Antibiotics

1. Warmup: Medical Scenario
2. Lecture: PPT Slides & Notes
3. Math Connection: Graphing Activity
4. Assessment: Final Recommendation for Medical Scenario Citing Evidence
5. Enrichment: Article with Questions
You are an American doctor. A medical colleague in another country sends you the following email. **What recommendations do you have for him? Choose a partner and list some suggestions in your lab notebook.**

“We’ve seen a great increase in respiratory infections this winter. Lot’s of kids with green phlegm and sore throats. So many people are missing school and work that the town is in a panic. Parents and politicians want us to prescribe antibiotics to every runny nose that walks through the door. We’ve been prescribing penicillin as a precautionary measure to most folks who come in with respiratory infections and it seemed to help at first, but not anymore. Are you experiencing similar problems in your country? If so, is it viral or bacterial? Do you have any suggestions for how we can better handle things over here?”
Your Recommendations?

Let’s create a list of recommendations and check them against what we learn about antibiotics as we progress through the lesson.
What are Antibiotics?

Antibiotics are chemicals (usually proteins) that kill bacteria or stop them from growing and dividing

- some dissolve the cell membrane \((\text{kills})\)
- some prevent proper formation of the cell wall \((\text{kills})\)
- some prevent DNA replication \((\text{prevents replication})\)
- some prevent protein synthesis \((\text{prevents replication and may also kill the cell})\)
Antibiotic Targets

**Cell Wall Synthesis**
- Beta-Lactams (penicillins, cephalosporins)
- Glycopeptides (vancomycin)
- D-Cycloserine
- Fosfomycin
- Bacitracin

**Cell (Cytoplasmic) Membrane**
- Polymyxins
- Daptomycin

**RNA Synthesis**
- Rifampin

**Ribosomal Protein Synthesis**
- Aminoglycosides (streptomycin, gentamicin)
- Erythromycin
- Tetracyclines
- Clindamycin
- Chloramphenicol
- Linezolid

**DNA Synthesis**
- Fluoroquinolones
- Metronidazole
- Trimethoprim/sulfamethoxazole
What are Antibiotics?

- Antibiotics are anti-bacterial only (they only affect prokaryotic cells)
- They DO NOT affect viral infections because viruses are not cells, or fungal infections because fungi are eukaryotic cells
- Some antibiotics are “broad-spectrum antibiotics” - they affect a wide variety of bacteria (those that attack the cell wall or membrane, for example)
- Some antibiotics are “narrow-spectrum antibiotics” - they only affect very specific strains of bacteria (those that inhibit specific growth factors, for example)
How does this affect your recommendation so far?

- What do doctors use to treat bacterial infections?
- Is it important to know if the infection is caused by a bacteria versus some other pathogen?
- Is it important to know what type of bacteria is causing the infection?
- Should antibiotics be given “just in case”?
Antibiotic Resistance

- The antibiotic properties of plants and certain fermented foods have been recognized for thousands of years, but were not isolated and linked directly to bacterial infection until the 1940’s.

- The first was a chemical secreted by mold → **penicillin**

- Naturally occurring antibiotics are secreted by bacterial and fungal cells as a means:
  - of protection from other predatory bacteria
  - to kill other bacteria in order to consume them
  - to kill competitors for food and resources
Antibiotic Resistance

- Antibiotics were a medical breakthrough that saved millions of lives - prior to their widespread use, infectious diseases were the number one killer world-wide and the average life expectancy was less than 60 years old.
- Scientists began to quickly identify more naturally-occurring antibiotics and also to manufacture synthetic (man-made) ones.
- But within three years the first antibiotic-resistant bacteria began to appear and become wide-spread.
- Today there are several strains of deadly bacteria that are resistant to all forms of antibiotics.
Antibiotic Resistance

**Exposure to bacteria occurs.**

**Infection occurs and the bacteria spread.**

**Drug treatment is used.**

**Non-resistant Bacteria**

1. The bacteria multiply.
2. The bacteria die. The person is healthy again.

**Drug Resistant Bacteria**

1. The bacteria multiply.
2. The bacteria continue to spread. The person remains sick.
Same species of bacteria on the left and the right, but the one on the right is a strain that is resistant to three of the antibiotics tested.
What Causes Antibiotic Resistance?

These data were collected from a community in Finland from 1978 – 1993. The researchers collected data on the annual amount of antibiotics used in this community. They also collected samples of bacteria from young children with middle ear infections. They then examined the bacterial strains to see if they were susceptible to (killed by) or resistant to (not killed by) these antibiotics. The data given below are a measure of the amount of antibiotics used each year, and the percentage of the bacterial strains that were found to be resistant to the antibiotic (between 0 – 100%).

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Antibiotic Usage</th>
<th>Percent Resistant Strains</th>
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<tbody>
<tr>
<td>1978</td>
<td>0.84</td>
<td>0</td>
</tr>
<tr>
<td>1979</td>
<td>0.92</td>
<td>2</td>
</tr>
<tr>
<td>1980</td>
<td>1.04</td>
<td>29</td>
</tr>
<tr>
<td>1981</td>
<td>0.98</td>
<td>46</td>
</tr>
<tr>
<td>1982</td>
<td>1.02</td>
<td>45</td>
</tr>
<tr>
<td>1983</td>
<td>1.03</td>
<td>58</td>
</tr>
<tr>
<td>1984</td>
<td>0.95</td>
<td>61</td>
</tr>
<tr>
<td>1985</td>
<td>1.12</td>
<td>60</td>
</tr>
<tr>
<td>1986</td>
<td>1.06</td>
<td>49</td>
</tr>
<tr>
<td>1987</td>
<td>1.14</td>
<td>59</td>
</tr>
<tr>
<td>1988</td>
<td>1.21</td>
<td>58</td>
</tr>
<tr>
<td>1989</td>
<td>1.28</td>
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</tr>
<tr>
<td>1990</td>
<td>1.32</td>
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</tr>
<tr>
<td>1991</td>
<td>1.31</td>
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</tr>
<tr>
<td>1992</td>
<td>1.27</td>
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<tr>
<td>1993</td>
<td>1.28</td>
<td>91</td>
</tr>
</tbody>
</table>
What Causes Antibiotic Resistance?
What Causes Antibiotic Resistance?

![Graph showing the percentage of resistant strains over years](image-url)
What Causes Antibiotic Resistance?
What Causes Antibiotic Resistance?

Genetic Mutation Causes Drug Resistance

1. Non-resistant bacteria exist
2. Bacteria multiply by the billions
3. A few of these bacteria will mutate.
4. Some mutations make the bacterium drug resistant
5. In the presence of drugs, only drug resistant bacteria survive.
6. Drug resistant bacteria multiply and thrive.

Mutation in DNA
What Causes Antibiotic Resistance?

Gene Transfer Facilitates the Spread of Drug Resistance

1. Resistant and non-resistant bacteria exist

2. Bacterium multiply by the billions

3. Non-resistant bacteria receive new DNA.

4. Drug resistant bacteria multiply and thrive.

Bacteria that have drug resistant DNA may transfer a copy of these genes to other bacteria. Non-resistant bacteria become resistant. In the presence of drugs, only drug-resistant bacteria survive.
What Causes Antibiotic Resistance?

- Antibiotic resistance results from naturally occurring mutations that make bacteria immune to the effects of an antibiotic.

- However, human abuse and misuse of antibiotics is driving rapid mutation and spread of antibiotic resistance (evolution).
  - Using antibiotics when not needed (for infections not caused by bacteria, prophylactically to prevent illness in the meat industry)
  - Not using antibiotics for long enough to kill ALL of the bacteria
  - Using the wrong antibiotic for a bacterial infection (like is you use leftover pills for a different infection)
  - Improper disposal of antibiotics causing pollution of water supply
What can you do to help?

1. Never take antibiotics for infections caused by other types of pathogens - don’t pressure your doctor to prescribe antibiotics unnecessarily.

2. Always complete the full course of antibiotics when prescribed for a proper bacterial infection, even if you feel better before they are all gone.

3. Never share or save antibiotics.

4. Dispose of unused antibiotics (and all medications) properly:
   - throw them in the trash, DO NOT flush them
   - even better, drop them at a hazardous household waste collection day.

5. Support efforts to ban using antibiotics in ways that support resistance (like eating certified antibiotic-free meat).
How does this affect your final recommendation?

- Why did penicillin seem to work at first, but not anymore?
- What might have caused this to happen?
- What should doctors do when new patients come in sick with a respiratory infection before prescribing antibiotics?
- Should antibiotics be given to everyone who comes in with symptoms of the respiratory infection “just in case”?
- What should doctors be sure to tell patients when they do prescribe an antibiotic?