

SUPERBUG SPREAD

HOW ANTIBIOTIC RESISTANCE CAN SPREAD THROUGH A POPULATION

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Superbug Spread

How antibiotic resistance can spread through a population

Skill Level

Intermediate (6th-8th graders)

Advanced (9th-12th graders)

State Standards Addressed:

MS-LS4-4

MS-LS4-5

MS-LS4-6

Learner Outcomes

The learner will be able to:

- Understand that antibiotic resistance is a product of evolution (natural selection)
- Discuss how humans play a role in the rise of antibiotic resistance, and why it is a public health problem
- Collect and describe data on populations

Tag(s)

4-H Science

Time Needed

35-45 minutes

Materials Needed

Per team of two students:

- Two paper plates
- 50 mini marshmallows
- 40 M&Ms (or other hard-shell candies)
- One toothpick
- Timer
- Observation sheet

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Adapted from “Microbial Connections: The Evolution of Antibiotic Resistance” by Heather Kittredge kbs.msu.edu/2017/01/antibiotic-resistance-lesson/

Introduction to Content

Antibiotic resistant microbes are a major health issue. This lesson teaches concepts about how the use of antibiotics can cause antibiotic resistance to spread through a population of bacteria.

Introduction to Methodology

This activity uses marshmallows and hard-shelled candies (e.g. M&Ms) to represent susceptible and resistant bacteria in a population, respectively. After several rounds of antibiotic treatment and growth, students see how a small number of resistant bacteria can take over a population.

Terms/Concepts

Antimicrobial – A compound that kills or stops the growth of a microbe (bacteria, fungi, protozoan, etc.)

Antibiotic – An antimicrobial that specifically targets bacteria

Susceptible – An organism that can be harmed by antimicrobials

Antibiotic Resistance – When bacteria evolve a mechanism that protects them from the effects of antibiotics. Antimicrobial resistant microbes are sometimes called “superbugs”

Mutation – A change in an organisms’ DNA code, which may lead to a different phenotype (trait)

Natural Selection – The different survival of individuals because of differences in phenotypes (traits)



Setting the Stage/Opening Question

Set the Stage: Our bodies are home to trillions of microbes (sometimes called our microbiome). These microbes are mostly harmless or beneficial, helping to keep us healthy. But, of course, there are some bacteria out there that can cause infections and harm.

Ask: "Have you ever gotten an infection by harmful bacteria and had to take antibiotics? What is an antibiotic?"

Antibiotics are compounds that kill or stop the growth of bacteria. They are produced by some bacteria and fungi to outcompete their neighbors. We now use antibiotics widely in medicine, for example, to fight active infections, prevent infections during surgery and protect people who are more susceptible to infections (e.g. immunocompromised). Antibiotics can save lives!

Explain that despite the benefits, there is a downside to overusing antibiotics: antibiotic resistance.

Ask: "How might a bacteria become resistant to being killed by an antibiotic?"

Mutations and variation happen in natural populations all the time. A few bacteria in a population might have a mutation that allows them to be resistant.

Ask: "If there are a few resistant bacteria present, what happens when an antibiotic is introduced?"

Antibiotics will kill off the **susceptible** bacteria, leaving just a few resistant ones. These resistant ones will grow and spread, creating more **antibiotic resistance** in the population. This is the process of **natural selection**.

Ask: "What's the problem with having all these resistant bacteria?"

Antibiotic resistant "superbug" bacteria can be a big problem because they can't be controlled with antibiotics. Some examples are methicillin-resistant *Staphylococcus aureus* (MRSA) and drug-resistant tuberculosis. Antibiotic resistance can spread between people, animals and the environment because bacteria are everywhere!

Experience

1. Have students work in pairs. Explain what each of the materials represents:
 - a. Plate = human body
 - b. Toothpick = antibiotic; explain that the toothpick only works by stabbing an item to pick it up (no scooping or pushing items off the plate)
 - c. Marshmallows = bacteria causing you disease that are susceptible to an antibiotic
 - d. M&Ms = bacteria that have evolved resistance to the antibiotic

Strategies to Increase Student Engagement

WATCH: PBS Be Smart
"Antibiotic Resistance and the Rise of Superbugs"
www.pbs.org/video/antibiotic-resistance-and-the-rise-of-superbugs-osyamh

2. Explain the scenario: You go to the doctor with a sore throat. She determines that you have a bacterial infection and prescribes you an antibiotic. Our activity will simulate what happens to the bacteria when you take the antibiotic.
3. Have the students put 20 marshmallows (bacteria making them sick) on the plate (body).
4. **Dose.** Record the starting number of marshmallows on their worksheet (e.g. 20). Have one student in each pair time for 10 seconds while the other moves as many bacteria as possible with the toothpick. Record the number of remaining marshmallows on the worksheet. (Note: Adjust length of time based on your students' speed. You want most groups to be taking approximately half of the marshmallows each round. If they are taking too many, reduce the dosing time to five seconds.)
5. **Mutation!** Not all bacteria were killed by the antibiotic. Some might develop a mutation. Have students add one M&M to their plate to represent a bacterium that has evolved resistance to the antibiotic.
6. **Doubling.** Bacteria reproduce by binary fission – essentially, they split in two. Represent this in your population by adding enough marshmallows and M&Ms to double the number of each on their plates.
7. Repeat steps 4-6 to represent subsequent antibiotic doses. Continue until at least 6 doses have been completed.
8. Have students graph their data on the worksheet.

Notes

Share

Ask, "What was the effect of the antibiotic on the population of bacteria? Why?"

Process

Ask, "How effective will this antibiotic be on this patient next time?"

Generalize

Ask, "How do humans increase antibiotic resistance in themselves, animals or the environment?"

Apply

Ask, "What are some ways we can help prevent antibiotic resistance from spreading?"

References

World Health Organization "Antimicrobial resistance" [who.int/news-room/fact-sheets/detail/antimicrobial-resistance](https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance)

Centers for Disease Control "Antimicrobial resistance" [cdc.gov/antimicrobial-resistance/index.html](https://www.cdc.gov/antimicrobial-resistance/index.html)

Supplemental Information

Educational Standards Met

MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

MS-LS4-5. Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

TIPPS ***Life Skills***

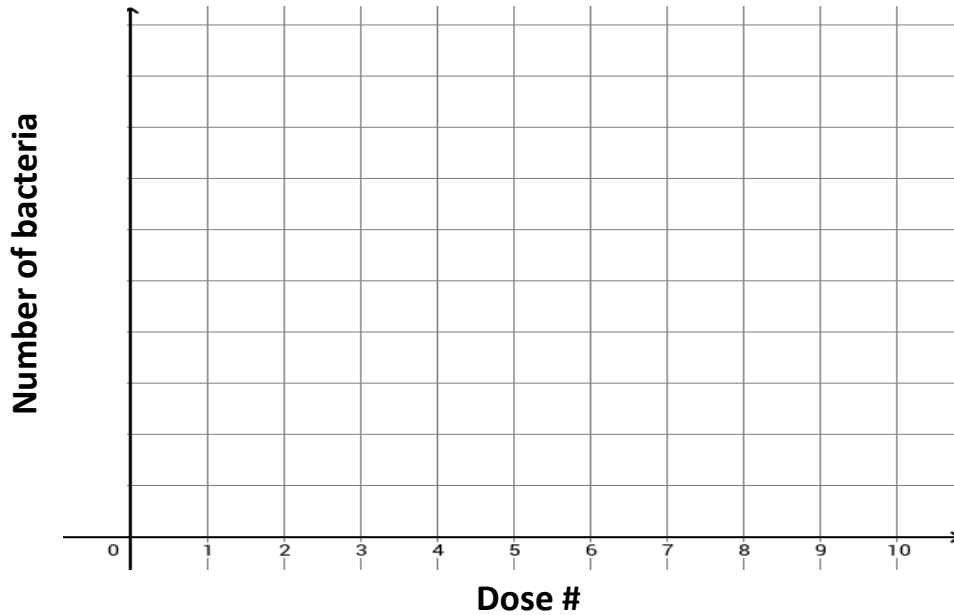
- Head - Thinking
- Health - Living

Student Worksheet

Name: _____ Date: _____

	<i>Marshmallows</i>		<i>M&Ms</i>	
	Start	Finish	Start	Finish
<i>Dose 1</i>				
<i>Dose 2</i>				
<i>Dose 3</i>				
<i>Dose 4</i>				
<i>Dose 5</i>				
<i>Dose 6</i>				

Graph the population sizes at the **finish** of each dose on the grid below. You should have two lines, one for susceptible bacteria (marshmallows) and one for resistant bacteria (M&Ms).



1. What was the effect of the antibiotic on the population of bacteria?
2. How effective will this antibiotic be on this patient next time?
3. How do humans increase antibiotic resistance in themselves, animals or the environment?
4. How can we prevent antibiotic resistance?



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