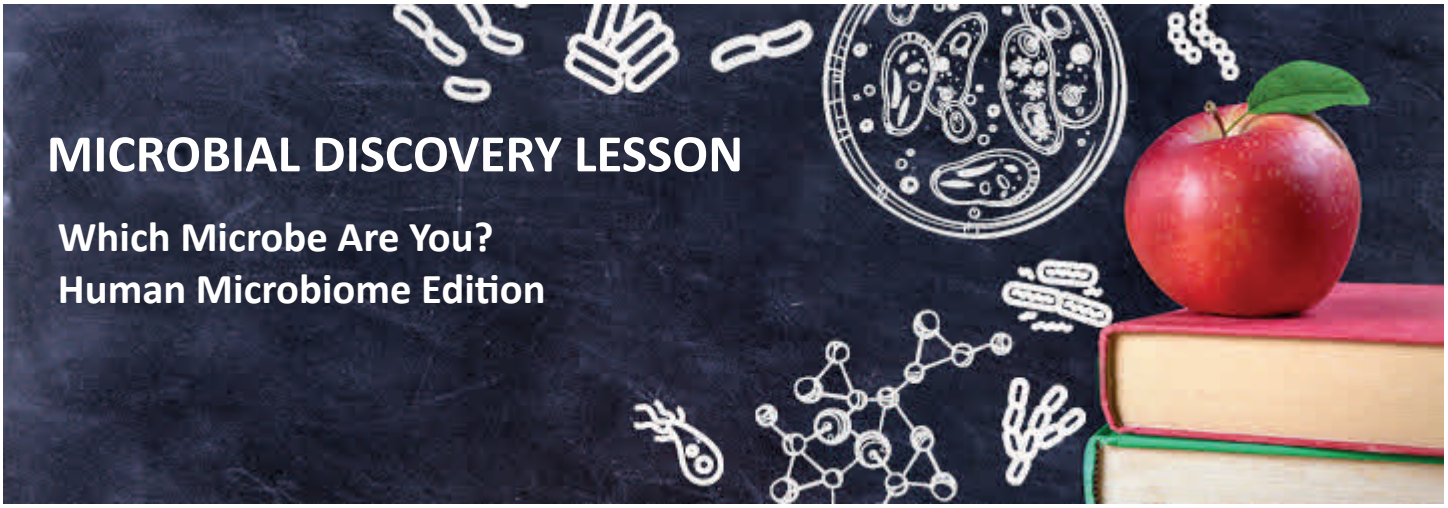


MICROBIAL DISCOVERY LESSON

Which Microbe Are You?
Human Microbiome Edition

Author Info

This lesson is inspired by the What Microbe Are You? activity by Michelle H. Hsia, PhD, Kimberley A. Thomas, PhD, and Barbara C. Bruno, PhD at the University of Hawaii at Manoa.

Erika C. Shugart, PhD, American Society for Cell Biology
Katherine S. Lontok, PhD, American Society for Microbiology

Description

Students explore the human microbiome in this lesson, first by voting on some discussion questions, then by taking a 'microbial personality' quiz that matches them with a particular microbiome microbe. From there, students create concept maps in small groups, incorporating their microbe and some general terms and ideas. Students also create their own quiz question by learning about additional species that are part of our microbiome. Finally, students revisit the discussion questions from the beginning and justify their answers using examples from the human microbiome.

Learning Objectives

At the completion of this activity, the students will be able to:

1. Define the terms "microbe" and "microbiome."
2. Describe some of the diverse features of microbes that live in or on the human body.
3. Explain some ways in which microbes in our microbiomes help us.

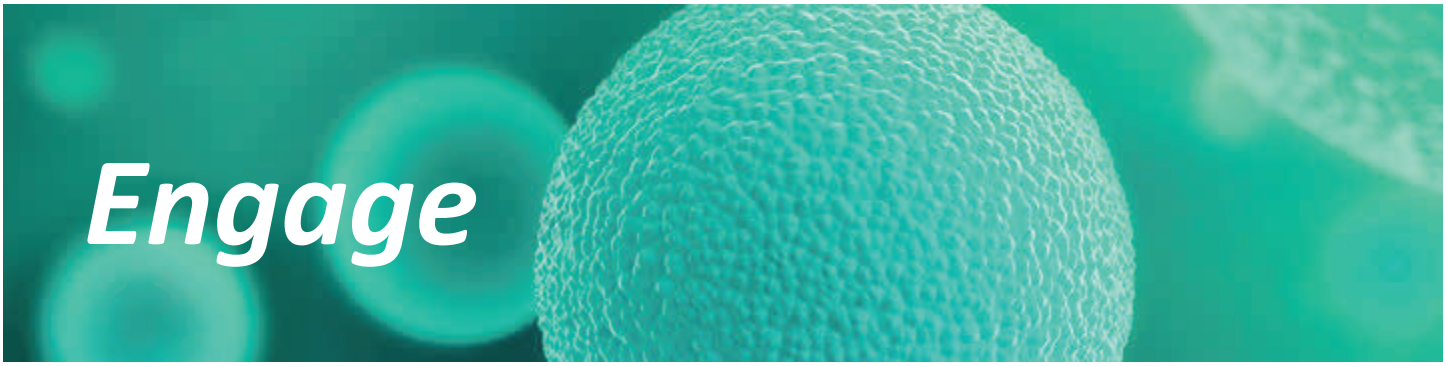
Total Activity Time
This activity takes approximately 120 to 150 minutes (3-4, 45 min class periods), depending on whether the Elaborate is done as homework or in class.

Grade Band
5-8, 9-12

NGSS
MS-LS1-1, HS-LS2-3

Topic
Human Microbiome

AMERICAN SOCIETY FOR MICROBIOLOGY



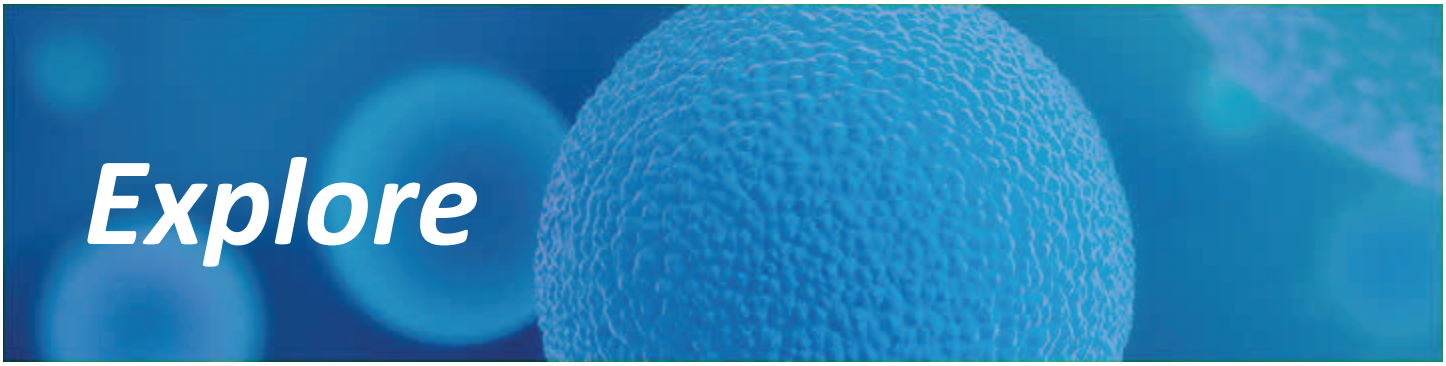
Engage

5 min

1. At the top of a piece of chart paper, write "What is a microbe?". Provide each student with a Post-It note. Have them write a brief answer on it, no more than one sentence, and stick it to the chart paper.
2. Quickly look for common words, phrases, or themes and summarize to the class without offering any judgement on the answers.

15 min

3. Write the following prompts at the top of separate sheets of chart paper and use a marker to draw a line down the middle of each sheet. Label one side "yes" or "good" and one side "no" or "bad." Provide each student with three Post-It notes. Have students vote on each prompt, one at a time, and hold a brief discussion after each vote. Listen to student reasoning, but do not provide judgements or answers.
    a. "You just finished playing soccer outside in the mud with your friends. Are there microbes living in or on you?" Ask students from each side (if applicable) to explain their reasoning.
    b. "After the soccer game, you took a long, hot shower and used lots of soap all over your body. You also vigorously brushed your teeth. When you finish your shower and brushing your teeth, are there still microbes living in or on you?" Ask students from each side (if applicable) to explain their reasoning.
    c. "Are microbes living in or on your body good or bad?" Ask students from each side (if applicable) to explain their reasoning.
4. Keep the Post-It tallies up in the classroom for the remainder of the lesson.



Explore

10 min

1. Explain to students that they are going to get to know some of the microbe species that live in and on the human body by taking a personality quiz.
2. Pass out the activity books (Appendix I) and have students start on page 1 and work through the questions. They should choose one answer for each question, and then proceed to the next question indicated for that answer. Have students keep track of the questions and their answers using the worksheet in Appendix II.
3. After three to four questions, students will be directed to a page that reveals their microbial identity and how their answers to the quiz questions align to the microbe's properties.

Explain

2 min

1. Have students who have the same microbial identity group together. Break up any large groups into several smaller groups of 3-4 students.

20 min

2. Ask each group to build a concept map using the following terms. Lines connecting terms should be accompanied by a brief explanation. Students can draw their final concept map on chart paper so they can present it to the class.
   - [Group's microbe]
   - [Microbe's home in the human body]
   - [Function(s) in its human body home, if known]
   - [Other places microbe lives, if applicable]
   - Archaea
   - Bacteria
   - Makes you sick
   - Does not make you sick
   - Microbe

30 min

3. Have a volunteer from each group briefly explain their concept map to the class. See Appendix III for an example of what a concept map might look like. Note that there are many "correct" configurations for each microbe, as long as the group can justify the connections.

10 min

4. Hold another class discussion. Ask "We've been using the term 'microbe' during this activity. Are there any new thoughts you want to add to our 'What is a microbe?' brainstorm?" Guide students toward the definition below.
   a. Microbe refers to any organism that has to be viewed with a microscope and cannot be seen with the naked eye. It is a category of organisms that is based on size rather than relatedness, and therefore encompasses a wide diversity of bacteria, viruses, fungi, protists (e.g. single-celled parasites, some algae), archaea, invertebrate animals (e.g. mites), and plants (e.g. other algae).
   b. 11 of the 12 microbial personas in this quiz are bacteria; however, *M. smithii* is an archaea. During this discussion, you can use students whose personas were *M. smithii* to point out that the terms bacteria and microbe are not interchangeable.

15 min

5. Ask "Has anyone heard of the term 'microbiome'? What do you think it means?" Guide students to the definition below. It may help to have students think of the definition of a biome first.

Explain

a. A microbiome is the collection of microbes/microorganisms that inhabit a particular environment, creating a microscopic ecosystem.
b. "Where do you think you might find a microbiome?"
    i. Microbiomes are being explored in many different places, such as ocean vents, on plant roots, and in various parts of our bodies.
c. "What are some things that might affect your microbiome?"
    i. Diet, exposure to different microbes, use of antimicrobial substances such as antibiotics or antimicrobial soaps.

Elaborate

30 min or HW

1. Have students come up with their own microbial persona quiz question to distinguish between any two of the organisms listed below (note, give students the organism name only). Students should work backward to determine biological differences between the organisms first (such as type of organism, habitat, metabolism, etc.) and then devise a personality question that aligns with that difference.
   a. Organisms
      i. *Actinomyces naeslundii* (bacteria, mouth)
      ii. *Lactobacillus casei* (bacteria, intestines, reproductive tract)
      iii. *Methanosphaera stadtmanae* (archaea, large intestine)
      iv. *Retortamonas intestinalis* (eukaryote, intestines)
      v. *Demodex folliculorum* (arachnid, hair follicles in skin)
      vi. *Demodex brevi* (arachnid, sebaceous glands skin)
      vii. *Staphylococcus haemolyticus* (bacteria, skin)
      viii. *Alloiococcus otitidis* (bacteria, middle ear)
   b. Suggested references:
      i. MicrobeWiki (https://microbewiki.kenyon.edu/index.php/MicrobeWiki)
      ii. Medical Microbiology and Infection at a Glance, 4th Edition. Stephen Gillespie, Kathleen Bamford. Wiley-Blackwell.
      iii. Meet Your Mites (http://robdunnlab.com/projects/meet-your-mites/)
   c. For example, the statements "My room is organized and I have a place for everything." versus "My room is not organized and my stuff is all mixed together." could represent a difference between eukaryotic cells (i.e. *Retortamonas intestinalis*) and prokaryotic cells (i.e. *Lactobacillus casei*).

Evaluate

15 min

1. Have students revisit the questions from the Engage and write a short paragraph for each one based on their new understanding of the human microbiome. Each student should answer the question and use specific examples from the lesson to support his/her answer.
    a. "You just finished playing soccer outside in the mud with your friends. Are there microbes living in or on you?"
        i. Yes, there are always microbes living both in and on your body.
    a. "After the soccer game, you took a long, hot shower and used lots of soap all over your body. You also vigorously brushed your teeth. When you finish your shower and brushing your teeth, are there still microbes living in or on you?"
        i. Yes, even after performing good hygiene, there are always microbes living both in and on your body. However, the numbers might be smaller in the area cleaned.
    a. "Are microbes living in or on your body good or bad?"
        i. The microbes that live in and on us can be both good and bad, depending on context. For example, *N. meningitidis* is very dangerous if it gets into our bloodstream. On the other hand, *E. coli* helps us digest food.

The Human Microbiome

The human microbiome comprises the bacteria, viruses, fungi, archaea, and microscopic animals associated with the human body. Our bodies provide a broad range of environments that can be exploited, and microbes have proven themselves capable of living in a very diverse set of them. Until relatively recently, many areas of the human body were thought to be mostly sterile in healthy individuals, but advanced gene sequencing techniques are making it possible to characterize even very small microbial populations that are otherwise difficult to isolate and culture.

The relationships between our own bodies and the organisms that live in (or on) it are complex and fluid. For most people, the majority of the microbiome exists in a commensal (nonharmful and nonbeneficial) relationship with the host environment. However, parts of the human microbiome are greatly beneficial, especially in the gut, where our microbiome makes possible the absorption of many important nutrients and synthesizes essential vitamins. Even commensal organisms have an important indirect function: they occupy and use the resources available in various body sites so that it is more difficult for other, potentially harmful species to do so.

The gastrointestinal tract hosts by far the largest and most thoroughly studied population of microbes in the human body. There are as many—or more—bacterial cells in the gut as there are human cells in a person's whole body. Of the estimated 30-50 trillion cells in the gut microbiome, the majority are in the large intestine, also known as the colon. In addition to nutrient uptake, other benefits that occur through interactions with our gut microbiome are enhancement of proper immune system function, hormone regulation, and even regulation of cognitive function.

As studies of the human microbiome progress, scientists are looking at body sites like the uterus, eyes, and placenta as places where commensal microbial populations live and may contribute to overall human health. The evolution of our understanding of humans' relationships with microorganisms has allowed us to see them not just as incidental hangers-on (or worse, agents that cause illness), but in fact as essential parts of the body's environment that aid in our development and allow our bodies to carry out the functions necessary for us to live and thrive.

Preparation

15 min

Step 1

Print a class set of microbial personality quiz booklets (Appendix 1). To print them correctly, choose the following options from the Adobe Acrobat print dialogue:

Pages to Print —> Pages 10-28
Page Sizing & Handling —> Booklet
Booklet subset —> Both sides
Sheets from —> 1 to 5
Binding —> Left
Orientation —> Portrait

30 min

Step 2

Once printed, the pages for each booklet can be stapled down the middle or laminated, cut in half and bound.

Step 3

Print one copy of the student worksheet (Appendix II) for each student.

WHICH MICROBE ARE YOU?

HUMAN MICROBIOME EDITION

AMERICAN
SOCIETY FOR
MICROBIOLOGY

QUESTION 1

I prefer to play inside.

(Go to **Page 2, Q2**.)

I prefer to look out the window or play outside.

(Go to **Page 2, Q3**.)

QUESTION 2

Eating beans does not make me fart.

(Go to **Page 3, Q4**.)

Eating beans makes me fart.

(Go to **Page 3, Q5**.)

QUESTION 3

I am tough. (Go to **Page 5, Q8**.)

I am not so tough. (Go to **Page 5, Q9**.)

QUESTION 4

I am tough. (Go to **Page 4, Q6**.)

I am not so tough. (Go to **Page 4, Q7**.)

QUESTION 5

I can hold my breath for a long time.
(Go to **Page 12**.)

I can't hold my breath for a long time.
(Go to **Page 11**.)

QUESTION 6

I prefer to eat string beans. (Go to **Page 8**.)

I prefer to eat peas. (Go to **Page 10**.)

QUESTION 7

When I go to the pool, I prefer to swim.
(Go to **Page 9**.)

When I go to the pool, I prefer to float.
(Go to **Page 7**.)

QUESTION 8

I prefer to hold hands with my family and friends.

(Go to **Page 6, Q10**.)

I prefer to hug my family and friends.

(Go to **Page 6, Q11**.)

QUESTION 9

I like to eat many different types of food.

(Go to **Page 14**.)

I am a picky eater. (Go to **Page 13**.)

QUESTION 10

At the beach, I like to dig holes in the sand.

(Go to **Page 17**.)

At the beach, I prefer to lie in the sand.

(Go to **Page 18**.)

QUESTION 11

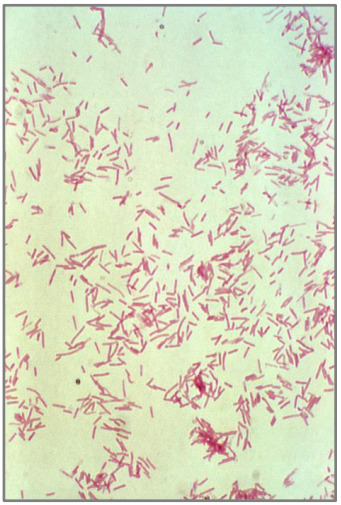
I prefer white cherry blossoms. (Go to **Page 16**.)

I prefer yellow daffodils. (Go to **Page 15**.)

Bacteroides fragilis

Who knew? You and *Bacteroides fragilis* have a lot in common!

- **Inside** your gut
- Thin cell wall is **not so tough**
- **Floats** instead of swimming



B. fragilis can be both helpful and harmful. As long as it stays in your gut, it helps you out by making chemicals that help you digest complex poly-saccharides (sugars) and by fighting off harmful bacteria. However, it can make you sick if it gets into other places in your body, such as the lining of your abdominal cavity. It is also naturally resistant to some antibiotics like penicillin.

(Image courtesy Public Health Image Library, CDC)

Bifidobacterium bifidum

Awesome! You are *Bifidobacterium bifidum!*

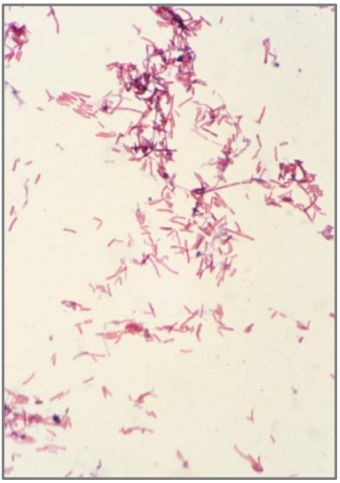
- **Inside** your intestines
- Thick cell wall is **tough**
- Shaped like a **string bean**

Bifidobacterium species are some of the good guys in the gut. They help you digest your food by making lactic acid (like in yogurt) and acetic acid (like in pickles). They help to break down tough vegetable material and to crowd out bad bacteria that could make you sick. Outside of the gut, you can find them in fermented dairy foods like yogurt. They are also used as probiotics (bacteria you eat to keep you healthy). Look for *B. bifidum* in the list of ingredients on your yogurt container!

Enterobacter cloacae

Wow! You are *Enterobacter cloacae*!

- **Inside** your gut
- Thin cell wall is **not so tough**
- **Swims** using its flagella (tails)



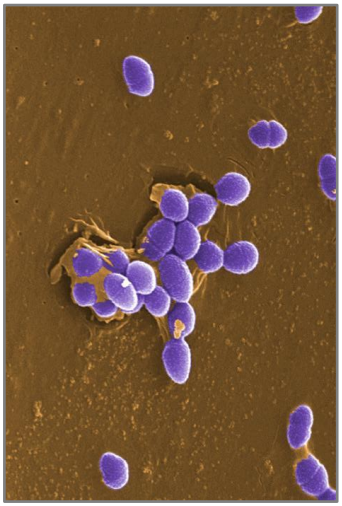
E. cloacae lives in many places besides your gut, including your skin, the surfaces of fruits and vegetables, and on medical devices.

E. cloacae is part of the normal gut flora, but is also an opportunistic pathogen. As long as you are healthy, it hangs around and doesn't affect very much. However, it can cause serious infections in people who are very young or old, or who have problems with their immune system. Washing your hands is the best way to keep this microbe in check.

Enterococcus faecalis

Super! You are *Enterococcus faecalis*!

- **Inside** your intestines
- Thick cell wall is **tough**
- Round like a **pea**



E. faecalis lives in many places, including the guts of other animals, on plants, and in soil and water. It is hardy and able to survive in harsh conditions.

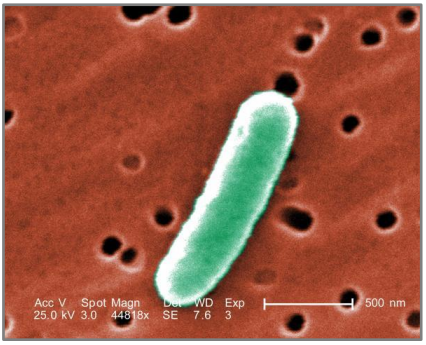
This bacterium can be both helpful and harmful. When it is in the gut, it is part of your normal bacterial ecosystem. It can even help reduce diarrhea when used as a probiotic (bacteria you eat to keep you healthy). However, if *E. faecalis* gets into the wrong places like open cuts or your urinary tract, it can cause infections and make you very sick. Scientists are trying to figure out how to use the good side of *E. faecalis*, while minimizing its bad side.

(Image courtesy Public Health Image Library, CDC)

Escherichia coli

Cool! You are *Escherichia coli*!

- **Inside** your large intestines
- Produces **gas**
- Likes oxygen and **can't hold its breath for long**



You might have heard of this microbe by the short version of its name – *E. coli*. Most *E. coli* strains are harmless, but a few strains (varieties) are dangerous and have been the cause of food poisoning outbreaks.

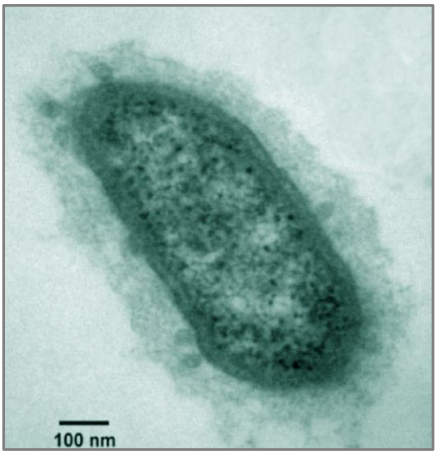
As part of your gut flora, *E. coli* helps absorb nutrients from your food and makes vitamin K for you. Scientists also use safe strains of *E. coli* as model organisms in the lab to learn about DNA, enzymes, evolution, and fundamental biological processes. *E. coli* is even being put to work in the biotechnology industry to make biofuels and medicines. *E. coli* is truly a versatile microbe!

(Image courtesy Public Health Image Library, CDC)

Methanobrevibacter smithii

Yipee! You are *Methanobrevibacter smithii*.

- **Inside** your gut
- Produces methane **gas**
- **Holds breath**, dies around oxygen



M. smithii is an archaea, an ancient prokaryotic lifeform that is distinct from bacteria. Archaea are most well-known for species that can survive in extreme environmental conditions like hydrothermal vents, but some also live in more ordinary places like our gut.

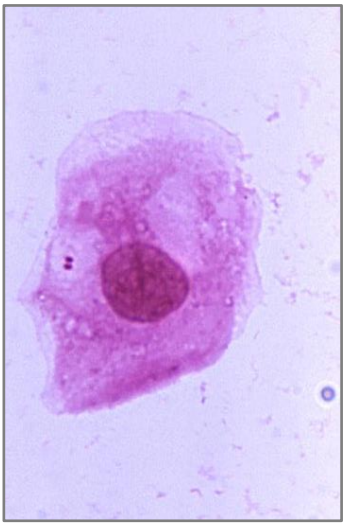
M. smithii has an important role in the gut where it converts carbon dioxide and hydrogen gases made by bacteria, such as *E.coli*, into methane. This microbe may even affect our weight by changing how much energy we are able to extract from our food!

(Image courtesy Dr. B. Samuel)

Neisseria meningitidis

Who knew? You and *N. meningitidis* have a lot in common!

- Looks **outside** from your nose
- Thin cell wall is **not so tough**
- **Picky** about what it eats



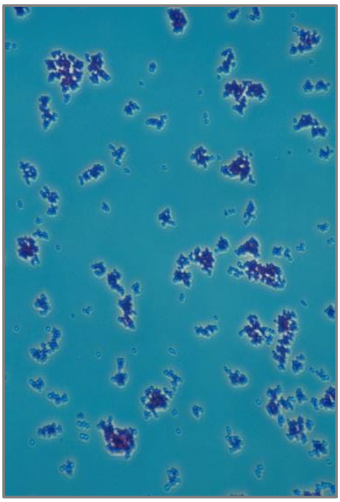
While harmless in your nose, *N. meningitidis* can be deadly if it gets into your bloodstream. It is a common cause of bacterial meningitis, or swelling of the covering of your brain. The meningococcal vaccine can protect against these serious infections. Anyone with a *N. meningitidis* infection needs to get to the doctor quickly!

(Image courtesy Public Health Image Library, CDC)

Neisseria sicca

How great! You are *Neisseria sicca*!

- Looks **outside** from your nose
- Thin cell wall is **not so tough**
- **Not picky**, eats lots of sugars

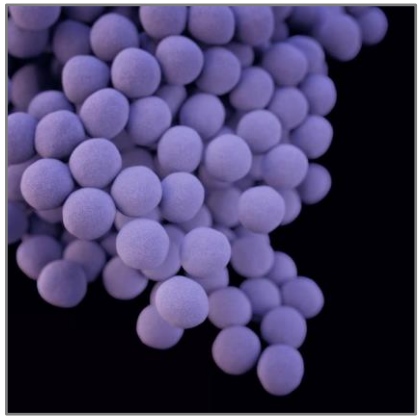


Like its cousin *N. meningitidis*, *N. sicca* hangs out in pairs, but unlike *N. meningitidis*, it does not cause infection. It is part of the normal microbial ecosystem in your nose and on other mucus membranes, including your mouth and upper respiratory tract. Scientists are still studying *N. sicca* to learn more about it.

Staphylococcus aureus

Amazing! You are *Staphylococcus aureus.*

- Found **outside** on your skin
- Thick cell wall is **tough**
- Forms **bunches**
- **Yellow** colonies



S. aureus is most well-known for causing staph infections if it gets into a cut or other skin abrasion. However, 20-30% of healthy people carry *S. aureus* on the surface of their skin where is it completely harmless. One strain, called MRSA, is resistant to most antibiotics, and so is very hard to treat if it causes an infection.

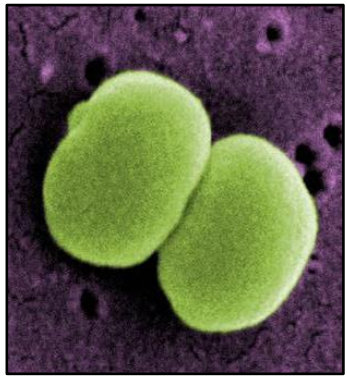
(Image courtesy Public Health Image Library, CDC)

Staphylococcus epidermidis

Fantastic! You are *Staphylococcus epidermidis*!

- Found **outside** on your skin
- Thick cell wall is **tough**
- Forms **bunches**
- **White** colonies

Most of the time, *S. epidermidis* is harmless. It is found on mainly on your skin and sometimes in your nose. However, it can form biofilms (slime) on medical devices, like I.V.s, which makes it a major cause of hospital-acquired infections.



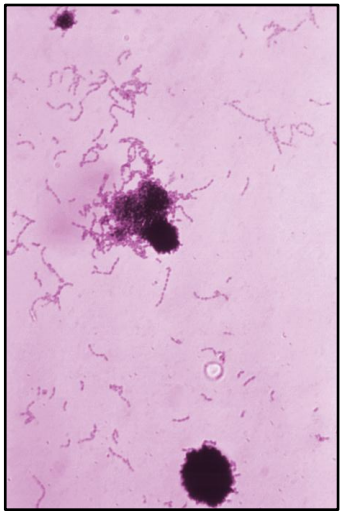
(Image courtesy Public Health Image Library, CDC)

Streptococcus mutans

Hooray! You are *Streptococcus mutans*!

- Looks **outside** from your mouth
- Thick cell wall is **tough**
- Forms **single-file** chains
- **Makes** holes in your teeth

Although *S. mutans* is found in almost 100% of adult mouths, it is one of the few species that live on us that is always harmful. This is because it turns sugars that we eat into acid that erodes the enamel of our teeth, causing cavities.



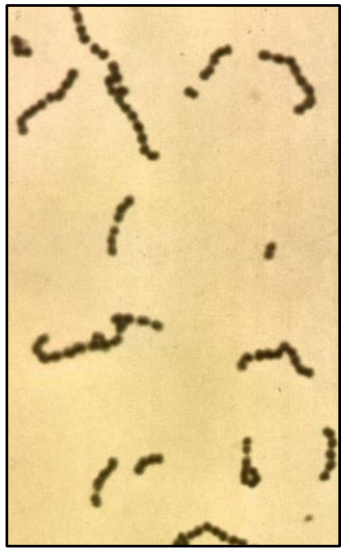
The mouth is a tough environment with many extremes – never mind the constant attack of the toothbrush! However, *S. mutans* holds on tight by sticking to teeth and forming a layer that can develop into dental plaque, a type of biofilm.

(Image courtesy Public Health Image Library, CDC)

Streptococcus sanguinis

Super! You are *Streptococcus sanguinis*!

- Looks **outside** from your mouth
- Thick cell wall is **tough**
- Forms **single-file** chains
- Lies **on top** of your teeth



S. sanguinis is both helpful and harmful. In the mouth, it competes with its cousin *S. mutans*, another bacterium that forms cavities. That means that *S. sanguinis* may indirectly fight cavities by muscling out *S. mutans*! However, if *S. sanguinis* gets into the bloodstream, for example, during oral surgery, it can cause bacterial endocarditis, which is inflammation that damages the inner layer of the heart.

(Image courtesy Wikipedia author GrahamColm)

Appendix II—Student worksheet

Question # 1

Answer: _____

Question # ____

Answer: _____

Question # ____

Answer: _____

Question # ____

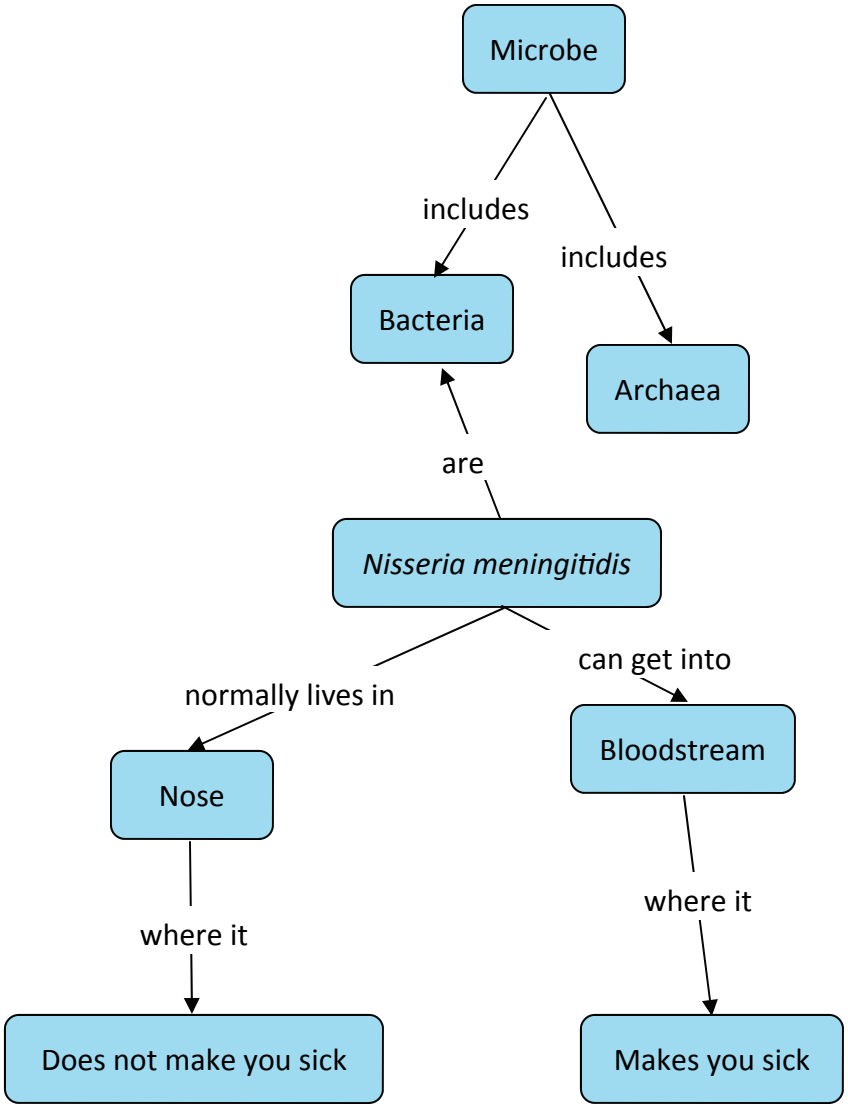
Answer: _____

Microbial Persona: _____

Appendix III—Example concept map

This is an example of a concept map that students might come up with for *Neisseria meningitidis*.

[Group's microbe]
[Microbe's home in the human body]
[Function(s) in its human body home, if known]
[Other places microbe lives, if applicable]
Archaea
Bacteria
Makes you sick
Does not make you sick
Microbe



AMERICAN SOCIETY FOR MICROBIOLOGY