particles?
The pieces of paper represent virus particles.

b. What represents the host cell?
The balloon represents the host cell.

12. What happens to the cell when a nonenveloped virus is released?
The cell is destroyed.

13. In summary, what are the two strategies that viruses use to exit infected cells? Write a sentence to describe each one.
The two strategies are budding and lysis. [add sample sentences for the descriptions?]

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