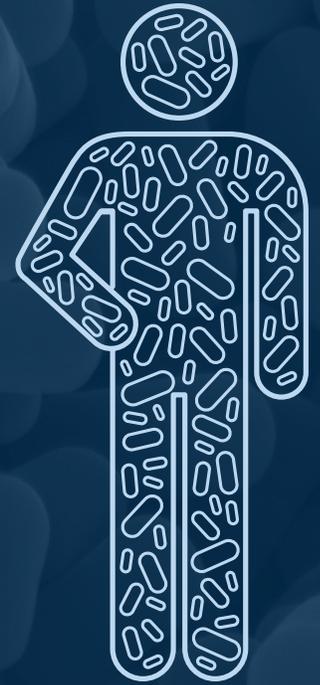


EDUCATOR'S GUIDE

THE SECRET WORLD Inside You



amnh.org/secretworldinsideyou/educators



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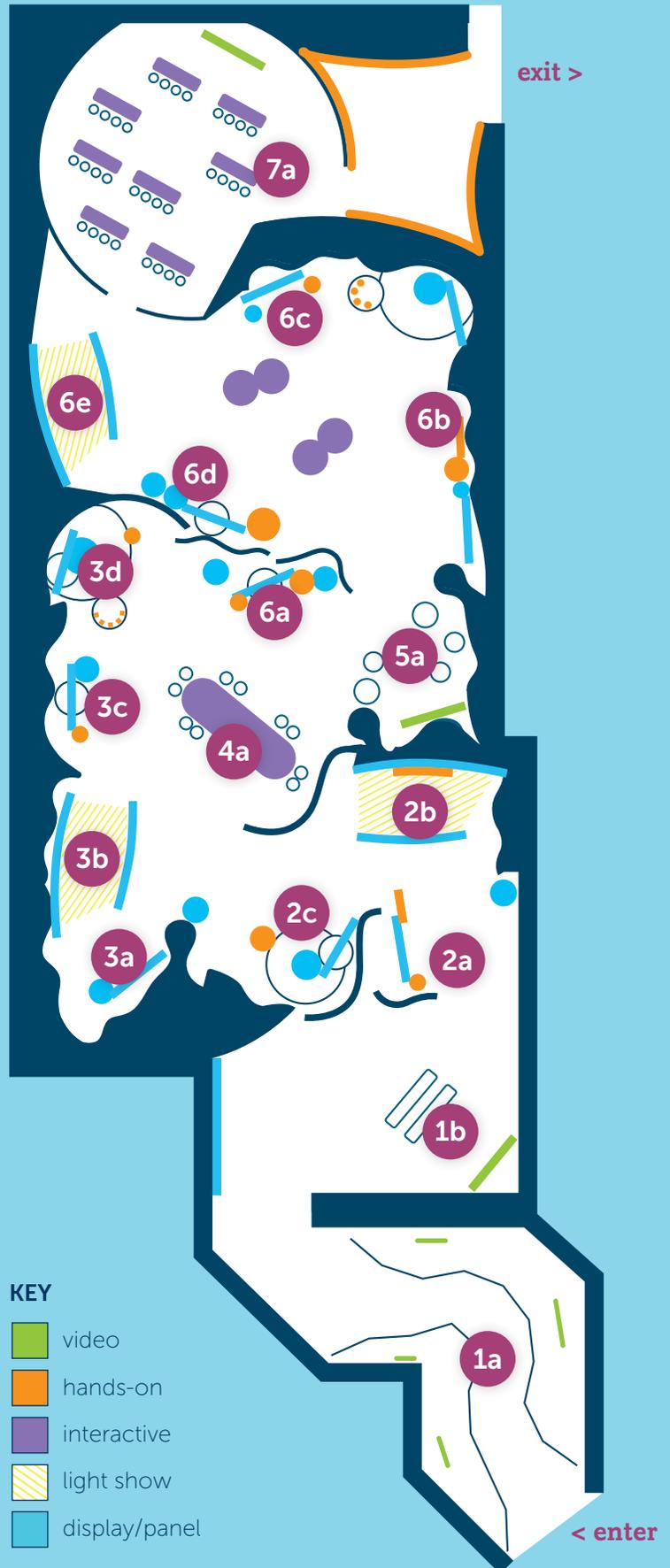
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ESSENTIAL Questions

Use the Essential Questions below to connect the exhibition's themes to your curriculum. Identify key points that you'd like your students to learn. Bolded words are defined in the Glossary.

What are microbes?

The oldest form of life on Earth, **microbes** are found everywhere, including in you and on you. These single-celled organisms are invisible to the eye, and vary widely in shape, structure, and size. The vast majority that live in and on the human body are **bacteria**. Although some of these microbes can cause disease, most of them help keep us healthy.

What is the human microbiome?

The human body is an **ecosystem**. It contains trillions of individual microbes that form communities in different places in and on the body. Together these communities make up the **human microbiome**. These microbes have **coevolved** with us to keep our digestive system, immune system, and even the brain working properly. These functions are so vital that the microbiome is like an additional organ — a part of the body that serves vital functions, like the skin or kidneys.

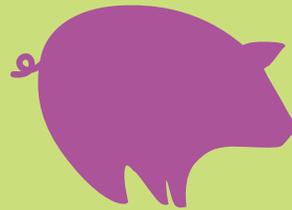
What factors influence our microbiome?

Each person's microbiome is unique. It changes over time, starting with the day we are born, and evolves as we interact with the world.

- **Birth:** A fetus is almost sterile. Like all mammals, human babies acquire their microbiomes from their mothers as they pass through the birth canal. Breast milk also delivers microbes, which help start and shape the immune system.
- **Environment:** Our skin is home to different communities of microbes, which are shaped by where and how we live. For example, people and animals that live together share many microbes. As we move through the world, we pick up and shed microbes. But over time, our skin microbes return to their original balance.
- **Diet:** Microbes in your mouth and gut process what you eat. For example, bacteria in your mouth that process sugar and excrete acid can cause cavities. In your gut, bacteria extract nutrients from food you otherwise wouldn't digest, and make things you can use, including Vitamin K and several B vitamins. You can increase the diversity of your microbiome by eating a variety of foods, especially plants that are high in fiber.

How is the microbiome reshaping our view of human health?

For a long time researchers focused solely on harmful "germs" and ignored the possible importance of **commensal** and **mutualistic** microbes. We now understand that our microbiome has a huge impact on our health. A healthy human microbiome is diverse. The overuse of **antibiotics**, antiseptics, and sanitizers, along with the high rate of Cesarean sections, has drastically reduced this diversity. Scientists are investigating potential links between disrupted microbiomes and a host of increasingly common conditions, including obesity, allergies, autoimmune and digestive disorders, and even anxiety, depression, and cancer. Since the development of antibiotics, each generation has arrived with fewer species of microbes and encounters fewer in the environment. Understanding that humans are ecosystems that contain many collaborating and competing species may change the practice of medicine.



Over 70% of the antibiotics used in the U.S. are fed to cows, chickens, and pigs — not just to cure disease but to make the animals gain more weight. Antibiotics in our food may have a similar effect.

How do scientists study the microbiome?

For centuries, identifying and observing microbes, even with microscopes, was a slow and laborious process. In the 21st century, advances in DNA-sequencing technology have opened the microbial world to sophisticated scrutiny for the first time. Our understanding of these organisms is growing incredibly quickly. Computers have made it possible to rapidly analyze microbial DNA to find out which species exist in our bodies, and to detect how the precise combination of species may differ from one person to another. Biologists are learning which species are most common among humans, and how they affect the way our bodies function. They are cataloguing species in the human microbiome, and gaining insight into the true diversity of this part of the evolutionary tree of life.

TEACHING in the Exhibition

1. Introduction

1a. Mirrored walkthrough: The many points of light in this hallway represent the trillions of microbes on and inside us. This immersive experience opens students' minds to the concept that a remarkable "universe" of microbes exists inside each of us.

1b. "An Unseen World" theater: This seven-minute film explains what microbes are and their crucial role on Earth on every scale, from making oxygen for the atmosphere to providing energy for our muscles. It also introduces the exhibition's underlying concept: every living thing, including each human being, is an ecosystem. Every plant and animal exists in partnership with vast communities of microorganisms, which eat, move, reproduce, interact, and coevolve.

2. Skin

2a. "Microbe Mix" area: A vast diversity of microscopic species covers your skin from head to toe. This part of the exhibition introduces students to some of the major species, and where on your body they live. The people and places you come in contact with also play a part in which microbes call you home.

2b. "Microbe Exchange" lights tunnel: Your skin is where your body meets the rest of the world. When you touch a surface, your skin picks up many new microbes and leaves others behind. As students walk through this tunnel, they can investigate how microbes are transferred between people, and from pets to humans. Direct students towards the "Gimme Five!" interactive to visualize this ongoing, transient exchange.

2c. "Microbe vs. Microbe" area: Your skin provides microbes with shelter, moisture, and the chemical building blocks they need to survive. Different species compete for this valuable turf. Students can examine a model of bacteria battling a fungus that causes athlete's foot. Bacteria, not our bodies, are responsible for most body odor. Direct students to the smell interactive, where they can learn about the bacteria that make feet stinky.



model of bacteria (purple)
protecting skin from a
creeping fungus (green)



3. Reproductive System

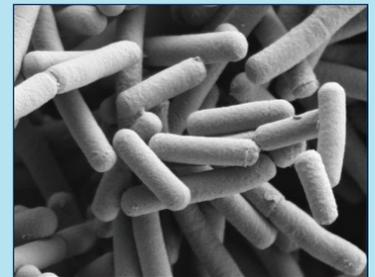
3a. "Before Birth" area: Inside the womb, a developing baby is almost completely isolated from its mother's microbiome and has yet to develop its own. Students can find out how the womb protects and nurtures a fetus, and why exposure to bacteria before birth could be deadly.

The amniotic sac cushions the baby and seals out most microbes.

3b. "Brand New Microbiome" lights tunnel: A baby's first exposure to large numbers of microbes happens during birth. As students walk through the tunnel, they can compare two ways this initial microbiome forms. As they pass through the birth canal, babies acquire a big batch of the mom's microbes, which then populate the infant's skin and its gut. In contrast, babies born via Cesarean section acquire bacteria from the doctor's hands and the hospital room.

3c. "Early Years" area:

Your microbiome changes over time. The biggest influence is diet. Here students can explore how breast milk and the introduction of solid food shape a baby's microbiome, and how it is affected by antibiotics and other experiences, such as being malnourished.



Nourished by breast milk, *Lactobacillus* bacteria picked up in the birth canal multiply rapidly in a newborn's gut and help the child develop.

3d. "Immune System" area: The microbes you acquire during childhood orchestrate the development of your immune system. Like a guard dog, the immune system needs to be trained when to attack and when not to. Overreactions of the immune system can result in allergies and asthma. Students can examine a model of an immune cell to see how it battles microbes that cause disease. They can also read about autoimmune diseases, which occur when your immune system turns against its own cells.

4. You Are an Ecosystem

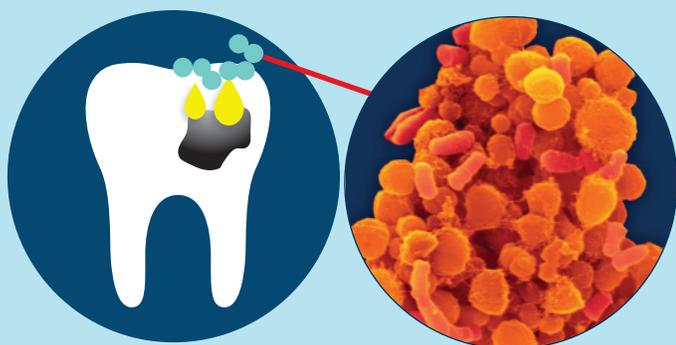
4a. Interactive table: From head to toe, microbial communities affect your health. At the table students can explore ecological concepts such as competition, mutualism, and niche adaptation. They can also investigate the roles microbes play in digesting food, causing and fighting infections, attracting mosquitoes, regulating the immune system to avoid allergies, and more.

5. New Paradigm

5a. "From Germ Theory to the Microbiome: A New View of Our Health" theater: This seven-minute film tells the story of our evolving understanding of health and disease. The first breakthrough, in the late 1800s, was "germ theory"—the discovery that certain microbes could cause specific diseases. Now we're increasingly seeing disease not as the result of a single pathogen, but as a disruption in the ecology of our microbiome. The video also explores ways to protect and nurture our microbial ecosystems, and the costs and benefits of antibiotic drugs.

6. Digestive System

6a. "Mouth" area: Your digestive system begins in your mouth, which contains many different environments. Different bacteria occupy these different spots. Students can investigate the role of bacteria in oral health, including what causes tooth decay and why you get morning breath.



Many bacteria produce acids that cause tooth decay. Scientists are working on a vaccine against one of the main culprits, *Streptococcus mutans*.

6b. "Digestive System" area: Because your large intestine contains lots of food, ninety-nine percent of your body's microbes live there. Trillions ferment fiber and other food you can't digest, producing useful nutrients and protecting your gut lining from

inflammation. Here students can see the effects of different kinds of food on the microbiome, and explore where and how gut bacteria extract nutrients from food.

Different foods nurture different bacteria.



Although **red meat** is an important source of protein in many cultures, it feeds bacteria that can cause heart disease. **Refined sugar** and **flour** raise your blood sugar. In addition they starve your good bacteria. Live bacteria in **probiotics** like **yogurt** stimulate your immune system and help keep out bacteria that cause disease. **Beans, vegetables, fruits, and whole grains** are **prebiotics** that feed beneficial bacteria.

6c. "Eating as Farming" area: Many organisms have coevolved with microbes that play a critical role in their digestion. For example, cows, which eat only grass, have acquired a microbiome that converts this food into the nutrients they need to survive.

6d. "Obesity" area: Your microbiome can affect your appetite and plays a role in how much you weigh. Students can explore how different kinds of food affect your microbiome, and therefore your health. They can also look at how antibiotic use across the United States correlates with obesity rates. Remind students that correlation and causation are often confused. Two variables may be related without one causing the other. Scientists often use correlation as a basis for testing hypotheses to see whether a causal relationship actually exists.

6e. "Mind-Altering Microbes" lights tunnel: There is such a thing as a "gut feeling." Your brain is in constant two-way communication with your gut. As they walk through the tunnel, students can investigate evidence that links the gut microbiome to behavior, anxiety, and depression.

7. The "Lab"

7a. Live presentation & sticker room: Technological advances over the last few decades have revolutionized our understanding of the role of microbes in human health. Here students can take part in a presentation on how scientists collect and study microbes. They will receive "microbe stickers" to place on the white wall on their way out. Explain that this symbolizes that microbes are everywhere, and that our bodies are ecosystems full of microbial life and diversity.

Come Prepared Checklist

- Plan your visit.** For information about reservations, transportation, and lunchrooms, visit amnh.org/plan-your-visit/school-or-camp-group-visit.
- Read the Essential Questions** to see how themes in the exhibition connect to your curriculum.
- Review the Teaching in the Exhibition section** for an advance look at what your class will encounter.
- Download activities and student worksheets** at amnh.org/secretworldinsideyou/educators. They are designed for use before, during, and after your visit.
- Decide how your class will explore the exhibition:**
 - You and your chaperones can facilitate the visit using the Teaching in the Exhibition section.
 - Students can use the worksheets and/or maps to explore the exhibition on their own or in small groups.

Next Generation Science Standards

Scientific and Engineering Practices • 1. Asking questions
• 2. Developing and using models • 6. Constructing explanations
• 8. Obtaining, evaluating, and communicating information

Crosscutting Concepts • 1. Patterns • 2. Cause and effect: Mechanism and explanation • 3. Scale, proportion, and quantity
• 4. Systems and system models • 7. Stability and change

Disciplinary Core Ideas • LS1.A: Structure and Function
• LS1.B: Growth and Development of Organisms • LS2.A:
Interdependent Relationships in Ecosystems • LS2.C: Ecosystem
Dynamics, Functioning, and Resilience • LS4.D: Biodiversity
and Humans

Glossary

antibiotics: chemical substances that can kill bacteria. Antibiotics can be naturally produced by microorganisms or synthetically produced in a lab.

bacteria: a type of one-celled microorganism without a nucleus

coevolution: the influence of closely associated species on each other as they evolve

commensalism: an interaction between two species that is beneficial to one organism and neither benefiting nor harming the other, e.g., the human body provides a habitat for many microbial species that neither help nor hurt us

ecosystem: a community of living things that interact with each other and their physical environment

human microbiome: the collection of microbes and their genes on and in your body

microbe: an organism too small to be seen with the naked eye but often visible with a microscope. Microbes include bacteria, archaea, viruses, and protists.

mutualism: an interaction between two species that is mutually beneficial to both of the two species

prebiotics: food for beneficial bacteria, to help them grow and multiply inside the host

probiotics: live organisms that benefit the host when ingested in sufficient quantities

virus: a microorganism that can replicate only inside a host cell

bacteriophage, a virus that infects and replicates within a bacterium



CREDITS

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