

Grade: 11	Subjects: University and College Preparation Biology	Units: Diversity of Living Things and Microbiology
Case Study-More Antibiotics?!		
<p>Rationale: Students will explore bacterial infection after a patient undergoes hip replacement surgery. Concepts related to the prescription of antibiotics, antibiotic resistance, biofilms and probiotics are analyzed.</p>		
<p>Background Information:</p> <p>Many bacteria are capable of producing biofilms, which are aggregates of bacteria that exist together. The bacteria anchor to a surface, release polysaccharide sugars and enter a dormant state. Biofilms are found in diverse places such as hostile natural environments, in shower drains and around artificial prosthetic implants. The formation of a biofilm makes bacteria more resistant to antibiotics. Researchers in the Nitz laboratory at the University of Toronto are trying to prevent the formation of biofilms by targeting enzymes that are necessary for biofilm release from a surface which allows the bacterial biofilm to attach elsewhere.</p> <p>After obtaining a greater understanding of biofilm formation and their role in causing disease, the desire to relate it to high school science concepts became a priority. Since biofilms are made up of bacteria, this relates to the diversity and microbiology units of Grade 11 University Preparation Biology and Grade 11 College Preparation Biology, respectively. A case study involving a woman that undergoes hip replacement surgery and subsequent bacterial infections is used to review the concepts of antibiotics, antibiotic resistance, biofilms and probiotics.</p>		
<p>Curriculum Connections:</p> <p><u>Grade 11 University Preparation Biology</u></p> <ul style="list-style-type: none"> ● B2.1 use appropriate terminology related to biodiversity, including, but not limited to: genetic diversity, species diversity, structural diversity, protists, bacteria, fungi, binomial nomenclature, and morphology ● B2.2 classify, and draw biological diagrams of, representative organisms from each of the kingdoms according to their unifying and distinguishing anatomical and physiological characteristics (e.g., vertebrate or invertebrate organisms, vascular or nonvascular plants) ● B3.2 compare and contrast the structure and function of different types of prokaryotes, eukaryotes, and viruses (e.g., compare and contrast genetic material, metabolism, organelles, and other cell parts) ● B3.3 describe unifying and distinguishing anatomical and physiological characteristics (e.g., types of reproduction, habitat, general physical structure) of representative 		

organisms from each of the kingdoms

Grade 11 College Preparation Biology

- C3. demonstrate an understanding of the diversity of microorganisms and the relationships that exist between them
- C2.1 use appropriate terminology related to microbiology, including, but not limited to: fission, conjugation, phage, dormancy, morphology, mycelium, spore, pathogen, and plasmid
- C3.1 describe the anatomy and morphology of various groups of microorganisms (e.g., eukaryotes, prokaryotes, viruses)
- C3.5 describe how different viruses, bacteria, and fungi can affect host organisms, and how those effects are normally treated or prevented (e.g., hepatitis viruses can damage the liver, but vaccinations can prevent infections; streptococcus bacteria can cause respiratory infections, which are treated with antibiotics; ringworm is a fungal infection of the skin, treated with fungicides)

Lesson Objectives/Concepts:

- Students will review concepts learned in class related to bacterial shapes and gram stain
- Students will gain a better understanding of antibiotics and antibiotic resistance
- Students will learn about biofilms and how they have increased antibiotic resistance
- Students will learn what probiotics are, and how they can help maintain a healthy gut when a person is taking antibiotics

Materials: Access to YouTube, student handout.

Time: 1.2 periods
A period is 75 minutes.

Introduction (20 minutes):

Questions to ask the class:

1. Are antibiotics effective against viral infections? No! They are only effective against bacterial infections.
2. What does it mean when bacteria are antibiotic resistant? The antibiotic is not effective in killing them.
3. Do you know what biofilms are? They are an aggregate of bacteria that live together on surfaces and have increased resistance to antibiotics.
4. Do you know what probiotics are? They are 'good' or 'helpful' bacteria that help our gut stay healthy.
5. Show students the following YouTube videos:
 What causes antibiotic resistance? <https://www.youtube.com/watch?v=znnp-lvj2ek>
 Biofilm: A New (Gross) Thing to Worry About:
<https://www.youtube.com/watch?v=twxPyvdc-EE>

Pickles, Probiotics, and Why Rotten Food Is Good For You:

<https://www.youtube.com/watch?v=1vwfGxVWYNk>

6. Introduce the Case Study. It involves Mary, a senior, who undergoes what was supposed to be a routine hip replacement surgery.
7. By the end of the case study, students will have a better understanding of antibiotics, antibiotic resistance, biofilms and probiotics.

Activities/Procedure (50 minutes)

Pre-teaching, done in advance of this lesson:

- Ensure you have taught students the basics of the bacterial kingdoms Eubacteria and Archaeobacteria, including their shapes, gram stain, respiration and the use of antibiotics.

Lesson:

- Students should be divided into small groups. They should work together as they go through the case study handout to understand the concepts within it, and to answer the questions that are found throughout.
- The teacher should circulate around the room guiding students as necessary and answering any questions that come up.
- Ask students to complete the case study questions for homework, if incomplete. Go over the answers next day as a class.

Summary/Closure (5 + 15 minutes next day):

- Ask students if anything surprised them about the case study contents/information.
- Take up the questions with the class at the start of next period, soliciting answers from students.

Assessment

- As you are circulating around the classroom, assess the level of understanding amongst the groups of students.
- You may collect student answers to assess them for accuracy and completion as a diagnostic tool.
- Answers to case study questions are provided.

Extensions/Connections

- This case study can be used as a jumping off point for the idea of adaptation of bacterial populations to their environments, including exposure to antibiotics. The formation of biofilms makes bacteria more antibiotic resistant. This would relate to the evolution unit of Grade 11 University Preparation Biology.
 - [C3.2 explain the process of adaptation of individual organisms to their environment (e.g., some disease-causing bacteria in a bacterial population can survive exposure to antibiotics due to slight genetic variations from the rest of the

population, which allows successful surviving bacteria to pass on antibiotic resistance to the next generation)]

Answers to Case Study Questions

1. List the pros and cons of each option. What option do you choose?

Nitrofurantoin

Pros: -Effective against numerous bacteria, including *E. coli*
-Fewer side effects
-Low resistance

Con: -Although resistance is low, you need to ensure that it is killing the type of bacteria that is infecting Mary or else resistant bacteria may develop

Ciprofloxacin

Pros: -Effective against numerous bacteria, including *E. coli*
-High effectiveness

Cons: -Pockets of resistance are beginning to emerge in some countries by *E. coli* UTIs
-Should only be used for more serious infections and if other antibiotics are not a suitable option

Nitrofurantoin is the best option, due to its low resistance and less side effects. Unless it isn't effective, or the infection gets worse, ciprofloxacin should not be the first choice of antibiotic.

2. What are the three main bacteria shapes?
-Coccus (Round), Bacillus (Rod) and Spirillum (Spiral)
3. What prefix is given for bacteria found in clusters?
-Staph-
4. What prefix is given for bacteria found in chains?
-Strep-
5. What is the purpose of gram staining?
-It is used to identify bacteria
6. What colour indicates gram positive bacteria?
-Dark purple
7. What colour indicates gram negative bacteria?
-Pink
8. A. What does aerobic mean?
-Requires oxygen
9. What does anaerobic mean?
-Requires the absence of oxygen

10. Using your knowledge of bacteria and resistance, why do you think biofilms are a smart survival mechanism for the bacteria that form them?
-There is protection in numbers. The group of bacteria goes into a slower state of living, and antibiotics that target actively growing bacteria are not very effective as a result.
11. Imagine you are a bacterium that is part of a biofilm and you are found on the surface of that biofilm. What do you think may happen to you when exposed to the antibiotic? What about other bacteria that are found in the center of the biofilm? Do you think they will be affected by the antibiotic?
-Bacteria found on the surface of a biofilm would be subjected to the full dose of antibiotic and will most likely be killed as a result. Those that are in the centre of the biofilm will have some protection from feeling the full effects of the antibiotic. That, along with the fact that growth is slowed down in biofilms will prevent these bacteria from being killed by the antibiotic. The low dose exposure to the antibiotic may create a resistant biofilm that requires stronger antibiotics to eradicate it.
12. What negative effects do you think could occur due to Mary taking more than one antibiotic at once?
-In general, taking an antibiotic can result in 'good' bacteria being killed, along with the pathogenic types. In Mary's case, since she is taking 2 antibiotics that are effective against more than one type of bacteria, she may kill off several strains of her 'good' bacteria that is present in her digestive system. This will disturb her regular intestinal flora and could cause digestive issues.
13. What are probiotics?
-Probiotics are 'good' or helpful bacteria that keep your gut healthy. They are found in some food and in supplement form.
14. Why can't Mary just increase her consumption of yogurt instead of taking probiotic pills?
-The type of probiotic strains in yogurt can vary widely. Some brands have certain types, while others have other types. Taking a supplement recommended by her doctor will ensure that she takes the right type of probiotic strain(s) and the supplement has a specific number of them (CFUs) in each pill.
15. Why are antibiotics not effective against colds?
-Antibiotics kill bacteria and colds are caused by viruses.
16. What are the dangers of using an antibiotic to treat a cold?
-Although antibiotics are ineffective against cold viruses, they kill bacteria. In the case of a cold, with no bacterial infection present, the antibiotics will kill the 'good' gut bacteria, which may result in digestive issues.