AmplifyScience

Microbiome

Investigation Notebook

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Developed by the Learning Design Group at the University of California, Berkeley's Lawrence Hall of Science.

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Safety Guidelines for Science Investigations

1. **Follow instructions.** Listen carefully to your teacher's instructions. Ask questions if you don't know what to do.
2. **Don't taste things.** No tasting anything or putting it near your mouth unless your teacher says it is safe to do so.
3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.
4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.
5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.
6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
7. **Tell your teacher if you have allergies.** This will keep you safe and comfortable during science class.
8. **Be calm and careful.** Move carefully and slowly around the classroom. Save your outdoor behavior for recess.
9. **Report all spills, accidents, and injuries to your teacher.** Tell your teacher if something spills, if there is an accident, or if someone gets injured.
10. **Avoid anything that could cause a burn.** Allow your teacher to work with hot water or hot equipment.
11. **Wash your hands after class.** Make sure to wash your hands thoroughly with soap and water after handling plants, animals, or science materials.

Name: _____ Date: _____

Microbiome
Unit Overview

How can having 100 trillion microorganisms on and in the human body keep us healthy? How can fecal transplants cure patients infected with harmful bacteria? That's what your classmates and you will set out to discover! Stepping into the role of a student researcher, you will interpret a case study about a very ill patient to find out how a fecal transplant played a role in his recovery. Your understanding of the tiny microorganisms living on and in the human body will help you determine whether a cutting-edge medical procedure, called a fecal transplant, deserves public money for more research.

Name: _____ Date: _____

Chapter 1: Microorganisms On and In the Human Body
Chapter Overview

In just a few days, you'll be waging a war against harmful bacteria that are too small to see! It may be hard to imagine fighting a problem that exists in a world full of the invisible. How do you get started? First, you will need to investigate more about the 100 trillion creatures that call the human body home, especially focusing on these creatures' very tiny sizes. They aren't on the human body to infect us—in fact, we couldn't survive without them! Soon, you'll be ready to step into the role of a microbiome student researcher to take on the harmful bacteria that endanger our microbiomes.

Name: _____ Date: _____

Lesson 1.1: Introduction to the Scale of Living Things

Welcome to an exciting new year of science! Over the next few weeks, you will learn to think like a life scientist as you investigate the world around you. In your role as a student researcher, you will help the Microbiome Research Institute work to increase funding for new medical treatments that depend on microorganisms found on and in the human body. The head scientist at the Institute will explain more about this research in a video. Then, you'll view some amazing pictures of tiny objects that live on and in the human body, which will help you begin to think about the actual sizes and scale of all different types of living things.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 1 Question

- How small are the microorganisms that live on and in the human body?

Vocabulary

- microorganism
- organism
- scale

Digital Tools

- Scale Tool

Name: _____ Date: _____

Quick-Write: Initial Ideas

Chapter 1 Question: *How small are the microorganisms that live on and in the human body?*

What initial ideas do you have about the Chapter 1 Question? Record some of your ideas below.

- Don't worry if you don't have a lot of ideas yet. These are just your initial ideas about the question.
- If you need help getting started, use some of the sentence starters below to help you record your ideas.

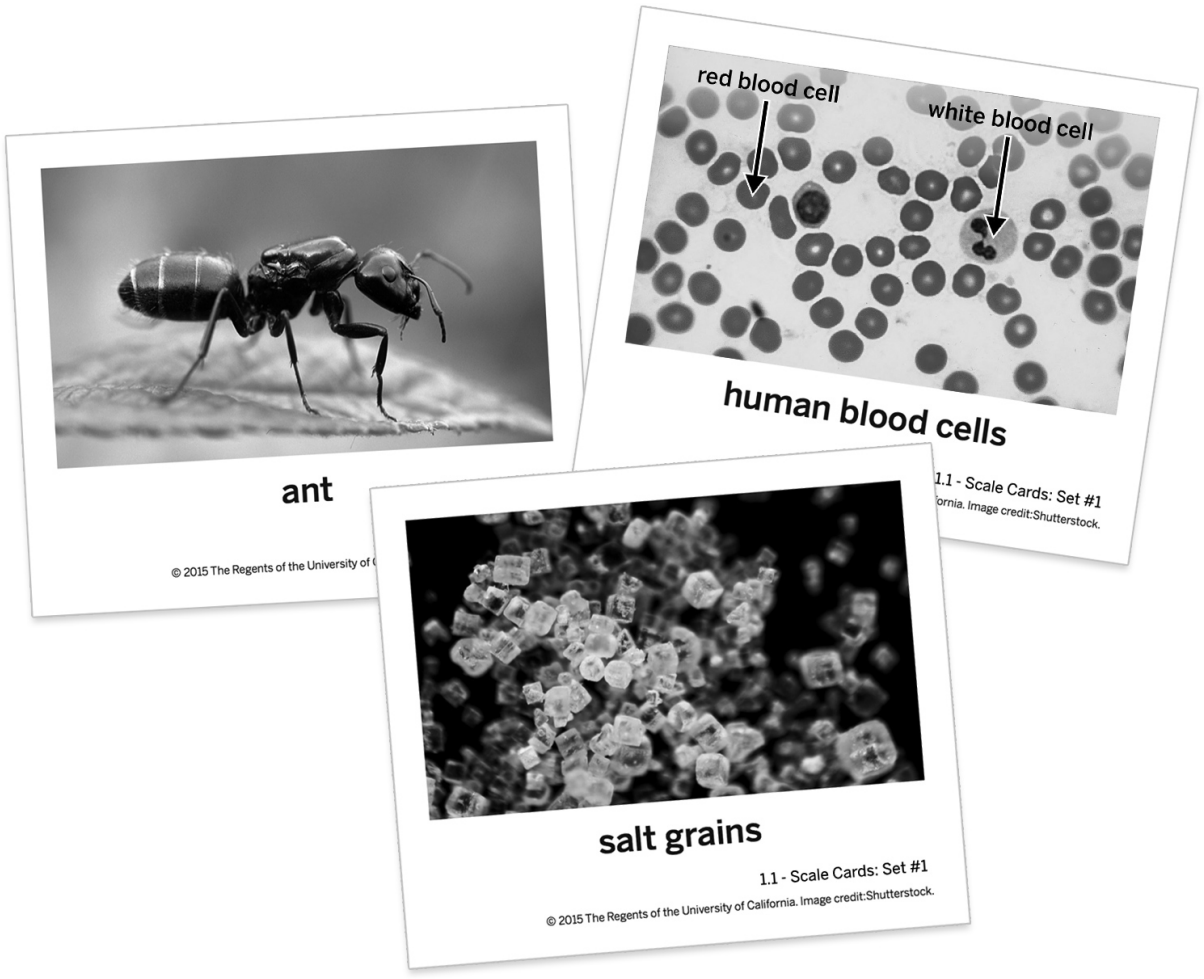
I think a microorganism is smaller than a . . .

I think this because . . .

Name: _____ Date: _____

Exploring Scale

Sort the organisms and objects on the Scale Cards: Set #1 from smallest to largest (left to right). Remember to discuss your ideas as you work!



Name: _____ Date: _____

Reflection

Below are some of the objects featured on the Scale Cards: Set #1.

1. Rewrite the objects to order them from smallest to largest (top to bottom).
2. Use the Scale Tool to help you order the objects, if needed.

Smallest

grain of salt _____

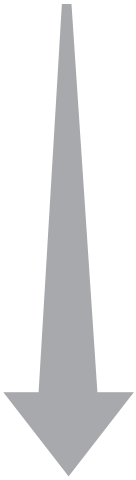
E. coli bacteria _____

human _____

water molecule _____

skin cell _____

Largest



Name: _____ Date: _____

Homework: Reflecting About Microorganisms

Respond to the two questions below. Try to use some of the words below that you heard today.

- bacteria
- cell
- microorganism
- microscopic
- organism
- scale

1. What was surprising or interesting to learn about the very small organisms and objects in today's lesson?

_____

_____

_____

_____

_____

2. What other questions do you have about microorganisms?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 1.2: How Small Is Small?

In the previous lesson, you learned that there are microorganisms living on and in the human body. You also compared the sizes of microorganisms to other tiny things. In this lesson, you will think very carefully about the small sizes of these microorganisms.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 1 Question

- How small are the microorganisms that live on and in the human body?

Key Concepts

- Many organisms are microscopic—so small that they cannot be seen with the naked eye.

Vocabulary

- cells
- microorganism
- microscopic
- organism
- scale

Digital Tools

- Scale Tool

Name: _____ Date: _____

Warm-Up

Check each statement below that is true. **Note:** You can select more than one statement.

- ☐ Cells come in different sizes and shapes.
- ☐ All organisms are made of many cells.
- ☐ Some organisms are made of just one cell.
- ☐ All cells are the same size and shape.
- ☐ Most cells are too small to see with the naked eye.

What else do you know about cells? Record your ideas or any questions you have about cells.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Understanding the Scale of Cells

Launch the Scale Tool to help you gather evidence about the objects on the new Scale Cards in Set #2.

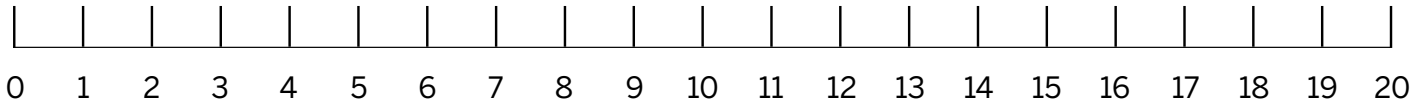
- Ringworm fungus
- *C. difficile* bacteria
- Human liver cell

You won't find these items in the Scale Tool, but you can use the measurements on the Scale Cards: Set #2 and the measurements of other objects in the Scale Tool to help you place these items in the Scale Card Sort!

Name: _____ Date: _____

Supersized Microorganisms

1. Choose two microorganisms from the Scale Cards or the Scale Tool.
2. Draw your microorganisms at 20,000 times their actual size.
3. Label each microorganism with its size and name.



scale: 20,000 times actual size
2 centimeters (cm) = 1 micrometer (µm)

Name: _____ Date: _____

Reflection

Check each statement below that is true. **Note:** You can select more than one statement.

- ☐ Cells come in different sizes and shapes.
- ☐ All organisms are made of many cells.
- ☐ Some organisms are made of just one cell.
- ☐ All cells are the same size and shape.
- ☐ Most cells are too small to see with the naked eye.

Refer back to your Warm-Up on page 11. Did any of your answers change from your Warm-Up response? If so, why? Record your changes and your explanations below.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Comparing Objects at Different Scales

In this lesson, you learned that:

- Living things are made of cells.
- Cells are very small—in fact, almost all cells are microscopic.
- Some living things are made of just one cell.

Think about how the scale of cells compares to the scale of other objects. Launch the Scale Tool and complete the table below by finding examples of objects at each scale that is listed. Some parts of the table have been completed for you.

Scale	**Objects at this scale**	**Size of object**
thousands of kilometers		
thousands of meters	depth of the Grand Canyon	
meters	orca	8 meters
centimeters		
micrometers	red blood cell	8 micrometers
nanometers		

Name: _____ Date: _____

Homework: Reading "Cells"

You have learned a lot about cells, but there is so much more to know! Read and annotate the article "Cells" and answer the questions below.

1. What is one new thing you learned about cells from this article?

2. What are organelles and why are they important?

3. How are cells, tissues, organs, and systems related?

Name: _____ Date: _____

Lesson 1.3: Observing Microorganisms

Microorganisms are tiny, but there are some things that are even smaller! In today's lesson, you'll think about things that are even smaller than microorganisms, and you'll also learn how scientists observe microorganisms without a microscope. Also, using a routine called Word Relationships and what you've learned in the last few lessons, you will talk and work like a scientist to revise your initial response to the Chapter 1 Question: *How small are the microorganisms that live on and in the human body?*

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 1 Question

- How small are the microorganisms that live on and in the human body?

Key Concepts

- Many organisms are microscopic—so small that they cannot be seen with the naked eye.
- All living things are made of cells.
- Almost all cells are microscopic.
- Even though they are both too small to see, cells are much bigger than molecules.

Vocabulary

- cells
- microorganism
- microscopic
- scale

Name: _____ Date: _____

Warm-Up

You've been learning about tiny organisms that are made of a single cell! But are there objects even **smaller** than a cell?

Circle "agree" or "disagree" for each statement below. It's okay if you aren't sure.

Cells are the smallest things that exist.	**agree**	**disagree**
Molecules are smaller than cells.	**agree**	**disagree**
Cells are smaller than molecules.	**agree**	**disagree**
Molecules are made of cells.	**agree**	**disagree**
Cells are made of molecules.	**agree**	**disagree**

Explain why you agree with some of the statements.

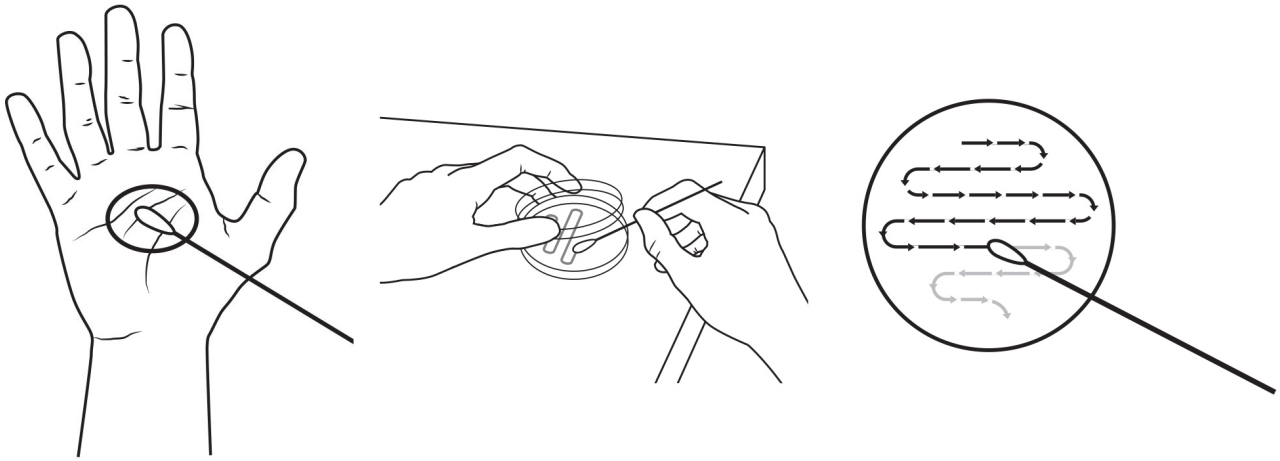
Name: _____ Date: _____

Investigating Microorganisms

Observing Microorganisms

1. Can you observe microorganisms on your hand? (circle one) **yes** **no**
2. Do you think there are any microorganisms on your hand? (circle one) **yes** **no**

The images below show how a microbiologist could prepare a culture in order to grow and observe the microorganisms found on a person's hand.



Name: _____ Date: _____

Observing Microorganisms: Day 1

Refer to the Day 1 image of the petri dish that your teacher projected, and answer the questions below.

Can you see evidence of microorganisms? (circle one) **yes** **no**

Describe what you observe in the petri dish.

_____

_____

_____

_____

Make a prediction: What do you think the petri dish will look like on Day 5?

_____

_____

_____

_____

Name: _____ Date: _____

Observing Microorganisms: Day 5

Refer to the Day 5 image of the petri dish that your teacher projected, and answer the questions below.

Can you see evidence of microorganisms? (circle one) **yes** **no**

Describe what you observe in the petri dish.

_____

_____

_____

_____

Make a prediction: What do you think the petri dish will look like on Day 9?

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Revising Responses to the Chapter 1 Question

Chapter 1 Question: *How small are the microorganisms that live on and in the human body?*

1. Turn back to page 6 and read over your previous response to the Chapter 1 Question.
2. Revise your response below so it includes what you have learned in the last few lessons. You may wish to use the following science words in your revised response.

    - cell
    - micrometer
    - microorganism
    - microscopic
    - molecule
    - nanometer

Name: _____ Date: _____

Chapter 2: Arguing for the Benefits of Fecal Transplants
Chapter Overview

The tiny microorganisms that live on and in the human body are tiny but powerful. They can be helpful or they can be deadly. You'll be using what you've learned about the microbiome to investigate a promising but controversial new treatment that involves transplanting microorganisms from a healthy person into a sick person. By the end of this unit, you'll be able to write a scientific argument explaining how this treatment works.

Name: _____ Date: _____

Lesson 2.1: Reading "The Human Microbiome"

Today, you will return to your bacteria culture to see more evidence about microorganisms that came from your body! Then, you'll read more about these microorganisms in "The Human Microbiome" article. Using this article, you will begin to learn how to read like a scientist, carefully and actively, making sure you understand the text and images. You will record your questions and ideas as you read, and you'll have a chance to discuss your thoughts about the article with others. After reading today, you'll have a better understanding of what the human microbiome is and how it is possible to have trillions of microorganisms on and in the human body.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Vocabulary

- cells
- microbiome
- microorganism
- microscopic
- organism
- scale

Name: _____ Date: _____

Warm-Up

Observing Microorganisms: Day 9

Refer to the Day 9 image of the petri dish that your teacher projected, and answer the questions below.

Can you see evidence of microorganisms? (circle one) **yes** **no**

Describe what you observe in the petri dish.

_____

_____

_____

_____

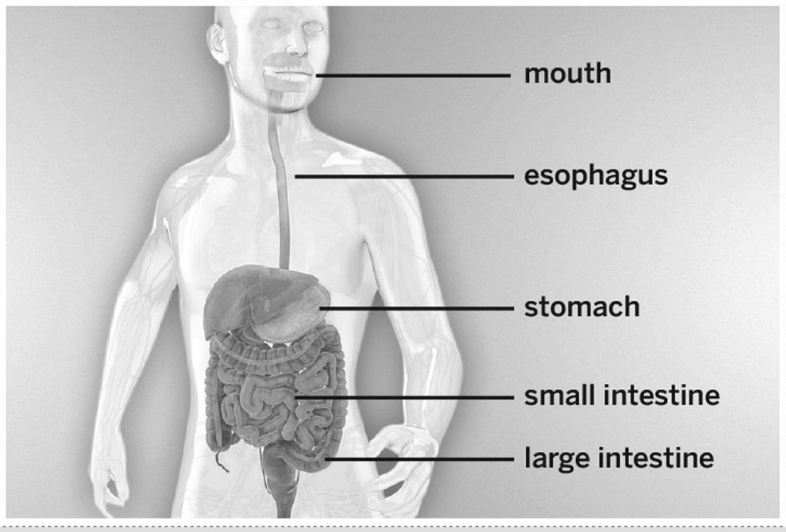
Name: _____ Date: _____

Introducing Active Reading

Analyzing Example Annotations

- What do you notice about this student's annotations?
- How do you know that she was thinking carefully while reading and trying to understand the text?

Certain combinations of bacteria, fungi, and other microbes in the human microbiome can cause health problems, but other combinations may be able to keep people healthy. By identifying which combinations make people sick, scientists might be able to tell what changes to the microbiome could treat those illnesses or prevent them from happening at all. Someday, Lynch believes that doctors will be able to tell patients exactly what combinations of bacteria, fungi, and other microbes they need in their systems to stay healthy.



Many of the microbes Dr. Susan Lynch studies are found in the human digestive system. (© 2015 The Regents of the University of California)

Do different people have different combinations? Why wouldn't they be all the same?

Note added three days ago EDIT

Diagram Question: Are microorganisms all over the body or just in the digestive system?

Note edited today EDIT

Diagram Question: Is the digestive system really red?

Note edited today EDIT

Name: _____ Date: _____

Reading "The Human Microbiome"

1. Read and annotate the article "The Human Microbiome."
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection questions below.

How similar is Active Reading to the way you normally read?

- ☐ I always read this way.
- ☐ It is somewhat similar to how I normally read.
- ☐ It is very different from the way I normally read.

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 2.2: Beginning a Case Study of Patient 23

Here's the deal: A politician wants to cut funding for research on a new treatment that's being used to cure patients infected with a harmful bacteria called *C. difficile.* 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'll start to construct this argument by learning more about helpful and harmful bacteria. Then, you'll examine data from a patient who actually received this treatment.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Vocabulary

- bacteria
- cells
- microbiome
- microorganism
- scale

Name: _____ Date: _____

Warm-Up

After reading "The Human Microbiome" article, you learned that there are trillions of bacteria in the human microbiome. Which of these statements do you agree with most right now? (check one)

- ☐ Bacteria are disgusting! Most bacteria in the human microbiome are harmful.
- ☐ Bacteria are great! Most bacteria in the human microbiome are helpful.
- ☐ I'm not sure! Bacteria are kind of disgusting, but some of them might be helpful.

What other interesting things did you learn from reading "The Human Microbiome" article?

_____

_____

_____

_____

What questions do you still have about the article?

_____

_____

_____

_____

Name: _____ Date: _____

Introducing Patient 23's Case Study

Analyzing Data in Pie Charts

1. Annotate the case study pie charts below with your comments and questions.
2. Then, discuss the following questions with your partner:
   - What is the **same** about the patient's gut microbiome data from week 1 to week 3?
   - What is **different** about the patient's gut microbiome data from week 1 to week 3?
3. When you are finished discussing with a partner, answer the questions about the patient on the next page.

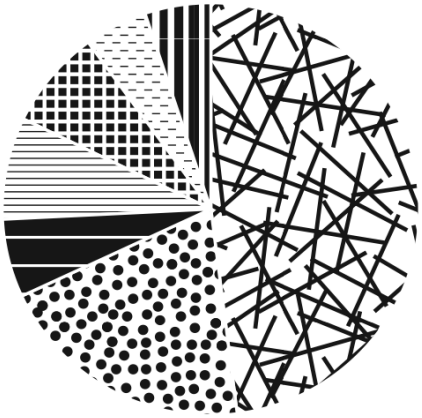
Patient 23's Gut Bacteria

WEEK 1

Doctor's Notes

Patient reports feeling normal.

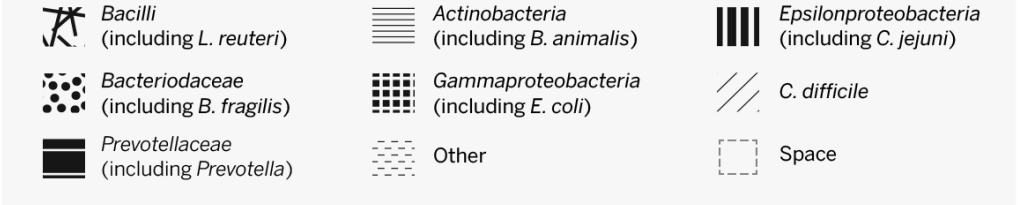
WEEK 3



Doctor's Notes

Patient reports vomiting, diarrhea, and a fever.

Gut Bacteria Key



Name: _____ Date: _____

Introducing Patient 23's Case Study (continued)

After your discussion, record your ideas below about why you think Patient 23 feels normal during week 1 but sick during week 3.

_____

_____

_____

The evidence that supports my ideas is . . .

_____

_____

_____

_____

Name: _____ Date: _____

Second Read of "The Human Microbiome"

Reread the sections: "Your Body: Home Sweet Home for Bacteria," "Helpful Bacteria and Alien Invaders," and "Antibiotics and the Microbiome" from "The Human Microbiome" article. Then, highlight or add annotations with your ideas to parts of the text that relate to Patient 23. Using your annotations, answer the questions below.

1. What do bacteria do in a healthy gut microbiome?

_____

_____

_____

2. What is one type of bacteria found in a healthy gut microbiome?

_____

_____

3. What is a type of harmful bacteria found in the human gut microbiome?

_____

_____

4. What do harmful bacteria do in the gut microbiome?

_____

_____

Name: _____ Date: _____

Reflection: Revising Explanations About Patient 23

Refer back to your initial explanation on page 31 about why Patient 23 felt sick during week 3. Use what you learned from your second read of "The Human Microbiome" to revise your explanation.

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 2.3: Investigating Antibiotics

Poor Patient 23! We've analyzed data about his gut microbiome and now have strong evidence that he is a victim of food poisoning (or a *C. jejuni* bacteria infection). This type of food poisoning is often treated with antibiotics, so today you'll evaluate evidence about the effects of antibiotics on the human microbiome, while also learning more about how to argue like a scientist.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Key Concepts

- The human microbiome contains approximately 100 trillion microorganisms. Most of these are bacteria.
- The human body provides an environment (food and space) for bacteria to survive.

Vocabulary

- antibiotics
- bacteria
- claim
- evidence
- microorganism
- reasoning
- scale
- scientific argument

Name: _____ Date: _____

Warm-Up

1. Read the arguments below.
2. Then, answer the question about the arguments.

Argument One: Patient 23 felt sick during week 3 because he was infected with the *C. jejuni* bacteria. From "The Human Microbiome" article, I know that "this kind of *C. jejuni* infection can cause diarrhea, vomiting, and fever—all the symptoms of food poisoning." These symptoms match the doctor's note for Patient 23 for week 3. When Patient 23 felt healthy during week 1, the *C. jejuni* bacteria was not present in his gut microbiome. In week 3, when he felt sick, *C. jejuni* was present. Therefore, *C. jejuni* is probably the cause of his sickness.

Argument Two: Patient 23 felt sick during week 3 because he was infected with the *C. jejuni* bacteria. *C. jejuni* is very bad for you. He probably ate something spoiled. My sister got food poisoning once.

These two arguments both answer the question *Why did Patient 23 feel sick during week 3?* Which of these arguments is more convincing? Explain your thinking below.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

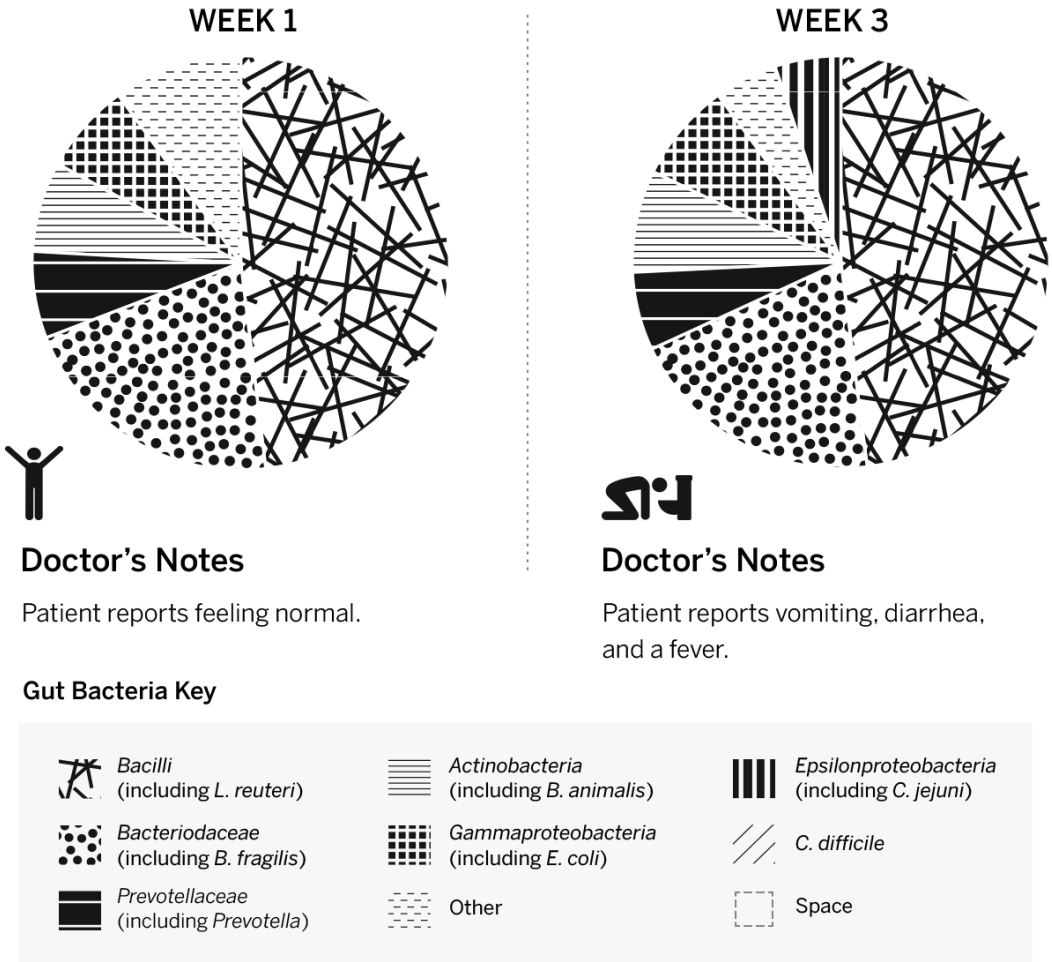
Evaluating Evidence About Antibiotics

Antibiotics Card Sort

How do antibiotics affect the microbiome?

1. Place the Claim card at the top of your desk and the Relevant and Irrelevant headers underneath it.
2. With your partner, discuss each evidence card and decide if it is relevant or irrelevant to the claim.
3. Place each evidence card under the appropriate header on your desk.

Patient 23's Gut Bacteria



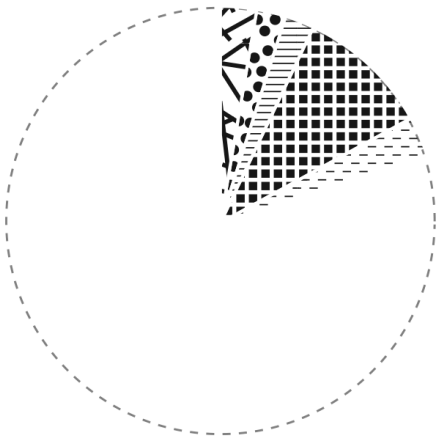
Name: _____ Date: _____

Returning to Patient 23

Analyzing Data for Patient 23 During Week 5

1. Analyze the new pie chart for week 5.
2. Then, answer the question below.

Treatment: antibiotics

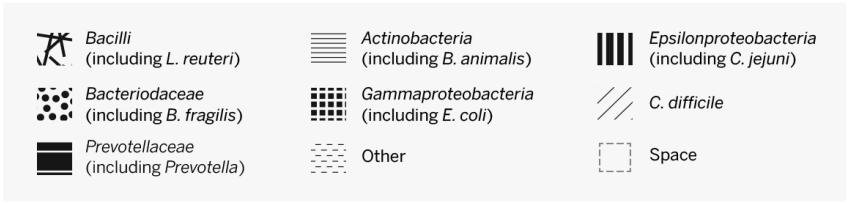


WEEK 5

Doctor's Notes

Patient feeling well again.

Gut Bacteria Key



Observe what happened to Patient 23 during week 5 (after he was treated with antibiotics). What do you notice? How do you think antibiotics affected his microbiome?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Reading "Meet a Scientist Who Studies the Human Microbiome"

Learn more about a scientist who studies the human microbiome. Read and annotate the article "Meet a Scientist Who Studies the Human Microbiome" and answer the question below.

What do scientists who study the human microbiome hope to achieve?

_____

_____

_____

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 2.4: Analyzing Experiments with Mice

Did you know that mice have microbiomes, too? Today, you will analyze data from an experiment conducted on laboratory mice. This experiment provides information about how a healthy gut microbiome full of different types of bacteria could be important to the overall health of an organism's body. By the end of this lesson, you will be able to use what you learned from the mouse experiment to figure out why Patient 23 got a different infection after being treated with antibiotics in week 5 of his case study.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Key Concepts

- The human microbiome contains approximately 100 trillion microorganisms. Most of these are bacteria.
- The human body provides an environment (food and space) for bacteria to survive.
- A healthy microbiome has various helpful types of bacteria.
- An infection of harmful bacteria in the human microbiome can make a person sick.

Vocabulary

- antibiotics
- bacteria
- claim
- evidence
- microorganism
- scale

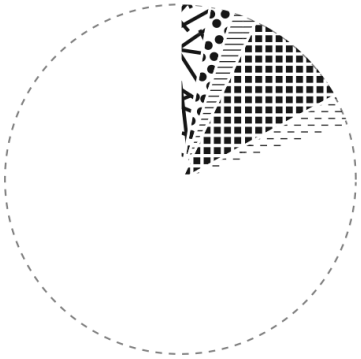
Name: _____ Date: _____

Warm-Up

The pie charts below show data about Patient 23 during weeks 5 and 7 of the case study. Using the Gut Bacteria Key, determine which new type of bacteria has been introduced to Patient 23's gut microbiome. Then, answer the questions below.

Treatment: antibiotics

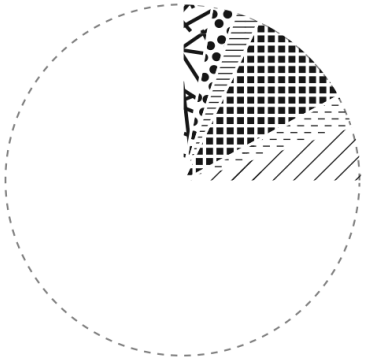
WEEK 5



Doctor's Notes

Patient feeling well again.

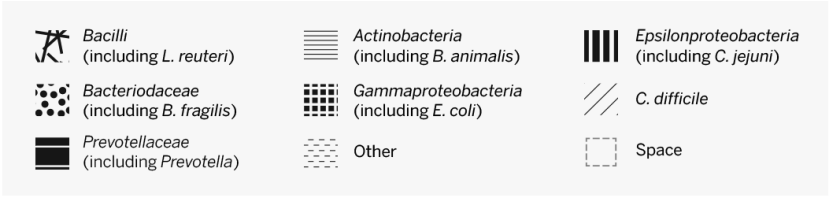
WEEK 7



Doctor's Notes

Patient reports stomach pains, diarrhea, and bloating.

Gut Bacteria Key



Which new type of bacteria was introduced to Patient 23's gut microbiome?

_____

What effect do you think this new bacteria will have on Patient 23's overall health?

_____

_____

_____

_____

Name: _____ Date: _____

Analyzing an Experiment About the Microbiome

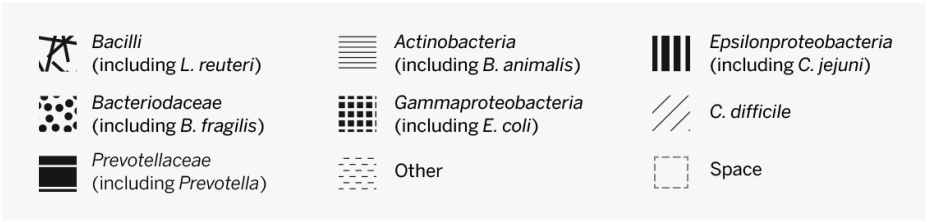
With your partner, discuss the similarities and differences between the healthy gut microbiomes of a mouse and a human.

Human and Mouse Gut Microbiomes

Normal Human Gut Microbiome

Normal Mouse Gut Microbiome

Gut Bacteria Key



Name: _____ Date: _____

Analyzing an Experiment About the Microbiome (continued)

Recording Observations About New Data

Record your observations about the mouse data by annotating the image below.

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

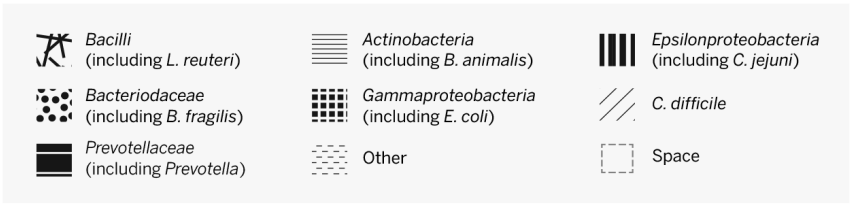
Low-Bacteria Gut Microbiomes of 20 Healthy Mice Before Experiment

Mice ingest the same amount of *Salmonella* bacteria

Test Results

20 get really sick from *Salmonella* infection

Gut Bacteria Key



Name: _____ Date: _____

Reading "Bacteria: *Salmonella*"

Carefully read the "Environment" section from the "Bacteria: *Salmonella*" article. Pay attention to your own understanding while you read.

As you read, think about how the information presented in the text could help you answer the following two discussion questions. Record your notes on the lines underneath the questions.

1. How do *Salmonella* bacteria in the gut microbiome affect the body?

_____

_____

_____

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

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

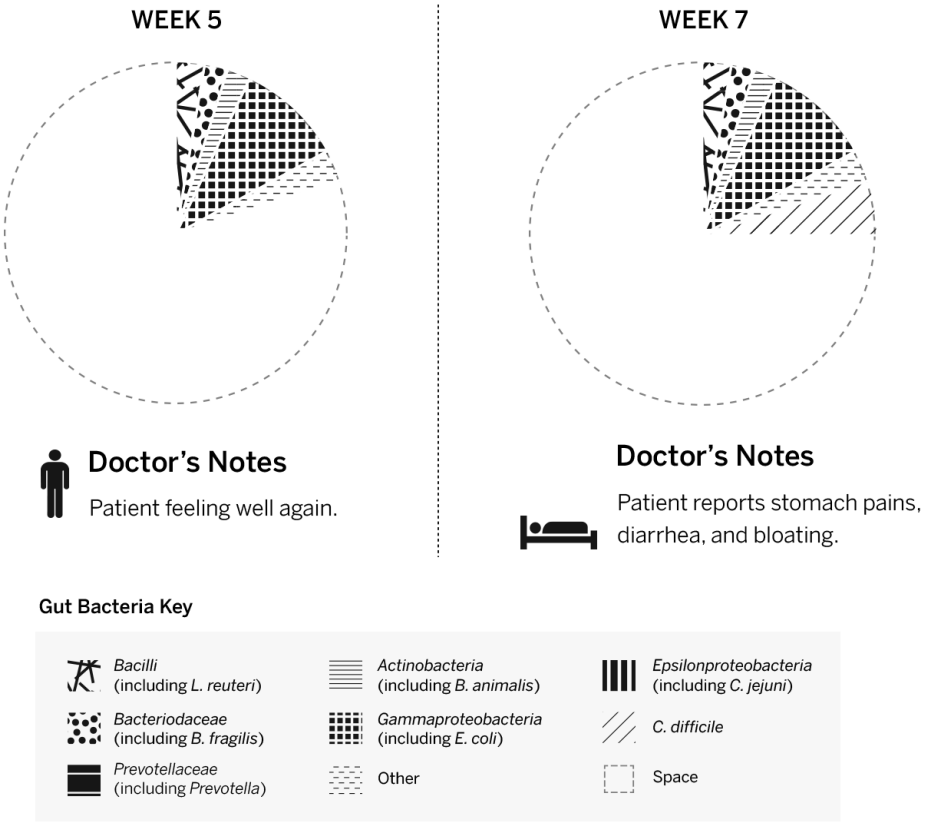
Name: _____ Date: _____

Applying New Understanding to Patient 23

Why did Patient 23 get a* C. difficile *infection after his treatment with antibiotics?

1. Use evidence from Experiment 1: *Salmonella* Bacteria, the "Bacteria: *Salmonella*" article, and the other case study data to support your ideas as you discuss the question above with your partner.
2. If you are having trouble expressing your ideas, use these sentence starters:
   - Patient 23 got a *C. difficile* infection after his treatment with antibiotics because . . .
   - The evidence that supports my idea is . . .

Treatment: antibiotics



Name: _____ Date: _____

Homework: Reading "Bacteria: *C. difficile*"

The week 7 data shows that Patient 23 is infected with the *C. difficile* bacteria. Read and annotate the article to learn more about this very harmful bacteria.

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 2.5: Analyzing Evidence About Fecal Transplants

The Microbiome Research Institute needs your help and expertise! In order to fight the senator's efforts to cut their funding, they are preparing a press release about the benefits of fecal transplants. Specifically, they need your help writing a scientific argument about how fecal transplants work, which they will include in the press release. You'll start by analyzing new data about Patient 23. Then, by relooking at all of the evidence you have gathered about fecal transplants, you can begin to reason about this evidence and write the first part of your argument.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Key Concepts

- The human microbiome contains approximately 100 trillion microorganisms. Most of these are bacteria.
- The human body provides an environment (food and space) for bacteria to survive.
- A healthy microbiome has various helpful types of bacteria.
- An infection of harmful bacteria in the human microbiome can make a person sick.
- Antibiotics reduce the number of helpful and harmful bacteria in the microbiome.
- Living things with fewer than normal helpful bacteria in their guts can become infected more easily because there is more food and space available for harmful bacteria.

Vocabulary

- antibiotics
- bacteria
- claim
- evidence
- microorganism
- scale

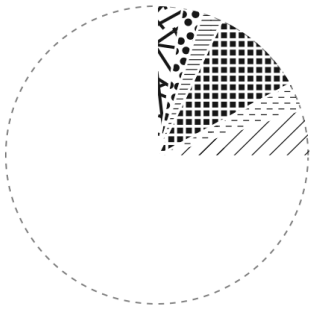
Name: _____ Date: _____

Warm-Up

1. Review the new data about Patient 23.
2. Then, answer the question below.

Treatment: fecal transplant

WEEK 7



Doctor's Notes

Patient reports stomach pains, diarrhea, and bloating.

WEEK 9

Doctor's Notes

Patient reports feeling normal again.

Gut Bacteria Key

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

What differences do you notice in Patient 23's gut microbiome between weeks 7 and 9? Record at least two observations.

_____

_____

_____

_____

Name: _____ Date: _____

Message from the Microbiome Research Institute

To: Student Researchers
From: Mara, Head Scientist
Subject: Fecal Transplant Procedure Presentation
Attachment: FT Procedure

MRI Microbiome Research Institute

Thank you for your careful work analyzing the data for Patient 23. As you know from the politician's speech, the fecal transplant procedure has something to do with feces. I've sent you a slideshow presentation to review that includes a detailed explanation of how the procedure works. I think this information will help you understand more about how a fecal transplant helps cure a patient infected with harmful bacteria.

We also want to include your research in a press release in which we will publicly present our arguments against the senator's effort to cut our funding. In this press release, we are going to present our evidence in support of this claim: A fecal transplant can work to cure a patient infected with a very harmful bacteria, such as *C. difficile*, in many different ways. We think we have strong evidence to support this claim, but we will need your help to research and write a convincing scientific argument.

Name: _____ Date: _____

Discussing Evidence and Reasoning

Explaining Evidence

With a partner, take turns explaining how each piece of evidence helps support the subclaim.

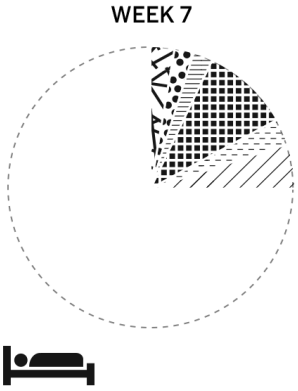
- Partner A describes the evidence below.
- Partner B asks "Why does this evidence matter?"
- Partner A explains how this evidence supports the claim.
- Partners switch roles, using a new piece of evidence (see chart on the next page).

How can fecal transplants cure patients infected with harmful bacteria?

Subclaim 1: Bacteria from the fecal transplant can fill up the space in the gut, limiting the food and space for invading harmful bacteria.

Evidence from Patient 23's Case Study, Week 7 and Week 9

Treatment: fecal transplant



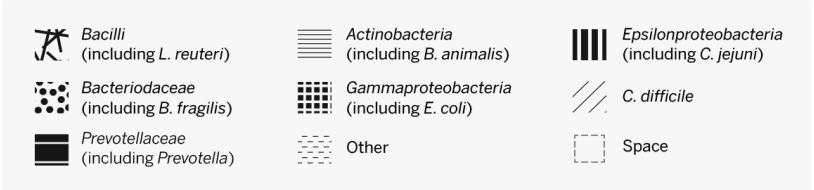
Doctor's Notes

Patient reports stomach pains, diarrhea, and bloating.

Doctor's Notes

Patient reports feeling normal again.

Gut Bacteria Key



Name: _____ Date: _____

Discussing Evidence and Reasoning (continued)

Explaining Evidence

With a partner, take turns explaining how each piece of evidence helps support the subclaim.

- Partner B describes the evidence below.
- Partner A asks "Why does this evidence matter?"
- Partner B explains how this evidence supports the claim.
- Partners switch roles, using a new piece of evidence (on the next page).

How can fecal transplants cure patients infected with harmful bacteria?

Subclaim 1: Bacteria from the fecal transplant can fill up the space in the gut, limiting the food and space for invading harmful bacteria.

Evidence from Experiment 1: *Salmonella* Bacteria

Normal Gut Microbiomes of 20 Healthy Mice Before Experiment

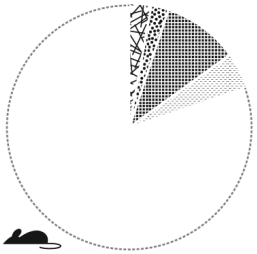
Mice ingest the same amount of *Salmonella* bacteria

Test Results

5 mice are unaffected and remain healthy

12 get slightly sick from *Salmonella* infection

3 get really sick from *Salmonella* infection



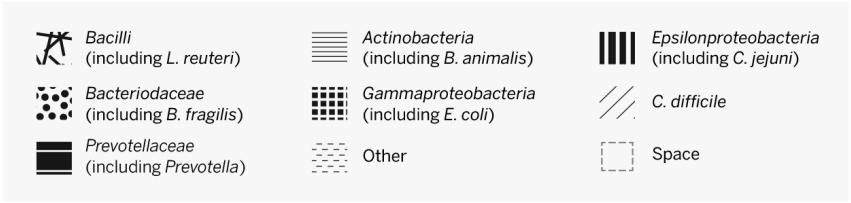
Low-Bacteria Gut Microbiomes of 20 Healthy Mice Before Experiment

Mice ingest the same amount of *Salmonella* bacteria

Test Results

20 get really sick from *Salmonella* infection

Gut Bacteria Key



Name: _____ Date: _____

Discussing Evidence and Reasoning (continued)

Explaining Evidence

With a partner, take turns explaining how each piece of evidence helps support the subclaim.

- Partner A describes the evidence below.
- Partner B asks "Why does this evidence matter?"
- Partner A explains how this evidence supports the claim.

How can fecal transplants cure patients infected with harmful bacteria?

Subclaim 1: Bacteria from the fecal transplant can fill up the space in the gut, limiting the food and space for invading harmful bacteria.

Evidence from "The Human Microbiome"

"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."

Name: _____ Date: _____

Reasoning Tool

How can fecal transplants cure patients infected with harmful bacteria?

Subclaim 1: Bacteria from the fecal transplant can fill up the space in the gut, limiting the food and space for invading harmful bacteria.

Evidence	**This matters because . . .**	**Therefore, . . .**
From Patient 23's case study data for weeks 7 and 9		
From Experiment 1: *Salmonella* Bacteria		
From "The Human Microbiome" "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."		

Name: _____ Date: _____

Homework: Press Release

PRESS RELEASE

MRI Microbiome Research Institute

A fecal transplant can work to cure a patient infected with a very harmful bacteria, such as *C. difficile,* in many different ways.

Write a paragraph that supports Subclaim 1. Include evidence and explain how your evidence supports this subclaim.

Subclaim 1: Bacteria from the fecal transplant can fill up the space in the gut, limiting the food and space for invading harmful bacteria.

- To help you write, review your work from this lesson, including the Reasoning Tool.
- To help you organize your thinking and construct your ideas, refer to the Scientific Argumentation Sentence Starters.
- The Microbiome Research Institute will publish this press release as a way to inform the public and defend their funding.

Scientific Argumentation Sentence Starters

Describing evidence:	**Describing how evidence supports a claim:**
The evidence that supports my claim is . . .	If _____, then . . .
My first piece of evidence is . . .	This is important because . . .
Another piece of evidence is . . .	Since . . .
This evidence shows . . .	Based on the evidence, I conclude that . . .

Name: _____ Date: _____

Homework: Press Release (continued)

Name: _____ Date: _____

Lesson 2.6: Evaluating Evidence About Bacteria

As we already discovered, bacteria from a fecal transplant can take up food and space in the gut, which leaves very little room for harmful bacteria. Now, we want to know if there are other ways the added bacteria from a fecal transplant can help a patient, as well. Today, you'll analyze experiments and read about two new types of bacteria that are added to the gut microbiome during a fecal transplant: *B. fragilis* and *L. reuteri.* You will select one of these types of bacteria to study in this lesson, and you'll evaluate evidence about the bacteria you choose. This will prepare you to write one more argument about this bacteria to add to the press release.

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Key Concepts

- The human microbiome contains approximately 100 trillion microorganisms. Most of these are bacteria.
- The human body provides an environment (food and space) for bacteria to survive.
- A healthy microbiome has various helpful types of bacteria.
- An infection of harmful bacteria in the human microbiome can make a person sick.
- Antibiotics reduce the number of helpful and harmful bacteria in the microbiome.
- Living things with fewer than normal helpful bacteria in their guts can become infected more easily because there is more food and space available for harmful bacteria.

Vocabulary

- antibiotics
- bacteria
- claim
- evidence
- microorganism
- scale

Name: _____ Date: _____

Warm-Up

Read your draft of your initial argument (on page 53) and evaluate it based on the criteria below. Select how well you completed each task.

I stated my claim clearly.

- ☐ Definitely
- ☐ Somewhat
- ☐ Not really
- ☐ Not at all

I included evidence to support my claim.

- ☐ Definitely
- ☐ Somewhat
- ☐ Not really
- ☐ Not at all

I made my reasoning clear by explaining how the evidence supports the claim.

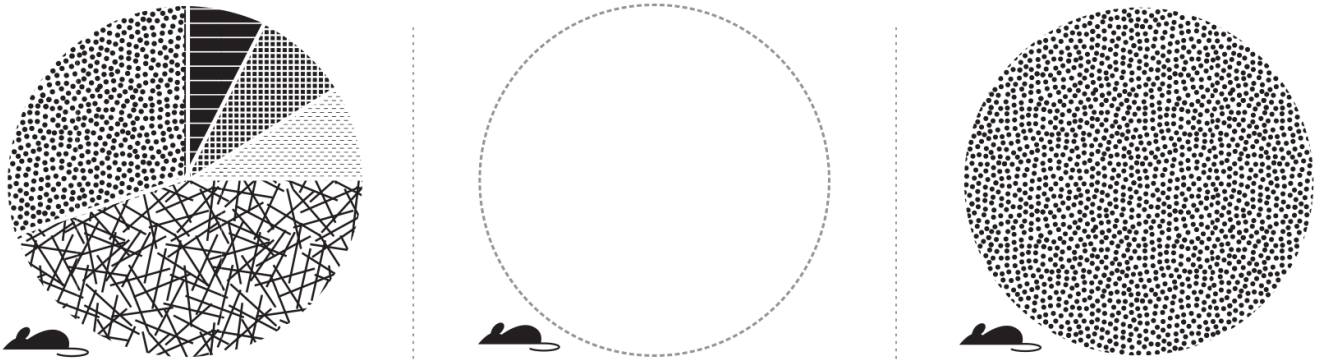
- ☐ Definitely
- ☐ Somewhat
- ☐ Not really
- ☐ Not at all

Name: _____ Date: _____

Analyzing Experiments About Bacteria

1. Choose an experiment to focus on in this lesson, either from this page or the next page.
2. Work with your partner to observe and analyze the results of the experiment you chose.
3. Add annotations to the experiment data.

Experiment 2: *B. fragilis* Bacteria



Normal mouse gut microbiome

Test Results

- Immune Cells: High
- Gut Mucus: High

Mouse with no bacteria in gut

Test Results

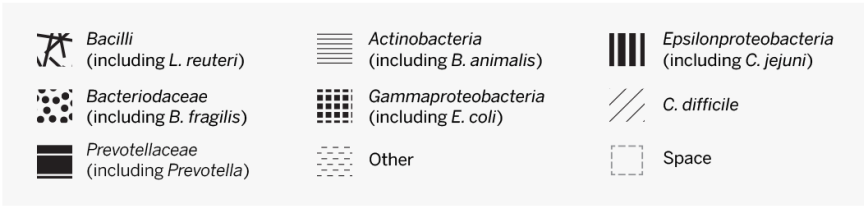
- Immune Cells: Low
- Gut Mucus: Low

Mouse with only *B. fragilis* in gut

Test Results

- Immune Cells: High
- Gut Mucus: Low

Gut Bacteria Key

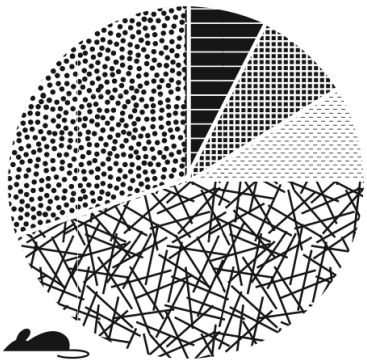


Question: *How does* B. fragilis *bacteria in the gut microbiome affect mouse gut health?*

Name: _____ Date: _____

Analyzing Experiments About Bacteria (continued)

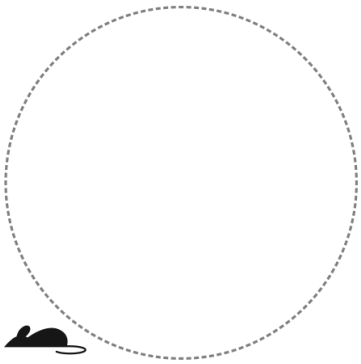
Experiment 3: *L. reuteri* Bacteria



Normal mouse gut microbiome

Test Results

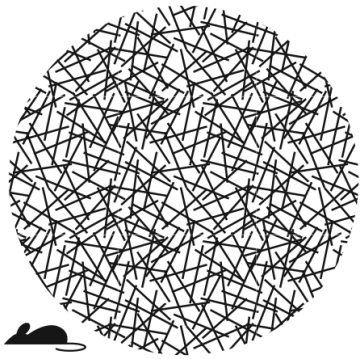
- Immune Cells: High
- Gut Mucus: High



Mouse with no bacteria in gut

Test Results

- Immune Cells: Low
- Gut Mucus: Low

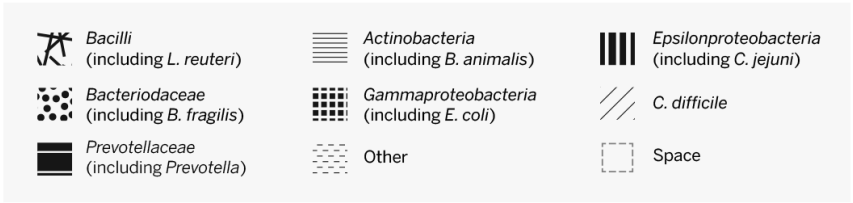


Mouse with only *L. reuteri* in gut

Test Results

- Immune Cells: Low
- Gut Mucus: High

Gut Bacteria Key



Question: *How does* L. reuteri *bacteria in the gut microbiome affect mouse gut health?*

Name: _____ Date: _____

Reading About Bacteria

1. Read the article about the bacteria you analyzed in the previous experiment:
   - "Bacteria: *B. fragilis"*
   - "Bacteria: *L. reuteri"*

2. Highlight or make notes about specific parts of the article that could be supporting evidence for your argument.

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Evaluating Evidence with the Evidence Gradient

Which experiment did you analyze? (check one)

- ☐ **Experiment 2:** *B. fragilis* Bacteria
- ☐ **Experiment 3:** *L. reuteri* Bacteria

Which claim do you think the evidence from the experiment helps support? (check one)

- ☐ **Subclaim 2:** Bacteria from the fecal transplant can help the patient's body produce immune cells that kill invading bacteria.
- ☐ **Subclaim 3:** Bacteria from the fecal transplant can help the patient's body produce mucus that protects the gut from invading bacteria.
- ☐ Both claims.
- ☐ Neither claim.

Bacteria Evidence Card Sort

1. Choose the claim that is best supported by the evidence in your experiment and article and clip it to the top of your Evidence Gradient. Write your names on the claim you chose.
2. Discuss each Bacteria Evidence Card with your partner. Remove any irrelevant cards.
3. Discuss the relevant Bacteria Evidence Cards. Place each one on the Evidence Gradient, according to how strongly it supports your subclaim.

Name: _____ Date: _____

Homework: Revising Your Argument

1. Look back to your initial argument on page 53 and the evaluation of your argument that you completed in today's Warm-Up on page 56.
2. Then, revise your argument to make it more convincing.

PRESS RELEASE

MRI Microbiome Research Institute

A fecal transplant can work to cure a patient infected with a very harmful bacteria, such as *C. difficile,* in many different ways**.**

Subclaim 1: Bacteria from the fecal transplant can fill up the space in the gut, limiting the food and space for invading harmful bacteria.

Revise your paragraph that supports the subclaim above. Include evidence and explain how your evidence supports this subclaim.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Revising Your Argument (continued)

Name: _____ Date: _____

Lesson 2.7: Writing a Final Argument

Today is the last day of your Microbiome Research Institute mission! The Institute is anxious for you to help them create their press release in support of funding for fecal transplant research. You have already written a short argument about one way that fecal transplants help battle dangerous infections. Today, you will complete your contributions to the press release by writing another argument about a different way the bacteria transferred during a fecal transplant can help cure a patient. Make sure your argument is clear and convincing!

Unit Question

- How can having 100 trillion microorganisms on and in the human body keep us healthy?

Chapter 2 Question

- How can fecal transplants cure patients infected with harmful bacteria?

Key Concepts

- Many organisms are microscopic—so small that they cannot be seen with the naked eye.
- All living things are made of cells.
- Almost all cells are microscopic.
- The human microbiome contains approximately 100 trillion microorganisms. Most of these are bacteria.
- The human body provides an environment (food and space) for bacteria to survive.
- A healthy microbiome has various helpful types of bacteria.
- An infection of harmful bacteria in the human microbiome can make a person sick.
- Antibiotics reduce the number of helpful and harmful bacteria in the microbiome.
- Living things with fewer than normal helpful bacteria in their guts can become infected more easily because there is more food and space available for harmful bacteria.

Vocabulary

- antibiotics
- bacteria
- claim
- evidence
- microorganism
- reasoning
- scale
- scientific argument

Name: _____ Date: _____

Warm-Up

A Convincing Argument?

Read the following statement from Senator Naismith, and then answer the question.

> *Fecal transplants will make people sick. My evidence is that I think poop is gross, and everyone knows that poop does not contain anything healthy.*
>
> **— Senator Naismith**

Is Senator Naismith making a convincing argument? Why or why not?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Reasoning Tool

Choose the subclaim that you will support with evidence in order to answer the question:

How can fecal transplants cure patients infected with harmful bacteria?

- ☐ **Subclaim 2:** Bacteria from the fecal transplant can help the patient's body produce immune cells that kill invading bacteria.
- ☐ **Subclaim 3:** Bacteria from the fecal transplant can help the patient's body produce mucus that protects the gut from invading bacteria.

Fill out the Reasoning Tool with evidence that supports the subclaim you selected.

Evidence	This matters because . . .	Therefore, . . .

Name: _____ Date: _____

Reasoning Tool (continued)

Evidence	This matters because . . .	Therefore, . . .

Name: _____ Date: _____

Writing Final Argument Paragraphs

PRESS RELEASE

MRI Microbiome Research Institute

Select the subclaim that you will use in your argument:

- ☐ **Subclaim 2:** Bacteria from the fecal transplant can help the patient's body produce immune cells that kill invading bacteria.
- ☐ **Subclaim 3:** Bacteria from the fecal transplant can help the patient's body produce mucus that protects the gut from invading bacteria.

Write a new argument that supports the subclaim you chose above. This argument will be the second part of the press release, so make sure it is clear and convincing.

- Include evidence and explain how this evidence supports this subclaim.
- Look back at your work from this lesson.
- You may also want to use the Scientific Argumentation Sentence Starters for help with organizing your thinking and constructing your argument.

Scientific Argumentation Sentence Starters

Describing evidence:	**Describing how evidence supports a claim:**
The evidence that supports my claim is . . .	If _____, then . . .
My first piece of evidence is . . .	This is important because . . .
Another piece of evidence is . . .	Since . . .
This evidence shows . . .	Based on the evidence, I conclude that . . .

Name: _____ Date: _____

Writing Final Argument Paragraphs (continued)

Name: _____ Date: _____

Homework: Revising Your Final Argument

Read your new argument and evaluate it based on the criteria below. Select how well you completed each task by checking off one option for each statement.

I stated my claim clearly.

- ☐ Definitely
- ☐ Somewhat
- ☐ Not really
- ☐ Not at all

I included evidence to support my claim.

- ☐ Definitely
- ☐ Somewhat
- ☐ Not really
- ☐ Not at all

Revise your new argument below. Remember, this argument will be the second part of the press release, so make sure it is clear and convincing.

Name: _____ Date: _____

Homework: Revising Your Final Argument (continued)

Name: _____ Date: _____

Homework: Reading "Viruses: On the Edge of Life"

Find out what a virus is and how it is different from bacteria. Read and annotate the article "Viruses: On the Edge of Life" and answer the questions below.

1. How is a virus different from bacteria?

_____

_____

_____

_____

_____

2. Do you think a virus should be considered a living thing? Why or why not?

_____

_____

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Microbiome Glossary

antibiotics: medicines that kill microorganisms, especially bacteria

antibióticos: medicinas que matan los microorganismos, especialmente las bacterias

bacteria: tiny organisms that are made of a single cell

bacterias: organismos diminutos que están hechos de una sola célula

cells: the tiny structures that make up all living things and are the smallest units able to perform life functions

células: las estructuras diminutas que constituyen todos los seres vivientes y que son las más pequeñas unidades capaces de desempeñar las funciones de la vida

claim: a proposed answer to a question about the natural world

afirmación: una respuesta propuesta a una pregunta sobre el mundo natural

evidence: information about the natural world that is used to support or go against (refute) a claim

evidencia: información sobre el mundo natural que se utiliza para respaldar o rechazar (refutar) una afirmación

infection: sickness caused by harmful microorganisms

infección: una enfermedad causada por microorganismos dañinos

microbiome: all of the microorganisms that live in a particular environment, such as a human body

microbioma: todos los microorganismos que viven en un ambiente específico, por ejemplo en un cuerpo humano

microorganism: an organism that is too small to be seen with the naked eye

microorganismo: un organismo que es demasiado pequeño como para ver a simple vista

microscopic: too small to be seen with the naked eye

microscópico: demasiado pequeño como para ver a simple vista

organisms: living things, such as plants, animals, and bacteria

organismos: seres vivientes, como plantas, animales y bacterias

population: a group of the same type of organism living in the same area

población: un grupo del mismo tipo de organismo que vive en la misma área

reasoning: the process of making clear how your evidence supports your claim
razonamiento: el proceso de aclarar cómo tu evidencia respalda tu afirmación

scale: the relative size of things
escala: el tamaño relativo de las cosas

scientific argument: a claim supported by evidence
argumento científico: una afirmación respaldada por evidencia

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