The History of Vaccines Lesson Plan: The Scientific Method in Vaccine History

Overview and Purpose: The purpose of this lesson is to familiarize students with the history of vaccination and the use of the scientific method in the development of vaccines and the study of infectious disease. Explain that in this lesson, students will explore the processes that health officials and researchers use in identifying agents of infectious disease, the source of an infection, and how the infection spreads. Additionally, Part 2 of the lesson plan includes a role-playing activity to engage students in the use of the scientific method in a disease outbreak investigation. This lesson plan gives you a one-period class option (Part 1 or Part 2), a two-period class option (any combination of Parts 1, 2, and 3), and a three-period class option (Parts 1, 2, and 3).

Grade Level: Grades 9-12
Estimated Time Allotment
Part 1: One 50-minute class period
Part 2: One 50-minute class period
Part 3: One 50-minute class period

Curriculum Focus: Biology, Health

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

- describe the importance of vaccination to the development of human society
- identify historic milestones in the development of vaccination procedures and vaccines
- recognize the names of pioneers in the development of vaccines
- list the steps in the development and licensing of vaccines

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

- explain how public-health officials study the sources and spread of infectious diseases
- list the main steps of the scientific method as it is applied to the study of infectious disease
- model the development and revision of scientific explanations
- describe the importance of public-health activities in improving the health of the members of a community

After completing Part 3 of this lesson, students will be able to:

- design a scientific investigation of vaccine safety and effectiveness

Standards Addressed
National Science Education Standards
Unifying Concepts and Processes: Systems, order, and organization; Evidence, models, and explanation
CONTENT STANDARD A Science as Inquiry: Abilities necessary to do scientific inquiry; Understandings about scientific inquiry
A.1.a Identify questions and concepts that guide scientific investigations.
A.1.b Design and conduct scientific investigations.
A.1.d Formulate and revise scientific explanations and models using logic and evidence.
A.1.e Recognize and analyze alternative explanations and models.
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 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. Students will:

4. analyze how the family, peers, and community influence the health of individuals
7. analyze how public health policies and government regulations influence health promotion and disease prevention
8. analyze how the prevention and control of health problems are influenced by research and medical advances

Health Education Standard 2: Students will demonstrate the ability to access valid information, products, and services to enhance health. Students will:

1. evaluate the validity of health information, products, and services.
2. demonstrate the ability to evaluate resources from home, school, and community that provide valid health information.

Health Education Standard 4: Students will analyze the influence of culture, media, technology, and other factors on health. Students will:

1. analyze how cultural diversity enriches and challenges health behaviors.
3. evaluate the impact of technology on personal, family, and community health.
4. analyze how information from the community influences health.

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 Scientific Method resources, click *Educators*. Explore the information and links on the page.

Teacher Preparation:

- Plan to have the students use the Internet during class.
- Locate the resources for The Scientific Method in the History of Vaccination (see below for specifics).
- 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.
- Preview the many video clips available in the *Gallery* section of the HOV website for other media to use to enrich students' understanding of the use of the scientific method in the study of vaccines.

Part 1: **Opening Activity–Introduce the History of Vaccination**

Time: 10 minutes

1. Introduce the topic of vaccination by asking students to recall some of the diseases for which children are routinely vaccinated. Answers may include measles, mumps, polio, and tuberculosis. Ask, *Which of these diseases commonly occurs in the United States?* Students should recognize that today, none of these diseases is common in the U.S because of the practice of vaccination. Tell students that in this lesson, they will be learning about the history of vaccination and the use of the scientific method in the study of infectious disease and the development of vaccines.
2. Show the video clip "Plotkin and the Role of Vaccination" found in the Gallery section of the HOV web site. Explain that the speaker is Stanley A. Plotkin, MD, Emeritus Professor of Pediatrics at the University of Pennsylvania, who developed several vaccines in use today. Tell students that they will find many other videos that present the views of renowned researchers in the field of vaccinology in the Gallery

Read About the History of Vaccination and Vaccine Development

Time: 30 minutes

1. Have all students explore the contributions of some of the researchers who developed early vaccines, using the History of Vaccines timelines. Tell students they can access the information by clicking TIMELINES in the main navigation bar and then clicking *Pioneers*.

2. Divide the class into groups of three or four. Tell the students that they will be using web resources to explore the history of vaccination and vaccine development.
3. Have all student groups read and discuss the article *The Scientific Method in Vaccine History* found under History and Society of the *Articles* section of the HOV website.
4. Give each group the appropriate recording sheet(s) to complete as they read and discuss the assigned article. 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 the resources they need.
5. Also assign each small group of students one of the following articles found under Vaccine Information in the menu of the *Articles* section.
   a. *Vaccine Side Effects and Adverse Effects*
   b. *Government Regulation*
   c. *Vaccine Development & Licensing Events*
   Explain that each article brings together elements of the overall timeline for the history of vaccines. Tell students that all groups will read and discuss their assigned articles. Have the groups take notes on the articles and give a brief oral summary of each article to the class, using their notes.

Closing Activity

Time: 10 minutes

1. Have groups of students view the *Breakthroughs* section of the History of Vaccines timelines. Tell students they can access the timeline by clicking TIMELINES in the main navigation bar and clicking *Breakthroughs*.
2. Have students view the video clip "Combined MMR vaccine" (in the 1971 entry), in which Maurice Hilleman, PhD, who developed many vaccines, including those for measles and mumps, gives some perspective on the importance of vaccines.

Part 2: **Opening Activity—Introduce the Scientific Method**

Time: 10 minutes

1. Tell students that in this part of the lesson, they will learn about how the scientific method is used in studying the spread of disease. Ask, *What is the scientific method?* (Responses will vary.) Emphasize that it is a systematic way of asking and answering questions in science.
2. Have students prepare for the activity by reading the article *Identifying Pathogens & Transmission Vectors* under Vaccine Science in the *Articles* section of the HOV website.

The Scientific Method Activity

Time: 40 minutes

1. Divide the class into groups of two or three. Have students access The Scientific Method simulation by clicking ACTIVITIES on the main navigation bar. Explain that students will have 30 minutes to complete the simulation, in which they will act as the Director of Public Health for a city.
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 responsible for the information they learn about the scientific method. Circulate among the groups as they work, ensuring that they stay on task and have the resources they need.
3. Have each group of students report on what they learned, using their recording sheets as a guide. Encourage other groups to add to or correct information given by other groups, as needed.

Part 3: Opening Activity—Introduce Improving Research Methods

Time: 5 minutes

1. Tell students that they will now continue exploring web resources related to the use of the scientific method in the development and testing of vaccines. Explain that after reading an article on vaccine development, they will use what they have learned about modern methods of investigation to update the research protocol used by a famous inventor of an important vaccine.

2. Show students the video clip "Plotkin and the Future of Immunization" found in the Gallery section of the HOV website.

Vaccine Development, Testing, and Regulation

Time: 20 minutes

1. Have each small group of students read and discuss the article Vaccine Development, Testing, and Regulation found under the heading Vaccine Information in the menu of the *Articles* section. Have each group make a list of points and questions about the information in the article that they would like to discuss with the class as a whole.
2. Conduct a class discussion of the article in which students may pose their questions for discussion and ask for clarification of the information.

Improving Research Methods in Vaccine Development

Time: 20 minutes

1. Tell students that they are going to work in their small groups to update Jenner's protocol for testing the effectiveness of his smallpox vaccine by adding the elements of a control group, randomization, and double-blinding. First, though, let them know that contemporary research guidelines and ethics prevent researchers from try to infect healthy humans with diseases in vaccine tests. Rather, for studies involving humans, experimental and control groups are observed for signs of illness, and research subjects may be tested to see if they have developed a certain immune response. Ask students to adhere to this requirement in their designs.
2. Tell students they can use the information they gathered on their recording sheets and the original resources from the HOV website to design a new trial for the smallpox vaccine. Then give them time to work.
3. Have each group create an outline that describes their new experimental design.

Closing Activity

Time: 5 minutes

Have each student complete the matching game "Pioneer Breakthroughs" on the ACTIVITIES page.

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 3 only: Have students submit their brief report describing how they would modify Jenner's trial of his smallpox vaccine by adding randomization and blinding to his protocol.

Extensions

- Have students complete the miniactivity "Koch's Postulates" found on the ACTIVITIES page.
- Have students read and discuss the article *Cultural Perspectives on Vaccination*, found under the History and Society heading in the menu of the *Articles* section.
- Have students read and discuss the article *Ethical Issues and Vaccines*, found under the History and Society heading in the menu of the *Articles* section.

Scientific Method in Vaccine History

1. Why is there no single model of the scientific method?

2. Do scientists try to prove their ideas by using the scientific method? Explain.

3. What are the four main steps of the scientific method?

   a.

   b.

   c.

   d.

4. What are the qualities of a good hypothesis?

   a.

   b.

   c.

   d.

5. What three types of scientific studies?

   a.

   b.

   c.

6. What is the difference between the experimental group and the control group in an investigation?

7. How did Edward Jenner test the observation of a milkmaid that having cowpox protected a person from the deadly disease smallpox?

8. What was Robert Koch's method of identifying the cause of a disease?

9. What was Pearl Kendrick's contribution to the development of a scientific method for testing vaccines?

10. How did Jonas Salk's method of testing his polio vaccine improve the way new vaccines are tested?

Student Name: _____ The Scientific Method
Student Recording Sheet 2

The Scientific Method Activity

Overview

1. What problem will you be investigating with the scientific method?

2. What can cause the data an investigator collects to be compromised, or invalid?

Observation

3. Which of the four reports describe an illness that could be traced to a likely cause? Explain.

4. What were some similarities in the information contained in the other three reports?

5. What three steps did you take in gathering information about each case?

a.

b.

c.

6. Why did the expert recommend the use of the fastest methods for investigating the three cases?

7. What patterns were uncovered in the initial investigation?

Hypothesis

8. What qualities did the expert say that good hypotheses for this investigation should have?

9. What two possible causes of the outbreak did you choose to explore?

10. Why were the other two proposed diseases discarded as possible causes? Why?

11. Which hypothesis did you decide to investigate first? Why?

Testing & Experimentation

12. What laboratory tests are used to identify the pathogen in a disease outbreak?

13. Which test was chosen as the best one to use? Why?

14. What is the name for the study of how a disease spreads?

15. What are the two main methods used to study how a disease spreads?

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16. Which tool of epidemiology uses case histories of a control group, as well?

17. What were the results of the tests conducted?

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18. In which group were case histories and rapid PCR tests not performed? How are these cases being treated?

19. What was causing the illness among recruits and at the senior center?

Analysis & Conclusions

20. What did the odds ratios show about the spread of the disease among the affected groups?

21. What was the "unexpected finding" in the data?

22. What should you look for when you have an unexpected finding?

23. What was the cause of error in this investigation?