Vaccines and Health

Disease Snapshot

COVID HACKS
Healthy Actions • Community Knowledge • Science

FOR GRADES
9–12

OVERVIEW

Students learn about the impact of vaccines on human health by exploring one of the 16 diseases for which they have (or should have) received a vaccine. Student teams will share what they learned with the class. Informational text for students will provide them with additional information about new vaccines being developed for non-communicable diseases.

LEARNING OBJECTIVE

After completing the lesson module, students will be able to:

- Describe how vaccines have impacted human health.
- Describe how many contagious diseases are prevented by routine vaccinations in the U.S.
- Describe the types of diseases that are not prevented by vaccines and why they are not easily preventable.
- Describe how vaccines are being developed to treat non-communicable diseases.

COMMON CORE STANDARDS FOR ENGLISH LANGUAGE ARTS

- ELA-LITERACY.RST.9-10.1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

NGSS SCIENCE AND ENGINEERING PRACTICES

- Analyzing and interpreting data
- Obtaining, evaluating and communicating information

MATERIALS FOR SCIENCE INVESTIGATION

Each student will need:

- Digital or print activity sheet, Student Sheet A (*Vaccines and Health: Look What You are Missing!*)
- Electronic or paper reading article, Student Sheet B (*Vaccines for Everything? Not Quite*)
- MS Word file of *Vaccine Impacts Snapshot*
- Device with internet access

Teacher will need:

- Accompanying slides to guide student discussion

TIME

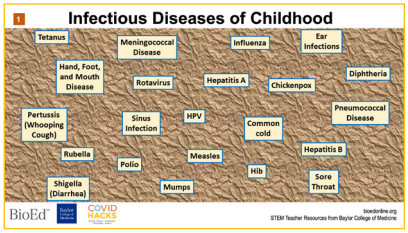
- 2 class periods

PROCEDURE

ENGAGE

1. Use the accompanying slides to engage students in a discussion about vaccines. Show Slide 1, Infectious Diseases of Childhood, and ask, *Have you heard of these diseases?* Accept all answers.

SLIDE 1



Infectious Diseases of Childhood

- *When you saw the list of vaccines that are recommended for people to get by age 18, were you surprised at how many there were?* Many vaccines are given when children are infants or toddlers, so you probably don't remember. But hopefully you remember getting a flu shot recently. This slide shows the common infectious diseases that can often affect children, according to the CDC.

EXPLORE

2. Distribute Student Sheet A (Vaccines and Health: Look What You are Missing!) electronically (or printed).

3. Have students read the first section of the sheet during class or as homework.

4. Next, direct students to work in teams or individually, select one of the following diseases and conduct literature-based research using resources from the CDC website. If you prefer, you may assign the different disease topics to students.

1. Chickenpox	**5.** Hepatitis B	**9.** Measles	**13.** Pneumococcal Disease
2. Diphtheria	**6.** Human Papillomavirus	**10.** Mumps	**14.** Rotavirus
3. Hib	**7.** Influenza (Flu)	**11.** Pertussis	**15.** Rubella
4. Hepatitis A	**8.** Meningococcal Disease	**12.** Polio	**16.** Tetanus

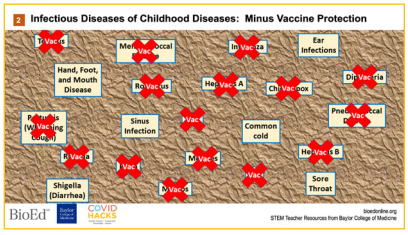
5. Students will use information from the CDC website (links provided in their student sheet). They will fill in a *Vaccine Impacts Snapshot* table about the disease they selected. This should be a brief assignment to engage their interest in the diseases they will not contract due to vaccines, not a comprehensive research report. Ideally, students should share their Snapshot tables so the class gets an overview of the variety of diseases prevented by their childhood vaccines.

EXPLAIN

6. During the next class session, have students present or share their disease Snapshots.

7. Use slides 2 and 3 in the accompanying slide deck to explain more about vaccines and disease prevention.

SLIDE 2



Infectious Diseases of Childhood Minus Vaccine Protection

- This is the same slide you saw earlier, but we have eliminated the infectious diseases from which children are protected by vaccines.
- As you can see, the remaining diseases make up a relatively short list: colds, sore throats, ear and sinus infections, diarrhea, and a viral disease called Hand, Foot, and Mouth disease (for the tiny blisters that form on those tissues). Although these infections can be uncomfortable, they are less likely to be life-threatening compared to diseases such as polio or measles.

- *Why don't we have vaccines for these diseases?* They are caused by a variety of microorganisms including both viruses and bacteria so creating a single vaccine would be difficult. However, a universal flu vaccine is in human trials now, so we may not have to get a vaccine every year in the future. *What about a common cold vaccine?* That will be harder since there are more than 160 different strains of rhinovirus and other viruses that cause colds in humans!
- Will you get other vaccines in your lifetime? Yes! In addition to annual flu shots, your doctor will recommend additional vaccinations for pneumonia and shingles as you get older. If you travel to different countries, you may need to get vaccines for diseases that are found there but not in the US (for example, yellow fever). And, in your lifetime, it is likely that your will have access to vaccines to treat or prevent cancer, heart disease, and other diseases that are not infectious.

SLIDE 3

Don't Forget the Animals

- We tend to think of vaccines created to prevent diseases in humans, but animals also receive vaccines.[1] By preventing diseases in animals, humans are also protected from contracting diseases that can pass from animals to humans (and visa versa) such as rabies.
- Vaccines also keep animals healthy. Vaccines protect our dogs from rabies, distemper, kennel cough and parvovirus. Cats are protected by both rabies and feline leukemia vaccines. Most agricultural animals get vaccinated, including pigs, cattle, horses, and poultry. Even salmon grown in farm tanks are vaccinated to protect them from a disease found among wild salmon. And don't forget the wildlife. Animals in zoos get vaccinated for rabies and other diseases to keep them healthy.

EXTEND AND EVALUATE

To extend the activity, have students look at two issues through a brief reading: 1) why we don't have vaccines for all communicable diseases; and 2) whether it is possible to make vaccines to treat non-communicable diseases. Make certain that students have electronic or paper copies of the article, Student Sheet B (*Vaccines for Everything? Not Quite*).

Conduct a class discussion of their findings, or ask students to summarize the key points that are explained in the article.

We tend to think of vaccines created to prevent diseases in humans, but animals also receive vaccines.[1] By preventing diseases in animals, humans are also protected from contracting diseases that can pass from animals to humans (and visa versa) such as rabies. (NCBI. Current Status of Veterinary Vaccines. 10.1128/CMR.00005-07.)

COVID HACKS
Healthy Actions • Community Knowledge • Science

COVID HEALTHY ACTIONS, COMMUNITY KNOWLEDGE AND SCIENCE

A SCIENCE-BASED CURRICULUM FOR THE COVID-19 PANDEMIC

We are grateful to Laura and John Arnold and other community donors for their generous support, which enabled development of the COVID HACKS curriculum materials. We also thank the many scientists, educators and physicians from Baylor College of Medicine (BCM) who provided content, feedback and technical reviews.

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STUDENT PAGE A

Vaccines and Health: Look What You Are Missing!

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LEARNING OBJECTIVES

After completing this exploration, you will be able to:

- Describe how vaccines have impacted human health.
- Describe how many contagious diseases are prevented by routine vaccinations in the U.S.
- Describe the types of diseases that are not prevented by vaccines and why they are not easily preventable.
- Describe how vaccines are being developed to treat non-communicable diseases.

VACCINES PREVENT MANY DISEASES

When was the last time you received a vaccination? It may have been an annual flu shot or a booster shot to prevent tetanus if you had an injury. But you probably have had a lot of vaccinations in your life. By age 18, in the United States you might have been vaccinated for more than 15 diseases![1]

Vaccines have transformed our world. Smallpox is a good example. Smallpox killed 400,000 Europeans each year in the 1700s, including five reigning monarchs. It killed large segments of the native populations in the Americas and Australia when it was brought accidentally by European explorers and settlers. More than 80% of children who got smallpox died. The development and worldwide distribution of an effective smallpox vaccine totally eradicated the disease in the US by 1949 and in the world by 1979. There is no cure for smallpox even today. The disease was defeated by vaccinating large portions of the world population. This created worldwide "herd immunity."

Herd immunity means that most people in a community are protected from getting a disease, because they've already had the disease or they've been vaccinated. Herd immunity makes it hard for the disease to spread from person to person, and it even protects those who cannot be vaccinated, like newborns.[2]

What about current diseases? The World Health Organization (WHO) states that, "Immunization currently prevents 2-3 million deaths every year from diseases like diphtheria, tetanus, pertussis, influenza and measles."[3] These are not exotic diseases. They are diseases that you could catch here in the US but are unlikely to do so. *Why not?* It is because you probably have been immunized against each of them.

1 https://www.cdc.gov/vaccines/schedules/easy-to-read/child-easyread.html
https://www.cdc.gov/vaccines/schedules/easy-to-read/adolescent-easyread.html
2 https://www.cdc.gov/coronavirus/2019-ncov/communication/vaccination-toolkit.html
3 https://www.who.int/health-topics/vaccines-and-immunization?gclid=Cj0KCQiAqdP9BRDVARIsAGSZ8AmJBarClOmnOFCEoHcOpd-bT6HVXqcch6BWH_4nkQG1wjHnATBiXEkaAtwBEALw_wcB#tab=tab_1

INSTRUCTIONS

1. Pick one disease (or the disease assigned by your instructor).

2. Go to the Centers for Disease Control and Prevention Website (www.cdc.gov).

3. Search for the disease you selected on the CDC website. Each disease has a page describing the disease.

4. Use the separate *Vaccine Impacts Snapshot* table to record your findings. Below, a sample has been provided for you; it describes smallpox. The sources listed below are considered accurate.

   a. **First Reported or Observed:** When was the first evidence of this disease. The website "The History of Vaccines" (https://www.historyofvaccines.org/) is a good source. You can filter their timeline by clicking on the green "FILTER" button on the right. Also try CDC or Wikipedia for info:
      - https://www.nature.com/articles/d41586-020-02801-8 or https://media.nature.com/original/magazine-assets/d41586-020-02801-8/d41586-020-02801-8.pdf.

   b. **Status:** *Is the disease found in the US, other countries, or both?* If it is no longer in the US, *is there danger of it being brought in by travelers?*

   c. **How It Spreads:** *Is this spread from person to person? Airborne? Touch? Animal vector (e.g., mosquito)?*

   d. **Description of the Disease**: *What is this disease like? Is it common in many parts of the world or isolated? How many people are affected? Are children affected more than adults? Does it have long-term effects?*

      HINT: Hear what a whooping cough: https://www.aboutwhoopingcough.com/understand-the-risk.html.

   e. **About the Vaccine:** *What impact has the vaccine had? Did the number of people with the disease decrease? Are there interesting stories about the disease or vaccine development?*

   f. **Personal Impacts:** *Did anyone in your family have or know someone who had this disease? Do your parents or grandparents remember when there was not a vaccine for this disease?*

VACCINE IMPACTS SNAPSHOT (SAMPLE)

Disease:	Smallpox
Cause:	Variola virus
First Reported or Observed:	Ancient Egypt, 300 BCE
Status:	Eradicated worldwide in 1975 by wide vaccine use; no need to vaccinate now.
How It Spreads	Human-to-human contact
Description of the Disease:	Begins with fever, fatigue, vomiting and overall discomfort. After a few days, flat red spots form on the skin; then the spots turn into blisters. The blisters eventually form scabs and fall off, leaving deep, pitted scars. Smallpox causes severe illness and sometimes is fatal.
About the Vaccine:	Dr. Edward Jenner used material from cowpox blisters (a related disease), to vaccinate people against smallpox in the late 1700s. Modern vaccinations left small scars on the arm because the vaccine used live cowpox viruses. Vaccines no longer are needed for smallpox, because the disease has been eradicated.
Personal Impacts:	Often caused permanent scarring on face, arms and legs. Sometimes led to blindness. Caused death in about one third of all cases.

VACCINE IMPACTS SNAPSHOT

Use the table below to share what you learned with the class.

NOTE: This assignment is not asking you to do a comprehensive report. Just give the highlights! However, remember to use your skills in identifying good science information sources.

Disease:	
Cause:	
First Reported or Observed:	
Status:	
How It Spreads	
Description of the Disease:	
About the Vaccine:	
Personal Impacts:	

Vaccines for Everything? Not Yet

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Historically, vaccines have had tremendous impacts on human health. Vaccines have reduced threats from diseases such as smallpox, polio, pertussis, tetanus, chickenpox, shingles, yellow fever, cholera, typhoid fever and rabies. Vaccines continue to improve health on the world's population. For example, measles vaccines prevented more than 14 million deaths in low-income countries between 2011 and 2020. During that period, other vaccines prevented an additional 9 million deaths from diseases such as Hepatitis B, pneumococcal pneumonia, yellow fever, meningitis, encephalitis, and rubella.[1] Undoubtedly, the COVID-19 vaccines being manufactured and distributed today will become another example of vaccines helping to stop a deadly worldwide pandemic.

1 Centers for Disease Control and Prevention. The Global Impact of Vaccines in Reducing Vaccine. https://www.cdc.gov/globalhealth/infographics/immunization/global_impact_of_vaccines.htm.

Vaccines stimulate the body's own defense system, called the immune system, to defend against a particular disease, exactly like it would if you were exposed to the disease. After getting vaccinated, you develop immunity to the disease, without having to get the illness first.

With all these successes, why do we have to suffer through the common cold? Why haven't we stopped the spread of HIV with a vaccine? Why do we still have Lyme disease or West Nile virus? In other words, w*hy don't we have a vaccine for every communicable disease out there?* The reasons are both scientific and practical.[2]

The scientific reasons center around the nature of the organism that causes the disease. Some vaccines contain killed or weakened versions of a germ that causes a disease. Other vaccines contain only a part of the disease microbe. The newest vaccines, such some of the vaccines for COVID-19, are based only on a single protein molecule. Cells of the immune system recognize the protein as foreign, and the process of developing immunity begins. Later, if the actual microbe enters the body, the immune system recognizes the protein and mounts a defense against infection by microbe.

Deciding what part of the virus, bacterium, or parasite to use to develop an effective vaccine is complicated for several reasons, which are listed on the following page.

2 The New York Times. Why Don't We Have Vaccines Against Everything?. https://www.nytimes.com/2018/11/19/health/vaccines-poverty.html.

- **Not All Diseases Cause Lifetime Immunity**
  For many communicable diseases, after a person recovers from having a disease, their immune system has memory cells that remember and recognize the disease. These persons are protected from contracting a serious case of the disease, often for their lifetimes. But this doesn't happen with all diseases. Those who are infected with malaria or tuberculosis, for example, do not develop immunity and can become infected again. The absence of lasting immunity makes creating a vaccine for these diseases exceedingly difficult.

- **Microbes Are Complex**
  In order to be effective, a vaccine should contain a unique piece of a microorganism that stimulates a protective immune response. Most disease-causing microbes are complicated organisms. So, vaccine developers must figure out which component of a microbe should be used in a vaccine to stimulate the strongest and longest lasting immunity.

- **Microbes Change Over Time**
  You can't assume that the target protein or other component of a microorganism will stay the same. If the microbe mutates rapidly, the part targeted by the vaccine may have changed by the time you get the vaccine ready to test. For example, everyone has to get a new flu shot every year because the influenza virus mutates rapidly. HIV changes even more quickly. It mutates "as fast in one day as flu does in a year."[3].

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3 The New York Times. Why Don't We Have Vaccines Against Everything?. https://www.nytimes.com/2018/11/19/health/vaccines-poverty.html.

Vaccines are expensive and time consuming to develop. It usually takes more than 10 years and between $1 and $2 billon to develop and test a vaccine.[4,5] Even with that investment, not all vaccines work well enough during clinical trials to become widely used. Clinical trials evaluate the effectiveness and safety of vaccines. If the clinical trial data do not show a strong, positive effect without significant side effects, all the years of work are set aside, and the vaccine never makes it to the doctor's office. Not surprisingly, pharmaceutical companies focus on vaccines that have strong potential for success and for which they have a market that can help them recover some of their investment cost. Pharmaceutical companies sometimes partner with government agencies and private funding agencies to work on vaccines. The COVID-19 vaccines are a good example of government pairing with industries, universities, and private donors to create safe effective vaccines. Scientists around the world built on more than 10 years of existing research to quickly and collaboratively develop and test COVID-19 vaccines.

What about non-communicable diseases? Are there vaccines for things like cancer, heart disease, and diabetes? The answer is both yes and no.

- Some diseases can be worse for persons with problems like heart disease, cancer, and diabetes. In these cases, it is especially important to get regular vaccinations for influenza, pneumococcal disease,

4 The New York Times. Why Don't We Have Vaccines Against Everything?. https://www.nytimes.com/2018/11/19/health/vaccines-poverty.html.

5 The Washington Post. Does It Really Cost $2.6 Billion to Develop a New Drug?. https://www.washingtonpost.com/news/wonk/wp/2014/11/18/does-it-really-cost-2-6-billion-to-develop-a-new-drug/.

tetanus, pertussis, diphtheria, and shingles, to protect against severe illness.[6]

- Cervical cancer is caused by the human papillomavirus (HPV), but it can be prevented by the HPV Vaccine. Hepatitis B, a liver disease, can be prevented by the Hepatitis B vaccine.[7]

- Cancer treatment vaccines are a new approach designed to be used in people who already have cancer. The cancer treatment vaccines target molecules that are on the surface of cancer cells, but not on the surface of normal cells in a person. Most cancer treatment vaccines still are being developed and only are offered through clinical trials.[8]

- Because the immune system is involved in the destruction of the pancreatic cells that make insulin in Type I diabetes, researchers are exploring the possibility of using vaccines to treat Type I diabetics.[9]

Do we have a vaccine to prevent you from ever having cancer diabetes, or heart disease? Not yet, but there is great potential in vaccine research as we learn more about these diseases and as researchers learn more about the immune system and its interactions with our other body systems.

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6 Centers for Disease Control and Prevention. Heart Disease, Stroke, or Other Cardiovascular Disease. https://www.cdc.gov/vaccines/adults/rec-vac/health-conditions/heart-disease.html.

7 Centers for Disease Control and Prevention. Vaccines (Shots). https://www.cdc.gov/cancer/dcpc/prevention/vaccination.htm.

8 National Cancer Institute. Cancer Treatment Vaccines. https://www.cancer.gov/about-cancer/treatment/types/immunotherapy/cancer-treatment-vaccines.

9 PubMed. Vaccine Therapies for the Prevention of Type 1 Diabetes Mellitus. https://pubmed.ncbi.nlm.nih.gov/12956615/.

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Vaccines for Everything? Not Yet

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