What Are Vaccines?

And, How Do They Work?

COVID HACKS
Healthy Actions • Community Knowledge • Science

FOR GRADES
6–8 9–12

OVERVIEW

Students learn how vaccines work and how they are made by viewing two short videos and answering questions that promote critical thinking related to vaccines and the immune system. Student discussion is guided through a slide presentation provided by the teacher.

LEARNING OBJECTIVE

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

- Describe how vaccines work.
- Describe how vaccines are developed and how we know they are safe.

SCIENCE, HEALTH AND MATH SKILLS

- Comparing and contrasting
- Interpreting information

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 Activity Guide: *What Are Vaccines?*
- Device with internet access.Students will access two videos developed by the scientific journal, Nature
  a. Vaccines 101: How Vaccines Work
     https://www.youtube.com/watch?v=4SKmAlQtAj8
  b. Vaccines 101: How New Vaccines are Developed
     https://www.youtube.com/watch?v=2t_mQwTY4WQ

Teacher will need:

- Accompanying slides to guide student discussion

TIME

- 1 or 2 class periods; you may choose to have students watch the two video segments as homework or have them watch the videos during class time as a group.

PROCEDURE

ENGAGE

1. Ask students to share what they know about vaccines. Encourage all answers. Follow by asking students, *What would you like to know about vaccines?* Create a list on a whiteboard or electronic bulletin board.
2. Tell students they will have an opportunity to learn more about vaccines and how they are produced. They will revisit their list afterward to make certain that all of their questions have been answered.

EXPLORE

3. Students will watch two short, animated videos that provide 1) an overview of how the immune system fights infections and how vaccines work; and 2) a brief description of the process used in developing a new vaccine. Provide students with the links to the two videos to watch asynchronously or show the videos in a live classroom session, pausing occasionally for questions or discussion.
4. Make certain that students have copies of the Student Sheet *What Is a Vaccine* before they watch the videos. Have students read the questions before watching the video and write or type key information on the Sheet during and after watching the video.

   NOTE: These videos were developed in September 2020 by a team of research, pharmaceutical, and lab testing companies that are involved in the development of COVID-19 vaccines as well as other vaccines and medicines. The videos were reviewed by other scientists for accuracy. The videos do not mention the particular vaccines or medicines being developed by the companies and do not promote the companies or their products.

   a. Vaccines 101: How Vaccines Work
   https://www.youtube.com/watch?v=4SKmAlQtAj8
   b. Vaccines 101: How New Vaccines are Developed
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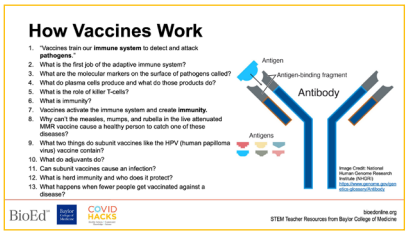
EXPLAIN

5. Use the accompanying slides to discuss students' responses to the questions on the Student Sheet. If students have new questions, add them to the class list you started at the beginning of the activity.

SLIDE 1



Vaccines 101: How Vaccines Work

- You watched the short animated video about how the immune system and vaccines work. Let's discuss what you learned.

  a. Vaccines train our immune system to detect and attack pathogens." Pathogens are organisms that cause disease. Examples of pathogens include bacteria, multicellular eukaryotic organisms, fungi and viruses. The organism that is invaded by a pathogen is called the host.

  b. *What is the first job of the adaptive immune system?*
  It's first job is to recognize an invader.

  c. *What are the molecular markers on the surface of pathogens called?*
  Antigens.

  d. *What do plasma cells produce and what do those products do?*
  Plasma cells produce antibodies that bind specifically to the antigen on the pathogen.

e. *What is the role of killer T-cells?*
Killer T-cells recognize and destroy cells that are infected with the pathogen.

f. *What is immunity?*
Immunity is when the body produces long-lived memory T and B cells that are ready to produce antibodies and killer T cells, if the antigen is ever encountered in the body again.

g. Vaccines activate the immune system and create immunity.

h. *Why can't the measles, mumps, and rubella in the live attenuated MMR vaccine cause a healthy person to catch one of these diseases?*
The vaccine contains a weakened version of the pathogen that can't make a healthy person ill.

i. *What two things do subunit vaccines like the HPV (human pappilloma virus) vaccine contain?*
1) Part of the pathogen, but not an infectious particle.
2) Adjuvant.

j. *What do adjuvants do?*
Adjuvants activate the immune system so it recognizes and responds to the subunit.

k. *Can subunit vaccines cause an infection?*
No, subunit vaccines don't have the genetic material from the pathogen and cannot cause an infection.

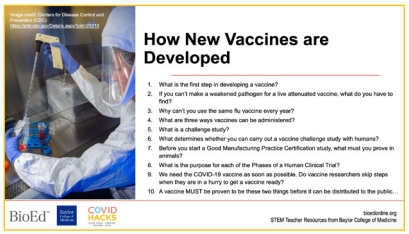
l. *What is herd immunity and who does it protect?*
Herd immunity is reached when a large segment of the population has been vaccinated or is immune to a disease because they have been infected. Herd immunity makes it hard for a disease to spread from person to person, because most people have immunity. Herd immunity protects people who can't get vaccines or who have weakened immune systems.

m. *What happens to herd immunity when fewer people get vaccinated against a disease?*
The disease can reappear and spread. You lose herd immunity.

6. Conclude the discussion by helping students understand that the immune system is designed to recognize and attack pathogens that enter the body. Immune cells guard all parts of your body, including even the "external-facing" respiratory and gastrointestinal tracts, skin, eyes and ears. In many cases, if you become ill with an infectious pathogen, the immune system develops antibodies and other strategies to prevent you from getting sick the next time you are exposed to that pathogen. Vaccines "teach" the immune system how to recognize and attack a pathogen, but without you having to suffer the actual illness first board.

7. Conduct a debriefing discussion of the second video on how vaccines are developed. Use the following notes to guide your discussion.

SLIDE 2



Vaccines 101: How New Vaccines are Developed

- This video gave you an overview of how new vaccines are developed. Let's review what you learned.

a. *What is the first step in developing a vaccine?*
Identify the pathogen causing the disease.

b. *If you can't make a weakened pathogen for a live attenuated vaccine, what do you have to find?*
Antigens, which are protein markers (molecules), on the exterior of the pathogen.

c. *Why can't you use the same flu vaccine every year?*
Because the antigens on the surface of the virus particle change over time.

d. *What are three ways vaccines can be administered?*
1) Injection
2) Oral
3) Nasal spray

e. *What is a challenge study?*
The humans or animals who receive a test vaccine are exposed to the pathogen to test whether the vaccine protects them. It is called a "challenge study," because the immune system of the individuals is challenged to defend against the pathogen.

f. *What determines whether you can carry out a vaccine challenge study with humans?*
The disease must not be too serious or effective treatments must be available.

g. *Before you start a Good Manufacturing Practice Certification study, what must you prove in animals?*
You must demonstrate that the vaccine is safe.

h. *What is the purpose for each of the Phases of a Human Clinical Trial?*
Phase I: Give the vaccine to a small number of healthy people to assure that it is safe.
Phase II: Give the vaccine to hundreds of volunteers to figure out what dose is needed to trigger the immune response.
Phase III: Give the vaccine to thousands of people to see how effective it is.
Phase IV: Monitor for rare negative reactions. Medicines and vaccines are watched over a long period of time even after they are approved for use.

i. *We needed the COVID-19 vaccine as soon as possible. Do vaccine researchers skip steps when they are in a hurry to get a vaccine ready?*
No. All phases must be completed in order to assure that the vaccine will be safe and effective before distribution.

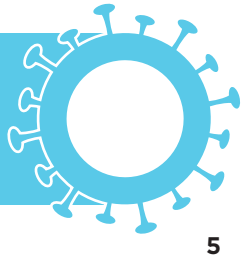
j. A vaccine must be proven to be these two things before it can be distributed to the public. Researchers and doctors use clinical trials to learn whether a vaccine or a new drug is safe and effective.

EXTEND AND EVALUATE

8. Revisit the list of questions created before and during the activity. Have the class decide if any questions remain unanswered. Assign teams of students to use resources on the Centers for Disease Control and Prevention (CDC) website or other scientific websites (from universities or hospitals, these website URLs end in ".org" or ".edu") to find answers to the questions.
9. Have student teams present their questions and their findings on a single PowerPoint slide to the class. The teams should cite all sources for their responses.
10. You also may want to collect students responses to the questions related to each of the videos that they viewed, as a knowledge assessment.
11. Information about the new SARS-CoV-2 vaccines is being updated on a regular basis. Please check the CDC website for the most recent information.
    - https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines.html.

SAFE AND EFFECTIVE VACCINES

Researchers and doctors use clinical trials to learn whether a vaccine or a new drug is safe and effective. Effective means that the vaccine has been evaluated to see if it prevents illness or reduces the risk of severe illness in the real world.



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

What Are Vaccines?
Student Activity Guide

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OVERVIEW

We're all looking forward to the end of the COVID-19 pandemic. Teams of infectious disease scientists and physicians have worked hard to develop vaccines against the coronavirus that causes the illness called COVID-19. But, *what are vaccines and how are they made?*

PART 1

WHAT ARE VACCINES?

Watch the video linked below and answer the questions. This video was created by a team of scientists and science educators.

- https://www.youtube.com/watch?v=4SKmAlQtAj8

1. "Vaccines train our _____ to detect and attack _____." (Fill in the blank.)

2. *What is the first job of the adaptive immune system?*
   -

3. *What are the molecular markers on the surface of pathogens called?*
   -

4. *What do plasma cells produce and what do those products do?*
   -

5. *What is the role of killer T-cells?*
   -

6. *What is immunity?*
   -

7. Vaccines activate the immune system and create _____. (Fill in the blank.)

8. *Why can't the measles, mumps, and rubella in the live attenuated MMR vaccine cause a healthy person to catch one of these diseases?*

9. *What two things do subunit vaccines like the HPV (human pappilloma virus) vaccine contain?*

10. *What do adjuvants do?*

11. *Can subunit vaccines cause an infection?*

12. *What is herd immunity and who does it protect?*

13. *What happens to herd immunity when fewer people get vaccinated against a disease?*

In summary, the immune system is designed to recognize and attack pathogens that enter the body. Immune cells guard all parts of your body, even including the "outside" parts of the respiratory and gastrointestinal tracts, your skin, eyes and ears. In many cases, if you become ill with an infectious pathogen, the immune system develops antibodies and other strategies to prevent you from getting sick the next time you are exposed to that pathogen. Vaccines "teach" the immune system how to recognize and attack a pathogen, but without you having to suffer the actual illness first.

PART 2

VACCINES 101: HOW NEW VACCINES ARE DEVELOPED

Watch the video linked below and answer the questions.

NOTE: The video from Nature has already been checked for scientific accuracy.

- https://www.youtube.com/watch?v=2t_mQwTY4WQ

1. *What is the first step in developing a vaccine?*

2. *If you can't make a weakened pathogen for a live attenuated vaccine, what do you have to find?*

3. *Why can't you use the same flu vaccine every year?*

4. *What are three ways vaccines can be administered?*

5. *What is a challenge study?*

6. *What determines whether you can do a vaccine challenge study with humans?*

7. *Before you start a Good Manufacturing Practice Certification study, what must you prove in animals?*

8. *What is the purpose for each of the Phases of a Human Clinical Trial?*

9. *We needed the COVID-19 vaccine as soon as possible. Do vaccine researchers skip steps when they are in a hurry to get a vaccine ready?*

10. *A vaccine must be proven to be these two things before it can be distributed to the public.*
    a.

    b.