The History of Vaccines Lesson Plan: Viruses and Evolution

Overview and Purpose: The purpose of this lesson is to prepare students for exploring the biological basis of vaccines. Students will explore the nature of viruses, specifically their structure and ability to adapt through evolution. This lesson plan gives you a one-period class option (Part 1) and a two-period class option (Parts 1 and 2). Both options give students the chance to explore information and graphics that describe the nature of viruses and how they evolve. Additionally, Part 2 of the lesson plan includes modeling activities to engage students in a process of science and to enhance their understanding of complex concepts.

Grade Level: Grades 9-12
Estimated Time Allotment
Part 1: One 50-minute class period
Part 2: One 50-minute class period

Curriculum Focus: Biology, Health

Learning Objectives
After completing Part 1 of this lesson, students will be able to:

- describe a **virus** as a nonliving **pathogen** that consists of a **nucleic acid** and a protective coat
- describe the protective coat of a virus as a **capsid** made up of protein molecules
- identify **evolution** as the outcome of change in the genetic makeup of organisms
- recognize the nucleic acid of a virus as either **DNA** or **RNA**
- recall that DNA is the **genetic material** in cells and that RNA assists with the process of **protein synthesis**

After completing Part 2 of this lesson, students will be able to:

- describe the ability of a nucleic acid to replicate and to undergo changes in its **nucleotide-base sequence**
- relate permanent changes in nucleic acids to **mutations**
- differentiate the mutability of an RNA virus from that of a **DNA virus**
- describe the structure of an **RNA virus**
- explain that some viruses develop a **viral envelope** made of host cell membrane as well as viral proteins and **glycoproteins**
- describe the reproductive cycles of influenza viruses that enable them to evolve through either antigenic shift or antigenic drift

Standards Addressed
National Science Education Standards
Unifying Concepts and Processes: Systems, order, and organization; Evidence, models, and explanation; Evolution and equilibrium; Form and function
CONTENT STANDARD A Science as Inquiry: Abilities necessary to do scientific inquiry; Understandings about scientific inquiry
A.1.f Communicate and defend a scientific argument.
A.2.a Scientists usually inquire about how physical, living, or designed systems function.
CONTENT STANDARD C Life Science: The cell, The molecular basis of heredity, Biological evolution
C.1.c Cells store and use information to guide their functions.
C.2.a In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T).
C.2.c Changes in DNA (mutations) occur spontaneously at low rates.
C.3.a Species evolve over time.
CONTENT STANDARD E Science and Technology: Understandings about science and technology
CONTENT STANDARD F Science in Personal and Social Perspectives: Personal and community health; Science and technology in local, national, and global challenges
CONTENT STANDARD G History and Nature of Science: Science as a human endeavor, Nature of scientific knowledge, Historical perspectives

Health Standards

National Health Education Standards

Health Education Standard 1: Students will comprehend concepts related to health promotion and disease prevention.

1. students will analyze how behavior can impact health maintenance and disease prevention
4. students will analyze how the family, peers, and community influence the health of individuals
7. students will analyze how public health policies and government regulations influence health promotion and disease prevention

Health Education Standard 3: Students will demonstrate the ability to access valid information, products, and services to enhance health.

1. students will analyze the role of individual responsibility for enhancing health
6. students will demonstrate ways to avoid and reduce threatening situations

Lesson Procedures

Teacher Background: Familiarize yourself with the different sections of the History of Vaccines website so that you can provide support to students as they work. All of the different sections are available from the main navigation bar. To access the Viruses and Evolution resources, click *Articles* and then *Disease and Infection Information* in the upper-left menu. Additional information about viruses, evolution, and immunity can be found at Kimball's Biology Pages, an online biology textbook by John W. Kimball @ http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/.

Teacher Preparation:

- Plan to have the students use the Internet during class.
- Locate the Viruses and Evolution article and preview the sources *Evolution from a Virus's View* and *HIV: The Ultimate Evolver* listed at the bottom of the article.
- Make copies of the recording sheets, one per student. The reproducibles are found at the end of this document.
- Email vaccines@collegeofphysicians.org to receive answers to questions on recording sheets. Type **Worksheet Answers** in the subject line. If you do not email from a school district address, then provide a school phone number.
- Before Part 2, assemble an adequate number of kits of modeling materials in plastic zipper bags. Suggested materials per group of 2 or 3 students include: 1 hollow-core ball (e.g., tennis ball, foam ball, paper-mache cast, etc.) with a wedge-shaped opening cut out to model the virus's protein coat, an assortment of pipe cleaners of different colors to models viral RNA molecules, and a variety of push pins of different shapes and colors to model the surface proteins and antigens.

Part 1: Opening Activity – Introduce Viruses and Evolution

Time: 10 minutes

1. Introduce the topic of viruses and evolution by leading a class discussion. Remind students that viruses are pathogens, which are disease-causing agents. Ask students, *What are some other kinds of pathogens?* Students should recall that some bacteria, protozoans, and fungi are pathogens. Ask, *What do these three kinds of pathogens have in common?* Students should understand that all are living organisms and that each of these pathogens consists of at least one cell, the structural and functional unit of life.
2. Explain that viruses are not cells. Ask students, *If viruses are not cells, are they alive?* Encourage students to justify their opinions with examples of how viruses have some characteristics of life (e.g., a chemical composition based on organic macromolecules, genetic material, and the ability to evolve) but lack others (e.g., metabolism, growth and development, ability to self-reproduce, ability to respond to stimuli, and ability to maintain homeostasis).
3. Prompt students to recall the process of change over time, or **evolution,** that occurs in living things. Students may also identify this process as "natural selection." Clarify that selection--both artificial and natural--is a mechanism that drives change in living things and that it works through interactions between the environment and the genetic material of living things. Students may wonder if something that is not

alive is capable of evolving. Assure them that viruses are indeed capably of evolving. As they learn more about the structure and behavior of viruses, they will see why.

Read About and Discuss Viruses and Evolution

Time: 30 minutes

1. Divide the class into groups of three or four. Tell the students that they will be using web resources to explore viruses and evolution.
2. Assign each small group of students one of the following sources found in the links listed at the end of the Viruses and Evolution article.
   a. *Evolution from a Virus's View*
   b. *HIV: The Ultimate Evolver*
   Explain that all groups will read the first four paragraphs of the *Viruses and Evolution* article before they read and discuss their assigned sources.
3. Give each group the appropriate recording sheet(s) to complete as they read and discuss their assigned sources. Let students know that they are responsible for gathering information and reporting to the class what they have learned. Circulate among the groups as they work, ensuring that they stay on task and are finding what they need.

Part 1: Closing Activity

Time: 10 minutes

Have groups of students (at least one for each source) summarize what they learned from their reading. Tell them they may use their recording sheets as a guide. Encourage other groups to add to or clarify information given about each of the readings.

Part 2: Opening Activity—Introduce Molecular Genetics and Viruses

Time: 5 minutes

1. Ask students to name the parts of a virus. Students may recall that viruses consist of a nucleic acid core surrounded by a protective protein coat. Ask students, *What is an example of a nucleic acid?* Students should recall that DNA and RNA are nucleic acids. Ask, *How are nucleic acids important to organisms?* Be sure students understand that the genetic material of life on Earth consists of nucleic acids.
2. Ask students to recall the roles of nucleic acids in cells and that changes in the nucleotide-base sequences of nucleic acids, called **mutations,** are common. Then ask, *Why is it so hard to eradicate viral diseases? Why do think researchers have been unable to develop vaccines for significant viral diseases such as AIDS?* Students should be able to relate a possible cause to the nature of nucleic acids and the processes of natural selection that lead to evolution. Explain that the way viruses adapt to and interact with their living hosts is an excellent example of evolutionary change.

Part 2: Exploring and Modeling the Structure of a Virus

Time: 15 minutes

1. Divide the class into groups of two or three. Tell students they will be using web resources to explore the structure of viruses. Explain that they will begin by reading paragraphs five and six of the Viruses and Evolution article.
2. Give each group the appropriate recording sheet(s) to complete as they read and discuss the assigned article. Let students know that they will be using the information they learn about influenza viruses to build a model of an influenza virus.
3. As groups finish the reading assignment, distribute a set of modeling materials (influenza virus kit) to each group. Explain that each kit contains a ball with a wedge-shaped opening, several pipe cleaners of different colors, and an assortment of pushpins of different shapes and colors. Tell students that the ball represents the protein coat of an individual virus, a pipe cleaner represents the RNA strand in the influenza viral core, and the pushpins represent the viral surface proteins. Instruct students to use the web graphics and articles as guides for building their viruses. Emphasize that students must make a key

that identifies what the different colors of pipe cleaners and colors and shapes of pushpins represent (e.g., RNA molecules with different genes and specific kinds of surface proteins). Circulate among the groups as they work, ensuring that they stay on task and have the resources they need.

Part 2: Modeling Evolution in Influenza Viruses

Time: 20 minutes

1. Tell students that they will now continue exploring web resources related to viruses and evolution. As groups finish their models of an influenza virus, have two or three of the smaller students groups form larger working groups. Assign each group one of the following sections of the Viruses and Evolution web article.
   a. Antigenic Drift (including the graphic resource)
   b. Antigenic Shift (including the graphic resource)
2. Give each group the appropriate recording sheet(s.) Let them know they are responsible for gathering information and reporting to the class what they have learned.
1. Give students about half the allotted time to read and discuss their assigned section of the Viruses and Evolution article and its related web graphics.
2. Encourage students to use the models of influenza viruses they made earlier to model the evolutionary process they were assigned. Some students may be confused about how to show the genetic variation among influenza viruses. If so, explain that genetically different virus particles can be made by using different combinations of the two types of surface proteins. Also explain that students can combine pieces of differently colored pipe cleaners to show recombination of the genes on RNA strands.

Part 2: Closing Activity

Time: 10 minutes

Have each group of students report on what they learned, using their recording sheets as a guide.

Parts 1 and 2: Assessment

- Anecdotally observe students during whole group discussions and independent work.
- Assess content knowledge by evaluating students' recording sheets and oral reports. Email vaccines@collegeofphysicians.org to receive answers for recording sheets.
- Part 2 only: Have students describe the outcome of the modeling activities in a brief, written report. In the report, students should state the strengths and weakness of their models and summarize their opinions about the usefulness of the models in understanding viral evolution.

Extensions

- Have students read and discuss the link *Influenza Viruses*, found in the links listed at the end of the *Viruses and Evolution* article.
- Hold a class debate about recent efforts by governments and health agencies worldwide to avoid and deal with influenza pandemics. Ask students to debate whether flu vaccination should be mandatory for certain populations (such as health care workers or schoolchildren).
- Invite students to investigate the structure of HIV and its infection cycle by reading *Recombination in HIV: An Important Evolutionary Strategy*, found in the sources listed at the end of the Viruses and Evolution article.

Viruses and Evolution, Part 1

1. What natural processes have shaped viruses?

2. What are the three parts of a pathogen's "job"?

   a.

   b.

   c.

3. Briefly, what is one way that hosts protect themselves from a pathogen such as a virus?

4. What may happen to a viral lineage if the viruses kill their hosts?

5. How do viruses adapt to a host's immunity?

6. What is the advantage of constantly changing viral surface proteins?

Web Article: Evolution from a Virus's View

1. How would a virus describe itself?

2. How would a virus describe its pathogenic characteristics that destroy cells and make a host feel sick?

3. Name four transmission strategies viruses have developed for escaping a host's immune system.

   a.

   b.

   c.

   d.

4. What is the evolutionary trade-off between virulence and transmission?

5. Why, from an evolutionary standpoint, did improving sanitation reduce the virulence of the cholera pathogen?

Web Article: HIV: The Ultimate Evolver

1. What may be a way to control the spread of the human immunodeficiency virus, or HIV?

2. What two factors contribute to the fact that HIV is one of the fastest evolving entities known?

   a.

   b.

3. Which other viruses is HIV closely related to?

4. What is an important difference between HIV infections and SIV and FIV infections?

5. What is CCR5?

6. Where is the protective mutant CCR5 allele most prevalent and least prevalent?

7. Why does treatment for HIV involve the use of “drug cocktails”?

Viruses and Evolution, Part 2

8. How are influenza viruses and HIV similar?

9. Are DNA viruses or RNA viruses more stable and less likely to evolve new forms through mutation? Explain.

10. Why do RNA viruses evolve so quickly?

11. What is the basic structure of an influenza virus?

12. What causes evolution in influenza viruses?

ANTIGENIC DRIFT:

13. What are HA and NA?

14. What does the designation H1N1 refer to?

ANTIGENIC SHIFT:

15. What are the three main types of influenza viruses?

16. Which type of influenza virus evolves through antigenic shift? What is the key to its ability to do so?

17. Describe the two ways in which antigenic shift occurs.

    a.

    b.

18. Why didn't the 2003 outbreak of bird flu become a pandemic?

