Lesson 3.11: The Immune System

Task	Page(s)	Learning Target
1	2	I can describe how the body defends against pathogens.
2	3-4	I can analyze a scientific model in order to describe steps of the immune response.
3	5-6	I can use text evidence to complete a data table that describes types of pathogens and how the body protects against them.
4	7	I can describe how HIV affects the immune system and can lead to the development of AIDS.
5	8	I can create a visual model that describes how HIV affects the immune system and can lead to the development of AIDS.
6	9	I can define transmission and explain how HIV is transmitted.
7	10	I can explain how HIV is transmitted by responding to common misconceptions.
8	11	I can describe and evaluate a model that shows how HIV and other STI's can be transmitted in a population.
9	12-14	I can critique a model for its effectiveness in modeling STD Transmission by describing strengths and limitations.
10	15-16	I can describe ways to avoid or reduce the risk of infection by HIV and other STIs.
11	17	I can use an advice protocol to describe ways to avoid or reduce the risk of infection by HIV and other STIs.
12	18-26	I can analyze and interpret information from various text and data sources about the effect of a fecal transplant on the microorganisms and bacteria that make up the patients gut microbiome in order to build and argument for fecal transplant therapy.
13	27-29	I can analyze and interpret information from various text and data sources about the effect of a fecal transplant on the microorganisms and bacteria that make up the patients gut microbiome in order to build and argument for fecal transplant therapy.

Task 1 Learning Target: I can describe how the body defends against pathogens.

https://www.brainpop.com/health/bodysystems/immunesystem/

1. 1st Line of Defense (General Response)

A. Skin:

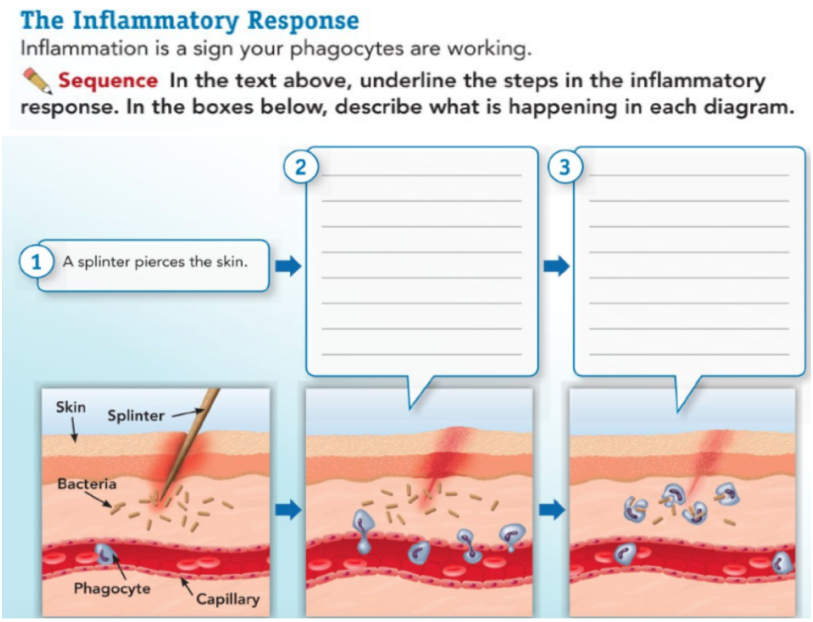
B. Breathing Passages:

C. Mouth and Stomach:

2. 2nd Line of Defense (General Response)

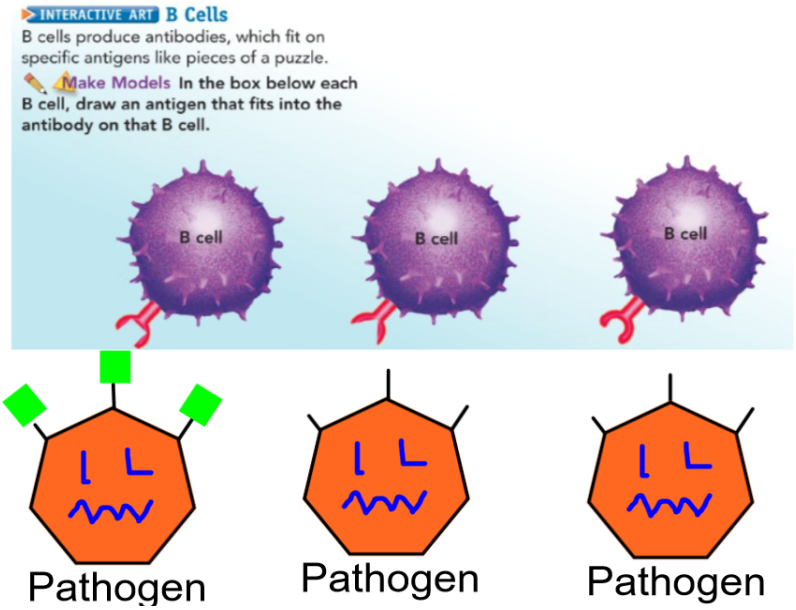
A. Inflammatory Response:
   a. Inflammation:
   b. WBCs engulf:
   c. Fever: high temperature = dead bacteria

**Draw and describe the 3-step diagram:



3. 3rd Line of Defense

A. Immune Response: T cells and B cells react to specific antigens on pathogen
   a. How does a T cell start the immune response?
   b. What is the role of the B cell?
   c. Copy and complete the image:



Task 2 Learning Target: I can analyze a scientific model in order to describe steps of the immune response.

Be sure to use the following words/phrases:
identify; divides; attack; destroy; activate; antibodies; antigen; clump;

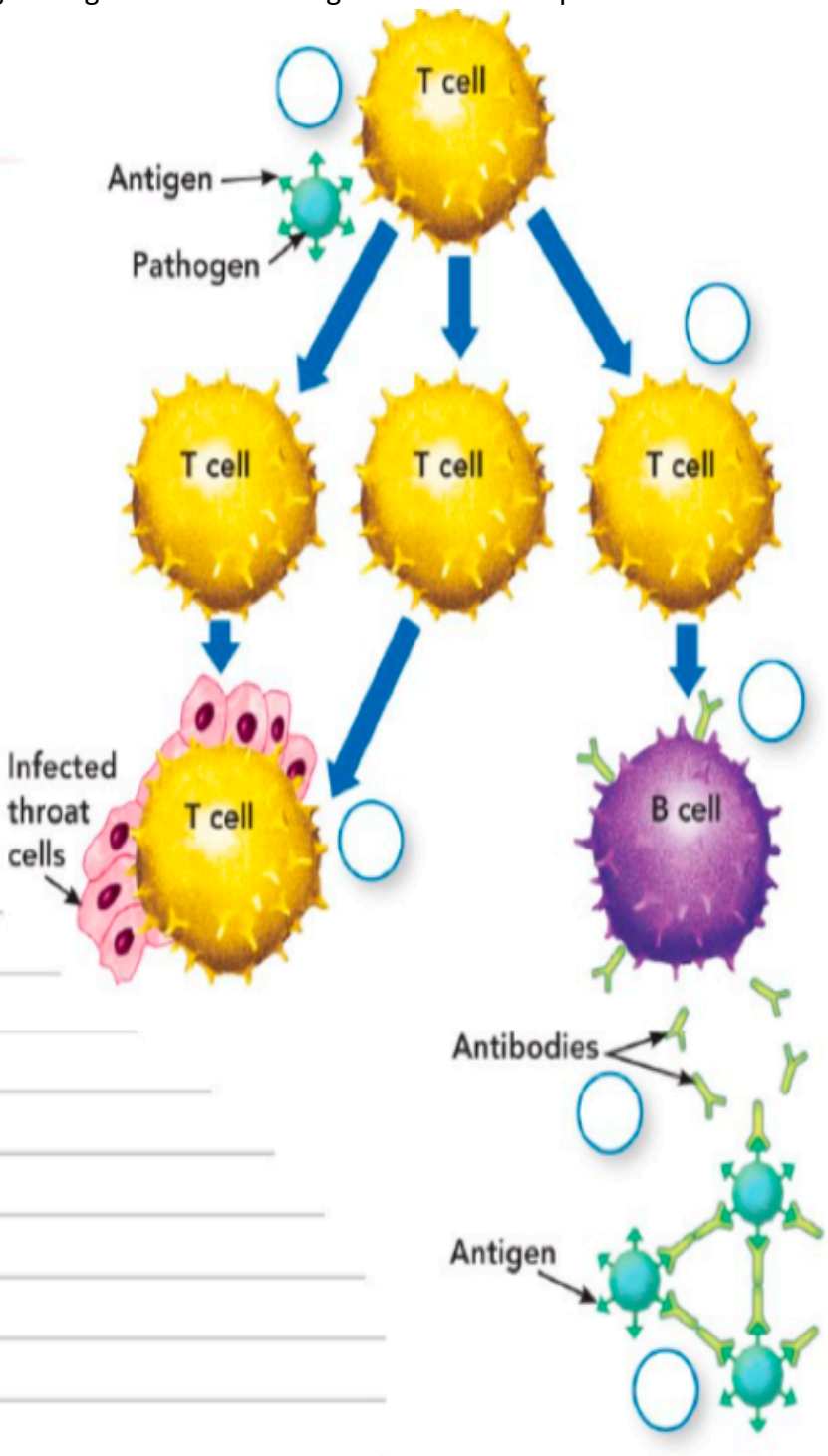
*You can use the phrases on the following page as a guide for describing the different steps.

apply it!

Certain bacteria cause strep throat. Your T cells and B cells work together to combat the infection.

1 Identify Number each step in the immune response.

2 Sequence Describe each step of the immune response against the bacteria that causes strep throat.



B cells make antibodies against a pathogen's antigens.

A T cell recognizes a pathogen's antigen.

The antibodies bind to antigens on pathogens causing them to clump together and be destroyed.

Some T cells attack the cells damaged by the pathogen so that _____.

Other T cells activate B cells.

The T cell divides many times, producing more T cells that recognize the antigen.

Task 3 Learning Target: I can use text evidence to complete a data table that describes types of pathogens and how the body protects against them.

What Pathogens Cause Infectious Disease and How Are They Spread?

You share Earth with many kinds of organisms. Most of these organisms are harmless, but some can make you sick. Some diseases are caused by multicellular organisms, such as worms. However, most pathogens can be seen only with a microscope.

The four major types of human pathogens are bacteria, viruses, fungi, and protists. They can be spread through contact with a sick person, other living things, or objects in the environment.

Bacteria are one-celled microorganisms. They cause many diseases, including ear infections, food poisoning, tetanus, and strep throat. Some bacteria damage body cells directly. Other bacteria, such as those that cause tetanus, damage cells indirectly by producing a poison, or toxin.

If you get a bacterial disease or infection, you might be given an antibiotic. An antibiotic is a chemical that kills bacteria or slows their growth without harming body cells. Some bacteria and fungi make antibiotics naturally. They also are made in factories. Some antibiotics, such as amoxicillin, cause the cell walls of certain bacteria to burst.

Viruses are tiny nonliving particles much smaller than bacteria. They can reproduce only inside living cells. The cells are damaged or destroyed when the new virus particles are released. The new virus particles then infect other cells. Viruses cause many diseases including colds and the flu. There are more than 200 kinds of cold viruses alone.

Medicines you take when you have a cold or flu do not kill the viruses because they are nonliving. But, medicines can reduce the symptoms so you feel better. Always follow the medicine directions. Medicine can sometimes hide symptoms that should send you to the doctor.

Some fungi, such as molds and yeasts, also cause infectious diseases. Fungi that cause disease can be one-celled or multicelled living organisms. Fungi grow best in warm, dark, moist areas of the body. Athlete's foot and ringworm are two fungal diseases.

Athlete's foot is treated with topical antifungal medication (a drug placed directly on the skin) in most cases. Severe cases may require oral drugs (those taken by mouth). The feet must be kept clean and dry since the fungus thrives in moist environments.

Most protists are single-cellular microorganisms and some can cause disease. They are larger than bacteria but still tiny. Many diseases caused by protozoa are often transmitted through drinking bad water or through an insect bite. One type of protist causes the disease of malaria, which is common in tropical areas. African sleeping sickness and hiker's disease are other diseases caused by protists.

Many diseases caused by protists can be treated with medicines that will kill the parasite in the body. Although this is true, parasitic infections most often occur in parts of the world where effective treatments are largely unavailable. For this reason, the battle against the spread of malaria focuses on prevention.

Pathogen	Size	Characteristics	Types of Disease	Treatment
Bacteria	1	2	3	4
Viruses	5	6	7	8
Fungi	9	10	11	12
13 Protists	14	15	16	17

Analysis Questions: (To Be answered on the back of the data table)

1. How does the treatment for bacterial infections compare to the treatment for viral infections?
2. Would amoxicillin be used to treat the flu? Explain your answer.
3. Would amoxicillin be used to treat all bacterial infections? Explain your answer.
4. Why might athletes be most commonly affected by Athlete's foot?

Task 4 Learning Target: I can describe how HIV affects the immune system and can lead to the development of AIDS.

1. Watch BrainPop and take notes: https://www.brainpop.com/health/diseasesinjuriesandconditions/aids/

2. Watch YouTube Medical Animation and take notes: https://www.youtube.com/watch?v=ng22Ucr33aw

3. Read "Process of HIV Infection" and complete Tasks a-d **See below:

Process of the HIV Infection:

1. A person is exposed to HIV. (Note that a person cannot be exposed via casual contact such as shaking hands, sharing drinks, or sneezing, and that the methods of transmission will be covered in the next lesson).

2. The virus enters the body and attacks T cells (also known as CD4 cells).

3. The virus enters the T-cells (and uses them to multiply or make copies of itself). This process is called replication.

4. When the virus is finished using the Helper T-cell to copy itself, the T-cell may die. The virus may make many copies and burst out of the cell, or the cell is identified as infected, and is destroyed by the immune system. Because the Helper T-cell signals other cells what to do, as the Helper T-cells die off, the immune system doesn't work as well. With appropriate treatment, the immune system can remake CD4 cells.

5. As HIV infection progresses in the body, the number of CD4 cells decreases. Healthy individuals have between 500 and 1500 CD4 cells per cubic millimeter of blood. As the disease progresses in a person with HIV, the CD4 count gets lower, and the person is more likely to become ill.

6. As the CD4 count continues to decrease, the body becomes susceptible to opportunistic diseases. These are illnesses that normally do not occur in people with healthy immune systems. They are called opportunistic because they take advantage of the opportunity presented to them by the weakened immune system of the person with HIV.

7. A person, already infected with HIV, is said to have AIDS when the CD4 count falls below 200 cells or the person has one or more of the opportunistic infections on a special list created by the Centers for Disease Control and Prevention. AIDS, then, is not a specific disease but rather a specific group of related bodily symptoms and health problems with HIV as the underlying cause.

Complete the following:

A. What is the difference between HIV and AIDS?

B. How does the replication of the HIV virus lead to the development of AIDS?

C. What are opportunistic infections?

D. Briefly describe 1 of the most common opportunistic infections.
The list and description of illnesses and opportunistic infections associated with AIDS can be found at https://www.cdc.gov/hiv/basics/livingwithhiv/opportunisticinfections.html

Task 5 Learning Target: I can create a visual model that describes how HIV affects the immune system and can lead to the development of AIDS.

With your group, create a 4-step model that shows how HIV can lead to the development of AIDS.

Task 6 Learning Target: I can define transmission and explain how HIV is transmitted.

1. Why do you think is it essential that people your age learn about HIV and AIDS?

2. Read the following statistics:

HIV in the United States:
– The U.S. Centers for Disease Control and Prevention (CDC) estimates 1.2 million people in the U.S. are currently living with HIV/ AIDS infection and 1 in 5 are unaware of their infection.
– As of December 2010, New York City had 110,736 people living with HIV/AIDS. During 2001-2009, 1,090 males and 534 females 13-19 years of age were diagnosed with HIV infection.
–AIDS reporting began in 1981. Through 2009, over a million (1,108,611) persons were diagnosed with AIDS in the U.S., of whom 165,805 were diagnosed in New York City (the city with the highest cumulative number of AIDS cases in the U.S.

3. Re-answer: Why is it essential that people your age learn about HIV and AIDS?

4. Define **Transmission**: _____

5. Copy the following note: HIV is not spread through casual contact (for example, touching) but through specific bodily fluids that are capable of carrying the virus.

6. A. Make a T Chart that separates the following: Can Transmit HIV Cannot Transmit HIV
   B. Sort the following phrases/terms into your T Chart

shaking hands	swimming with infected people	abstinence from sexual intercourse
Preseminal fluid ("Pre-cum") – the small amount of clear fluid that appears at the tip of the penis when it becomes erect prior to orgasm.	sharing needles, syringes, and other equipment used to inject drugs with an infected person	*Menstrual blood* – blood that leaves the body through the vagina during a woman's menstrual period.
hugging	sexual intercourse with an infected person	sharing a meal or a drink
using the same bathroom as a person who has the virus	insect bites	*Vaginal fluids* – the natural wetness, also called secretions, in a woman's genitals.
from an infected woman to her child during birth, or breastfeeding *Breast milk* – the nutritious fluid produced by a mother for feeding her baby.	blood transfusions receiving a blood transfusion and donating blood	*Semen* – the fluid, which contains sperm that is ejaculated from the penis during sexual activity and orgasm.

7. Explore the following link to learn if your ideas were correct: https://www.cdc.gov/hiv/basics/transmission.html

8. Copy the following note: Anyone who practices **risk behaviors** can become infected with HIV, regardless of age, race, economic status, country of origin, gender, gender identity, or sexual orientation/identity.
   If people do not practice risk behaviors, they greatly reduce their chances of being at risk of HIV infection.

Task 7 Learning Target: I can explain how HIV is transmitted by responding to common misconceptions.

"Some People Say..."

Directions: Below are things that "some people say" about HIV/AIDS.
In your notebook, decide if the statement is either true or false. Explain your reasoning.

1. Some people say that only gay and bisexual men are likely to be infected with HIV. True or false? Why?

2. Some people say that only people with multiple sexual partners are likely to be infected with HIV. True or false? Why?

3. Some people say that you can get HIV from donating blood. True or false? Why?

4. Some people say that alcohol and illicit drug use can make people vulnerable to HIV infection when they share needles/syringes/works/skin-popping equipment. True or false? Why?

5. Some people say that you can contract HIV by sharing a drink with someone who has HIV. True or false? Why?

6. Some people say that having other sexually transmitted infections (STIs) can make it more likely that you'll get HIV. True or false? Why?

7. Some people say you can tell if someone has HIV by looking at him or her. True or false? Why?

8. Some people say you can get HIV from insect bites. True or false? Why?

9. Some people say that tears transmit HIV. True or false? Why?

10. Some people say it is rare to get HIV from a blood transfusion in the United States. True or false? Why?

11. Some people say the risk of HIV transmission from a healthcare provider (doctor, dentist, nurse, technician) is small. True or false? Why?

Task 8 Learning Target: I can describe and evaluate a model that shows how HIV and other STI's can be transmitted in a population.

1. **Procedure:**

Slowly and quietly move around the room. "**Switch"-** trade liquids by pouring a little bit into one cup and then a little back into the first cup. The amounts of fluid should be roughly equal after the trade. ***Do not drink, splash or smell** the liquid. **You will not go to the bathroom to wash your hands. After you have had time to complete 4 trades, you will return to your seats.

2. Test your fluids with pH paper.

3. Did anyone model: *Abstinence? Monogamy?* Explain.

4. *Answer the questions A-G below:*

A. *Describe how the number of "infected" individuals change over the course of the activity? Is this realistic? Explain. **Bonus: How might our data represent exponential growth?*

B. *Could you tell – just by looking – which cups were infected? Explain if this represents HIV?*

C. *How did we model abstinence and monogamy? How might it feel to be abstinent or monogamous?*

D. *How can abstinence and monogamy reduce the risk of HIV infection? Use data evidence to support your claim.*

E. *How could we model the use of a "condom" and how would it work to prevent transmission?*

F. *How did it feel to be "tested"? Did the emotions you felt accurately represent the emotions one might feel when getting tested for HIV?*

G. *Evaluate the model by describing strengths and limitations? You can make a T chart to organize your ideas.*

Task 9 Learning Target: I can critique a model for its effectiveness in modeling STD Transmission by describing strengths and limitations.

Critique: **How was the "fluid exchange" activity an effective model for STD transmission?**

Introduction

- ✓ Briefly describe the activity (in 3-4 sentences):
- ✓ Establish a thesis statement:
- ✓ Your word choice should encourage readers to continue reading.

Body

- ✓ Provide evidence for your thesis:
  - Describe the activity in greater detail. (fluid exchange and testing)
  - Describe how the activity relates to the transmission of HIV and other STDs.
  - How did the number of "infected" individuals change over the course of the activity?
  - What were the strengths and limitations to the model?

Conclusion

- ✓ Restate your thesis in a different way:
- ✓ Leave off with a fresh idea:
  - What actions reduce the risk of STD transmission?

Words and Phrases To Use and Define in Your Writing			
model	limitation	monogamy	condom usage
transmission	strength	abstinence	testing

	3	2	1
Introduction and Thesis (CCLS ELA.W.7.1A)	Clearly and interestingly introduces a topic in a manner that follows from the task and purpose.	Introduce a topic in a manner that follows generally from the task and purpose.	Introduce a topic in a manner that does not logically follow from the task and purpose.
Support of Topic (CCLS ELA.W.7.1B)	Relevant, telling, quality details give the reader important information that supports the thesis.	Supporting details and information are relevant, but key issues or portions are unsupported. There is a need for more supporting details.	Supporting details and information are typically unclear or not related to the topic.
Conclusion (CCLS ELA.W.7.1E)	The conclusion clearly and interestingly follows from the topic and information presented.	The conclusion follows generally from the topic and information presented.	The conclusion is illogical or unrelated to the topic and information presented.
Domain Specific Vocabulary (CCLS ELA.W.7.2D)	Exhibits skillful use of vocabulary that is precise and purposeful. All domain specific vocabulary words are used correctly and thoroughly.	Exhibits reasonable use of vocabulary that is precise and purposeful. Few vocabulary words are missing and/or are not used correctly/thoroughly.	Lacks use of vocabulary that is precise and purposeful. Several vocabulary words are missing and/or are not used correctly/thoroughly.
Control of Conventions (CCLS ELA.W.2)	Demonstrates grade-appropriate command of conventions, with few errors that do not hinder comprehension.	Demonstrates emerging command of conventions, with some errors that may hinder comprehension.	Demonstrates a lack of command of conventions, with frequent errors that hinder comprehension.

STD Transmission Essay

Introduction

Hook: _____

_____

Introduce activity and materials: _____

_____

_____

Thesis Statement: _____

_____

_____

Body Paragraph 1

Describe the fluid exchange activity: _____

_____

_____

_____

_____

Describe the "testing:"_____

_____

_____

_____

_____

Describe how the activity relates to the transmission of HIV and other STDs :

_____

_____

_____

_____

_____

Describe how the number of "infected" individuals change over the course of the activity (data evidence): _____

_____

_____

_____

_____

Body Paragraph 2

Describe strengths:

Describe limitations:

Conclusion

Restate thesis:

Restate 1 main point from each body paragraph:

Conclude with a fresh idea (What actions reduce the risk of STD transmission?):

Task 10 Learning Target: I can describe ways to avoid or reduce the risk of infection by HIV and other STIs.

1. Make a KWL chart as displayed on the following page.
2. Use the Socrative Quiz to guide the record what you Know and Want to Know about condoms.
3. Read the following text and complete the remaining sections of the KWL chart

What are some things people do that increase the risk of infection from HIV and other STIs?

- Having sexual intercourse without using a male or female condom, using a male condom that is not latex or polyurethane, or using a condom incorrectly.
- Using the same needles/syringes or other equipment for injection of drugs, including steroids.
- Using drugs, including alcohol, that can impair judgment and lead to risk behaviors that could result in infection from HIV and other STIs.

What is a condom?

- A sheath that fits over the erect penis; semen goes into the reservoir, the space at the tip of the condom.

What is a female condom (or FC2)?

- A polyurethane pouch placed inside the vagina before sex to prevent semen from entering.

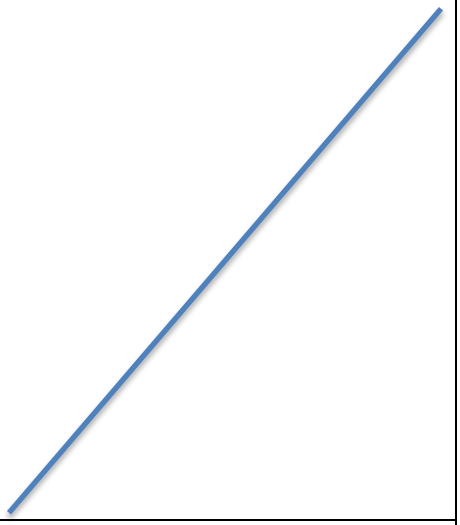
For people who are sexually active, using condoms is the best way to prevent HIV infection.

Many people think they can tell if a partner has HIV. But most people who are HIV-positive do not look sick and one in five people living with HIV in the United States today do not even know that they are infected. Because it is not possible to tell if someone is HIV-positive just by looking at him or her, it is important to use a condom every time you have sex with someone who has not been tested in the past three months. Yet it is also true that not everyone will report accurately about testing results or about any risk behaviors since testing occurred. Using condoms every time protects you from infection and helps give you peace of mind.

Why do condoms sometimes fail?

When people use condoms incorrectly, they sometimes fail. These are some of the ways that people use condoms incorrectly:

- Not using the condom from start to finish.
- Using an oil-based lubricant, which damages latex condoms, instead of a water-based lubricant.
- Using a lambskin condom instead of a latex or polyurethane one. Lambskin condoms should never be used as the skin has tiny pores through which body fluids can travel, which increases the possibility of infection of either partner by STIs.
- Having inadequately lubricated intercourse, especially anal, during which friction can stress and break the condom.
- Inadvertently tearing the condom on fingernails or jewelry or when opening the packet.
- Using a condom that has been stored near a heat source (greater than 80°F).
- Using a condom after the expiration date on the packet.
- Reusing a condom.
- Improperly putting on or removing a male condom.
- Improperly putting in or removing the FC2.
- Using a female condom with a male condom. Choose one or the other.

	Know	Want to Know	Learned
Pre Reading	I know…	I want to know…	
During/Post	I already knew but forgot to write …	I want to know more about … I was confused and need further explanation with…	Something new I learned…

Task 11 Learning Target: I can use an advice protocol to describe ways to avoid or reduce the risk of infection by HIV and other STIs.

Pretend that you are an advice columnist. Someone has sent you the following letter:

Dear Advice Columnist:
I'm an eighth grader.
My boyfriend is a few years older than I am.
I've told him I want to be abstinent until I'm older, but he's been pressuring me to have sex with him. Sometimes I feel confused and unsure.
I don't want to regret my decision.
Do you have any ideas about what I should do?
Signed,
Feeling the Pressure

Read and respond to the letter using the Advice Protocol:

Advice Protocol:
(1) State the problem.
(2) List alternative solutions.
(3) List the pros and cons of each possible choice.
(4) Encourage a responsible and low-risk decision.
(5) Evaluate the outcome.

Task 12 Learning Target: I can analyze and interpret information from various text and data sources about the effect of a fecal transplant on the microorganisms and bacteria that make up the patients gut microbiome in order to build and argument for fecal transplant therapy.

A politician wants to cut funding for research on a new treatment that's being used to cure patients infected with a harmful bacterium called *C. difficile.* The senator is claiming that tiny microorganisms are too small to affect human health. The treatment involves transplanting helpful bacteria from the poop of a healthy person into the gut of a sick person. Is this an amazing medical breakthrough, or is it just crazy? The Microbiome Research Institute needs your help to build an argument about how this treatment isn't crazy. (In fact, it actually saves lives.) You will construct an argument by learning more about helpful and harmful bacteria. Then, you'll examine data from a patient who actually received this treatment.

https://sites.google.com/a/ps207tigers.org/207sci/fecaltransplant

To: Student Researchers
From: Mara, Head Scientist
Subject: Case Study of a Fecal Transplant Patient

MRI Microbiome Research Institute

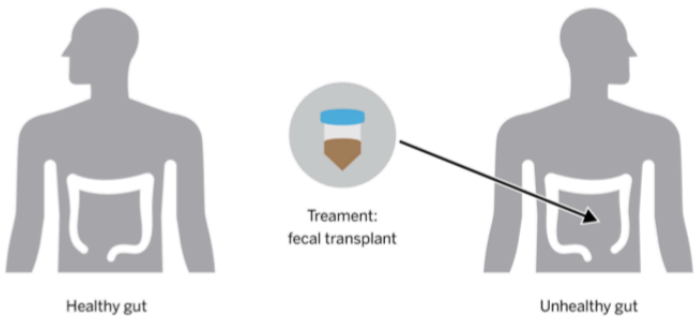
At the Microbiome Research Institute, we collect data from many patients that have undergone a fecal transplant procedure. We collect information about these patients so we can more clearly understand what is going on in their gut microbiomes before and after the procedure. This practice of carefully collecting data about one patient is called a case study.

I'm sending you a case study about Patient 23, a 64-year-old man. We collected data about this patient's gut microbiome over nine weeks while he was undergoing a fecal transplant procedure. At the end of the nine weeks, he was cured of a potentially deadly infection. How did the fecal transplant procedure cure this patient of a very harmful infection?

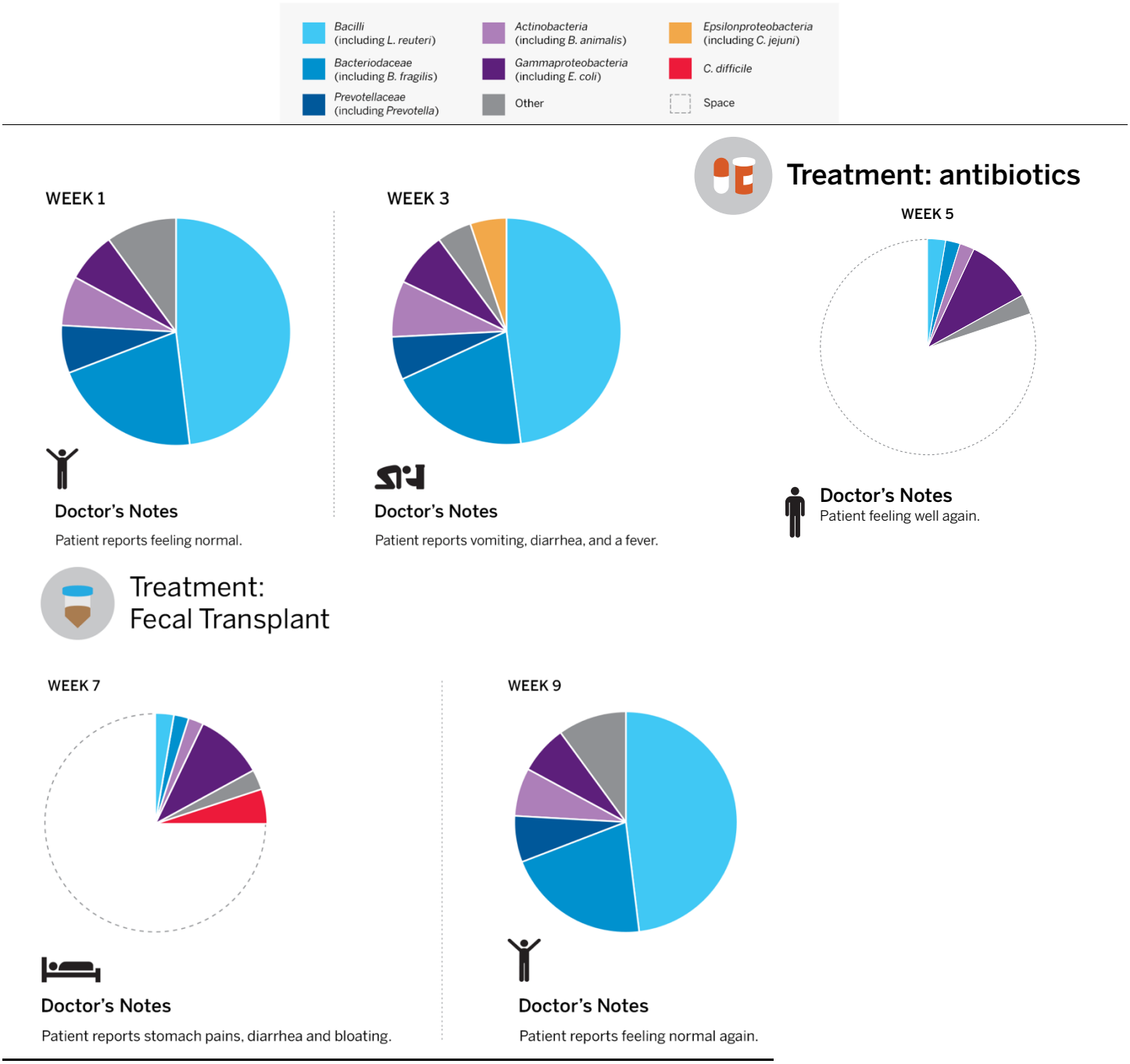
Please analyze the information collected about Patient 23's gut microbiome to help us answer this question as we build our argument against the senator.

Notes About a Fecal Transplant Procedure

A fecal transplant is a treatment where a doctor takes the feces from a person with a healthy gut microbiome and puts it into the gut of a person with an unhealthy gut microbiome during a medical procedure.



Artifact 1- Pie Chart Data: Patient 23's Gut Bacteria
Analyze the following pie charts and complete prompts a-d:



a. What is the same about the patient's gut microbiome data from one week to the next?
b. What is different about the patient's gut microbiome data from one week to the next?
c. Why do you think Patient 23 felt normal during week 1 but sick during weeks 3 and 7?
d. Record 1 question you have about the information presented.

Artifact 2- Articles: The Human Microbiome and Bacteria *C. difficile*
Read the articles on the following pages and complete prompts e-f:

The Human Microbiome

A World Inside You

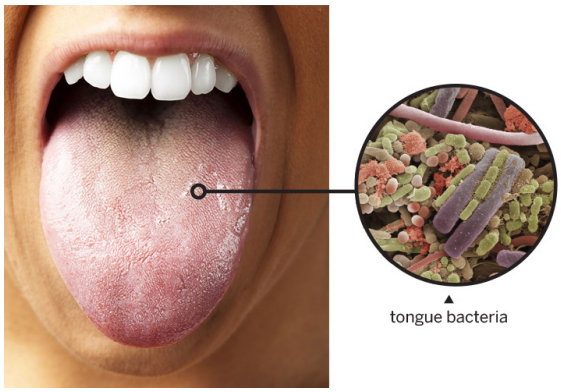
There's a world filled with strange creatures. The creatures of this world are invisible, and they're not human. Aliens sometimes threaten to invade the world these creatures call home. . . .

This world is not a far-off planet: it's your body! The creatures are called microorganisms, and your body is home to more than 100 trillion of them. Microorganisms live on your skin, in your gut, in your nose and mouth, and pretty much everywhere else on and in your body.

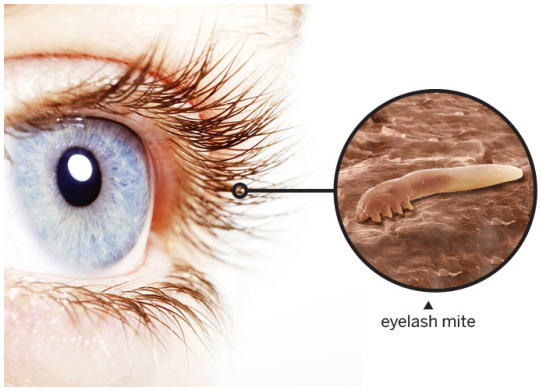
Your Body: Home Sweet Home for Bacteria

The microorganisms living in and on your body range from fungi to eyelash mites, but most of them are bacteria. Bacteria are among the smallest microorganisms on Earth. Most are made of a single cell—that's the tiny structure that makes up all living things. However, bacteria are not all the same. They come in different shapes, use different things as food, and live in different places. Thousands of different kinds of bacteria live in and on your body.

Even though they are tiny, bacteria are living things with the same basic needs that all living things share. The human body provides bacteria with the food and living space they need—that's what makes our bodies such a good environment for bacteria. One word for an environment and the organisms living there is *biome*, so we call the bacteria living in and on the human body "the human microbiome." All together, the bacteria living in an average human's microbiome weigh



Your tongue is covered with bacteria like the ones in this photo, which was taken through a microscope. Bacteria are some of the smallest microorganisms that live in and on your body: these bacteria are actually 10,000 times smaller than they look in this photo! The bacteria colored green in this photo are 1 micrometer long, about 100 times too small to see with the naked eye. (The colors are not real: they were added to make the photo easier to see.)



This microscopic animal is an eyelash mite. It is harmless, and lives next to the roots of eyelashes. The photo was taken through a microscope, and shows the mite about 300 times larger than its actual size. This mite is about 210 micrometers in length. You might just barely be able to detect an eyelash mite with the naked eye in perfect conditions—if it weren't nearly transparent!

about 2 to 5 pounds. The number of bacteria in the microbiome of one human is millions of times greater than the number of people living on Earth!

Helpful Bacteria and Alien Invaders

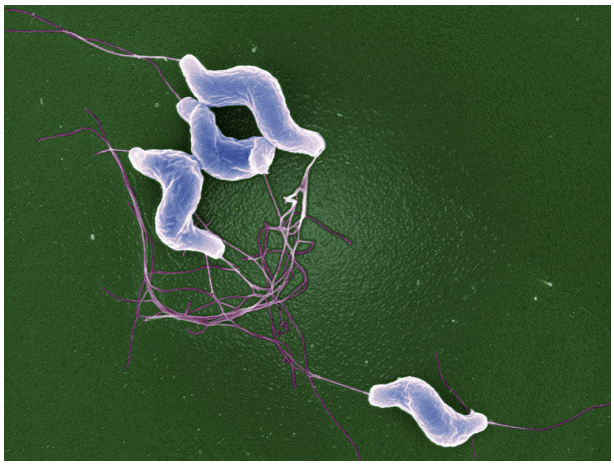
Most bacteria in the human microbiome won't hurt you. In fact, the opposite is true. Many bacteria do important jobs for the human body. For example, bacteria living in your gut help break down food that your body couldn't digest otherwise. Other bacteria help protect your body from infection, which helps to keep you healthy. All these helpful bacteria use the food and shelter your body provides. You depend on these bacteria, and they depend on you.

Unfortunately, not all bacteria are helpful. Harmful bacteria can invade the human microbiome through cuts, spoiled food, and even the air we breathe. An invasion of harmful bacteria or other microorganisms is called an infection, and infections can make people very sick. For example, a type of bacteria called *C. jejuni* produces a poison that harms cells from the human gut. When those cells can't function, the gut can't repair itself. This kind of *C. jejuni* infection can cause diarrhea, vomiting, and fever—all the symptoms of food poisoning.

Antibiotics and the Microbiome

Often, doctors treat infections with antibiotics. Antibiotics are medicines that kill bacteria. Antibiotics can stop dangerous infections, and they save millions of lives every year.

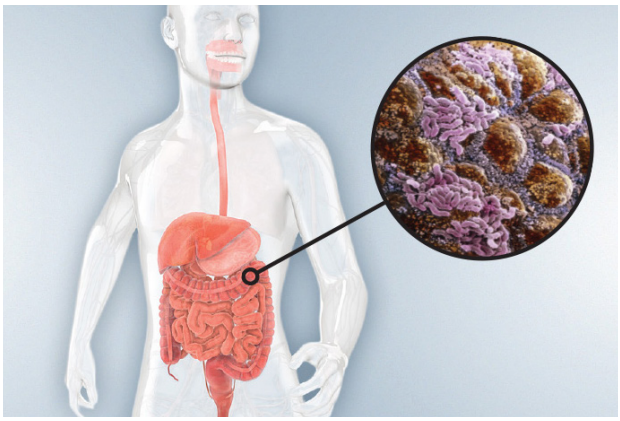
However, antibiotics don't just kill harmful bacteria—they kill helpful bacteria, too. A person who has just taken antibiotics has fewer bacteria than normal. Helpful bacteria will grow back in time, but often the bacteria that return are different from the ones that were there before. Taking antibiotics changes a person's microbiome.



What people call "food poisoning" isn't caused by poisoned food: it's usually an infection with harmful bacteria such as *C. jejuni*. (People added the colors in this photo to make the bacteria easier to see.)

Your Own Little World

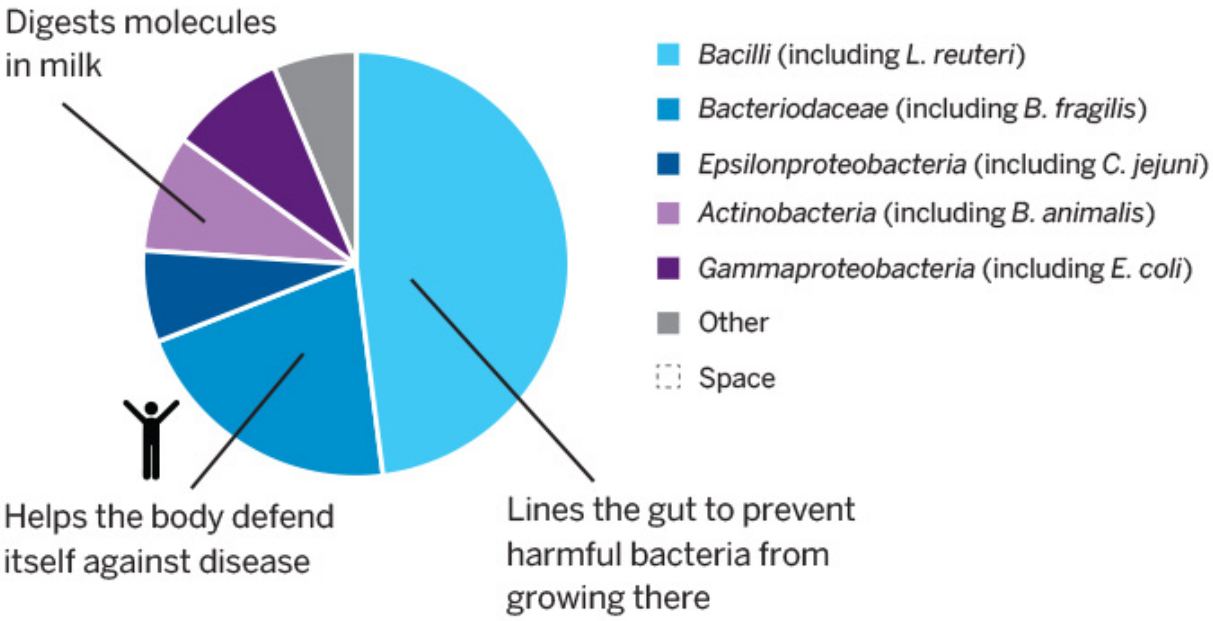
Your body is the whole world to the bacteria of your microbiome. It's an environment that provides microorganisms with everything they need, including food and space to live. What you do affects your bacteria, and they affect you, too. Your body is a world in miniature—a microbiome.



This microscope photo shows some bacteria in their natural environment: the human gut. The gut includes the intestines and stomach. In the photo, the bacteria appear 3,750 times larger than actual size. These bacteria are about 2 micrometers in length—nearly 50 times too small to see. (People added the colors in this photo to make the bacteria easier to see.)

Chart 1: Bacteria in a Healthy Gut Microbiome

Total number of bacteria: about 90 trillion



This pie chart compares the relative amounts of different kinds of bacteria in a typical healthy human's gut.

Bacteria: *C. difficile*

When scientists first discovered *C. difficile* (cee-diff-uh-SEEL), they named these bacteria difficile (which means "difficult") because the bacteria were so hard to grow in the lab. Today, *C. difficile* might be considered difficult in another way: it causes hard-to-treat gut infections that kill thousands of people every year. Because it causes potentially deadly infections, *C. difficile* is sometimes referred to as "killer bacteria."

Environment

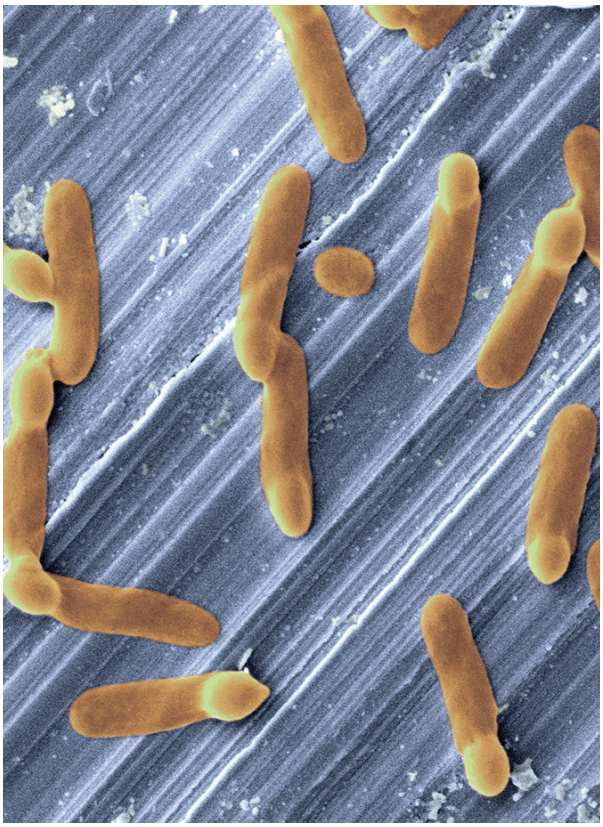
Although difficult to grow in a lab, *C. difficile* bacteria are very common in nature. These microorganisms are especially numerous in soil, where they use nearly anything as food. They can also survive in the environment of the human gut.

C. difficile has a surprising weakness: oxygen can kill it. However, it also has an amazing defense. When *C. difficile* is exposed to oxygen in the air or other dangers, it shrinks and forms a tough outer covering. In this state, *C. difficile* can survive oxygen, hand cleaners, acids, and even many antibiotics. Once the danger passes, the bacteria return to normal and begin multiplying.

Normal Role in Humans

Most healthy people do not have any *C. difficile* bacteria in their microbiomes. Even if someone accidentally swallows some *C. difficile* bacteria, the other bacteria in the gut keep the number of *C. difficile* low, and therefore safe. *C. difficile* cannot survive when there is a lot of competition from other bacteria for food and space.

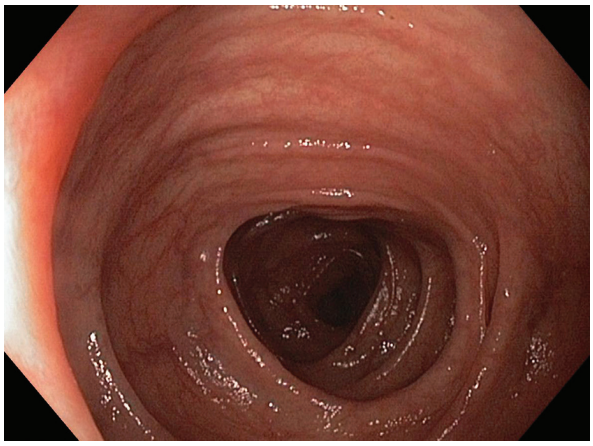
***C. difficile* bacteria can cause dangerous infections in humans. They are between 1 and 4 micrometers long. (This photo was taken in black and white; colors were added to make it easier to see.)**



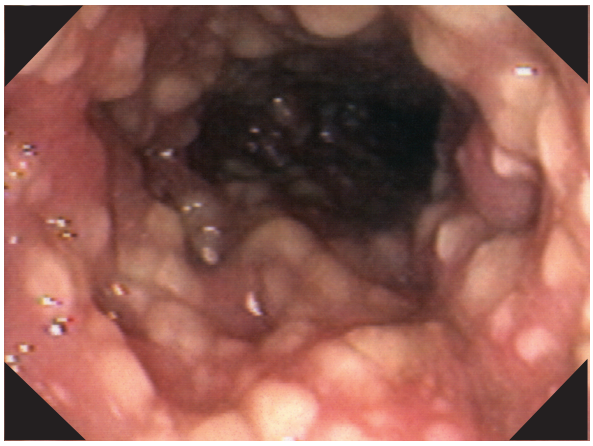
Exposed to the air on a steel surface, these *C. difficile* bacteria are shrinking and forming protective coverings. (This photo is zoomed in much closer than the previous photo.)

Role in Disease

When sick people take antibiotics, helpful microorganisms in the gut are killed along with the harmful ones. With the helpful gut microorganisms out of the way, *C. difficile* can multiply rapidly and take over the gut microbiome. The growing population of *C. difficile* produces powerful poisons, which irritate the cells of the gut lining and eventually cause the cells to die. *C. difficile* bacteria will then eat the dead cells—and may even escape through the damaged gut into the blood, spreading the infection. *C. difficile* infections can be very dangerous, and in some cases end in death. Bloating, diarrhea, and stomach pain are the most common symptoms. By causing constant irritation, *C. difficile* can make it harder for the immune system to function. Antibiotics can kill *C. difficile*, but until the person's normal microbiome is restored, the infection can come back.



This photo was taken inside a healthy human gut. The gut lining is smooth and healthy. (No bacteria are visible in the photo because they are too small to see in this view.)



This photo shows the gut of a human with a *C. difficile* infection. The gut lining is irritated and damaged. (No bacteria are visible in the photo because they are too small to see in this view.)

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e. Refer back to your initial explanation about why Patient 23 felt sick during weeks 3 and 7. Use what you learned from "The Human Microbiome" to revise your explanation.
f. Record 1 question you have about the text.

Artifact 3- Article with Experimental Data: "Bacteria Salmonella"
Read the article and analyze the pie charts on the following pages and complete prompts g-k:

Bacteria: *Salmonella*

Food poisoning isn't caused by poison at all. Instead, what we call "food poisoning" is usually caused by bacteria, including *Salmonella*, a type of bacteria commonly found in chickens and other animals. *Salmonella* finds its way into our food and water and causes thousands of cases of food poisoning every year.

Environment

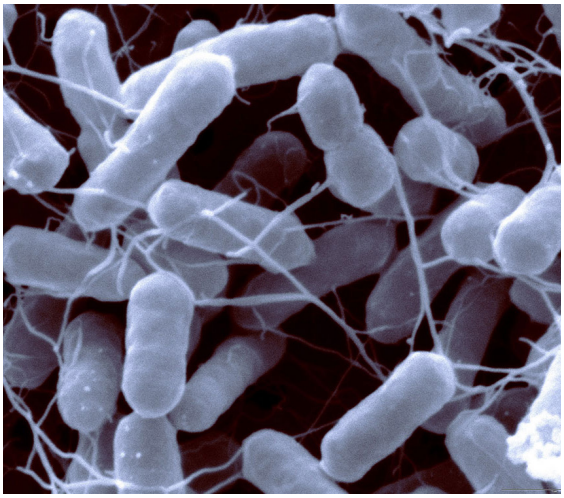
Salmonella lives in the guts of all kinds of animals, especially birds and reptiles, and usually gets passed around through animal waste. Whether a person gets sick from ingesting certain kinds of *Salmonella* can depend on the amount of food and space available in his or her gut microbiome. If the gut is home to lots of beneficial bacteria, the *Salmonella* bacteria can't get enough food and space to reproduce. On the other hand, if there are *not* many beneficial bacteria in the gut, the *Salmonella* population can grow and take over, causing illness—which in this case is more commonly known as food poisoning. *Salmonella* can be killed using heat, so cooking food properly is one way to keep from becoming sick.

Normal Role in Humans

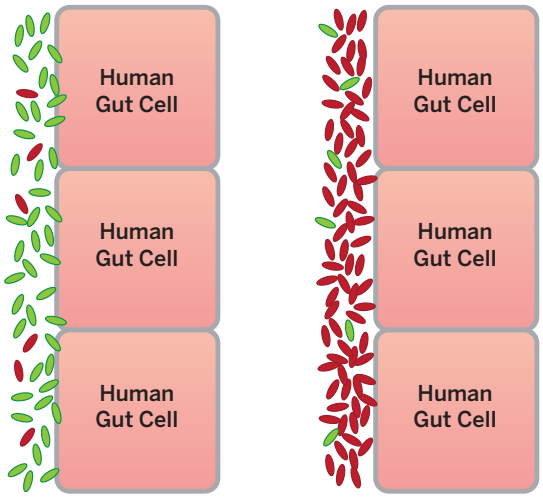
Salmonella can sometimes be found in small amounts in the guts of healthy humans, but is more likely to be found in the microbiomes of people who have recently become sick from *Salmonella* infection.

Role in Disease

In most cases, *Salmonella* causes vomiting, diarrhea, and intestinal pain for up to a week. Most people get better without treatment from a doctor, but in severe cases, *Salmonella* can leave the intestines and move into the blood, where it causes severe disease and even death.



***Salmonella* bacteria can cause the illness that people call "food poisoning."**



When lots of helpful bacteria (shown here in green) are present in the gut, there is little space and food available to harmful bacteria like *Salmonella* (shown here in red). This helps prevent the harmful bacteria from infecting the gut. When there are fewer helpful bacteria in the gut, there is more space and food available for harmful bacteria that can cause disease.

Scientists questioned whether a low-bacteria gut microbiome affected a mouse's vulnerability to Salmonella infection. They ran an experiment with 40 laboratory mice. At the start of the experiment, 20 mice had normal gut microbiomes and 20 mice had low-bacteria gut microbiomes. Both groups were healthy at the start of the experiment. Then, each group of mice ingested Salmonella bacteria.

Human and Mouse Gut Microbiomes

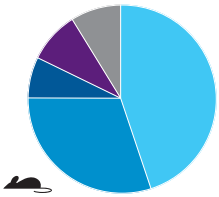
Normal Human Gut Microbiome

Normal Mouse Gut Microbiome

Gut Bacteria Key

- *Bacili* (including *L. reuteri*)
- *Bacteriodaceae* (including *B. fragilis*)
- *Prevotellaceae* (including *Prevotella*)
- *Actinobacteria* (including *B. animalis*)
- *Gammaproteobacteria* (including *E. coli*)
- Other
- *Epsilonproteobacteria* (including *C. jejuni*)
- *C. Difficile*
- Space

Experiment 1: *Salmonella* Bacteria



Normal Gut Microbiomes of 20 Healthy Mice Before Experiment

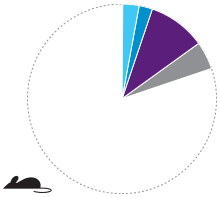
Mice ingest the same amount of *Salmonella* bacteria

Test Results

5 mice are unaffected and remain healthy

12 get slightly sick from *Salmonella* infection

3 get really sick from *Salmonella* infection



Low-Bacteria Microbiomes of 20 Healthy Mice Before Experiment

Mice ingest the same amount of *Salmonella* bacteria

Test Results

20 get really sick from *Salmonella* infection

Gut Bacteria Key

- *Bacili* (including *L. reuteri*)
- *Bacteriodaceae* (including *B. fragilis*)
- *Prevotellaceae* (including *Prevotella*)
- *Actinobacteria* (including *B. animalis*)
- *Gammaproteobacteria* (including *E. coli*)
- Other
- *Epsilonproteobacteria* (including *C. jejuni*)
- *C. Difficile*
- Space

g. Describe the similarities and differences between the healthy gut microbiomes of a mouse and a human.

h. Why were the low-bacteria mice in the experiment more likely to get a *Salmonella* bacteria infection?

i. *Why did Patient 23 get a* C. difficile *infection after his treatment with antibiotics?* Use evidence from "Experiment 1: *Salmonella* Bacteria" pie chart data.

j. How can having fewer than normal bacteria in the gut microbiome affect the overall health of the body? Use evidence from the article "Bacteria Salmonella."

k. Record 1 question you have about the text.

Task 13 Learning Target: I can analyze and interpret information from various text and data sources about the effect of a fecal transplant on the microorganisms and bacteria that make up the patients gut microbiome in order to build and argument for fecal transplant therapy.

A politician wants to cut funding for research on a new treatment that's being used to cure patients infected with a harmful bacterium called *C. difficile.* The senator is claiming that tiny microorganisms are too small to affect human health. The treatment involves transplanting helpful bacteria from the poop of a healthy person into the gut of a sick person. Is this an amazing medical breakthrough, or is it just crazy? The Microbiome Research Institute needs your help to build an argument about how this treatment isn't crazy. (In fact, it actually saves lives.) Construct an argument by writing a paragraph that addresses the following question:

Question: *How can fecal transplants cure patients infected with harmful bacteria?*

Support your claim by including evidence and explain how your evidence supports your claim.

Reasoning Tool:

A complete and convincing scientific argument needs to have evidence (information about the natural world) that supports the claim, and scientists obtain evidence about things in the natural world by investigating, observing, and gathering data. Scientists can only make arguments about things that can be observed and investigated. Also, scientific arguments clearly explain how or why the evidence supports the claim, and that process of thinking or explaining is often called reasoning. Using the following reasoning tool can help you develop a strong scientific argument.

Question: *How can fecal transplants cure patients infected with harmful bacteria?*
Claim:

Describe the Evidence	Reasoning (Why does the evidence matter?)
Artifact 1- Pie Chart Data: Patient 23's Gut Bacteria (Focus on weeks 7 and 9)	
Artifact 2- Articles: The Human Microbiome and Bacteria *C. difficile*	
Artifact 3- Article with Experimental Data: "Bacteria Salmonella"	

Use the checklist and rubric to assess your work:

- I stated the claim clearly.
- I included evidence to support the claim.
- I made my reasoning clear by explaining how the evidence supports the claim.

	2	1	0
Understanding of Science Concepts	Response correctly describes that: An infection of harmful bacteria in the human microbiome can make a person sick. **AND** Helpful bacteria can help the body fight off harmful bacteria that can make a person sick.	Response correctly describes that: An infection of harmful bacteria in the human microbiome can make a person sick.	Response is off-target or does not yet demonstrate understanding of key concepts from the unit.
Constructing Scientific Arguments	Argument proposes a claim that: -takes a stance by clearly stating a claim that directly addresses the question -employs several pieces of high-quality information as evidence to support the claim -clearly explains how each piece of evidence supports the claim	Argument proposes a claim that: -takes a stance by stating a claim that addresses the question -employs few pieces of information as evidence to support the claim -attempts to explain how each piece of evidence supports the claim	Argument does not propose a claim supported by evidence.