

First Shot — Vaccinations

Secrets of the Sequence Video Series on the Life Sciences • Grades 9 — 12
Teaching materials developed by VCU Life Sciences

V i r g i n i a C o m m o n w e a l t h U n i v e r s i t y

Classroom Tested Lesson

Video Description

“Secrets of the Sequence,” Show 121, Episode 1

“First Shot - Vaccinations” – approximately 11 minutes viewing time

Vaccines do protect us from diseases but are they all that benign? Vaccine protection may exact a price on both individual and public health. The question has become, which is more dangerous – the threat of smallpox or the actual smallpox vaccine?

Ward Television

Producer: Paul Gasek,

Featuring: Barry R. Bloom, Dean of Faculty, Harvard School of Public Health, David, M. Knipe, Microbiology and Molecular Genetics, Harvard Medical School

Lesson Author; Reviewers: Peggy Deichstetter; Catherine Dahl, Dick Rezba, and Kieron Torres

Trial Testing Teachers: Molly Shabica

National and State Science Standards of Learning

National Science Education Standards Connection

CONTENT STANDARD C: As a result of their activities in grades 9-12, all students should develop understanding of

- The cell
- Molecular basis of heredity
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

CONTENT STANDARD F: As a result of activities in grades 9-12, all students should develop understanding of

- Personal and community health
- Population growth
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Selected State Science Standards Connections

Use <http://www.eduhound.com> (click on “Standards by State”) or a search engine to access additional state science standards.

Virginia

- BIO.2 The student will investigate and understand the history of biological concepts. Key concepts include
a) evidence supporting the cell theory; and
c) causative agents of disease.
- BIO.5 The student will investigate and understand life functions of monerans, protists, fungi, plants, and animals, including humans. Key concepts include
e) human health issues, human anatomy, body systems, and life functions
- BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include
e) effects of genetic recombination and mutation;
- BIO.8 The student will investigate and understand how populations change through time. Key concepts include
c) recognizing how adaptations lead to natural selection; and
d) exploring how new species emerge

Illinois

Goal 12: Understand the fundamental concepts, principles and interconnections of the life, physical and earth/space sciences.

12. A Know and apply concepts that explain how living things function, adapt and change.

12. B Know and apply concepts that describe how living things interact with each other and with their environment.

Goal 13: Understand the relationships among science, technology and society in historical and contemporary contexts.

13. A Know and apply the accepted practices of science.

13. B Know and apply concepts that describe the interaction between science, technology and society.

Overview

This lesson addresses the need for vaccines, where vaccines come from, how vaccines work, the future of vaccines using genetic engineering and the economics of health, including vaccinations and pharmaceutical companies.

A need for protection from smallpox bioterrorism has made the United States re-evaluate its policy of vaccinating its population. Edward Jenner, an English physician, first developed the vaccination in 1796 after observing that farm workers who got cowpox did not get smallpox, a deadly viral disease that killed 40% of those infected. In 1977, after nearly two centuries, smallpox was considered eradicated from the world, so the US policy of vaccination for smallpox was terminated at that point. Unfortunately, the result is that there are many people alive today who have never been vaccinated against this disease and therefore would be vulnerable. With the threat of bio-terrorism should the US begin vaccinating for smallpox again?

In addition to smallpox which is a viral infection, other diseases we once thought conquered are re-emerging. Tuberculosis, a very tough bacteria that is not easily killed, now infects 8 million people. An antibiotic-resistant form can be found in many US cities. TB, Malaria, and AIDS are ravaging third world countries. Yet, drug companies earn no profits in developing vaccines for poor countries. How soon will these diseases re-emerge in epidemic form in the United States and other developed nations?

Complicating the issue of re-instituting certain vaccinations as well as continuing others is that in developed nations citizens have forgotten the terrors of disease epidemics. They now focus only on the possible negative side effects of the vaccines. Concern over these side effects has led many parents to refuse vaccinations for their children. This is a dangerous trend in light of the clear and present threats of bio-terrorism.

Vaccines work by tricking the immune system into believing it is being attacked. The immune system responds to the attack and produces antibodies that protect the body from future attacks. Recently, scientists have been genetically engineering vaccines for specific responses. For example, David Knipe at Harvard Medical School has genetically engineered a herpes virus that will live only for one generation. This is enough time to stimulate the immune system but not so long that the body is infected. Another innovation is to genetically engineer Killer-T cells to attack specific diseased cells in the body, leaving all healthy cells free. These new methods that address concerns over side effects may well lead to the development of a vaccine against cancer.

Testing: A sample related multiple choice item from State Standardized Exams

Edward Jenner (1749-1823) was a British physician whose research led to the elimination of the disease of smallpox. Smallpox is a contagious viral disease that infects the bloodstream of its victims. Smallpox was not always deadly, but it often left scars on its victims, who afterward were immune to the disease. Jenner noticed that farm workers who had been infected with a similar, but milder disease known as cowpox never caught smallpox. He administered a small dose of cowpox to a child, who proved immune to smallpox two months later.

Which of the following would be a control for Jenner's experiment?

- a person who had been infected with either cowpox or smallpox
- a person with cowpox who had already survived a smallpox epidemic
- a person who survived cowpox, but became infected with Lyme disease
- a person who had never had cowpox, but came in contact with smallpox *

Source: Michigan Standardized Exam, 2002

Video Preparation

Preview the video and make note of the locations at which you will later pause the video for discussion.

Before Viewing

1. Read the following excerpt from the September 22, 2003 Washington Post, page A10 written by David Brown

"A case of measles was once a rite of passage for every child, and a route to the grave for about one in every 300. Worldwide, there are still 30 million to 40 million cases a year, and 745,000 deaths, mostly in Africa. In the affluent world, however, measles have been as good as gone for a generation. But it is coming back in an unlikely place. In England, the number and size of measles outbreaks is steadily climbing. In 1996, the country recorded 112 cases. Last year (2002), there were 308. This follows a steady drop in the proportion of children immunized against the virus by their second birthday. In 1996, it was 92 percent. By last year, it had fallen to 84 per cent."

Ask the following questions and record students' responses on the board or an overhead transparency:

- a) Develop a hypothesis of why the number of measles cases in England is increasing.
- b) Were you vaccinated against measles? Why or Why not?
Note: Draw a table with 3 columns : yes/no/I don't know to fill in student responses.
- c) Why are parents choosing not to have their children vaccinated against measles?

2. Prepare a video worksheet or display the following questions on the board or screen for students to answer while they watch the video.
 - a) Where does the word vaccination come from?
*Vaccination comes from the Latin word **vacca** for cow. Jenner's vaccine came from cowpox.*
 - b) Why aren't pharmaceutical companies working on vaccines for Tuberculosis and Malaria? *There is little*

- or no profit in developing vaccines that will be used only in third world countries.*
- c) How do vaccines work? *They trick the immune system into believing the pathogen they are vaccinating against is attacking them.*

During Viewing

1. **START** the video.
2. **PAUSE** the video (9:00 minutes into the video) after Dr. Knipe says, "... and that will protect against real life infection at a later time." Tell students that Dr. Knipe of Harvard Medical School is working with a herpes vaccine. He plans on creating "an infection to prevent an infection".

Ask: "How does he plan to do this?"

*He has genetically engineered a herpes virus that can infect a second set of cells.
This virus will infect cells that in turn will activate the immune system.*

Ask: Think about the statement: 'creating an infection to prevent an infection'.

"Is this a revolutionary new idea? Why or Why not?" No, Edward Jenner infected people with cowpox to protect against smallpox over two hundred years ago.

Ask: "If Dr. Knipe is successful, how can this technology be used?"

Answers may vary but hopefully someone will see the possibility of using this technology on AIDS and other infectious diseases.

3. **RESUME** the video and play to the end.

Note: Although too many pauses may cause students to lose their focus, one trial test teacher found pausing at the explanation of the T and B cell immune response at 7:20 minutes into the video was helpful to students in their understanding.

After Viewing

1. Refer students to the board or overhead transparencies with their responses to the questions posed to them before viewing the video.

Ask: "Now that you have seen the videos, what would you change about your initial responses?"

2. Review students' answers to the questions given to them to answer while they were watching the video. There is a common misconception that antibiotics and vaccinations are the same thing.

Ask: "What is the difference between an antibiotic and a vaccine?" *An antibiotic is taken after a person is sick. It prevents bacteria from reproducing. It helps a person recover from a disease but gives NO immunity for that disease. A vaccine is a preventative (prophylactic) measure. It is usually given before a person gets the disease. It is a weakened, dead or genetically engineered form of a disease pathogen that shouldn't make the individual sick but should elicit an immune response. A vaccine gives immunity to the disease.*

Teacher Notes for the Student Activity: Epidemic - The Deadly Fuchsia Disease

Materials

1 test tube or small plastic cup for each student for each part of the activity
1 clean dropper for each student
0.1M NaOH
0.1M HCL, vinegar, or other weak acid
1% phenolphthalein

Chemical Information

1. **1% Phenolphthalein solution** can be purchased from scientific supply houses such as Ward's Natural Science. <http://wardsci.com/product.asp?pn=9465302>
2. **Sodium hydroxide solution, 0.1M**
Place 4g NaOH pellets in a 1 L flask and slowly add 50mL distilled water with constant swirling until dissolved. Avoid creating and breathing dust. Then add enough distilled water to bring the total to 1000mL.
Disposal: Place 250mL in a 1 L beaker. Slowly add 0.5M sodium bisulfate until neutrality is confirmed by litmus test. Place beaker in a sink and run water to overflowing for 10 minutes.
3. **Hydrochloric Acid, 0.1 M**
Slowly add 8 mL concentrated HCL to 500 mL distilled water in a volumetric flask and fill to the 100mL mark.
Disposal: Neutralize only small amount (< 250mL) at one time. Slowly add 1M sodium bicarbonate until neutrality is confirmed by litmus test. Place beaker in a sink and run water to overflowing for 10 minutes.

Additional safety precautions during the preparation and disposal of NaOH and HCL

- Use face shield over goggles
- Use rubber nitrile gloves
- Use fume hood
- Ensure eyewash station nearby
- Ensure safety shower in close proximity to dispensing activities
- Label both containers of NaOH and HCl: **CAUTION: Irritant**
- Use NaOH and HCl only with close teacher monitoring

First aid: Eye/skin contact: Immediately flush with large amounts of water for 15 minutes, including under eyelids, Contact physician if irritation persists.

Ingestion: DO NOT INDUCE VOMITING. If patient is conscious, give large amounts of water followed by dilute vinegar or fruit juice. Contact physician.

Part I

This is a simple simulation of an epidemic using the indicator phenolphthalein as the Deadly Fuchsia Disease (pH 8 clear - pH 10 Hot Pink). It spreads through the class at a geometric rate. Initial field-testing demonstrated the need for a *full* dropper of liquid to be used to infect the next student. When students used only a few drops, only a faint pink tint could be observed.

Set up - Each student in the class *except one* will need their own test tube of 0.1 M NaOH and a clean dropper (a small disposable plastic cup also works well). Select one student to be 'infectious'. Give the 'infectious' student a special test tube (or cup) and dropper with Phenolphthalein. Use a timer to cause the spread of infection every 5 minutes (or less). Record the number of newly infected and total infected students in each 5 minute period (representing a day).

Procedure - "Day" 1 (first 5 minute period *or less*): The teacher instructs the infectious student to infect two students by giving one *full* dropper of fluid from his/her test tube to each of the other students' test tubes.

NOTE: *Once a student has infected two others, assume that he or she is quarantined and does not continue to share his or her liquid.* Record 2 as newly infected and 3 (1 + 2) as total infected in the class data table (see below).

"Day" 2 (second 5 minute period): The two newly infected students from "Day"1 each infect two more students with droppers of their liquids. Those students not infected will have clear tubes, but once infected their tubes will turn pink. Students record the number of students who are newly infected (4) as well as the total number of students infected (1 + 2 + 4).

"Day" 3 (third 5 minute period): The 4 students who were infected on Day 2 are now infectious and each infects two new students. Students record the number of students who are newly infected (8) and the total infected (1 + 2 + 4 + 8).

"Day" 4 (fourth 5 minute period): The 8 students who were infected on Day 3 each infect two new students. Students record the number of students who are newly infected (16) and the total infected (1 + 2 + 4 + 8 + 16).

This infection causes individuals to remain ill for 5 days. After five days they either recover or die. (For example, on Day 5, the first student who has been ill for 5 days recovers or dies. On day 6 the two students who were ill from Day 1 either recover or die. And so on.)

Have students graph the number of infected individuals per day.

Answer key for Epidemic Part I for a class of 31 students

Day	Newly infected	Total Infected	Recovered or died
		1	
Day 1	2	3	
Day 2	4	7	
Day 3	8	15	
Day 4	16	31	
Day 5		30	1
Day 6		28	2
Day 7		24	4
Day 8		16	8
Day 9		0	16

Part II

The concept of **Herd Immunity** is simulated in Part II. Herd Immunity is the protection of a whole population by vaccinating a certain percent of the population. This activity shows that the epidemic is either stopped or slowed when 50% of the population is vaccinated. If the epidemic wasn't stopped at 50%, you might repeat the activity with a higher percent of vaccinated students. To help the student relate the idea of Herd Immunity to real life, turn the discussion back to measles in England. Because of the duration of the disease and the rate of transmission a minimum vaccination of 85% of the population is necessary to prevent an epidemic of measles.

The same procedure is used as in Part I, but this time 50% of the students have been vaccinated against the Deadly Fuchsia Disease.

Set-up - Once again the students receive test tubes or cups with a clear fluid. This time, however, half of the test tubes contain an acidic solution: 0.1M HCL or vinegar, and the other half contain 0.1M NaOH.

Procedure - The procedure continues the same as before but only newly infected students (those with pink fluid) share their fluids with others on the next "day". Once a student has attempted to infect two other students, assume that he or she is quarantined and does not continue to share his or her liquid. **Note, therefore, that if by chance only 'vaccinated' students received fluids from infected students, the 'epidemic' would end.**

"Day" 1 (first 5 minutes or less): The teacher instructs the infected student to infect two students by placing one *full* dropper of fluid from his/her test tube into two other students' test tubes. If they are infected, their tubes will turn hot pink. If not, they have been **vaccinated** and their tube will **not** turn pink. (Tubes remain clear but may cloud slightly depending on the concentration.) Students record the number of newly infected and the total infected in the class data table.

"Day" 2: The students who were **newly infected** on Day 1 (only those with pink test tubes) now attempt to infect two more students each. Record the number newly infected and the total infected.

"Day" 3: If any student were **newly infected** on Day 2, he or she now attempts to infect two new students. Record the number newly infected and the total infected.

"Day" 4: This procedure/epidemic continues until everyone in the class who was not vaccinated is infected or ends abruptly on any given day if only vaccinated students receive fluids, and hence can't continue the spread of the infection.

Answer key for Epidemic Part II for a class of 31 students (50% vaccinated)

Day	Newly infected	Total Infected	Recovered or died
		1	
Day 1	(answers will vary)		
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			
Day 9			

Have students graph the number of infected individuals per day.

Note: A trial test teacher suggested that the students draw this graph on the same paper as in Part 1 and that they should be reminded that they draw them on the same scale to facilitate comparison.

Follow-Up:

Have students answer the following questions:

1. Summarize what happens in your first graph:
 - a. Describe the graph
 - b. Explain what is happening in relation to the disease
2. Repeat question #1 for the second graph.
3. Compare your two graphs:
 - a. How are they different and/or the same?
 - b. Why are they different?
4. What would happen to the class epidemic if on any particular day only students who were vaccinated received fluid from infected students?
5. After doing this lab would you choose to have your children vaccinated against diseases? Why or why not?

Data and graph will vary. But in Part I all the students became ill at a geometric rate while in Part II the epidemic was either slowed or stopped by vaccinating a significant percent of the population (called herd immunity).

Optional Section

You may want to extend your students investigation of this topic with the following exercises: If so, make a handout for this section. Have students do all of them or pick one exercise to work on.

1. Herd Immunity for a specific disease is determined by four variables:
 - Virulence
 - Duration of infection
 - Rate of transmission
 - Level of immunity

Go to the following website:

<http://science.education.nih.gov/supplements/nih1/diseases/activities/activity4.htm> and determine the effect of each variable on Herd Immunity (preventing an epidemic).

Challenge

Explain how each variable affects the spread of a disease and thus the percent of people who need to be vaccinated to cause herd immunity.

2. There are numerous Web sites that claim vaccinations are unnecessary and dangerous. With your teacher's help, arrange a class debate on the issues related to vaccination.
3. You work for an advertising agency. Design a poster or commercial to tell people about the importance of vaccinations.
4. Have the students make a connected scatter-plot graph for Parts I and II on a graphing calculator. They can express each graph alone and then express them both together. After this they can connect their calculator to a computer and print out their graphs for a final project/lab/exhibition.

Student Handout: Epidemic-The Deadly Fuchsia Disease

Section 1

Safety: Wear your safety goggles

Procedure

1. How does a disease spread? In this activity you will see how a disease spreads through a community over several days. Each “Day” will last about 5 minutes.

Your teacher will give you each a container of a clear liquid and a dropper. One student in your class has been infected with the Deadly Fuchsia Disease. This student has just arrived from part of the world where Fuchsia Disease is *endemic* (widespread). On “Day” 1 the student who is infected will infect two other students by putting a **full** dropper of his or her clear liquid into their containers.

What happened to the liquid in the infected students’ containers?

2. For “Day” 1 record the number of newly infected students and the total infected in your data table.
 3. The next day the two newly infected students each infect two more students by giving them a *full* dropper of their liquid. Record the number of newly infected students and the total infected in your data table.
 4. Repeat step 3 until the whole class is infected. *NOTE: only newly infected students can infect additional students. Assume that previously infected students are quarantined and thus unable to continue infecting more students.*
 5. This disease causes an individual to be ill for five days. After five days, they either recover or die.
 6. Graph the number of infected individuals per day (use the data in the Total Infected column). Write a sentence or two that summarizes what happened.
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Day	Newly Infected	Total Infected	Recovered or died
		1	
Day 1	2		
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			
Day 9			
Day 10			

Section 2

Safety: Wear your safety goggles

Procedure

1. How can an epidemic be stopped?
2. In Part II of this activity you will see how a disease can be contained or stopped by vaccinating a percentage of the population. You may or may not be vaccinated for the Deadly Fuchsia Disease. You will know if you are vaccinated only after you are exposed to the infection.

Your teacher will give you another container of clear liquid and a dropper. Your teacher will decide which student in your class has been infected with the Deadly Fuchsia Disease. The student who is infected will infect two other students by putting a **full** dropper of his or her clear liquid into their containers. What happened to the liquid in the infected students' container?

If a change in a student's container is observed, the student is infected and can infect others the next "day". If no change is observed, the student was vaccinated and is not infected. Vaccinated students do not share liquid with other students.

3. Record the number of newly infected students and total infected students in your data table.
4. Every "day" each of the newly **infected** students (if there are any) infects two more students by giving them a *full* dropper of his or her liquid.
5. Repeat step 4 until no new student is infected in any one day. At that point the disease is contained.
6. This disease causes an individual to be ill for five days. After five days, they either recover or die.
7. Graph the number of infected individuals per day (use the data in the Total Infected column). Write a sentence or two that summarizes what happened.
8. _____

Day	Newly Infected	Total Infected	Recovered or died
		1	
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			
Day 9			
Day 10			

Follow-Up:

Answer the following questions:

1. Summarize what happens in your first graph:
 - a. Describe the graph

 - b. Explain what is happening in relation to the disease

2. Repeat question #1 for the second graph.
 - a.

 - b.

3. Compare your two graphs:
 - a. How are they different and/or the same?

 - b. Why are they different?

4. What would happen to the class epidemic if on any particular day only students who were vaccinated received fluid from infected students?

5. After doing this lab activity would you choose to have your children vaccinated against diseases? Why or why not?

Additional Resources

Because Web sites frequently change, some of these resources may no longer be available. Use a search engine and related key words to locate new Web sites.

<http://science.education.nih.gov/customers.nsf/HSDiseases?OpenForm>

Emerging and Re-emerging Infectious Disease

The National Institute of Health offers this free high-school curriculum supplement. Student activities include lab experiments with bacteria, accompanied by online video support for experiments.

<http://www.sc.edu/library/spcoll/nathist/jenner.html>

Edward Jenner and the Discovery of Vaccination

This is the Library of North Carolina University website; it gives the history of Edward Jenner and vaccinations.

<http://www.nlm.nih.gov/medlineplus/immunization.html>

Immunization

This is the Medline site that gives the latest research on vaccination and outbreaks of diseases.

<http://www.cdc.gov/nip/>

National Immunization Program

This is the Center for Disease Control website. Included in this site are diseases, vaccines, news and links to other resources.

Washington Post

Measles Cases Rebounding in Affluent Society

By: David Brown, Staff Writer

Monday, September 22, 2003

Genomic Revolution

http://www.ornl.gov/sci/techresources/Human_Genome/education/education.shtml

The Web site to the government-funded Human Genome Project with links about genomics, the history of the project, and more.

Secrets of the Sequence Videos and Lessons

This video and 49 others with their accompanying lessons are available *at no charge* from www.vcu.edu/lifesci/sosq