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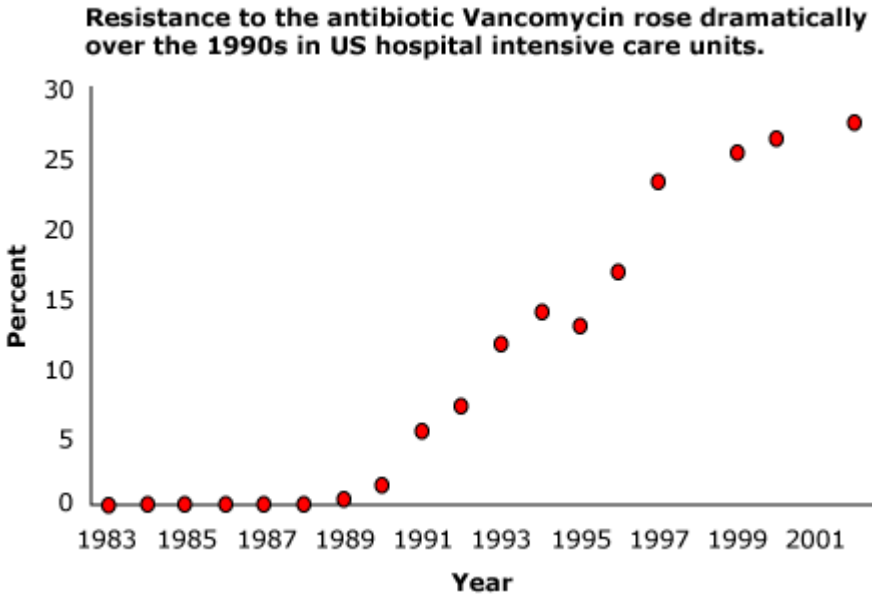
Antibiotics and Bacteria

Introduction:

In the 1940s, a new group of miraculous drugs that were thought to be the universal answer to fighting bacterial infections was introduced. Antibiotics appeared to be a miracle cure for fighting human diseases like pneumonia, typhoid, bubonic plague, and gonorrhea. However, within a short time, resistant strains of bacteria emerged that could survive in the presence of antibiotics designed to kill them.

Medical personnel and researchers were not worried. They believed that as long as they had one antibiotic to use as the drug of "last resort", everything would be fine. That antibiotic was vancomycin. So, for the next 40 or so years, doctors not only dispensed antibiotics freely, but also prescribed the same antibiotics over and over again. Patients, once they felt better, often did not finish the prescribed dosage of antibiotics. In addition, pharmaceutical companies stopped developing new antibiotics because they thought we were safe.

By the late 1980s, hospitals began to identify vancomycin-resistant infections. By 1996, the unthinkable happened. Bacteria that cause staph infections often found in hospitals were showing resistance in Japan, Michigan, New York, and New Jersey. There were no antibiotics left in the world that did not have some bacteria resistant to their effects. Below is a graph of bacterial resistance to vancomycin during the 1990s from reported infection cases in U.S. intensive care units.



So, how did this mess occur??? The answer is simple ----- EVOLUTION!

Today, this problem is like running on a treadmill. Medical researchers must sweat just to stay in the same place in their race against bacterial infections. Drug companies develop and introduce a new antibiotic, only to see the evolution of resistant bacterial strains within a few years. The researchers have to race to develop yet another antibiotic, which, in turn, becomes useless in the face of newly evolved resistant bacteria.

So how exactly does resistance occur? Imagine a population of bacteria infecting a patient in the hospital. The patient is treated with an antibiotic to kill off the bacteria. The antibiotic kills most of

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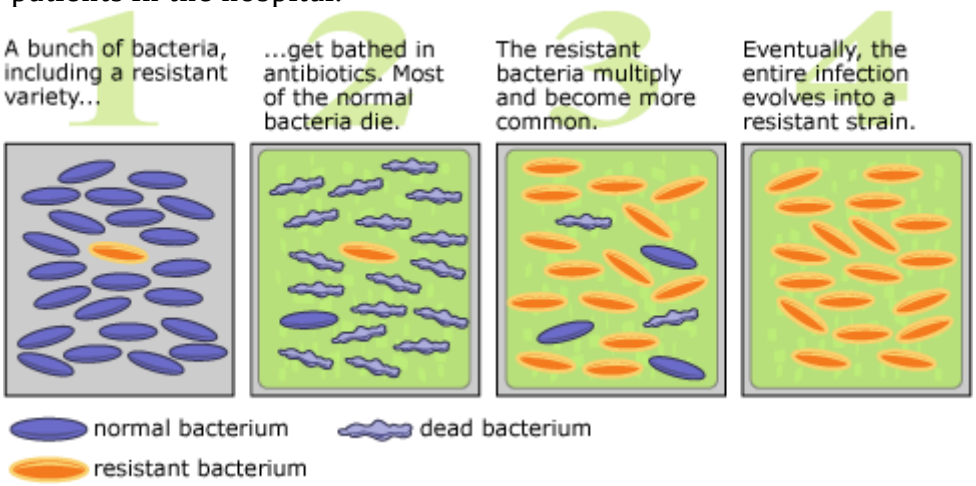
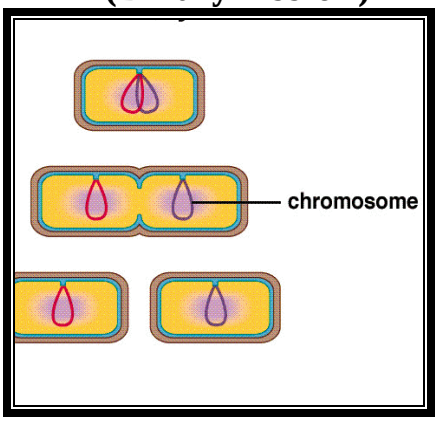
the bacteria but there are a few bacteria that have the variation to resist the antibiotic. These survivors reproduce, passing their resistance to their offspring. Soon the patient is populated with an antibiotic resistant infection. This infection not only affects the original patient, but can also be passed to other patients in the hospital.

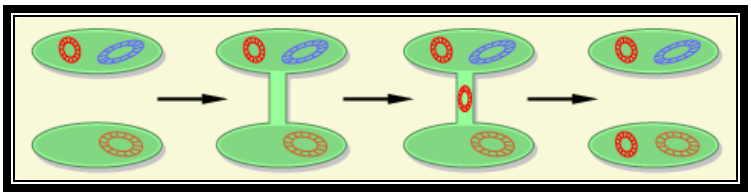


To make matters worse, bacteria reproduce very quickly, so lots of bacterial cells can be generated in a very short period of time. Bacteria reproduces ***asexually*** by a process called ***binary fission***. The bacterial cell makes a copy of its DNA (found in the cytoplasm of the cell since bacteria have no nuclei) and then they split into 2 daughter cells. The daughter cells have the same DNA as the parent cell so there are no variations, except it there is a spontaneous mutation (see diagram below).

Asexual Reproduction of Bacteria
(Binary Fission)



Although there is no gene shuffling during reproduction among bacteria since they are basically clones of the parent cell, bacteria do have a method by which they can exchange parts of their DNA ring (called a plasmid) to other bacteria, even those of a different species. This process, known as ***conjugation,*** occurs when an individual bacterium transfers copied genetic material to another bacterium by creating a temporary connection between the two. In this diagram, the upper bacterium passes a ring of copied genetic material to the lower one.



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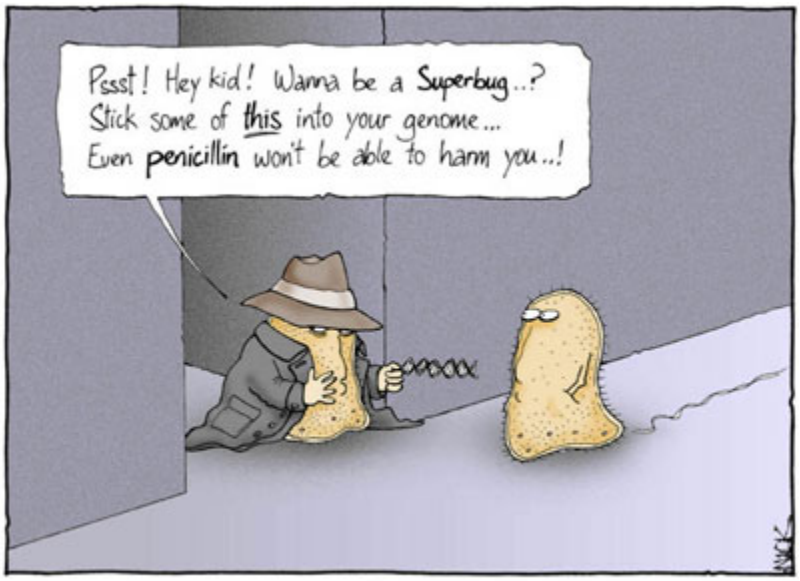
Genetic variations can occur as a result of conjugation. Resistance to antibiotics can be passed to other bacteria in this manner, further increasing the trait of antibiotic resistance among a population of bacteria in a relatively short time.

Part I

Questions: (separate paper please. Save my eyes- try to write neatly!!!)

1. In the second paragraph of this reading, it states: "They believed that as long as they had one antibiotic to use as the drug of "last resort", everything would be fine." Explain what this statement means within the context of this reading.
2. Describe 3 ways humans contributed to antibiotic resistance.
3. Describe what happened in the 1980s that now has medical professionals worried about successfully treating bacterial infections.
4. Using your knowledge of natural selection explain how bacterial resistance developed?
5. Explain why the number of bacteria resistant to vancomycin rose so dramatically (see graph on page 1).
6. In your own words, describe the process of natural selection in the development of antibiotic resistant bacteria.
7. Describe the process of asexual reproduction in bacteria.
8. Compare the daughter cells to the parent cell in terms of genetics.
9. Explain the process of conjugation in bacteria.
10. Describe how short reproduction time and conjugation increase the rapid growth of bacteria resistant to antibiotics.
11. Read the cartoon below and explain its meaning.



It was on a short-cut through the hospital kitchens that Albert was first approached by a member of the Antibiotic Resistance.

Part II

Problem:

You are a member of a team of microbiologists that hired by a drug company to trace the development of antibiotic resistance of salmonycin, the antibiotic used against *Samonella,* the bacteria that causes food poisoning.

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1. Using the data table below**, calculate the percentage of the <u>total population</u>** of Samonella that are susceptible to salmonycin and that are resistant to salmonycin for **year 1 and year 10**.

COPY THIS ONTO TO YOUR ANSWER PAPER!

Year 1: % of bacteria susceptible to antibiotic: _____
% of bacteria resistant to antibiotic_____

Year 10: % of bacteria susceptible to antibiotic: _____
% of bacteria resistant to antibiotic_____

2. Construct a bar graph that reflects the changes in the number of susceptible and resistant bacteria for each year.

Year	# of bacteria susceptible to salmonycin	# of bacteria resistant to salmonycin
1	999,999	1
2	896,407	37
3	901,363	590
4	889,242	3,611
5	870,011	15,423
6	869,692	195,687
7	627,916	380,197
8	243,020	569,882
9	7,438	867,103
10	512	987,833

Conclusions:

1. Describe what happened to the percentage of each type of bacteria over the ten year period.
2. Explain the roles of natural selection and human intervention in the emergence of salmonycin resistant bacteria.
3. Discuss three things we can do to slow down the evolution of bacterial resistance to antibiotics.

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