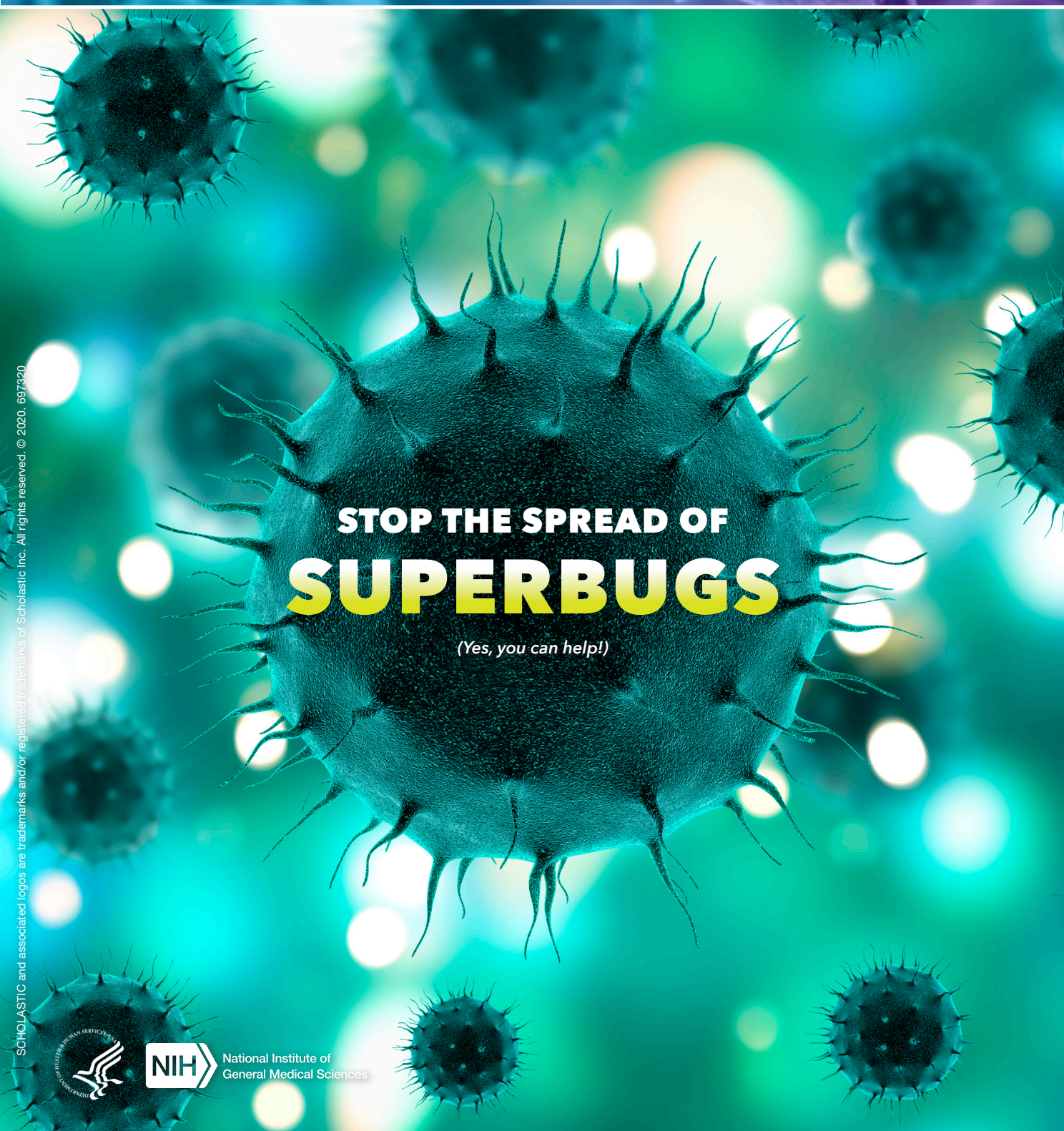
Sponsored Educational Materials

The Superbug Issue

SCHOLASTIC

PATHWAYS

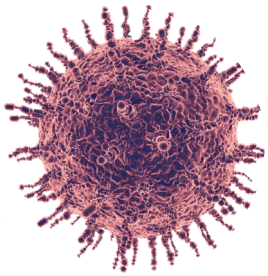


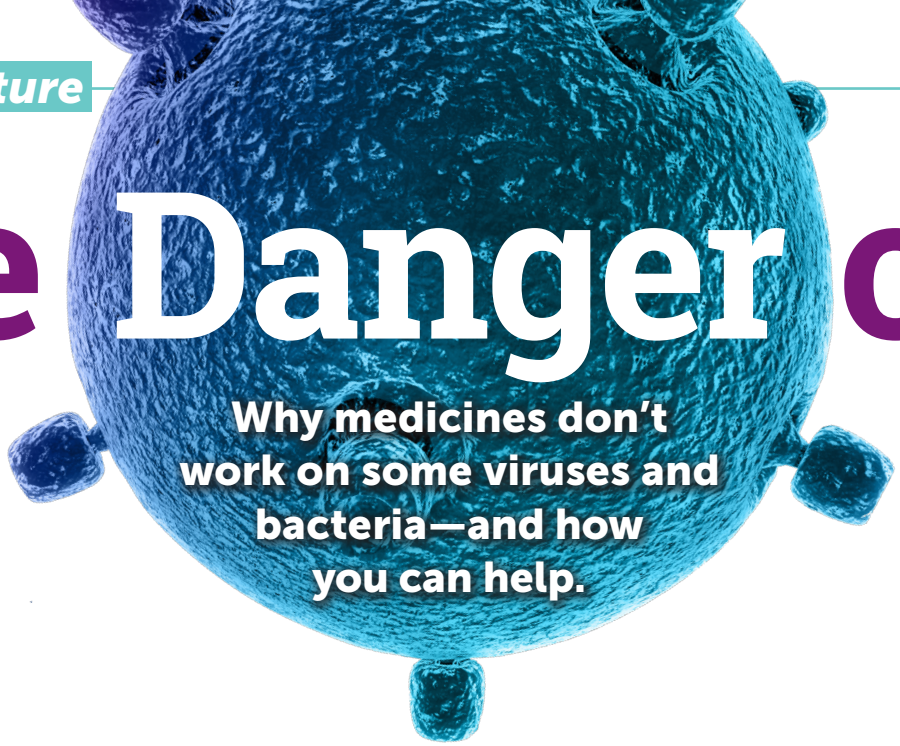
STOP THE SPREAD OF SUPERBUGS

(Yes, you can help!)

NIH National Institute of General Medical Sciences

The Danger of



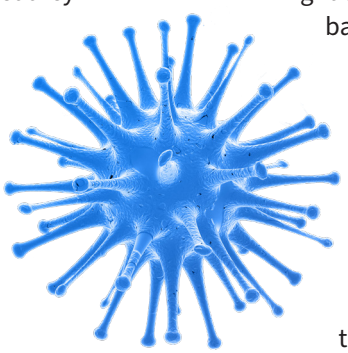


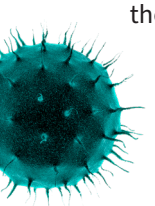
Why medicines don't work on some viruses and bacteria—and how you can help.

WHEN YOU WERE LITTLE AND HAD A PAINFUL EAR infection or strep throat, chances are your doctor prescribed you "the pink bubble gum medicine." And that medicine was likely some version of penicillin, a powerful antibiotic discovered in 1928 that has saved the lives of people around the world.

Antibiotics work by killing the bacteria that cause infections. But bacteria aren't the only things that can cause disease. Viruses like those that cause the common cold and COVID-19 can also make people sick—but antibiotics don't work on viruses. Bacteria and viruses are both types of pathogens (germs), yet they are very different.

"Many viruses replicate (copy themselves to increase their numbers in your body) much, much faster than bacteria do," explains **Matt Daugherty, Ph.D.,** an assistant professor at the University of California, San Diego. Another big difference: Bacteria have several thousand genes (that code for the proteins that make up their cells), but most viruses have only about 10 genes. "As a result, there are far fewer targets you can hit on a virus to wipe it out," says Dr. Daugherty. For these reasons, scientists have had trouble finding drugs to treat some viral infections.



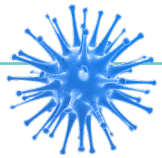


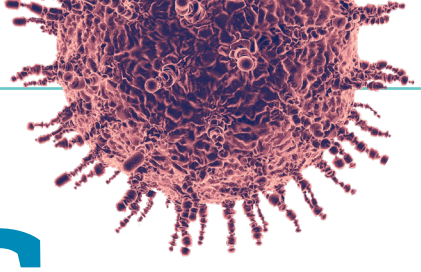
Bacteria can also live on their own—in soil, for example—or in our bodies, but viruses need to be inside of our cells to be able to replicate, says **Nels Elde, Ph.D.,** associate professor at the University of Utah. "Technically they're not really alive the way that bacteria are. When they infect a cell or they infect a host, you might consider them to almost become alive, whereas bacteria can live by themselves."

Medicine Matters

The differences between bacteria and viruses help explain why we don't fight them the same way. Since bacteria have so many proteins to latch on to, it can be easy to treat them with antibiotics. Because viruses are harder to wipe out with medicine, we usually try to prevent them with vaccines, which protect you from infection altogether, explains **Lauren Ancel Meyers, Ph.D.,** a professor at the University of Texas at Austin. Vaccines spare millions of kids each year from contagious diseases like measles and whooping cough.

When antibiotics aren't used correctly, bacteria can change and become resistant to these medicines, which means the medicines no longer work to make the person



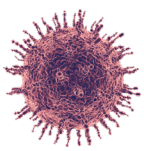


Superbugs

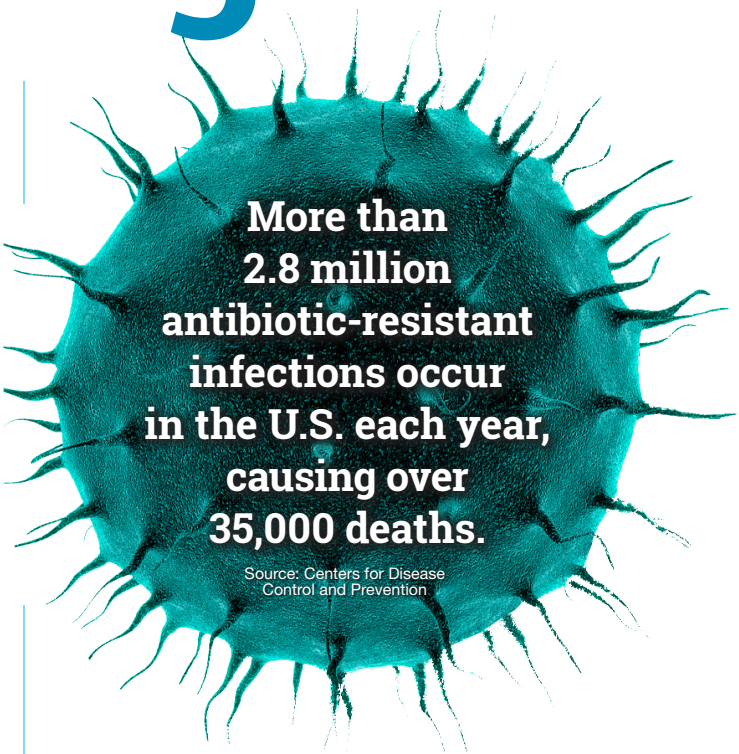
better. This can happen, for example, when someone with a bacterial infection doesn't follow their doctor's instructions about how long to take an antibiotic, or takes an antibiotic when they actually have a viral infection. Resistant bacteria—as well as viruses we can't prevent with vaccines—can be called superbugs because they can't be fought off with medicine at all. (For more about antibiotic resistance, see the infographic on the next page.)

Safety Steps

Superbugs can form in the environment, too.



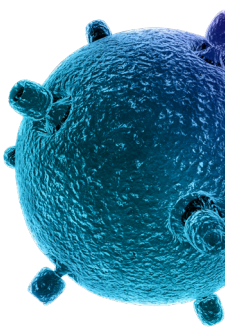
For instance, if you don't take all of your antibiotic because you start to feel better before the last day, and you pour it down the drain, that medicine can end up in our water supply. "If there's just a little bit of antibiotic in the water—and there are also some bacteria related to the kinds that make us sick that now get exposed to that antibiotic—the bacteria might mutate and evolve. Now we have more superbugs that might come and infect us," explains Dr. Elde.



More than 2.8 million antibiotic-resistant infections occur in the U.S. each year, causing over 35,000 deaths.

Source: Centers for Disease Control and Prevention

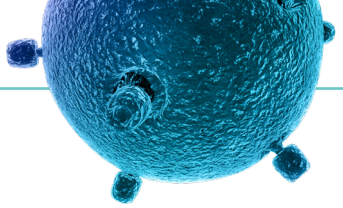
The same goes for agriculture: When farm animals are dosed with antibiotics, drug-resistant bacteria sometimes survive and mutate in their intestines. These superbugs can contaminate the meat and poultry we eat, making us sick. The resistant germs could also spread to soil through animal poop, then contaminate vegetables and fruits.



Scientists are learning as much as they can about how bacteria and viruses evolve, and what can be done to stop the spread of drug-resistant germs and keep people healthy. It may seem like solving this problem is out of your control, but there are things you can do. First, take steps to keep from getting sick: Wash your hands, cover your cough, and stay home if you don't feel well. Always take your medicine exactly as your doctor instructs. Never share antibiotics with someone else who feels sick. And dispose of all medicines safely: Bring them to your pharmacy or doctor so they don't end up in local water or soil. We all can play a role in the fight against superbugs!

Can Bacteria Be...*Delicious*?

Bacteria don't just make us sick—and they're not all bad! "They also help make the world work," says Dr. Elde. Take, for example, the good bacteria that are part of producing yogurt, pickles, and sourdough bread. "Bacteria invisibly make lots of things happen that we don't even recognize," he says. Your body also naturally contains good bacteria that help protect your digestive system, skin, and more.



Picture It

This is one way that antibiotic resistance can happen when someone has a bacterial infection.

Scientists in the Spotlight

Lauren Ancel Meyers, Ph.D., professor of biology and statistics, the University of Texas at Austin

Were you always interested in math? Yes! I even went to math camp as a kid, and I always loved things like puzzles. In college, I spent a summer internship doing mathematical cryptography (making and breaking secret codes), and I saw how math could be used to solve real-world problems.

How did you get involved in the work you do now? During graduate school, someone from the Centers for Disease Control and Prevention showed up asking for mathematicians who could help build a better mathematical model for controlling disease outbreaks.

What do you hope to discover with your research? My lab is trying to answer three basic questions about diseases: Where are infectious diseases spreading today around the globe? Where might they be spreading tomorrow, or next week, or next month? And how can we use our limited public health resources to slow or stop their spread?

Dustin Hancks, Ph.D., assistant professor of immunology, UT Southwestern Medical Center

Were you curious about science as a kid? Some of my earliest memories are of reading encyclopedias. I was always interested in knowing things.

What inspired you to pursue a science career? It began when I got interested in the story that DNA can tell us. I was actually the first person in my immediate family to go to college, and eventually beyond, to grad school. My dad told me to get the best grades that I could, so that I'd have the most opportunities to choose from.

What advice do you have for aspiring scientists? Keep at it. If possible, get into a lab and do experiments. Remember: Science really is everywhere, and it's super important when it comes to solving a variety of problems. And know that you can reach out to experts and professors by email—most of the time, people will respond! Above all, stick to your dreams, no matter what other people say.

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SCHOLASTIC

GRADES 6–12

PATHWAYS

Investigating the Science of Superbugs

MAGAZINES & ACTIVITY SHEETS

TEACHING GUIDE

Science, ELA, and Health Activities About Drug Resistance in Viruses and Bacteria

Visit **scholastic.com/pathways** for additional lessons, videos, and more.

BROUGHT TO YOU BY:

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Viral and Bacterial Superbugs

Explore the basics of infectious diseases, then help students investigate why some bacteria and viruses can't be treated with drugs.

Objective

Students will use evidence to develop an explanation for why drugs sometimes fail to cure a disease.

NGSS Standards

MS-LS1-5 Explain how reproduction rates affect microbial evolution

MS-LS3-1 Model how microbes can become drug resistant

MS LS4-4 Explain heritable traits in organism survival

HS-LS4-4 Use evidence to explain drug resistance and natural selection

Time

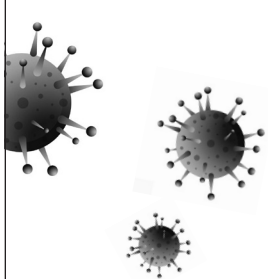
Part A: 60 minutes

Part B: 60 minutes

Allow extra time for writing, research, and presentations as needed.

Materials

- *Pathways* magazine
- Why Did the Medicine Fail? activity sheet
- Spread the Word About Superbugs activity sheet
- Vocabulary list at **scholastic.com/pathways**



PART A

1 **Ask** students to raise their hands if they've ever had a cold. Explain that colds are infectious diseases, meaning they can spread from one person to another. Ask: *Can you think of any other infectious diseases?* Record student responses, which could include strep throat, flu, measles, chicken pox, and COVID-19. (They might also include noninfectious diseases such as cancer or heart disease.)

2 **Assess** prior understanding about the causes and treatment of infectious diseases. Ask: *What do you think caused your cold? How do you think you "caught" it?* Have students work in pairs to discuss what they know so far about how science is used to try to reduce the spread of the diseases you recorded above.
For grades 9–12: Focus on the differences between viruses and bacteria. Ask: *How does bacterial reproduction compare with viral reproduction? Are viruses "alive"?*

3 **Conduct** a demonstration (or provide hands-on materials to groups of students). Try to pick up a marble or button with one chopstick. Then spear a piece of clay with the single chopstick and show how you were able to pick it up. Ask students what they observed and concluded. Have them explain how this might relate to the discussion. (Answer: You need the right tool to attach/capture a specific object. It's the same with illness. Medicine targeted to a bacterium won't work on a virus.)

4 **Hand out** the student magazine (and vocabulary sheet as needed). Lead a discussion about the reasons drugs designed to cure an infection sometimes fail. To connect to other lessons you are teaching, you may wish to discuss:

- structural differences between viruses and bacteria
- how bacteria and viruses change/evolve over time
- natural selection (bacteria and viruses with certain traits are better adapted to survive and reproduce)

5 **Discuss** antibiotic and antiviral drug specificity in curing infections. Challenge students to consider how a prescribed drug might be inappropriate for a disease. Have students take their best guess at why antibiotics are ineffective against viruses, and why it's important to follow your doctor's instructions for taking an antibiotic even if you are feeling better before the medicine runs out.

6 **Hand out** the Why Did the Medicine Fail? activity sheet. Answers:

Q1) Antibiotics are ineffective against viruses. Drugs have specificity.

Q2) Taking the medicine for the right number of days reduces the chance that some pathogens will survive and reproduce with mutations that resist the medicine. Then it could spread to new people, and the medicine won't work.

Q3) Tyler's medicine wasn't specific to his illness (e.g., antibiotics don't work on viruses) *or* his pathogen was already drug resistant. When Natasha stopped taking her medicine, only some of the population of the pathogen had been killed. What was left reproduced in her body and made her sick again.

Q4) People may die in larger numbers of diseases that hadn't been that deadly when medicines worked against them.

PART B

7 **Hand out** the Spread the Word About Superbugs activity sheet. Students will create a presentation to educate the public. They can choose their format (op-ed, poster, slides; see activity sheet).

To level down: Pair up students and assign a science concept to help narrow the focus.

Name _____

Why Did the Medicine Fail?

Read about two teens who got sick and went to see their doctors. Then come up with a hypothesis for what might have happened.

Scenario 1 Tyler woke up with stomach cramps and felt like he might throw up. He shuffled into the kitchen and told his mom he was sick. At first she was skeptical, and asked if maybe he was just nervous about his big math test that day. But when she took his temperature and saw he had a high fever, she took him to an urgent-care clinic. A doctor examined him and prescribed a five-day course of antibiotics. After five days, Tyler still felt terrible.

Scenario 2 Natasha had a scratchy throat and a headache for three days. She didn't want to tell anyone because she had a big track meet coming up. She attended practices and ran her race. The next day she felt worse than ever: Her throat felt like it was on fire and her head was pounding. Her doctor checked her out and gave her an antibiotic to take for five days. After two days of taking the medication, Natasha felt great and stopped taking the medicine. But five days later her symptoms came back.

1. Why is it important for a doctor to determine the type of pathogen (or type of germ) causing the symptoms before writing a prescription?

2. If someone is prescribed a medication, why is it important to take the medication for the number of days your doctor instructs?

3. Develop a hypothesis about why each of the scenarios above ended the way they did. Use your understanding about viruses, bacteria, and drug resistance to defend your conclusion.

4. What might happen in the coming years if people don't take action to stop the spread of drug-resistant germs?

Name _____

Spread the Word About Superbugs

Educate the public—other students, your family, or your community—about bacteria and viruses that can't be treated with drugs by creating an informational presentation.

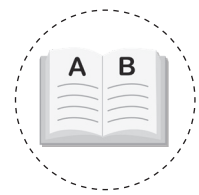
STEP 1

CHOOSE Your Presentation Type

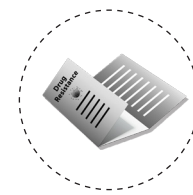
Pick from this list or make up your own (then clear it with your teacher).

Write an **op-ed** for the school newspaper

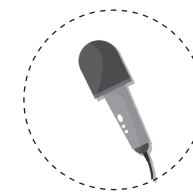
Prepare a **poster** or **slide presentation** for the local library or PTA



Write a **children's book** for primary-grade students



Create a **graphic pamphlet** to distribute at school



Produce a **podcast** or **webpage** and include an interview with a doctor

STEP 2

PLAN Your Presentation Structure

On a separate sheet or document, organize what you will include in each section.

1 **Hook** Grab the audience's attention with a question or anecdote. Make sure your tone is appropriate for your audience (little kids, classmates, adults, etc.).

2 **Problem** Explain why some bacteria and viruses can't be treated with drugs and why this is a problem. Decide which concepts are important to present and how you will explain them. What vocabulary and level of detail will help your audience?

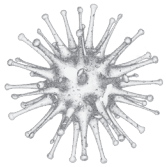
- Definition of infectious diseases
- Causes of infectious diseases
- Differences between viruses and bacteria
- How antibiotics and antiviral drugs work
- Specificity of medications
- How use of the drugs may cause resistance (mutation, natural selection)
- Molecular basis of drug resistance

3 **Call to Action** Your presentation should persuade your audience to take action, so make sure you explain clearly what steps they can take to tackle the problem.

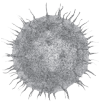
VOCABULARY LIST

KNOW YOUR MICROORGANISMS

Microbe *(noun):* a microscopic organism, such as a bacterium, virus, fungus, and amoeba.



Pathogen *(noun):* a medical term for any type of microbe that can cause disease, such as a bacterium or virus. In everyday language, pathogens are also known as germs or bugs.



Superbug *(noun):* an informal term for types of pathogens that can't be treated with medicine, such as bacteria that have mutated to be resistant to antibiotics or viruses for which we haven't found an effective vaccine.

antibiotic *(noun, adjective):* medicine used against bacteria (not for viruses).

gene *(noun)*: a small section of DNA that contains the instructions for making a specific protein. Proteins control the processes that occur in the body's cells.

host *(noun)*: an organism that another organism lives in or on (which can be helpful or harmful or the host).

► **For example**, the human gut hosts "good" bacteria that help humans with digestion. Cells in which disease-causing viruses live also act as hosts.

mutation *(noun)*: a change in an organism's genes, which gives the organism a new trait, such as the ability to resist a medicine.

► **Note**: A mutation can be positive, negative, or neutral for an organism's survival.

natural selection *(noun)*: a process through which species change and survive over time; the main process of evolution. Natural selection occurs when organisms develop new traits (through mutations) that better help them survive in their environment and reproduce (pass on a new trait to new generations). Since organisms with the new trait survive better than those without the trait, the species changes over time.

replicate *(verb):* to make an exact copy.

specificity *(noun):* when medicines are only effective against a particular, specific organism or group of organisms (for example, antibiotics don't work against viruses).

vaccine *(noun):* a substance that helps protect against certain diseases by helping the immune system recognize and destroy specific microbes.

TAKE IT FURTHER

Choose five vocabulary words that you think will be hardest to remember, then write a paragraph with them (nonfiction or fiction).