Lesson Plan 5: Spread of Superbugs

Time: 1 hour 30 minutes

The ability of bacteria to reproduce quickly and exchange bits of DNA enable bacteria to have a high degree of adaptability that creates more and more superbugs. The next two activities demonstrate this.

Activity 1: Bugs swap powers!

This activity demonstrates how bacteria transfer their resistance to other bacteria

Overview: Students model how horizontal gene transfer (e.g., conjugation) contributes to the spread of antibiotic resistance genes in bacteria. Students will be able to explain how bacterial cells can acquire new genes through conjugation, describe how a population of bacteria can evolve to become antibiotic resistant, understand how rapidly bacteria reproduce, and discuss how this reproduction rate makes it possible for populations of bacteria to quickly adapt to new antibiotics.

Time: 45 minutes

Materials:

1. Sheets of green and yellow construction paper: Cut the construction paper into 1" circles. For a class of 30, make 25 yellow circles and 125 green circles. Green circles represent plasmids that do not carry a gene for antibiotic resistance. Yellow circles represent plasmids that do carry a genefor antibiotic resistance.
2. News paper bags (one per student)

Prepare a paper bag for each student. For every five students in the class, one bag should contain five yellow circles. The remaining bags should each contain five green circles. For a class of 30, you should have five bags containing yellow circles and 25 bags containing green circles.

3. On an overhead or on the board, draw the table found on the student handout.
4. Scissors.

Activity Sheet

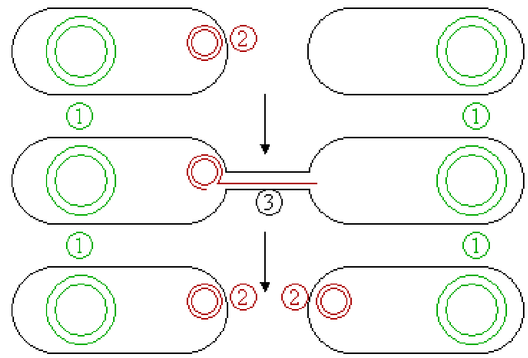
	Number of students with yellow circles	Number of students without yellow circles
Before Round 1 Exchanges		
After Round 1 Exchanges		
After Round 2 Exchanges		
After Round 3 Exchange		

Activity:

Bacteria have a superpower that they use to spread resistance which makes them become superbugs really quickly. This is their ability to transfer their DNA from one to another without reproduction. This is an ability that only bacteria have and is as easy for them as shaking hands. Let us see how this works.

Before beginning the activity, remind the students what they have learned in the previous class about bacterial cell structure: Bacteria are single-celled prokaryotic organisms, which means that they lack a nucleus. Bacterial DNA floats freely in the cytoplasm. Most often, this is in the form of a single, circular chromosome, though some bacterial strains have multiple circular chromosomes or occasionally linear chromosomes. Many bacterial cells also contain additional loops of DNA called plasmids. These structures carry genes in addition to the genes on the bacterial chromosome and can replicate independently of the chromosome.

Explain to the students that plasmids often contain genes for antibiotic resistance. Bacterial cells differ from human cells in their ability to manipulate and share their DNA. Bacteria of different species can exchange bits of DNA through a process called conjugation, in which one bacterium extends a tube-like projection to another and delivers a plasmid or plasmids to it. Conjugation is one form of a process called horizontal gene transfer, which is an exchange of genetic material by methods other than direct transmission from parents to offspring (which is called vertical gene transfer).



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Explain to the students that Conjugation is one way antibiotic resistance spreads. This can happen between different strains of bacteria too and is not restricted to the same strain. Antibiotic resistance can also spread when bacteria pick up the resistant plasmid from dead bacteria.

Researchers suggest horizontal gene transfer is one means by which previously harmless bacteria may acquire the genes that give them antibiotic resistance. Given the rapid rate at which bacteria reproduce, it's easy to see how newly acquired genes—especially those that help bacteria fight the drugs meant to kill them—can quickly spread through a population.

Show them the animation Infectious disease: bacterial conjugation.

Round 1

1. Hand out the paper bags. Tell students to look inside their own bag, but not to tell other students what their bag contains. Explain that the bags represent individual bacterial cells, and that each bag contains paper circles that represent plasmids.
2. Explain that they will walk around the room simulating bacterial conjugation—each student will exchange circles by taking a circle from another student's bag without looking at it and then placing it in his or her own bag. They should do this until everyone has made five exchanges with different students.
3. After the five exchanges, have students count how many yellow circles they have in their bags. Indicate in the table the number of students with yellow circles, as well as the number of yellow circles per student. Have students write their answers in the second row, "After Round 1 Exchanges, " of the table on the handout.
4. Ask students to raise their hands if they started out with no yellow circles and then to lower their hands if they still have no yellow circles. Ask for a volunteer to describe the change that took place. At this point, you may reveal the number of students who started out with yellow circles.
5. Have students fill in this number on the first row of the table, under the column "Actual number of students with yellow circles." They also should fill in the number of students who started out without yellow circles before the Round 1 exchange. Ask for a volunteer to describe how these numbers changed after round 1.
6. Ask the class to predict how the number of students with yellow circles might change after the next round. Make sure students complete the first two rows of the table on the handout before they begin Round 2.

Round 2

7. Have students repeat the exchange round once more (5 exchanges), and tally the number of students with and without yellow circles, as well as the number of yellow circles each student has.

8. Ask students to predict what will happen if the class is exposed to an antibiotic, and enter their predictions in the table. They should recognize that any students with yellow circles will "survive."

Round 3

9. Have students repeat the exchange round once more (5 exchanges). This time, tell them they will simulate antibiotic exposure. Have students with no yellow circles sit out this round. Tally the number of students with and without yellow circles, as well as the number of yellow circles each student has.

10. Ask for a volunteer to explain why students without yellow circles sat out this round. You may need to review the role of antibiotic-resistance genes on the yellow "plasmids."

Raise the following points for discussion:

How many students have more than one yellow circle? More than two? Three or more?

Remind students that yellow circles represent plasmids carrying genes for antibiotic resistance. What would be an advantage to a bacterial cell of having more than one of these plasmids? Do students think plasmid number has any effect on a bacterium's ability to resist antibiotics? (Having more number of plasmid copies will confer more resistance due to more expression of the required protein).

Why do doctors tell people to take antibiotics for ten to fourteen days? Why not just one dose? (As we saw in the lessonplan 3, one dose is hardly enough to get rid of all infection causing bacteria).

Activity 2: Superbug babies

Overview: Through this interactive activity, children will understand how quickly bacterial populations can change from normal to antibiotic resistant even with-in one course of antibiotic. This will also demonstrate how stopping antibiotic mid-course can lead to antibiotic resistance and reinforce how misuse and overuse of antibiotics contributes to resistance.

Optional video to explain how fast bacteria reproduce: Reproduction song - play from 0.38 seconds A simple activity can also be to ask students to calculate how many bacteria (*e.g.* E.coli that divides every 20mins) one can generate from one bacterium in 60 mins

Time: 45 minutes

Materials:

- 50 Chickpeas (Chane) soaked and cooked representing bad bacteria (bugs). Alternative material: White beads with holes (hole should be big enough for the toothpick to get in).

- About 40 uncooked chickpeas representing antibiotic resistant bacteria (superbugs). Alternative material: White beads of the same size and appearance with no holes

- Tooth picks representing antibiotics

- Glass bowls, to hold the different pulses/beads

- Activity Sheets

Antibiotic Dose	Bugs		Superbugs	
	Start	Finish	Start	Finish
0				
1				
2				
3				
4				
5				
6				
7				

Activity:

1. Put 50 cooked chickpeas (bad bacteria, bugs) into the glass bowl. This is a patient that this group of doctors have to now treat. These bugs have given the patient a strep-throat and ask them what they would prescribe as doctors? (Antibiotic)

2. Choose a volunteer to simulate the antibiotic. Explain that for the sake of this activity, we shall assume that for each dose, antibiotic is able to kill 25 bacteria. Have the volunteer put the antibiotic into the patient and pull out 25 bacteria by poking through the chickpeas.

3. At the end of the dose, count the number of bugs remaining in the bowl and note it in the table provided.

4. Explain to the students that “bacteria reproduce through cell division, with each bacteria dividing into two. Bacteria do this very quickly with some like E.coli even dividing every 20 minutes. For the sake of this activity, let us assume that these bacteria divide once a day. Now the bugs in the patient have also divided once, add the number of chickpeas equal to those remaining in the bowl. For eg, if 25 are remaining, add another 25 from the pile.”

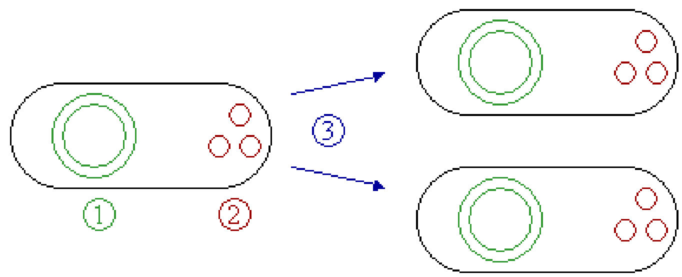

Image: Wikimedia.org

5. “During this reproduction in antibiotic rich environment, one of the bugs has mutated into a resistant bacteria, superbug.” Ask the students to remove one cooked chickpea and replace it with uncooked chickpea representing antibiotic resistant bacteria (superbug). Note down the number of starting bugs and superbugs in the table provided.

6. Let a different volunteer simulate the antibiotic and remove 25 bugs by poking through the chickpeas. The superbugs remains unpicked.

7. At the end of the dose, count the number of bugs and superbugs remaining in the bowl, note it in the table provided.

8. Explain to the students, “the bacteria have again divided, add the number equal to those remaining in the bowl for both bugs and superbugs”

9. Let the students take turns and repeat the above step 5 more times (representing full course of antibiotic of 7 days), each time counting the remaining bacteria and doubling the number.

The table should look like this at the end of the activity:

Antibiotic Dose	**Bugs**		**Superbugs**	
	Start	**Finish**	**Start**	**Finish**
1	**50**	**25**	**0**	**0**
2	**49**	**24**	**1**	**1**
3	**48**	**23**	**2**	**2**
4	**46**	**21**	**4**	**4**
5	**42**	**17**	**8**	**8**
6	**34**	**9**	**16**	**16**
7	**18**	**0**	**32**	**32**

Discussion:

What do you understand from this table? What was the predominant bacteria at the start of the activity? (Normal bugs). What happened to the population by the end of the treatment (the population has become resistant, turned superbugs). Can you see how the population can shift from normal to resistant (bugs to superbugs) even during one course of the antibiotic. This happens because of bacteria's ability to reproduce quickly.

Will this patient respond to this antibiotic, next time he has this infection? (No, he will require a different antibiotic).

Let us assume that the bacteria had not mutated and there are no superbugs. Concentrate only on the left side of the table. How many doses were required to completely get rid of all the bugs? (7). If the patient had stopped the course say after 4 days because he started to feel better, would he have gotten rid of the infection (No). If you stop taking the antibiotics too soon, bacteria can survive and potentially develop antibiotic resistances. In general, the shorter the course of the treatment, the more bacteria survive, increasing the chances of them potentially becoming resistant to the antibiotic. For bacteria that are not already fully resistant to the drug, it is better to take the antibiotics long enough so they can be killed and do not develop resistance.

An antibiotic course of 7 doses has been used here for demonstration purpose only. Doctors usually decide on the duration of the antibiotics based on the state of the infection, the bug causing it and the condition of the patient. Whatever the course prescribed by the doctor (3 days, 7 days, 5 days, 3 months etc…), it is important to always finish the full course.

Final activity - a summary animation film

End the session by showing them the video

This video summarises all that they have learnt in the previous sessions.

Closure: True or False Line questions

Have students stand in a line. Read the statements below. Students step one step forward if they think

the statement is true and one step back if they think the statement is false. Call on a student in the line to give a rationale and ask other students to add to previous students' comments.

• You should stop taking an antibiotic once you start to feel better. (False, you should take antibiotics until you complete the full course to prevent antibiotic resistance).

• Antibiotics kill good and bad bacteria. (True. Discuss with students how killing good bacteria affects the microbiome and our health).

• If you are sick with a cold, you should get rest, drink plenty of fluids, eat soup, and take antibiotics. (False. All are good actions except taking an antibiotic. A cold is caused by a virus, and antibiotics do not kill viruses).

• You should eat yogurt and other probiotics when taking antibiotics. (True. It replenishes the good bacteria. Make sure students know what probiotics are – good bacteria).

• It is better to be safe and take antibiotics than not (False, misuse of antibiotics causes antibiotic resistance and antibiotics may not work when you really need them. Important to follow Doctor's advice).

•Bugs evolve into superbugs due to mutations in their genes that give them a survival advantage (True, it is a natural process called evolution).

•Even one course of antibiotic is enough for bugs to turn into superbugs (True, it is therefore important not to misuse antibiotics).

•Bacteria divide very slowly (False, bacteria's ability to reproduce quickly is what leads them to evolve into more and more superbugs).

•Bacteria can transfer DNA without reproduction, also a reason why they can adapt so quickly and turn into superbugs (True, they do this very easily through a process called conjugation).

•The rise of antibiotic resistance is the most dramatic example of evolution (True, bugs have evolved to resist almost every antibiotic that is out there).

•Antibiotic resistance is a problem that concerns every one of us (True, all of us have to become superheroes to fight against superbugs, and to keep the antibiotics working).

Homework:

Suggestion 1: The government has formed a Committee to tackle antibiotic resistance and made you the head of it. List out 10 recommendations you would make to the government based on your understanding of the problem.

Suggestion 2: You are a pharmacist. Someone visits your pharmacy and requests an antibiotic to help with their cold and sore throat. What would you do? How would you make them understand why this is a problem?

Suggestion 3: Ask your parents if they know what the red line on medicine foils (covers) mean?

Visit your local pharmacy accompanied by an adult and try to buy 10 tablets of the antibiotic amoxicillin. Speak to the pharmacist and gather the following information from your pharmacist. Inform the pharmacist that this is an anonymous questionnaire and that his/her personal or the pharmacy details will not be recorded.

1. Do you deny selling antibiotics without a prescription?
2. Is this because (If they answered No to question 1, modify the question to - If you have to deny selling antibiotics without prescription, would that be because)
A) you believe misusing antibiotics could pose health risk to the patient/community
B) it is against law
3. If someone asks for an antibiotic without prescription, do you ask them what they are going to use it for and make your own suggestions?
4. Do you suggest antibiotics to people asking for medication to help their symptoms without visiting a doctor?
5. How many customers ask for an antibiotic every day without presenting a valid prescription?
6. Do you ever explain to the patients asking for antibiotics without prescription, the problems it could cause them?
7. Have you heard of antibiotic resistance? Do you believe it is a problem?
8. Do you know of the redline on some medicines and what it stands for?
9. Have you ever explained the meaning of the redline on medication to your customers?
10. What is the most common ailment people ask an antibiotic for without prescription?

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