Science & Literacy Activity

ACTIVITY OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduces students to scientific knowledge and language related to the human microbiome, the collection of microbes that live on and in us, and its impact on human health.

This activity has three components:

1. **BEFORE YOUR VISIT**, students will read a content-rich article about the microbes that make up the microbiome and their impact on human health. This article will provide context for the visit, and also help them complete the post-visit writing task.
2. **AT THE MUSEUM**, students will read and engage with additional texts (including printed text, digital and physical interactives, video, diagrams, and models). This information will help them complete the post-visit writing task.
3. **BACK IN THE CLASSROOM**, students will draw on the first two components of the activity to complete a CCSS-aligned explanatory writing task explaining how the microbiome is an ecosystem and how disruptions to this ecosystem can harm human health.

Materials in this packet include:

For Teachers

- Activity Overview (p. 1-3)
- Article (teacher version): "Human Microbiome: The Role of Microbes In Human Health" (p. 4-8)
- Answers to three-column graphic organizer (p. 9)
- Answers to student worksheet (p. 10)
- Essay scoring rubric (teacher version) (p. 11-12)

For Students

- Article (student version): "Human Microbiome: The Role of Microbes In Human Health" (p. 13-16)
- Three-column graphic organizer (p. 17)
- Student worksheet for *The Secret World Inside You* exhibition visit (p. 18)
- Student writing task (p.19)
- Essay scoring rubric (student version) (p. 20-21)

Common Core State Standards

RI.2.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.2.2 Determine the main idea of a text and explain how it is supported by key details; summarize the text.

W.2.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

New York State Science Core Curriculum

LE 6.3a

Next Generation Science Standards

DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience
A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

SEP 8: Obtaining, Evaluating and Communicating Information
- Integrate scientific information in written text with that contained in media and visual displays to clarify claims and findings.
- Read and synthesize information from multiple sources.
- Communicate scientific information in writing.

1. BEFORE YOUR VISIT

Students will read a content-rich article about the microbes that make up the microbiome and their impact on human health. This article will provide context for the visit, and help them complete the post-visit writing task.

Preparation

- Familiarize yourself with the student writing task and rubric (p. 11-12, 19-21).
- Familiarize yourself with the teacher version of the article (p. 4-8), and plan how to facilitate the students' reading of the article.

Instructions

- Explain the goal: to complete a writing task explaining how the microbiome is an ecosystem and how disruptions to this ecosystem can harm human health.
- Tell students that they will need to read an article before visiting the Museum, and read additional texts during the visit.
- Distribute the article, student writing task, and rubric to students.
- Review the rubric with students and tell them that it will be used to grade their writing.
- Read and discuss the article, using the teacher notes to facilitate.

Supports for Diverse Learners

This resource has been designed to engage all learners with the principles of Universal Design for Learning in mind. It represents information in multiple ways and offers multiple ways for your students to engage with content as they read about, discuss, view, and write about scientific concepts. Different parts of the experience (e.g. reading texts, or locating information in the Museum) may challenge individual students. However, the arc of learning is designed to offer varied opportunities to learn. We suggest that all learners experience each activity, even if challenging. If any students have an Individualized Education Program (IEP), consult it for additional accommodations or modifications.

Alternate Version of Article

Another version of the same article with a lower lexile level is available for download at amnh.org/secretworldinsideyou/educators. You can use this same activity with that article.

2. DURING YOUR VISIT

At the Museum, students will read and engage with additional texts (including printed text, digital and physical interactives, video, diagrams, and models). The information they'll gather from these multiple sources will help them complete the post-visit writing task.

Preparation

- Review the educator's guide to see how themes in the exhibition connect to your curriculum and to get an advance look at what your students will encounter. (Guide is downloadable at **amnh.org/secretworldinsideyou/educators**)
- Familiarize yourself with the student worksheet (p. 10, 18) and the map of the exhibition (p. 3 of educator's guide).

Instructions

- Explain the goal of the Museum visit: to read and engage with texts (including printed text, digital and physical interactives, video, diagrams, and models), and to gather information to help them complete the post-visit writing task.
- Distribute and review the worksheet and map. Clarify what information students should collect, and where.

Additional Suggestions for Facilitating the Museum Visit

- Have students explore the exhibition in pairs, with each student completing his or her own student worksheet.
- Encourage student pairs to ask you or their peers for help locating information. Tell students they may not share answers with other pairs, but may point each other to places where answers can be found.

3. BACK IN THE CLASSROOM

Students will use what they have learned from the pre-visit article and at the Museum to complete a CCSS-aligned explanatory writing task about explaining how the microbiome is an ecosystem and how disruptions to this ecosystem can harm human health.

Preparation

- Plan how you will explain the student writing task and rubric (p. 18-21) to students.

Instructions

- Distribute the student writing task and rubric. Explain that they will use it while composing, and also to evaluate and revise what they have written.

Suggestions for Facilitating Writing Task

- Before they begin to write, have students use the writing task to frame a discussion around the information that they gathered at the Museum. They can work in pairs, small groups, or as a class, and can compare their findings.
- Referring to the writing prompt, have students engage in some form of pre-writing. They may make an outline and/or talk through their writing plan with a partner. Students should refer back to relevant parts of the text as well as their notes from the exhibit. They may revise their writing plan based on peer conversations.
- They should use the rubric as well as the bulleted points in the writing task instructions to help guide their writing.

ARTICLE: TEACHER VERSION

About this Article

Lexile: 1155

Wordcount: 1212

Text Complexity: The Lexile level for this text falls in the upper range of the grade 9-10 CCSS text complexity band. However, science content and qualitative factors make this text appropriate for students in grades 9-12. Teachers should use their knowledge of students' independent reading levels to determine the appropriate level of support students need to read this text with a high level of comprehension."

Note: Assign partners prior to reading this text aloud with students and have them assign a "partner A" and "partner B."

Key for Teacher Notes

- Green text
  specific strategies
- Regular text
  instructions for teachers
- *Italicized text*
  teacher's instructions to students
- Underlined text
  important domain-specific words

Human Microbiome: The Role of Microbes in Human Health

You are an Ecosystem

An ecosystem is a community of living things that interact with each other and their physical environment. Forests, lakes, and caves are ecosystems. Each contains a unique mix of living components, like plants and animals, and non-living ones, like air, sunlight, rocks and water. The human body is also an ecosystem. We are home to thousands of kinds of bacteria, viruses, fungi, and other microscopic organisms, which number in the trillions. These organisms are called microbes. Together they form communities that make up the human microbiome. Like fingerprints, no two human microbiomes are the same. That makes each person not just an ecosystem, but a unique ecosystem.

Think-Pair-Share: *Wow—each one of us is an ecosystem! Many of you have probably learned about ecosystems, but not quite in this way… Take a moment to talk to your partner about what you know about the way ecosystems work. Think of an example of an ecosystem that you have heard of before.* Listen in to get a sense of students' knowledge base about the concept of ecosystem. Invite students to share out what they know about ecosystems and jot notes on chart that define "ecosystem" in general terms.

Think Aloud: *So, each one of us is home to a unique ecosystem. Just as bears, wolves and elk interact in the ecosystem of Yellowstone National Park, the living organisms that interact within our microbiome are microbes such as bacteria, viruses and fungi. Our body plus our microbiome is an ecosystem.*

The human body is an ecosystem. We are home to trillions of microbes.

Microbes first appeared over 3.5 billion years ago, making them the oldest form of life on Earth. Over the past five million years, humans and microbes have coevolved to form complex relationships. Humans need a microbiome to stay healthy, and the microbiome needs environments provided by the human body in order to survive.

Just like larger organisms, the species that make up a microbiome interact with each other and rely on these interactions to thrive. Different species live in different places in and on our bodies, and are adapted to these environmental conditions.

Scientists are studying how these microorganisms work in our bodies, and learning about the balance between different bacterial communities. Products like antibacterial hand sanitizers can wipe out all bacteria on a patch of skin, good and bad alike. Antibiotic drugs also destroy helpful bacteria along with their targets. Fungi evolved the the ability to produce anti-bacterial chemicals as they competed

Think-Pair-Share: *What more have you learned about the* **human microbiome** *from this section? Listen in and select student(s) to share out. It is important for students to understand that our microbiome is crucial for our health (even if they cannot explain exactly why yet), and that different locales on the human body provide ideal environments for different microbes to get what they need to thrive.*

with bacteria over millions of years of evolution. By studying these fungi, scientists learned how to manufacture these anti-bacterial chemicals and turn them into antibiotic drugs, which have saved millions of lives. At the same time, studies suggest that rapidly increasing antibiotic use in the United States has reduced the diversity of our microbiomes.

Supporting Players

Do the bacteria in your body act as friend or foe? As pathogen or protector? It depends.

Thousands of species of bacteria inhabit our bodies, and researchers are only beginning to understand the complex interrelationships among them—and between microbial cells and human ones. We know that some are pathogens and cause disease. Scientists are increasingly finding that the majority of bacteria are not harmful. Rather, many benefit us in a variety of ways, from aiding digestion to protecting our teeth.

Scientists are just beginning to understand what roles these organisms play in human health. It's a complicated dynamic, and depends on the size of their populations and on conditions in their ecosystem, the human body. The key? Balance. Here are some of the species that play an important part in maintaining a healthy equilibrium—bacteria that, you might say, have your back.

Think Aloud: *This paragraph is giving us important information about antibiotic hand sanitizers and antibiotic drugs.*

Think-Pair-Share: *Discuss the following questions with your partner...*

1) How did antibiotic medication originate?
2) Why is overuse of antibiotic medication problematic?

3) Why is using antibiotic hand sanitizers problematic?

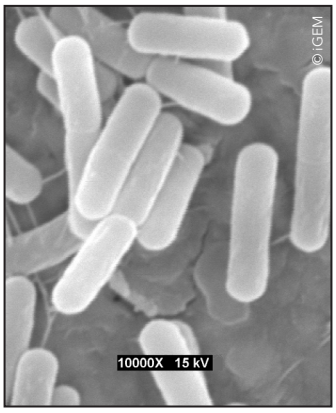
Explain your answers in your own words, but refer to the text as needed.

Listen in and select students to share out answers for each question.

Think-Pair-Share:
With your partner, in your own words, answer the question that was posed in the first paragraph of this section. Refer back to the text when you need to, but look away from the text and use your own words when answering the question. Listen in and select student(s) to share out. The goal is for students to know that there are microbes that harm us (pathogens) and microbes that help us (beneficial bacteria). Before moving on to the next section, think aloud about how having balance in the microbiome is crucial (referring to the second paragraph of this section). End this section with a Think Aloud: *This last sentence is setting us up for what we are going to learn about next. Look at the next four subtitles and notice the parts of the body that are mentioned.* Call on a student to read the next four subtitles aloud. For one, you may want to ask students if they can think of any examples of microbes either helping or hurting us in that part of the body. (E.g., antibiotics can give you stomach trouble–students may not know exactly why but activating their knowledge before reading on may aid their understanding).

The next four sections of the text describe the impact that different species of bacteria have on the body–some are beneficial, some are harmful, and some can be both depending on various factors. Explain to students that to keep track of this, they will use a strategy called text coding. When students come to the name of a specific species of bacteria, they should draw a box around it. When they find evidence that the bacteria is beneficial, they should underline the words that suggest that, and code them with a "B" for "Beneficial." When they find evidence that the bacteria is harmful, they should underline the words that suggest that, and code them with an "H" for harmful. **Through doing this, students will realize that some bacteria can be both beneficial and harmful.** Tell students that one type of bacteria may be coded with both a "B" and an "H." The coding will help students complete the Graphic Organizer Note Taking Sheet after the read aloud. You may opt to demonstrate coding on the next section if the strategy is new to students, or you can just have them work independently for the next four sections. To provide more support, you may have students read and code in partners.

Skin Deep



***Bacillus subtilis* releases toxic chemicals to kill fungus, possibly including Trichophyton interdigitale and other species that cause athlete's foot.**

Perhaps not surprisingly, skin—our interface with the world—supports a large number of the body's most diverse populations of bacteria. There are at least 1,000 different species of skin bacteria, along with dozens of fungi and other microbes. Most aren't harmful, and many protect us. They live among the dead skin cells that make up our skin's outer layer, and defend their own turf against other microbes. One strain of the bacterium *Bacillus subtilis*, which can be found on the skin, produces bacitracin, a toxin that helps it fight off other microbes. Scientists have taken advantage of bacitracin's antibiotic properties, using it in over-the-counter antibiotic ointments.

Coding Text: Demonstrate on the document camera or Smartboard. Draw a box around *Bacillus subtilis*. Underline "produces bacitracin, a common ingredient in many over-the-counter antibiotic ointments" and code with "B." Tell students that they should use that same coding strategy for the next three sections as they read on their own (or with a partner). If most students are struggling readers, read next three sections aloud and code on document camera, inviting students to offer suggestions for what to code after you have demonstrated adequately.

Gut Feeling

***H. pylori* can cause diseases like gastritis. It also helps protect against diseases that include asthma, allergies, and even cancer.**

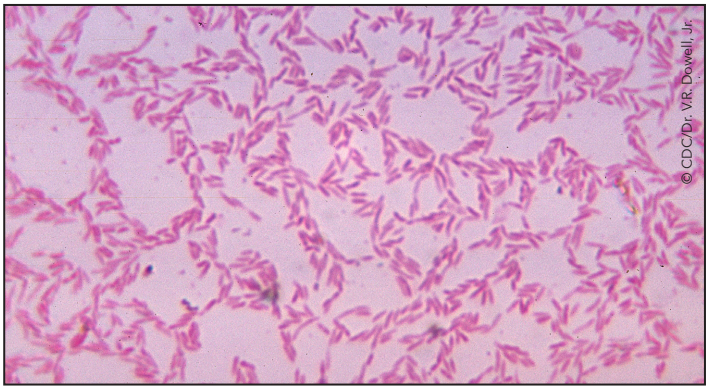
In the mid-1980's, internist Barry J. Marshall infected himself with the corkscrew-shaped bacterium *Heliobacter pylor*i. This earned him not only the nickname "guinea-pig doctor" but also the Nobel Prize, which he shared in 2005 with pathologist J. Robin Warren for their discovery that this common organism was a pathogen. *H. pylori* caused gastritis (irritation or inflammation of the stomach lining) and peptic ulcers, diseases long thought to be caused by excess acid resulting from stress. Treatment with antibiotics led to the near-eradication of stomach ulcers in developed countries, as well as to a drop in stomach cancers, for which gastritis is a risk factor. But as welcome as these cures are, researchers now think *H. pylori* also serves a positive role in human health. New diseases related to the loss of *H. pylori* are on the rise. Studies strongly suggest that it is essential to the prevention of asthma, allergies, gastroesophageal reflux disease, and esophageal cancer.

Look, Ma, No Cavities!

Who isn't familiar with the dreaded strep throat? An extremely painful inflammation of the back of the throat, it's caused by the bacterium *Streptococcus pyogenes*, which gave strep throat its name. The same bacterium causes rheumatic heart disease. But there are more than 50 recognized species of Streptococcus, many regularly found in the human mouth, respiratory tract, and other organs. Some, like *S. pyogenes*, are proven pathogens, causing conditions that range from cavities (*S. mutans*) to pneumonia (*S. pneumonia*). But others seem to do no harm, and may even work against troublesome strains of fellow *Streptococci*. *Streptococcus salivarius*, for example, which is found in the human mouth and respiratory tract, can be dangerous to people with weakened immune systems if it escapes outside the oral cavity. But in the mouth it appears to help prevent both gum disease and tooth decay.

Coding Text continued

Colon Colony



***Bacteroides* are by far the most numerous bacteria in the human body. They help the human body digest food.**

Far more bacteria live in the colon than anywhere else in the human body. Most species are anaerobic, which means they don't require oxygen. That includes species that belong to the genus *Bacteroides*, which are among the most predominant. Outside of the gut, strains of *Bacteroides* can cause abscesses in the abdomen, brain, liver, pelvis, and lungs, as well as bacteremia, an infection of the bloodstream. But in the colon they break down carbohydrates, produce enzymes that target specific foods, and extract energy from those foods. One species, *B. fragilis*, appears to stimulate immune cells called regulatory T-cells, which restrain aggressive inflammatory T-cells that can trigger colitis and other disorders. Researchers are also beginning to tease out the possible relationship between the overall makeup of a person's gut microbiome and a propensity toward obesity. Studies have even found that microbiomes have an effect on the moods of mice, suggesting that the bacteria in our gut could play a role in conditions like depression. It's probably impossible to overstate the usefulness of bacteria in the colon.

Being Healthy Means Having a Balanced Microbiome

We're covered in bacteria and other microorganisms from the time we are born. Our microbiome grows and changes with us over the course of our lives. It reflects the places we go, the things we do, and the food we eat. We now understand that a diverse and balanced microbiome is essential for a strong immune system. Some scientists think that infants who lack exposure to microorganisms develop a higher rate of allergies, asthma, eczema and other health problems. In fact, the microbiome is so important that it is like an additional organ—a part of the body that serves a vital function, like the skin or kidneys. Nurturing it helps keep our bodies functioning properly.

Coding Text continued

After the interactive read aloud, students can complete the following graphic organizer (see attached). Going back to look at their coding in the text will help them to this. To provide more support, this can be done as a whole-group activity with the teacher, as a partner activity, or a combination of the two. The graphic organizer can be completed before the quick-write and class discussion at the end so that students can refer to it during discussion.

THREE-COLUMN GRAPHIC ORGANIZER

Name _____ **ANSWER KEY**

Microbe	Possible Positive Impact on Human Health (include where in the body)	Possible Negative Impact on Human Health (include where in the body)
Bacillus subtilis	• *lives on skin and produces bacitracin, an antibiotic* • *releases toxic chemicals to kill fungus, possibly including Trichophyton interdigitale and other species that cause athlete's foot*	
H. pylori	• *studies suggest that it is essential to the prevention of asthma, allergies, gastroesophageal reflux disease, and esophageal cancer*	• *can cause gastritis (irritation or inflammation of the stomach lining) and peptic ulcers (gastritis has the potential to put one at risk for stomach cancer)*
Streptococcus pyogenes		• *causes strep throat; can cause rheumatic heart disease*
S. mutans		• *can cause cavities; is considered a proven pathogen*
S. pneumonia		• *can cause pneumonia; Is considered a proven pathogen*
Streptococcus salivarius	• *in the mouth it appears to help prevent both gum disease and tooth decay*	• *can be dangerous to people with weakened immune systems if it escapes outside the oral cavity*
Bacteroides	• *in the colon it breaks down carbohydrates, producing enzymes that target specific foods, and extracts energy from those foods. One species, B. fragilis, appears to stimulate immune cells called regulatory T-cells, which restrain aggressive inflammatory T-cells that can trigger colitis and other disorders*	• *outside of the gut, strains of Bacteroides can cause abscesses in the abdomen, brain, liver, pelvis, and lungs, as well as bacteremia, an infection of the bloodstream*

Quick-Write

- **What is the most important new information you have learned from this article?**
- **What questions do you have after reading this article?**

Options:

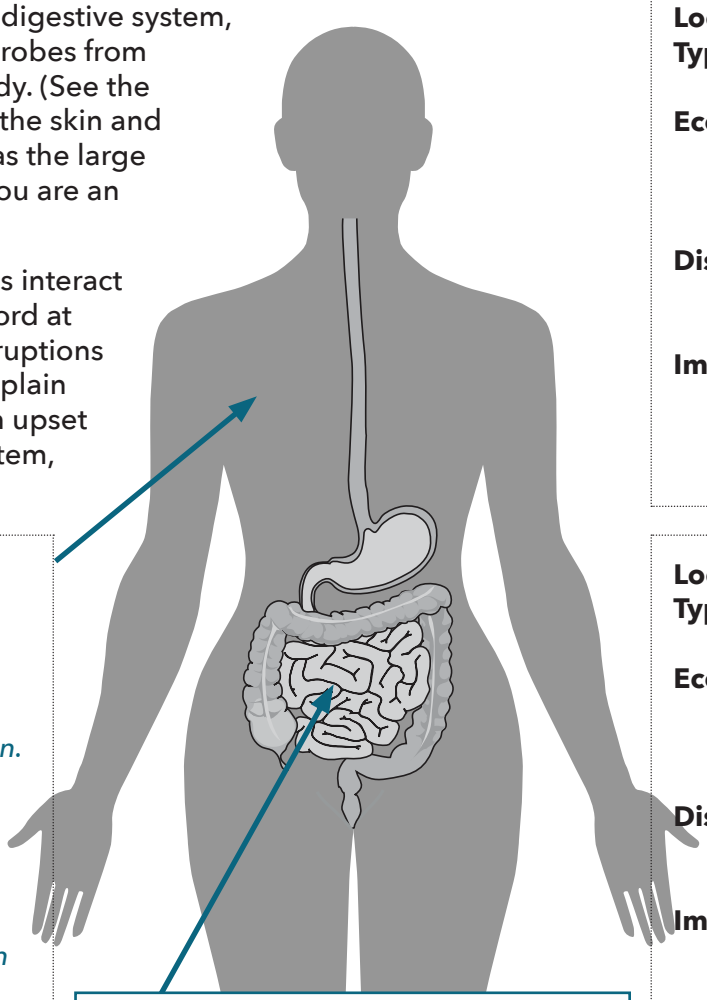
- **Invite selected students to share their** quick-write **responses to spark a whole group discussion.**
- **Do a** write-around **in which students respond in writing to one another's** quick-writes **in table groups.**

STUDENT WORKSHEET

Name _____ **ANSWER KEY**

Use the boxes below to record information about different species in the human microbiome.

- **Select** one type of microbes that lives on the skin, one found in the digestive system, and at least two other microbes from any part of the human body. (See the exhibition sections about the skin and digestive system, as well as the large interactive table called "You are an Ecosystem.")
- **Explain** how these species interact with their ecosystem. Record at least two examples of disruptions to the microbiome and explain how these disruptions can upset the balance in this ecosystem, harming human health.



Location: Skin
Type of microbe:
Bacillus subtilis
Ecosystem Interactions:
Lives on skin cells and oils. Competes with fungi on skin.

Disruption:
Use of skin sanitizer or antibiotic soaps.
Impact on Human Health:
A lack of helpful bacteria on the skin may allow harmful species to cause illness.

Location: Digestive system
Type of microbe:
Bacteroides thetaomicron
Ecosystem interactions:
Adds up to 260 enzymes to the digestive tract helping to break down food.
Disruption:
Use of Antibiotics

Impact on human health:
The loss of helpful species may allow for harmful species to invade the digestive system

TEACHER NOTE:
The answers above describe a few of the many organisms found in this exhibit. Students should fill all boxes while visiting a variety of sections in the exhibit including sections 2c (skin), 4a (interactive table), and 6b (digestive system) to gather information about microbes. Sometimes the species name is not given and students may describe the type of organism in general terms such as virus or bacterium. Students will need to find at least one skin-dwelling microbe, one from the digestive system, as well as at least two others from any part of the body.

Location:
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

Location:
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

Location:
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

ESSAY SCORING RUBRIC: TEACHER VERSION - page 1

Scoring Criteria		Exceeds	Meets	Approaches	Needs Additonal Support
		4	3	2	1
RESEARCH (worth 1/3)	**Article: "Human Microbiome: The Role of Microbes in Human Health"**	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the article	Presents paraphrased information from the article relevant to the prompt with accuracy and sufficient detail	Presents information from the article relevant to the purpose of the prompt with minor lapses in accuracy or completeness AND/ OR information is copied from the text	"Attempts to present information in response to the prompt, but lacks connections to the article or relevance to the purpose of the prompt"
	Museum Exhibition: *The Secret World Inside You*	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the exhibition	Presents paraphrased information from the article relevant to the prompt with accuracy and sufficient detail	Presents information from the exhibition relevant to the purpose of the prompt with minor lapses in accuracy or completeness AND/ OR information is copied from the text	Attempts to present information in response to the prompt, but lacks connections to the exhibition content or relevance to the purpose of the prompt
SCIENCE (worth 1/3)	**Science Explanations**	Integrates relevant and accurate science content with thorough explanations that demonstrate in-depth understanding of how different kinds of microbes get what they need in the different environments on the human body	Accurately presents science content relevant to the prompt with sufficient explanations that demonstrate understanding of how different kinds of microbes get what they need in the different environments on the human body	Briefly notes science content relevant to the prompt; shows basic or uneven understanding of how different kinds of microbes get what they need in the different environments on the human body; minor errors in explanation	Attempts to include science content in explanations, but understanding ofhow different kinds of microbes get what they need in the different environments on the human body; content is irrelevant, inappropri-ate, or inaccurate
WRITING (worth 1/3)	**Focus**	Maintains a strongly developed focus on the writing prompt for the entire essay	Maintains focus on the writing prompt for the majority of the essay	Addresses the prompt but is off-task some of the time	Does not address the prompt for most or all of the essay
		Clearly introduces the topic of microbes and how they get what they need in the dif-ferent environments on the human body	Introduces the topic of microbes and how they get what they need in the different environments on the human body; introduction may lack detail	Attempts to introduce microbes and how they get what they need in the different environments on the human body; intro-duction is inaccurate or incomplete	Does not introduce microbes and how they get what they need in the different environ-ments on the human body
		Provides a relevant concluding paragraph	Provides a relevant concluding section	Provides a concluding statement	Provides no sense of closure

ESSAY SCORING RUBRIC: TEACHER VERSION - page 2

Scoring Criteria		Exceeds	Meets	Approaches	Needs Additonal Support
		4	3	2	1
WRITING (worth 1/3)	**Development**	Clearly introduces three environments where microbes live in and on the human body	Introduces three environments where microbes live in and on the human body	Introduces only one or two environments where microbes live in and on the human body	Does not introduce any environments where microbes live in and on the human body
		Clearly and accurately describes how three microbes get what they need in three different environ-ments on the human body	Describes how three microbes get what they need in three different environments on the human body	Describes how one or two microbes get what they need in three different environments on the human body OR attempts to describe how three microbes get what they need in three different environments on the human body in a man-ner that is inaccurate or incomplete	Does not describe how three microbes get what they need in three different environments on the human body
		Consistent use of pre-cise and domain- spe-cific language where appropriate	Some use of precise and domain-specific language	Little use of precise and domain-specific language	No use of precise and domain-specific language
	Clarity	"Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors; response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt"	Demonstrates a command of standard English conventions and cohesion, with few errors; response includes language and tone appropriate to the purpose and specific requirements of the prompt	Demonstrates an uneven command of standard English conventions and cohesion; uses language and tone with some inaccurate, inappropriate, or uneven features	Attempts to demon-strate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics

ARTICLE

Human Microbiome: The Role of Microbes in Human Health

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with bacteria over millions of years of evolution. By studying these fungi, scientists learned how to manufacture these anti-bacterial chemicals and turn them into antibiotic drugs, which have saved millions of lives. At the same time, studies suggest that rapidly increasing antibiotic use in the United States has reduced the diversity of our microbiomes.

Supporting Players

Do the bacteria in your body act as friend or foe? As pathogen or protector? It depends.

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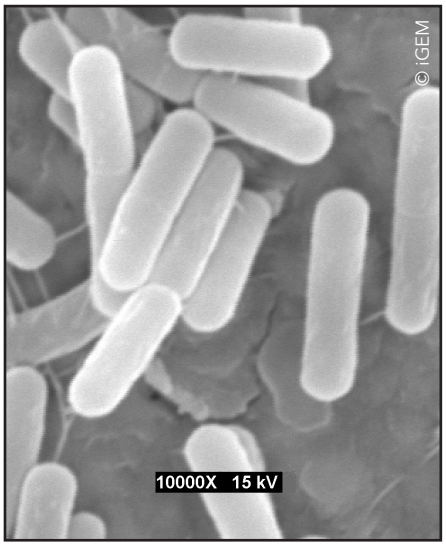
Scientists are just beginning to understand what roles these organisms play in human health. It's a complicated dynamic, and depends on the size of their populations and on conditions in their ecosystem, the human body. The key? Balance. Here are some of the species that play an important part in maintaining a healthy equilibrium—bacteria that, you might say, have your back.

Skin Deep



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Perhaps not surprisingly, skin—our interface with the world—supports a large number of the body's most diverse populations of bacteria. There are at least 1,000 different species of skin bacteria, along with dozens of fungi and other microbes. Most aren't harmful, and many protect us. They live among the dead skin cells that make up our skin's outer layer, and defend their own turf against other microbes. One strain of the bacterium *Bacillus subtilis*, which can be found on the skin, produces bacitracin, a toxin that helps it fight off other microbes. Scientists have taken advantage of bacitracin's antibiotic properties, using it in over-the-counter antibiotic ointments.

Gut Feeling

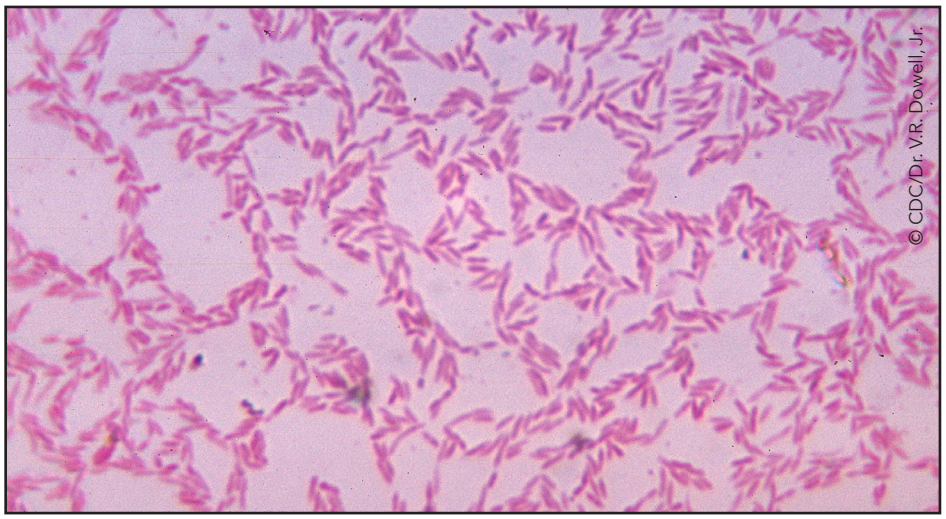
***H. pylori* can cause diseases like gastritis. It also helps protect against diseases that include asthma, allergies, and even cancer.**

In the mid-1980's, internist Barry J. Marshall infected himself with the corkscrew-shaped bacterium *Heliobacter pylor*i. This earned him not only the nickname "guinea-pig doctor" but also the Nobel Prize, which he shared in 2005 with pathologist J. Robin Warren for their discovery that this common organism was a pathogen. *H. pylori* caused gastritis (irritation or inflammation of the stomach lining) and peptic ulcers, diseases long thought to be caused by excess acid resulting from stress. Treatment with antibiotics led to the near-eradication of stomach ulcers in developed countries, as well as to a drop in stomach cancers, for which gastritis is a risk factor. But as welcome as these cures are, researchers now think *H. pylori* also serves a positive role in human health. New diseases related to the loss of *H. pylori* are on the rise. Studies strongly suggest that it is essential to the prevention of asthma, allergies, gastroesophageal reflux disease, and esophageal cancer.

Look, Ma, No Cavities!

Who isn't familiar with the dreaded strep throat? An extremely painful inflammation of the back of the throat, it's caused by the bacterium *Streptococcus pyogenes*, which gave strep throat its name. The same bacterium causes rheumatic heart disease. But there are more than 50 recognized species of Streptococcus, many regularly found in the human mouth, respiratory tract, and other organs. Some, like *S. pyogenes*, are proven pathogens, causing conditions that range from cavities (*S. mutans*) to pneumonia (*S. pneumonia*). But others seem to do no harm, and may even work against troublesome strains of fellow *Streptococci*. *Streptococcus salivarius*, for example, which is found in the human mouth and respiratory tract, can be dangerous to people with weakened immune systems if it escapes outside the oral cavity. But in the mouth it appears to help prevent both gum disease and tooth decay.

Colon Colony



***Bacteroides* are by far the most numerous bacteria in the human body. They help the human body digest food.**

Far more bacteria live in the colon than anywhere else in the human body. Most species are anaerobic, which means they don't require oxygen. That includes species that belong to the genus *Bacteroides*, which are among the most predominant. Outside of the gut, strains of *Bacteroides* can cause abscesses in the abdomen, brain, liver, pelvis, and lungs, as well as bacteremia, an infection of the bloodstream. But in the colon they break down carbohydrates, produce enzymes that target specific foods, and extract energy from those foods. One species, *B. fragilis*, appears to stimulate immune cells called regulatory T-cells, which restrain aggressive inflammatory T-cells that can trigger colitis and other disorders. Researchers are also beginning to tease out the possible relationship between the overall makeup of a person's gut microbiome and a propensity toward obesity. Studies have even found that microbiomes have an effect on the moods of mice, suggesting that the bacteria in our gut could play a role in conditions like depression. It's probably impossible to overstate the usefulness of bacteria in the colon.

Being Healthy Means Having a Balanced Microbiome

We're covered in bacteria and other microorganisms from the time we are born. Our microbiome grows and changes with us over the course of our lives. It reflects the places we go, the things we do, and the food we eat. We now understand that a diverse and balanced microbiome is essential for a strong immune system. Some scientists think that infants who lack exposure to microorganisms develop a higher rate of allergies, asthma, eczema and other health problems. In fact, the microbiome is so important that it is like an additional organ—a part of the body that serves a vital function, like the skin or kidneys. Nurturing it helps keep our bodies functioning properly.

THREE-COLUMN GRAPHIC ORGANIZER

Name _____

Microbe	Possible Positive Impact on Human Health (include where in the body)	Possible Negative Impact on Human Health (include where in the body)

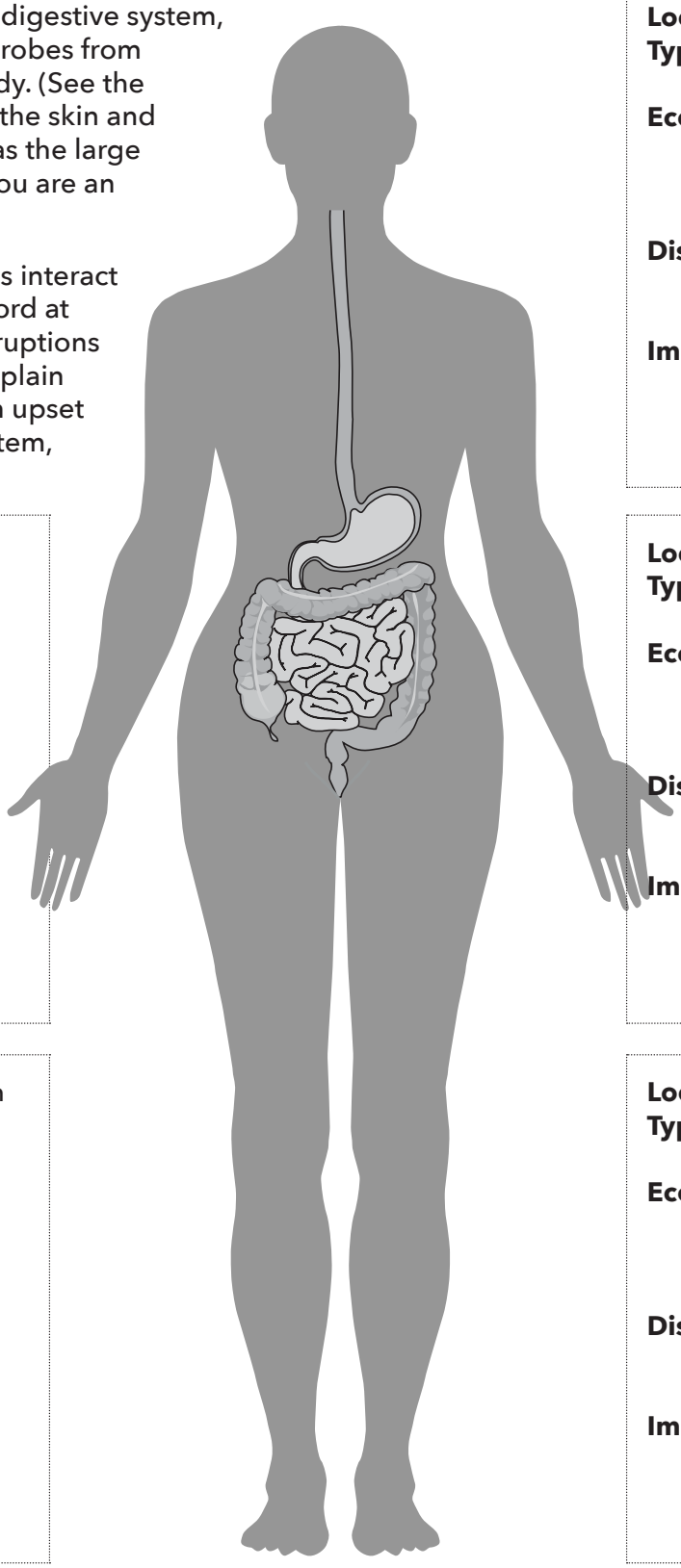
Differentiation: Teachers can fill in the name of the microbe for some students

STUDENT WORKSHEET

Name _____

Use the boxes below to record information about different species in the human microbiome.

- **Select** one type of microbes that lives on the skin, one found in the digestive system, and at least two other microbes from any part of the human body. (See the exhibition sections about the skin and digestive system, as well as the large interactive table called "You are an Ecosystem.")
- **Explain** how these species interact with their ecosystem. Record at least two examples of disruptions to the microbiome and explain how these disruptions can upset the balance in this ecosystem, harming human health.



Location:
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

Location: Skin
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

Location:
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

Location: Digestive System
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

Location:
Type of microbe:

Ecosystem interactions:

Disruption:

Impact on human health:

STUDENT WRITING TASK

The Museum exhibition called *The Secret World Inside* You states that: "You're not just an individual, you're an ecosystem. Learning to work with our inner microbes is revolutionizing human health." In the writing task below, you will elaborate on this statement.

After reading "Human Microbiome: The Role of Microbes In Human Health" and taking notes in *The Secret World Inside You* exhibition, write an essay in which you explain how the human microbiome is an ecosystem, describe how the microbiome can support human health, and how disruptions to the microbiome can harm human health.

Be sure to:

- Define an ecosystem and explain how the human body is an ecosystem
- Give one example of a microbe from the reading, explain what this microbe does, and how a disruption to this part of the microbiome can harm human health.
- Give one example of a helpful microbe from the exhibition, explain what this microbe does, and how a disruption to this part of the microbiome can harm human health.

ESSAY SCORING RUBRIC: TEACHER AND STUDENT

Scoring Criteria		Exceeds	Meets	Approaches	Needs Additonal Support
		4	3	2	1
RESEARCH (worth 1/3)	**Article: "Human Microbiome: The Role of Microbes in Human Health"**	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the article	Presents paraphrased information from the article relevant to the prompt with accuracy and sufficient detail	Presents information from the article relevant to the purpose of the prompt with minor lapses in accuracy or completeness AND/ OR information is copied from the text	Attempts to present information inresponse to the prompt, but lacks connections to the article or relevance to the purpose of the prompt
	Museum Exhibition: *The Secret World Inside You*	response to the prompt, but lacks connections to the article or relevance to the purpose of the prompt"	Presents paraphrased information from the article relevant to the prompt with accuracy and sufficient detail	Presents information from the exhibition relevant to the purpose of the prompt with minor lapses in accuracy or completeness AND/ OR information is copied from the text	Attempts to present information in response to the prompt, but lacks connections to the exhibition content or relevance to the purpose of the prompt
SCIENCE (worth 1/3)	**Science Explanations**	Integrates relevant and accurate science content with thorough explanations that demonstrate in-depth understanding of how the human microbiome is an ecosystem, and how the microbiome can impacts human health	Accurately presents science content relevant to the prompt with sufficient explanations that demonstrate understanding of how the human microbiome is an ecosystem, and how the microbiome can impacts human health	Briefly notes science content relevant to the prompt; shows basic or uneven understanding of how the human microbiome is an ecosystem, and how the microbiome can impacts human health	Attempts to include science content in explanations, but understanding of how the human microbiome is an ecosystem, and how the microbiome can impacts human health; content is irrelevant, inappropriate, or inaccurate
WRITING (worth 1/3)	**Focus**	Maintains a strongly developed focus on the writing prompt for the entire essay	Maintains focus on the writing prompt for the majority of the essay	Addresses the prompt but is off-task some of the time	Does not address the prompt for most or all of the essay
		Clearly introduces the topic of the microbiome, and its role in human health	Introduces the topic of the microbiome, and its role in human health	Attempts to introduce the topic of microbiome, and its role in human health; introduction is inaccurate or incomplete	Does not introduce the topic of microbiome, and its role in human health
		Provides a relevant concluding paragraph	Provides a relevant concluding section	Provides a concluding statement	Provides no sense of closure
		Thoroughly and accurately defines the word ecosystem and explains how the human body is an ecosystem	Defines ecosystem and explains how the human body is an ecosystem	Defines ecosystem but does not explain how the human body is an ecosystem	Does not define ecosystem ort explain how the human body is an ecosystem

ESSAY SCORING RUBRIC: TEACHER AND STUDENT

Scoring Criteria		Exceeds	Meets	Approaches	Needs Additonal Support
		4	3	2	1
WRITING (worth 1/3)	**Development**	Clearly introduces two microbes	Introduces two microbes	Introduces only one microbe	Does not introduce any microbes
		Clearly and accurately explains what two types of microbes do as part of the ecosystem	Explains what two types of microbes do as part of the ecosystem	Explains what one type of microbe does as part of the ecosystem OR explains what two types of microbes do as part of the ecosystem but lacks sufficient development	Does not explain what any microbes do as part of the ecosystem
		Clearly and accurately explains what two types of microbes get from the ecosystem	Explains what two types of microbes get from the ecosystem	Explains what one type of microbe gets from the ecosystem OR explains what two types of microbes get from the ecosystem but lacks sufficient development	Does not explain what any microbes get from the ecosystem
		Consistent use of precise and domain-specific language where appropriate	Some use of precise and domain-specific language	Little use of precise and domain-specific language	No use of precise and domain-specific language
WRITING (worth 1/3)	**Clarity**	Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors; response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt	Demonstrates a command of standard English conventions and cohesion, with few errors; response includes language and tone appropriate to the purpose and specific requirements of the prompt	Demonstrates an uneven command of standard English conventions and cohesion; uses language and tone with some inaccurate, inappropriate, or uneven features	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics