Bacteria and Human Health

Unit Overview

Essential Questions:

- What is bacteria? Where is bacteria found? How is it useful and/or harmful?
- How do I know if water is safe to swim in?
- What types of pathogens are found in polluted surface water and how could they affect my health?
- How can I protect water quality in my community?

In this unit, students explore the connection between water quality and health. The first lessons introduce students to bacteria, where it is found, and the connections between bacteria, pathogens and health. In the final lab, students complete a water quality study in which they measure bacteria concentrations and bacteria loading at their stream sites.

Lessons:

- Bacteria: Friend or Foe?
- Invisible Microbes Everywhere
- Super Sleuths (Project WET)
- Poison Pump (Project WET)
- No Bellyachers (Project WET)
- *How* Much Bacteria?

Assessment:

How Much Bacteria? Lab Report

Background

Bacteria (singulär bacterium) are unicellular microorganisms from the Moneran kingdom that live in soil, water, plants, organic matter, or the live bodies of animals or people. They are prokaryotes, which are classified together because they lack nuclear membranes. They are the most primitive living beings, are present throughout the environment, and require a microscope to be seen.

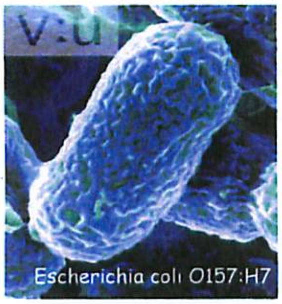
Bacteria may be free-living, saprophytic (feed on dead or decaying organic matter) or pathogenic (cause disease). Most bacteria use organic matter for their food and produce waste products as a result of their life processes. While some bacteria are helpful, some cause disease such as strep throat, most ear infections, pneumonia and tuberculosis.

Coliforms are a type of bacteria which occur widely in the environment including surface water, soil, and decaying organic matter. This group of bacteria includes the fecal coliform group which grows in the intestines of warm blooded animals. When feces from these animals enters waterways, the bacteria and all other pathogens present contaminate the water. Potential pathogens include cholera, thyphoid, crytoproidium, giardia, hepatitis A, dysentery, and parasites. Swimmers are at risk from these pathogens.

Background

While fecal coliform bacteria themselves are generally not harmful in and of themselves (except the *Escherichia coli* strain called O157:H7 which can cause disease), they have long been used as an indication of water quality since they are easier to test for than the individual pathogens.

Escherichia coli (E. coli), a type of fecal coliform bacteria, is commonly accepted as the best indicator of fecal contamination. The EPA mandates that drinking water can contain no E. coli. Public swimming water is often tested for this contaminant, and in Vermont swimming areas are closed when levels reach 77 colonies E. coli per 100mL of water, until the levels subside.



Bacteria and Human Health

Bacteria: Friend Or Foe?

Learning Objectives:

- Know the main characteristics of bacteria.
- Correctly classify two types of bacteria
- Know several common bacteria that affect our lives

◆Duration:

45 min.

◆Setting:

Classroom

◆Materials

Reference materials

"Most Wanted" handout

Paper

Colored pencils or Markers

◆Assessment

Most wanted rubric

◆Extensions

Yogurt making

Observing Bacteria Cultures in Yogurt

Summary

Students are introduced to the characteristics of several types of beneficial and harmful bacteria. Students choose various surfaces to swab and culture bacteria, then observe growth.

Focus questions:

- How do I know it is bacteria?
- How does bacteria affect my daily life?

In this lesson, students learn about the general characteristics of bacteria, then research one type of bacteria and complete a "Most Wanted Poster". Students take turns presenting their posters to the class.

Background

Bacteria are remarkably adaptable to diverse environmental conditions: they are found in the bodies of all living organisms and on all parts of the earth—in land terrains and ocean depths, in arctic ice and glaciers, in hot springs, and even in the stratosphere. Our understanding of bacteria and their metabolic processes has been expanded by the discovery of species that can live only deep below the earth's surface and by species that thrive without sunlight in the high temperature and pressure near hydrothermal vents on the ocean floor. There are more bacteria, as separate individuals, than any other type of organism; there can be as many as 2.5 billion bacteria in one gram of fertile soil.

Bacteria are grouped in a number of different ways. Most bacteria are of one of three typical shapes—rod-shaped (bacillus), round (coccus, e.g., streptococcus), and spiral (spirillum). An additional group, vibrios, appear as incomplete spirals. The cytoplasm and

Background

plasma membrane of most bacterial cells are surrounded by a cell wall; further classification of bacteria is based on cell wall characteristics (see Gram's stain). They can also be characterized by their patterns of growth, such as the chains formed by streptococci. Many bacteria, chiefly the bacillus and spirillum forms, are motile, swimming about by whip-like movements of flagella; other bacteria have rigid rod-like protuberances called pili that serve as tethers.

Harmless and beneficial bacteria far outnumber harmful varieties. Because they are capable of producing so many enzymes necessary for the building up and breaking down of organic compounds, bacteria are employed extensively by humans—for soil enrichment with leguminous crops (see nitrogen cycle), for preservation by pickling, for fermentation (as in the manufacture of alcoholic beverages, vinegar, and certain cheeses), for decomposition of organic wastes (in septic tanks, in some sewage disposal plants, and in agriculture for soil enrichment) and toxic wastes, and for curing tobacco, retting flax, and many other specialized processes. Bacteria frequently make good objects for genetic study: large populations grown in a short period of time facilitate detection of mutations, or rare variations.

Some bacteria (those known as aerobic forms) can function metabolically only in the presence of free or atmospheric oxygen; others (anaerobic bacteria) cannot grow in the presence of free oxygen but obtain oxygen from compounds. Facultative anaerobes can grow with or without free oxygen; obligate anaerobes are poisoned by oxygen.

Warm-Up

Pose several questions to the class for a show of hands:

- How many of you have eaten yogurt?
- Eaten cheese?
- Pickles? Vinegar? (all these foods are made using bacteria)
- Used the bathroom? (bacteria are used in septic tanks or WWTP to break down wastes)

What do all of these have in common? They all employ the services of bacteria. The world would not exist as we know it with out the help of bacteria.

Again pose several questions:

- How many have had strep throat?
- Heard of the plague?
- Gotten "food poisoning"? (all of these sicknesses are caused by bacteria)

These are examples of how harmful strains of bacteria can affect our lives. **There are more bacteria, as separate individuals, than any other type of organism on earth.**

Activity

Show PowerPoint lecture: Introduction to Bacteria.

Introduce "Bacteria: Most Wanted/Missing Person" Activity: Students will choose one type of bacteria from the list provided. They will research the bacteria to complete a wanted/missing person poster, following the guidelines provided. They will be given the rest of the period to begin research, and must finish the research out of class and bring in their completed posters for the next class. Each student presents their work during the next class period.

Guidelines for "Bacteria's Most Wanted" or "Bacteria Missing Person" poster—the following must be included on an 8 $^{1}/_{2}$ x 11 sheet for full credit:

- Picture or drawing of organism with scale
- Name and pronunciation key
- Likely hideout/last seen
- Identifying characteristics: how to ID the suspect/victim
- Modus operandi: how does this type of bacteria work; what is it "wanted" for?

Wrap-Up

Poster gallery with discussions or poster presentations

Extension

Homemade Yogurt—Using "Good" Bacteria (page 7)

As students learned through completing this lesson, not all bacteria are "bad"! In this extension activity, students use "good" bacteria to make a batch of yogurt at home.

Observing Bacteria Cultures in Yogurt (page 9)

Students observe live bacteria in yogurt using microscope (400x objective required)

Bacteria: Most Wanted/Missing Person Poster

Instructions: Choose a bacterium from the list to research. Be sure to get teacher approval before beginning.

"Beneficial" Bacteria

Lactobacillus bulgaricus: one of the bacteria used to turn milk into yogurt.

Streptomyces; soil bacteria wanted for making streptomycin, an antibiotic used to treat infections.

Pseudomonas putida: one of many microbes wanted for cleaning wastes from sewage water at water treatment plants.

Escherichia coli: one of many kinds of microbes that live in your gut. Wanted for helping you digest your food every day.

Bacillus thuringiensis: a.k.a "Bt", a common soil bacterium. Wanted as a natural pest-killer in gardens and on crops.

Methanotrophs: these methane-munching bacteria produce an enzyme that can break down more than 250 nasty pollutants into harmless molecules.

Rhizobacteria: beneficial bacteria which promote healthy plant growth and protect plant root systems from soil borne disease organisms.

Rhizobia: soil bacteria that fix nitrogen (diazotrophy) after becoming established inside root nodules of legumes (Fabaceae).

"Harmful" Bacteria

Streptococcus: some species can cause erysipelas (aka Saint Anthony's fire), scarlet fever, rheumatic fever, kidney disease, abscesses around the tonsils, and strep throat.

Bordetella pertussis: transmitted through airborne particles from infected individuals, causes whooping cough.

Corynebacterium diphtheriae —produces a toxin which causes Diphtheria, an upper respiratory tract illness characterized by sore throat, low-grade fever. Can be fatal in children.

Yersinia pestis: transmitted through flea bites, causes plague.

Escherichia coli (0157:H7): found in undercooked meat, can cause acute illness.

Mycobacterium tuberculosis: causes tuberculosis or "TB".

Vibrio cholerae: today primarily found in developing countries, transmitted through the fecal oral route.; causes cholera.

Salmonella typhi: causes Typhoid fever, a life-threatening illness still common in the developing world

Clostridium tetani: found in soil especially on farms, causes the potentially fatal disease tetanus or "lockjaw"

Bacteria: Most Wanted/Missing Person Poster Rubric

Homemade Yogurt—Using "Good" Bacteria

Yogurt is a dairy product produced by bacterial fermentation of milk using *Lactobacillus bulgaricus* and *Streptococcus thermophilus* cultures (some commercial yogurts use more types). Any sort of milk may be used to make yogurt, but modern production is dominated by cow's milk. It is the fermentation of milk sugar (lactose) into lactic acid that gives yogurt its gel-like texture and characteristic tang.

The history of yogurt

Cultured milk products have been produced as food for at least 4,500 years. The earliest yogurts originated in southeastern Europe, and were probably spontaneously fermented by wild bacteria residing inside goat skin bags used for transporting milk.

Yogurt remained primarily a food of India, Central Asia, Western Asia, South Eastern Europe and Central Europe until the 1900s, when a Russian biologist named Ilya Ilyich Mechnikov theorized that heavy consumption of yogurt was responsible for the unusually long life spans of Bulgarian peasants. Believing *Lactobacillus* to be essential for good health, Mechnikov worked to popularize yogurt as a foodstuff throughout Europe. It fell to a Spanish entrepreneur named Isaac Carasso to industrialize the production of yoghurt. In 1919 he started a commercial yoghurt plant in Barcelona, naming the business Danone after his son — better known in the United States as 'Dannon'.

Yoghurt was first commercially produced and sold in the United States in 1929 by Armenian immigrants, Rose and Sarkis Colombosian, whose family business later became Colombo Yogurt. (Wkipedia: http://en.wikipedia.org/wiki/Yogurt)

HOW TO MAKE YOGURT AT HOME

Yogurt is very simple to make at home. You will need the following materials:

Equipment

- heavy pot with lid, capacity 1+ gallon
- four 1 quart jars with lids, sterilized
- one 8 oz jar with lid, sterilized
- candy thermometer (range 0 to 225 °F)
- 1 medium sized cooler with close fitting lid

Supplies:

- 1 gallon fresh milk (whole milk makes richer flavored yogurt, skim milk makes it non-fat)
- 1 cup fresh plain yogurt **with active live cultures** (will not work without live cultures)

Homemade Yogurt—Using "Good" Bacteria

Procedure

1. Sterilize jars and lids which will be used to make the yogurt: place them in a 5 gallon pot with an inch of water in the bottom. Cover and bring to boil. Boil for ten minutes. Turn off heat, do not remove lid.
2. Using a pot with a thick bottom, add one gallon of milk. You may use whole, 2% or skimmed milk. Warm the milk over a medium fire (not so hot that it burns on the bottom). Heat until the temperature of the milk is 185-195 °F. It is not necessary to boil, and do not let boil over...what a mess!
3. Place the covered pot of milk in a pan of clean cold water to cool it down. Cool the milk to 122-130 °F. Remove the pot of scalded and cooled milk from the cooling bath.
4. Place one cup of the scalded and cooled milk in a two cup measure.
5. Add enough fresh, uncontaminated yogurt to bring the level up to two cups.
6. Stir to blend the yogurt starter into the scalded and cooled milk until homogeneous.
7. Stir the yogurt-milk slurry slowly into the 122 °F scalded and cooled milk. Stir very well to thoroughly distribute the yogurt starter.
8. Once thoroughly mixed, distribute the inoculated milk to the sterilized jars, filling to the neck. Cover immediately with sterile tops. Tighten well.
9. INCUBATE: Warm a gallon of fresh clean water to 130 °F, pour into a clean cooler. Place in a warm location. Carefully set the jars of inoculated milk in the water so the bottom of the lids are above the water.
10. Check to see that the water in the cooler is not below 122 °F or above 130 °F.
11. Close the cooler, place in warm place and let sit undisturbed for three hours. If the starter was active and the temperature correct, the yogurt will have gelled.
12. Place jars in the refrigerator. Add sweetener (maple syrup works great!) and/or fruit (fresh or preserved) and enjoy!

Note: do not consume if the yogurt has separated or is of non-typical consistency.

COOKING WITH YOGURT: YOGURT RECIPIES

http://www.thegutsygourmet.net/yogurt.html

http://recipes.stonyfield.com/recipecategories.cfm

Activity: Observing Bacteria Cultures in Yogurt

Materials:

- Plain yogurt with active cultures
- Light microscope
- Slides, cover slips
- Distilled water
- Dropper

Procedure:

1. Clean your slides and cover slips for dust and other particles.
2. Place a very small portion of plain yogurt onto the slide, and add one drop of water. Place the cover slip on top.
3. Under low power, find a section where the yogurt is pretty thin; this is where you will find the bacteria.
4. Switch to high power (400X for most microscopes) for a better view of the bacteria. If you have a microscope with an oil immersion lens, it will give you an even better view of these small organisms.
5. Make a sketch of your view under different magnifications.

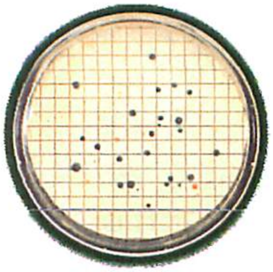
Questions:

How many different kinds of bacteria could you find?

What other foods have bacteria living in them?

Bacteria and Human Health

Invisible Microbes Everywhere



Learning Objectives:

- Correctly identify two types of microbes found in and around the classroom
- Understand the importance of hand washing

♦Duration:

1 40 min. class

Ongoing observation

♦Setting:

Classroom/lab

♦Materials

Petri dishes

Agar solution

Sterile cotton swabs

Antibacterial soap

Regular soap

Observation sheet

♦Assessment

Summary

Students choose various surfaces to swab and culture bacteria, then observe growth.

Focus questions:

- Where are bacteria found?
- What diversity of bacteria are found in and around my school? On my hands?
- What effect does washing my hands with and w/o soap have on bacterial growth?

In this lesson, students culture bacteria from various surfaces, as well as their hands before and after washing with soap.

Background

Bacteria live on or in just about every material and environment on Earth from soil to water to air, and from your house to arctic ice to volcanic vents. Each square centimeter of your skin averages about 100,000 bacteria.

Your body is home to trillions of microbes. Run your tongue over your teeth—you're licking thousands of microbes that normally live on your teeth, like those pictured here. Millions of them live on your tongue, too. A large part of "you" (that is, the mass of your body) is actually something else: bacteria, viruses and fungi. Isn't that a weird thought?

Pick up a fistful of garden soil and you're holding hundreds if not thousands of different kinds of microbes in your hand. A single teaspoon of that soil contains over 1,000,000,000 bacteria, about 120,000 fungi and 25,000 algae.

Background (Continued)

Fomites? What are fomites?

This is a term for any inanimate object that can carry disease-causing organisms. Your cutting board, kitchen sink, the change in your pocket and even that pen you keep putting in your mouth are all fomites. Very few things we encounter in our everyday activities are sterile, or microbe-free, including us. At birth, microbes immediately begin colonizing our bodies as they do most every object in the world. They float around until they come in contact with a surface that offers food and shelter. You are most likely to find microbes in and on dark, moist objects that frequently come into contact with food, dirt or vegetation. Bathroom surfaces, hairbrushes, refrigerators, kitchen sinks and cutting boards often have lots of microbes on them. But doorknobs and walls have fewer because they are nutrient-poor and dry.

Most of the microbes on our bodies and other surfaces are harmless, but some are pathogenic or disease-causing. For this reason, we want to control the number of microbes around us. The odds of becoming infected increase with the number of microbes on surrounding objects. But what can we do to affect the number of microbes on surfaces around us?

In this activity, students will test a chosen fomite for the presence of microbes and the effects of a disinfectant by growing colonies of bacteria in a medium on Petri plates. A medium has food, vitamins and salts that help microbes grow. You usually don't see bacterial colonies like those that form on Petri plates on everyday surfaces. That's because there is rarely such a perfect concentration of nutrients on fomites in nature.

Warm-Up

Hand washing and Fomites Warm-up Discussion:

Show students several "clean" looking objects: a desk, a pencil, etc. Ask students if they see anything there. Are there any microbes present? How do they know?

How many students washed their hands in the last hour? Last four hours? Before lunch? How many students use antibacterial soap at home? Why?

Introduce vocabulary:

fomite, microbe, antibacterial, culture, pathenogenic, microscopic

Introduce Experiments:

Students will conduct two experiments: test the effectiveness of two types of soap used in hand washing and also test several surfaces around the school for the presence of microbes.

Activity

Conduct Experiment

Hand out the "Invisible Microbes Everywhere" procedure and observations sheet. Students will work individually or in pairs to complete experiment

Daily tasks

Every day for the rest of the week, students will take 5 minutes to observe the dishes. Remember that microbes are very small, so it will take a couple of days before they multiply enough on the dish so that there are enough to see.

Students will record the following in science journals

On the top half of each page, students will record the date and the dish name (ie fomite name, or soap type) and draw what the dish looks like.

On the bottom half students will write two or three sentences:

- What color are the microbes?
- How many groups of microbes do there seem to be?
- Do all the microbes look the same, or do you think that there are different kinds growing?
- What has changed from the previous observation?
- Other observations?

Wrap-Up

After the students have finished observing the dishes for one week, students will complete the results and conclusions sheets.

Have students complete class data charts on the board. Include the name, surface tested, soap used, microbes identified.

Discuss results and share conclusions.

Invisible Microbes Everywhere

Procedure

Handwashing

1. Pick a type of soap (antibacterial or regular) to test and record type in journal. You are going to test the effectiveness of this soap by culturing your hands before and after use.
2. Get a Petri dish and a sterile swab in a package. The Petri dish is filled with agar, which contains nutrients that microbes like to eat.
3. When you are ready, rip open the packaging and rub the tip of the swab over your hands. Make sure that every part of the swab tip touches the surface of your skin.
4. Open the Petri dish and run the swab tip over the entire dish. You want to rub hard enough so that you transfer your sample from the swab to the dish, but not so hard that you tear through the agar.
5. Close the dish and tape it shut. Write your name, the date, and the words "before washing" with a Sharpie.
6. Wash your hands with the chosen soap and repeat steps 2-5, except write your name, the date, and the words "after washing" and the type of soap used with a Sharpie on the dish.
7. Throw the swab, the packaging, and your gloves away, and wash your hands.

Fomites

1. Pick a "fomite" that you want to test to see if it has bacteria on it. You can test your desk, the floor, your skin, etc.
2. Record fomite name in your journal and show it to your teacher.
3. Once your choice has been approved, you will be given a Petri dish and a sterile swab in a package. The Petri dish is filled with agar, which contains nutrients that microbes like to eat.
4. When you are ready, rip open the packaging and rub the tip of the swab over the surface that you have chosen. Make sure that every part of the swab tip touches the surface.
5. Open the Petri dish and run the swab tip over the entire dish. You want to rub hard enough so that you transfer your sample from the swab to the dish, but not so hard that you tear through the agar.
6. Close the dish and tape it shut. Write your name, the date, and the surface that you tested on the dish with a Sharpie. Throw the swab, the packaging, and your gloves away, and wash your hands.

Invisible Microbes Everywhere

Observations

Daily tasks

Every day for the rest of the week, take 5 minutes to observe your dishes. Remember that microbes are very small, so it will take a couple of days before they multiply enough on the dish so that there are enough to see.

Record the following in your science journal

On the top half of each page, record the date and the dish name (ie fomite name, or soap type) and draw what the dish looks like.

On the bottom half write two or three sentences:

- What color are the microbes?
- How many groups of microbes do there seem to be?
- Do all the microbes look the same, or do you think that there are different kinds growing?
- What has changed from the previous observation?
- Other observations?

Invisible Microbes Everywhere

Results

Handwashing

1. Which soap did you choose?
2. Are there bacteria on both of your petri dishes?
3. Can you see a difference between the dishes? Which one has more?
4. How many days did it take before you saw the bacteria?
5. How many colonies of microbes do you have now? (if there are too many to count easily, make a guess)
6. How many different colors of microbes do you see on your dish? What are they?

Fomites

1. Which fomite did you choose—where did you test for bacteria?
2. How many days did it take before you saw the bacteria?
3. How many colonies of microbes do you have now? (if there are too many to count easily, make a guess)
4. How many different colors of microbes do you see on your dish? What are they

For Both

Do you see any of the specific types of microbes that are described on the other handout? Make a check next to any of the types that you can find on your dishes.

Name	Fomite	Before hand washing	After hand washing
M. luteus,			
Staphylococcus aureus			
Steptococcus pyo-genes,			
Corynebacteria			
Other			

Invisible Microbes Everywhere

Conclusions

Handwashing

1. According to the class data, which soap was more effective in killing bacteria?
2. Do all of the "before hand washing" Petri dishes contain the same amount of bacteria? Why or why not?

Fomites

1) If there are bacteria on your fomite Petri dish, this means that there are bacteria living on the surface that you swabbed earlier this week. Why do you think there are bacteria on that surface?
2) Or, if there aren't microbes on your Petri dish, why? Do you think that there aren't microbes living on that surface? Could there have been a mistake in the experiment?
3) When you look at the class data on the board, which location in the room seems to have the most microbes living in it? Does this make sense? Why or why not?
4) If you got to do this experiment again, is there anything that you would do differently? (For example, would you pick a different location in the room? Change something about how you collected your sample?, etc.) Explain.

Considering the results from both experiments, why is hand washing so important?

Bacteria and Human Health

How Much Bacteria?

Learning Objectives:

- Work in cooperative groups to collect data during field trip.
- Apply the scientific method: formulate a hypothesis, design and complete an experiment to test the hypothesis, analyze results, and make conclusions.

Duration:

Field work: 1-1.5 hours

Lab work: 20 min

Calculations: 40 min.

Setting:

Field and Lab or Classroom

Materials

For collecting the data in the field:

Bacteria Sampling Field Sheet, clipboard, pencils, stop watch, tape measure, orange, meter stick, bacteria sample bottles

For processing the Bacteria Samples:

Bacteria Processing Sheet, Coliscan materials, water samples

Assessment

How Much Bacteria? Lab report

Summary

Students collect and process water samples to answer the following questions:

- Is it safe to swim at our site?
- How much bacteria does our stream carry in one day?

To complete this lab, students work in groups to collect the water samples and measure the discharge at the time of sampling. Upon returning to the classroom, students process collected water samples using the Coliscan method, then incubate them for 24 hours. In subsequent lessons, they count the bacteria colonies to estimate the bacteria concentration, determine if the site meets state water quality standard for swimming and calculate the total bacteria loading in a 24 hour period.

Background

E. coli bacteria is found in the intestines of all warm blooded animals. It is used as an indicator of fecal pollution. The presence of high levels of E.coli indicates the likely presence of waterborne pathogens such as Hepatits A, Giardia, parasites, Cryptosporidium and Cholera.

Students will test the water at their sites to determine the concentration of E. coli bacteria, compare the results to the state standard (77 colonies E.coli/100mL) for swimming, and determine the bacteria loading for this stream. Bacteria loading is the total amount of bacteria that the stream carries in a given time period. Streams with very high bacteria loads contribute to beach closings.

To calculate the bacteria loading, students will collect several field measurements, including stream velocity and cross-sectional area. They will also determine the bacteria concentration (colonies of E.coli/100 mL water) using the Coliscan method.

Background (Continued)

The product of the **stream velocity** (m/s) and the **cross-sectional area** (m^2) is called the **stream discharge** (m^3/s) or flow rate. The product of the bacteria concentration and the discharge of the stream is the total bacteria loading for one day (colonies bacteria per day).

Warm-Up

Write the following statement on the board: When people do not clean up after their pets (feces), it can make others sick.

Ask students to indicate whether they agree or disagree with the statement. Note the number of students in each category on board. Ask those who answered "agree" why, and ask those who answered "disagree" why.

Pose additional questions as needed to help students remember that feces contains bacteria and pathogens which can flush into waterways during rainstorms, putting swimmers at risk (from previous lesson—What is bacteria? What are the sources of bacteria? How could pet waste enter a stream and why is this a concern? Who is it a concern for and why? How and why is bacteria used as an indicator of water pollution?).

Introduce the field activity as an opportunity to investigate the level of bacterial contamination at their water site.

Getting Ready for the Field

- Hand out and review "**Bacteria Sampling Field Sheet**" including the procedures for each test and the journal questions.
- Students should decide who will fill each role as outlined in the "Group Roles" section of field sheet.
- Each group's "Technician" should collect all of the equipment needed, and everyone should proceed to the bus.

In the Field

Each group should head to their site and follow instructions on the "How Much Bacteria? Field Sheet". Students will need approximately one hour to complete the exercise.

Back in the Lab: Processing the Bacteria Samples

Students should regroup in the classroom. Offer each group and chance to reflect on their field experience: any comments or questions about the field trip? Was there anything that was more challenging than you expected? Did you notice anything unexpected about the stream?

Next, each group will need to gather the following:

- "How Much Bacteria? Sample Processing Sheet"
- Coliscan materials
- Water samples from their site

Students should follow the instructions on the sample processing sheet. Incubate the samples at 35 degrees Celsius for 24 hours.

Wrap-Up

Assign any unfinished journal questions from the field sheet for homework.

For Next Time

Students will follow the Coliscan instructions to count bacterial growth on their Petri dishes, then complete the Bacteria Lab Calculations sheet to estimate the daily bacteria loading.

How Much Bacteria? Field Investigation Sheet

The goal for this field study is to answer the following questions:

- **Is it safe to swim at our site?**
- **How much bacteria does our stream carry in one day?**

Our hypothesis:

Our reasoning:

To test our hypotheses we will need to answer the following:

What is the **velocity** of the stream at the monitoring site?

What is the **discharge** of the stream at the monitoring site?

What is the **concentration of E. coli bacteria** in the water at the monitoring site?

Group Roles

Each group member will choose a role for the field exercise, and complete all required tasks according to the role description.

Role	Role Description
Technician	Responsible for managing all equipment needed; making sure group brings all equipment too and from site and knows how to use all equipment
Scribe	Responsible for recording all data and relaying recorded data clearly to all
Facilitator	Responsible for making sure group is on task and working together; requires sensitivity and good communication skills
Timekeeper	Responsible for keeping time and making sure group completes all task in time allotted.

Equipment List

- datasheet
- stop watch
- tape measure
- meter stick
- clipboard
- pencil
- orange
- sample bottles