

The Fight Against Bacteria: Sammy's Struggle with an STD

by

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Part I – Antibiotic Resistance and Evolution by Natural Selection

Sammy had been anticipating going to college for what felt like ages. She and her parents pulled up to the North Carolina State University freshman residential halls with a van packed full of clothes and all the other items her mom insisted on purchasing before she left for school. Sammy and her parents eventually managed to move everything from the van into the dorm room, and with a short bittersweet goodbye, her parents were headed back to their small hometown in Tennessee.

Eager to get out and start doing college stuff, Sammy and her roommate, Angela, went to the dining hall. There, the pair ate a mediocre dinner, and then were ready to take on the first night of college. After hitting it off with some of the guys down the hall, they all decided to take a trip downtown to explore the Raleigh nightlife. Everyone agreed to go to the local hookah lounge to hang out. They smoked and ate some appetizers while they discussed life back in their hometowns. While there, they also talked about which extracurricular clubs looked cool, and fun things they heard about at NC State. Sammy ended up chatting to one of the boys in particular for a while. Sammy found that they had a lot in common, and they had a great conversation about their mutual love of country music, their favorite Netflix series, and what classes they were going to take in the fall.

An hour into their exclusive conversation, Angela finally interjected between Sammy and the boy, “Hey Sammy, we’re all about to head out to that frat my brother’s friend told me about. Are you guys gonna come?”

Sammy looked at the boy, trying to read his expression; she quickly replied, “Sure, let’s all go. Why not?”

The rest of the night was history.

Classes were about to start when Sammy and Angela finally adjusted to living on a college campus. After only a few days, the pair had ended up becoming great friends. They went to fitness classes in the gym, ate in the dining hall together and signed up to join a few clubs. One day when they were talking, Angela randomly asked Sammy, “Hey, have you ever heard back from that guy from the first night?”

Sammy responded, “No. I don’t know what happened. He just straight up ghosted me.”

Angela said, “Oh. Well, whatever. It doesn’t really matter. We’re about to start classes tomorrow so we have other stuff to worry about.”

Sammy said, “Yeah, that’s true. And Will from down the hall told me that intro bio is going to be really tough. Since we’re both pre-med we have to stay ahead of the game.”

Angela agreed. “Yeah, I heard Dr. Goller gives the hardest exams. We should try to get to lecture early tomorrow so we can get a good spot.”

The next morning, Angela and Sammy went to their lecture hall for introductory biology. The class was filled with hundreds of students trying to pile in, and the pair quickly took seats near the front of the room.

The rest of the syllabus week went by quickly, and the semester was well underway until one day Sammy started to feel really sick. Angela knocked on the bathroom door and asked, “Sammy, you okay? What are you doing in there? You’ve been in the bathroom a long time and I need to shower before class.”

Sammy groaned, “Ugh, no. I don’t know, something weird is going on. It really hurts to pee.”

“What? Really? That’s not good. You know there’s a health clinic here, right? It’s actually right down the road,” Angela replied.

Sammy soon found her way to the women’s health clinic. During her appointment, the nurse asked Sammy a bunch of uncomfortable questions, such as, “Have you been sexually active in the last year?”

Sammy nervously replied, “Um, yeah.”

The nurse quickly filled out an online report and then followed up with more questions. “So in the past 12 months, how many sexual partners have you had?”

“Well, just the one,” said Sammy.

The nurse continued, “Is this a past or current partner?”

“Past, but it was weeks ago.”

“Did you use any kind of protection?”

“No.”

“Have you ever been tested for sexually transmitted diseases?”

“No.”

The nurse explained that she would perform a vaginal swab in order to screen for different types of sexually transmitted diseases (STDs), including gonorrhea, chlamydia, and trichomonas. She also suggested doing blood work to test for HIV, syphilis, hepatitis B and C. She explained to Sammy, “Many people who contract STDs have no symptoms at all, and if symptoms such as abnormal discharge or burning during urination do appear, they may not even occur until several weeks after sex with an infected partner. This can lead people who are asymptomatic to spread the STD to other partners without knowing it. It’s always a good idea to get tested at least once during the year if you are sexually active. We’ll get the results from your blood work and vaginal swab in one to two days, and we’ll let you know what our next steps will be for treatment, if necessary. If you do need any treatment, we’ll set up a follow-up appointment and get you taken care of.”

The next day, Sammy’s test results came back from the health clinic and she was officially diagnosed with chlamydia. When she returned to the health clinic, she was given a prescription for an antibiotic treatment of doxycycline. The nurse told her to take one antibiotic pill in the morning and one pill at night for seven days straight.

Two days into Sammy’s treatment, she started to feel better. She tried to follow the instructions given by the nurse, but things were getting hectic with her schoolwork, so on the third morning she forgot to take a morning pill. The next night, she took two pills to compensate. On the fourth day of her treatment, Sammy forgot to take the antibiotics. Since she had been feeling better anyway, she stopped taking the antibiotic pills altogether.

It was almost two weeks later when in the middle of the night, Sammy woke up with a stabbing pain in her lower abdomen. She got up to go to the bathroom, but it hurt so much to pee. She called out in pain, “Angela! Can you help me get to the health clinic?”

Angela woke up and tried to help Sammy out of the bathroom, but Sammy could barely stand up. She touched Sammy’s forehead and found that Sammy was burning up. Angela was very worried about her and replied, “It’s like 1 am and they’re definitely not open. Maybe we should go to the hospital. Something could be really wrong.”

Questions

1. What infection was Sammy diagnosed with? Why do you think she felt sick after taking the antibiotic pills?
2. How do you think the bacterial chlamydia infection grew over time? Explain this in terms of natural selection.
3. What would a growth curve of the chlamydia bacteria look like starting from Sammy's initial infection? Draw a simple graph and indicate where (a) her antibiotic treatment started, and (b) two weeks post-treatment.
4. Figure 1 (see next page) depicts the timeline of Sammy's chlamydia infection. Each panel of the figure represents a blood sample, showing a stain of the chlamydia bacteria. The red dots indicate the initial chlamydia bacteria, and the yellow dots indicate the mutated chlamydia bacteria. Provide detailed captions for the images under the titles, specifically indicating how the bacteria population changed over time.

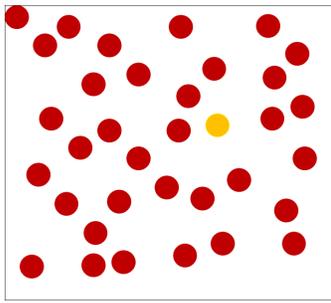


Figure 1a. Initial chlamydia infection.

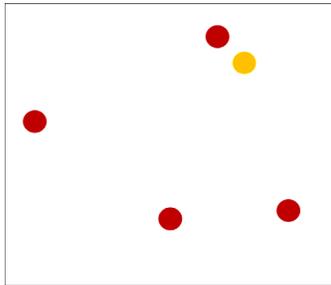


Figure 1b. Three days into the doxycycline treatment.

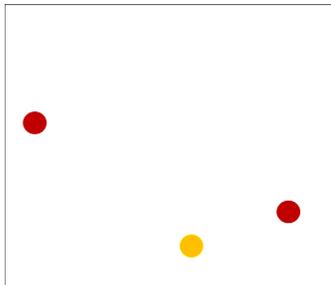


Figure 1c. Sammy stops taking her antibiotic pills.

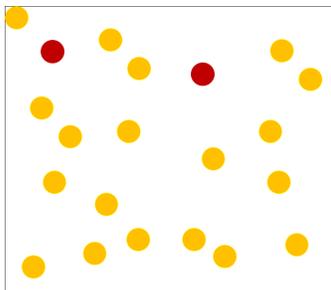


Figure 1d. One week after the doxycycline treatment.

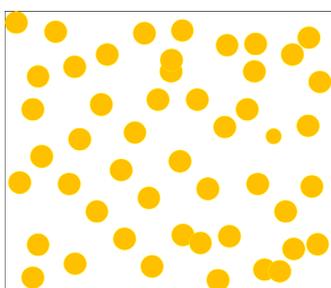


Figure 1e. Two weeks after the doxycycline treatment.

5. The following is a partial ribosomal DNA sequence of a chlamydia gene that encodes for one of its ribosomal proteins. Blood samples were taken from Sammy before and after she started the antibiotic treatment, and there is a change between the two populations. Please identify the point mutation and the amino acid that changed, and provide one reason why a ribosomal mutation could affect antibiotic resistance to doxycycline.

Pre-antibiotic treatment: ATG-GCT-GCT-AGC-GCT-TCA-AAG-GGC-AAG-AGT-AAA

Post-antibiotic treatment: ATG-GCT-GCT-AGC-GCT-TCA-AAC-GGC-AAG-AGT-AAA

6. Sammy was told by her nurse that she needed to contact all sexual partners she had had in the past six months to make them aware of their exposure to chlamydia, and to get tested for an infection, regardless of exhibiting any symptoms. While some states have specific laws on the transmission of STDs, North Carolina requires that a person who is aware of an STD infection inform previous partners. If you were Sammy, how would you tell your partner about getting tested for chlamydia?

Assignment

Write a paragraph on one way you would approach combating antibiotic resistance. This can include anything from scientific methods, like chemistry or biology, or government/policy, to societal awareness and communication. Feel free to be creative and be ready for a discussion on your answers next lecture.

Part II – Disease Rates and Prevention Methods

Sammy's trip to the hospital was quite eventful. She waited patiently to see the doctors, but due to a sudden influx of patients, she ended up in the ER longer than normal. Thankfully, Angela stayed with her the whole night. After waiting for a little over two hours, Sammy was finally seen by Dr. Gonzalez.

“So, what's your pain level on a scale of one to ten?” Dr. Gonzalez asked Sammy.

“It felt like a ten earlier, and I had a fever before, but after waiting for so long, now I'm at a seven.”

“I'm sorry about the wait but hopefully we can fix the pain that you're in. Can you explain your symptoms? I see that you wrote down abdominal pain on the form here. Is there anything else going on? Any new medications? Dietary changes?”

“Well,” said Sammy, “I have a lot of pain in my lower abdomen and it feels like it's burning when I pee. Something like this happened a few weeks ago but I didn't feel this much pain.”

“Did you go to the doctor or health clinic at that time?” asked the doctor.

“Yeah. I was infected with chlamydia but I was already treated for it a few weeks ago.”

“Hmm, I'll send out some tests and see what we can figure out from there. We have a point-of-care test that will give us results in about 30 minutes. It could be related to the previous chlamydia infection, but we'll get to the bottom of it soon.”

Dr. Gonzalez came back in 30 minutes with the results. “Your test results show that you have a chlamydia infection and we believe that as a complication, you might have pelvic inflammatory disease, or PID. PID can occur when a chlamydia infection goes untreated, and travels upwards from the cervix or vagina into the reproductive organs. PID can explain your lower abdominal pain, fever, and pelvic tenderness. We're going to give you an intramuscular injection and a round of antibiotics in order to treat the infection and PID.”

Sammy was treated for the infection and she learned about the importance of proper antibiotic usage. Dr. Gonzalez explained that the doxycycline antibiotics she was taking were part of a family of antibiotics called the tetracyclines. Antibiotics are used to treat bacterial infections by destroying or slowing the growth of bacteria in some manner. The tetracyclines, for example, work by preventing the association of aminoacyl-tRNA with the bacterial ribosome. She told Sammy, “It's tempting to want to stop taking antibiotics as soon as you feel better. However, a full treatment is necessary to stop the infection. When you stop taking your prescribed drugs prematurely, this can result in the spread of antibiotic-resistant bacteria.”

This time Sammy made sure to finish her full seven-day course of doxycycline treatment. Although she felt better on Day 3 of her treatment, she knew she had to finish the whole course of antibiotics. She wondered what would have happened if she had never experienced any symptoms from the chlamydia infection. Would she ever have found out she had it? Would she have gotten PID? What if she spread the infection to other people without even knowing it? And then they spread it to more people without knowing it? *How crazy!* she thought. She had never thought of herself as someone who would get an STD, but everything had happened so quickly; and she knew she and her partner should have used a condom. Even though she was slightly embarrassed to have to inform her sexual partner, she really felt proud of herself for dealing with the situation maturely.

Sammy committed to getting an STD screen every year, and informed her close friends about the significance of antibiotic resistance. After doing some research on the CDC website, she realized that infection rates of a lot of STDs were steadily increasing every year. As a pre-med student, she now felt passionately that one day she would help to combat this growing epidemic.



Your next task begins with a visit to “NCHHSTP AtlasPlus,” an online interactive tool hosted by the Centers for Disease Control and Prevention (CDC) at <https://www.cdc.gov/nchhstp/atlas/index.htm>.

Once you are there, perform the following steps:

- Choose “STD” for “Step 1. What data do you want to see?”
- Choose “Charts” for “Step 2. How do you want to see them?”
- On the new window that appears, verify that “Disease & SDOH” is set to “STD,” select “Chlamydia” for the “Indicator,” set “Geography” to the state in which you live and “Year” to the most current year available.
- Answer the following questions using the information for chlamydia in the state that you chose.

Questions

1. What was the rate per 100,000 people in the most recent year available? Is the trend of the graph increasing or decreasing?
2. Which age group had the highest rate of infection per 100,000 people? Which age group had the lowest rate of infection?
3. Which race/ethnicity had the highest rate of infection?
4. Change your view of the data from “Charts” to “Maps” at the top of the webpage. Make sure “Disease & SDOH” is still set to “STD,” the indicator is still set to “Chlamydia,” and the year is set to the most recent year available. How does your state compare to the rest of the United States? What color range is the state in?
5. Change the setting for “Year” from the option “Single year” to “Maps over time.” Scroll through the map from 2000 to the most recent year. Is the rate for chlamydia infections increasing or decreasing throughout time for the United States?
6. According to the reference below, what are the five major strategies that the CDC recommends for the prevention and control of STDs?
 - Workowski, K.A., and G.A. Bolan. 2015. Sexually transmitted diseases treatment guidelines, 2015. *MMWR Recommendations and Reports* 64(3): 1–137. <<https://www.cdc.gov/mmwr/preview/mmwrhtml/rr6403a1.htm>>