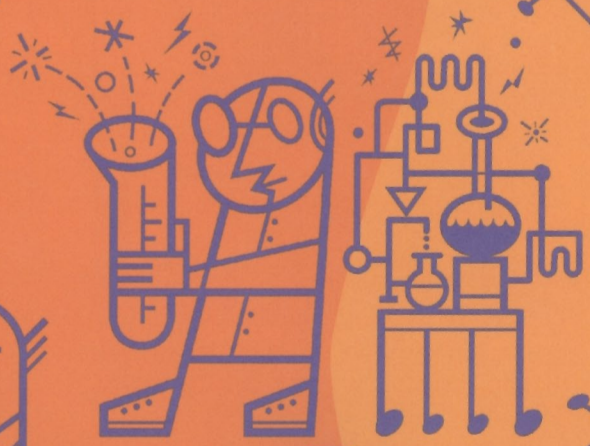
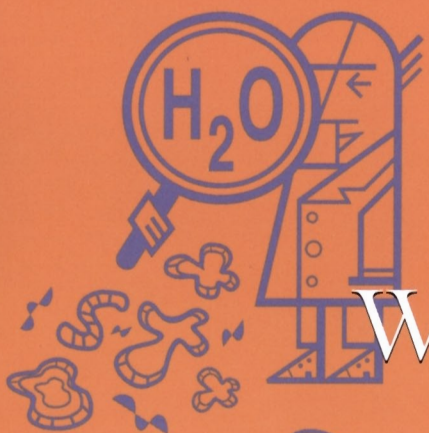
STUDENT BOOKLET

PART

2

Basic Science of Water Quality





Water Quality

MWD

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

It takes many specialized jobs to maintain the water distribution systems that bring you high-quality drinking water.

The Basic Science of Water Quality

Describing water quality is like describing how a person feels. You might feel OK, but still have a few warts or a slight heart murmur. A person with cancer might feel fine. A person with the flu might be sick as a dog for a week, but be healthy overall. The human body can heal itself and thrive, even when some things go wrong.

Bodies of water are much the same. They can get polluted, and they can become clean. It is hard to know just how "sick" a body of water is when it shows some signs of illness. Just as in human health, no single symptom or measurement reveals the overall health of a body of water.

When doctors examine us, they first look at key indicators, such as our blood pressure and our temperature. Likewise, water quality scientists look at key indicators in water, such as dissolved oxygen and how well the water supports life.

Doctors might also look at lifestyle factors such as smoking, drinking, eating a high fat diet and being exposed to pollution. Likewise, water quality specialists consider the land use around the water and the pollution that enters the water from factories, farms and roads.

Water quality scientists and technicians test for hundreds of chemicals and conditions to ensure high quality water. You will explore some of these conditions and observe their importance in this chapter. Some of these factors are:

- Dissolved Oxygen
- pH (acidity/alkalinity)
- Turbidity (cloudiness)
- Total Dissolved Solids ("saltiness")
- Hardness (calcium and magnesium)
- Taste and Odor
- Microorganisms

Each investigation in this unit includes a fact sheet that contains background information you can use to solve the problems posed in the lesson.

Water Quality Investigations and Fact Sheets

An overview of the eight investigations you can explore. Each highlights an important concept in the science of water quality.

INVESTIGATION	QUESTIONS TO EXPLORE	FACT SHEET
1: Oxygen, pH and the Diurnal Cycle	How does photosynthesis affect water?	1: Dissolved Oxygen and pH
2: Measuring Turbidity	How can you measure the cloudiness of water?	2: Turbidity
3: Designing a Test for Total Dissolved Solids	Does water conduct electricity?	3: Total Dissolved Solids and Salinity
4: Comparing Samples for Hardness	Is your water hard or soft?	4: Hardness
5: Nutrients and Water Plants	Is fertilizer good or bad for water?	5: Nutrients
6: The Taste and Odor Game	Can you identify qualities through taste and odor?	6: Taste and Odor
7: Microorganisms: Size, Scale and Filtration	How fine a filter do I need to catch a germ?	7: Microorganisms: Size, Scale and Filtration
8: Modeling a Genetic Test for *Cryptosporidium*	Is the parasite *Cryptosporidium* in our water?	8: *Cryptosporidium* and Genetic Tests

Oxygen, pH and the Diurnal Cycle

QUESTION

How does photosynthesis affect water?

RESEARCH MATERIALS

Fact Sheet 1: Dissolved Oxygen (DO) and pH

INTRODUCTION

In this investigation, you will see how two important water quality conditions interact with each other. Dissolved oxygen and pH are basic measures of the overall health of bodies of water. They are affected by natural cycles of daylight and darkness each day. You can simulate these natural cycles in your classroom and observe their effect on water.

Getting started

How does a body of water change throughout the day? Imagine a water plant that grows where it is warm and sunny 24 hours a day. Imagine another water plant that grows where it is dark and cool all day and night. Completely different kinds of fish, insects and plants would live in these two bodies of water!

In nature, both day and night exist every 24 hours. The sun rises, crosses the sky, then sets. Day turns to night. Temperatures rise and fall. All of these changes occur in a diurnal cycle: they happen every day. The diurnal cycle affects the level of dissolved oxygen in the water, the water temperature and its pH level or acidity. Plants and animals must adapt to these daily changes. This investigation will help you answer the following questions.

① How does the diurnal cycle affect water plants? How does it affect fish and other animals in the water?

② How do oxygen, temperature and pH level change throughout the diurnal cycle?

③ How can you detect the presence of oxygen in water? What can you measure that might indicate whether a plant is undergoing photosynthesis (producing oxygen and sugar) or respiring (consuming oxygen and releasing carbon dioxide)?

DEFINITIONS

Dissolved Oxygen (DO): DO is a measure of the amount of oxygen in water. Healthy levels are essential for a thriving ecosystem and high quality drinking water. Water receives oxygen from plant photosynthesis and turbulence (mixing with air).

Diurnal Cycle: "Diurnal" means daily, so the "diurnal cycle" describes changes that take place during the 24-hour day.

pH: The measure of acidity and alkalinity. Low pH level indicates acidity. A high pH level indicates alkalinity.

Photosynthesis: The process by which plants convert sunlight to food.

TRY THIS: BLOWING BUBBLES

Measure the pH of tap water in a glass. Then blow bubbles through a straw into the water and retest the pH level. What happened? Record your measurements in your journal. What does it mean?

Make a prediction

Consider the following questions and write your hypotheses in your journal.

① Imagine a body of water containing algae and plants at sunrise. In what ways would you expect the dissolved oxygen level, temperature and pH level to change after six hours of bright sunshine?

② How might the chemistry of the water reflect those changes?

③ What will happen if water containing a growing water plant is no longer exposed to sunlight?

Figure it out

Your teacher will provide you with a bowl or container and a water plant called *elodea* (pronounced e-lo'-dia). Over the next week or two, you will observe the changes in water with a growing plant throughout the diurnal cycle. Your task is to develop an experiment that will help you verify the hypotheses you made above. First, consider these questions:

① Does it make a difference what kind of water you use in the bowl? Why?

② What conditions should you observe and record? What equipment will you need?

③ Decide on a schedule for testing the water and observing the elodea a few times a day for several days in a row.

④ Record in your journal what you plan to do and how you plan to do it. Keep accurate details of your findings each day of the experiment.

What does it mean?

Use your journal to develop your conclusions about your experiment.

① Compare and analyze your measurements and observations over the course of the experiment. Compare your results with others in your class.

② What can you assume about dissolved oxygen levels based on your observations?

③ What can you conclude about the relationship between dissolved oxygen and pH?

④ How might you explain that relationship?

Make connections

① Can you think of any human activities that affect the DO and pH levels of water?

② How might geology and climate affect the DO and pH levels?

③ How might the pH level of water affect people? Fish? Plants?

TRY THIS: ACID AND ASPIRIN

Many minerals act as neutralizing agents that raise the pH of acids, bringing it closer to neutral, or 7. These neutralizers work not only in soil and water, but also in our stomachs. The primary ingredients in common over-the-counter pain killers are acidic. The main ingredient in Aspirin is acetylsalicylic acid; in Tylenol®, it is acetaminophen; and in Advil®, it is ibuprofen. Buffered aspirins add minerals to neutralize the acidity. Use narrow range pH paper to test the acidity of these three common medications. Which one do you think might be gentlest on your stomach?

What could you use to reduce acidity in lakes or rivers?

Research how water quality engineers treat water that is either too acidic or too alkaline.

Go further: Percent of saturation

Question: Does the temperature of the water affect the amount of oxygen it can hold?

Make a prediction

Write in your journal your prediction about whether the temperature of water affects the amount of oxygen it can hold.

Figure it out

Develop a method to test the effect of temperature on DO levels.

TRY THIS: SPEWING SODA

Find out whether cool liquids hold more gas than warm liquids. Place a one-liter bottle of carbonated soda in a refrigerator and another in a warm spot, such as in the sunshine. After about an hour, open them both. Which one spews more liquid? Why?

What does it mean?

① What impact might the temperature of water have on fish during the 24-hour cycle? During different seasons? In different climates?

② Develop a theory that explains the occurrence of "fish kills" in otherwise healthy bodies of water. When would they be most likely to occur? Why?

Measuring Turbidity

DEFINITIONS

Turbidity:
The measure of water's cloudiness.

QUESTION

How can you measure the cloudiness of water?

RESEARCH MATERIAL

Fact Sheet 2: Turbidity

INTRODUCTION

The turbidity of water affects the way it looks, tastes and smells, as well as how healthy it is. In this investigation, you will develop a device for measuring turbidity, and you will develop your own standard measuring unit.

PART 1: Developing a Turbidimeter and Making "Subjective" Observations

Getting started

Suppose you have two glasses of water. One looks cloudy and murky. The other looks crystal clear. Which one would you like to drink?

If you were a water agency and needed to treat water for drinking, which water sample do you think you would rather start with, the cloudy one or the clear one?

How can you measure the turbidity of a water sample?

Make a prediction

Your teacher will give you several water samples. Can you rank those samples from least turbid to most turbid by looking at them, or must you develop a special way of looking? Make a prediction or hypothesis about whether you can rank the samples accurately just by making a visual comparison. Write your hypothesis in your journal.

Figure it out

How will you test your prediction? Use your journal to describe a way to prove or disprove your hypothesis.

① What type of container might you use for comparing the samples?

② How could you make a visual comparison? Does the way you look at water affect your ability to detect differences in turbidity?

③ Rank the samples and record their order in your journal.

④ After your teacher tells you how turbid each sample really is, record whether your rank order was accurate.

A NOTE ON OBJECTIVITY AND SUBJECTIVITY

Things that are "objective" can be measured, quantified or dealt with scientifically. Any two people using the same level of precision should get identical results. Objectivity means "without the uncertainty of human experience."

"Subjective" measurement introduces the human element. It includes personal opinions and experiences that may not be measurable and that almost certainly differ from person to person. It depends on personal factors, such as how well a person sees or a person's beliefs.

For example, the temperature outside may be 35°C. The objective statement would be, "It's 35 degrees Celsius outside." A subjective statement may range from "It's stifling" to "It's hot enough to fry an egg outside" to "The chill is finally off the air," depending on an individual's response to warmth.

What does it mean?

How "objective" is your method of comparing the different water samples by looking at them?

PART 2: Devising Your Own "Objective" Measure of Turbidity

Getting started

Scientists need to use standard units of measurement. For example, yards and meters are standard units of length, and pounds and grams are standard units of density or weight.

Make a prediction

Can you devise a standard objective unit for measuring turbidity?

Figure it out

Develop a procedure to test your hypothesis and record it in your journal.

① Develop a list of materials and equipment you might use to develop a standard unit for measuring turbidity.

② When you are finished, name your unit. You may want to use a name such as "Jane's Turbidity Unit" or "JTU."

③ Get several kinds of turbid water from nature, such as from a pond, aquarium or an outdoor fountain, and measure that water's turbidity using your standard.

④ Share your turbidity standards with your classmates and compare measurements.

Talk it over

① In your journal, describe your measurement system, and then explain it to the class.

② What are the strengths and weaknesses of your system? Of your classmates' systems?

What does it mean?

① Write a paragraph in your journal about why it is important for scientists to establish standard units of measurement such as the one you have created.

② Sell your turbidity measure to the rest of your class. Develop an advertisement explaining why your measuring system is "the best." Consider making:

- a newspaper ad
- a one-minute TV spot
- a one-minute radio commercial
- a poster ad
- a billboard display
- a mock web page

Make connections

① Why is it important to know the turbidity of a drinking water source?

② What are the sources of turbidity in a watershed, and how can they be controlled?

③ What effect does high turbidity have on other aspects of a body of water?

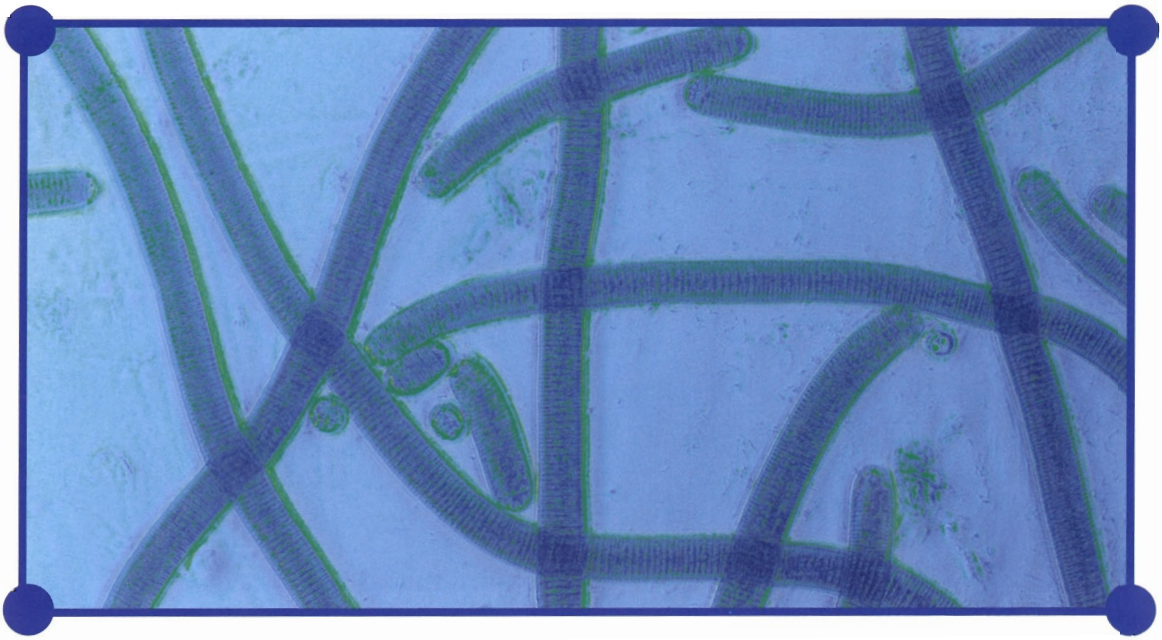
Go further

① How can we reduce turbidity in a turbid sample?

② Design and build a device that reduces turbidity.

③ What is the advantage of an objective standard of measurement over a subjective standard?

④ What are the standard units used by water scientists to determine turbidity?



Most turbidity is caused by dirt, dust and organic material, such as plankton, algae and leaves (algae pictured above).

Designing a Test for Total Dissolved Solids

DEFINITIONS

Total Dissolved Solids:
The total quantity of minerals and salts dissolved in water.

QUESTION

Does water conduct electricity?

RESEARCH MATERIALS

Fact Sheet 3: Total Dissolved Solids or TDS

INTRODUCTION

In this investigation you will build a device that can test whether different water samples can conduct electricity. This test will give you a way of measuring the level of dissolved solids in the water.

Getting Started

We have all learned to be careful of electrical appliances around water because water is a "good conductor of electricity." But is that totally true? If so, does all water conduct the same amount of electricity?

Make a prediction

Write in your journal your hypotheses about the following questions:

① Does distilled water conduct electricity?

② Do different types of water (distilled, fresh, brackish, salty) differ in their ability to conduct electricity?

IMPORTANT SAFETY NOTE: NEVER use 120-volt line during this investigation. Use BATTERIES only! DO NOT PLUG YOUR EQUIPMENT INTO A WALL OUTLET.

Figure it out

Your teacher will provide you with materials that you can use to test whether water really does conduct electricity and whether all water is equally conductive. Use your journal to develop a procedure for testing the conductivity of water.

① How can you verify that electricity is flowing through water?

② Does the water conduct electricity over long distances, or just across short distances?

③ Does varying the amount of a substance in water change the amount of electricity it might conduct?

④ With what kind of water should you start this investigation?

What does it mean?

① Propose a theory in your journal to explain what you have observed.

② Would you revise the statement, "Water conducts electricity," and if so, how?

③ What does the conductivity of water tell you about TDS? Does the water's conductivity give you information about all the solids dissolved in the water?

Make connections

① Do you think the conductivity of all the water delivered to Southern California's homes is the same throughout the year? Explain your reasoning in your journal.

② Check the electrical conductivity of various water samples, including tap water, rain water and water from streams, fountains or aquariums. Bring in samples of your own tap water. Does your water conduct electricity? Can you draw any conclusions about the sources of this water just by observing its ability to conduct electricity? What can the conductivity of water tell you about TDS?

③ Facilities engineers in many industrial plants carry conductivity meters in their shirt pockets for testing TDS in the same way that you carry a pencil. In these plants, complex networks of pipes carry water that is used primarily for cooling, so the temperature changes during each cycle, as the water takes in heat energy and releases heat energy. Why do you think TDS and conductivity might be important to these facilities engineers?

Many industries can only use water with a very low concentration of total dissolved solids.

Comparing Samples for Hardness

DEFINITIONS

Hardness: The total amount of calcium and magnesium dissolved in water.

QUESTION

Is your water hard or soft?

RESOURCE MATERIAL

Fact Sheet 4: Hardness

INTRODUCTION

The hardness or softness of water can affect its taste and healthfulness, as well as the health of pipes.

Getting started

You may already know your water is hard because it doesn't make many suds, or you have a bathtub ring, or your family has a water softener. How can you compare the hardness of your family's or school's tap water to other water, such as bottled water or distilled water?

Make a prediction

Record in your journal your hypothesis about how you could tell if a water sample is hard or soft.

Figure it out

① How can you develop a test for hardness that compares different samples of water? How long will the test take? Explain how your test works in your journal.

② Collect a few water samples from different sources and predict which will be soft and which will be hard.

③ Run the test you developed on each sample and record the results in your journal.

④ Rank the samples in order from softest to hardest.

What does it mean?

① How did your observations match your predictions?

② What are the advantages and disadvantages of having hard or soft water?

③ Do you think the test you devised would be helpful to water quality scientists? Why or why not?

Make connections

① If you have hard water, do you think you should try to soften it? Why or why not?

② In what circumstances might hard water become a concern?

③ Once a week for a month, measure the hardness of tap water using your methods. If you found any changes, how might you account for them?

④ How many families in your class have water softeners? How many have problems with scale in pipes or "scum" in sinks and tubs?

⑤ Why do people care whether their water is hard or soft?

⑥ If you have hard water, is the pH likely to be stable or variable? Why?

Nutrients and Water Plants

QUESTION

Is fertilizer good or bad for water?

RESOURCE MATERIALS

Fact Sheet 5: Nutrients

INTRODUCTION

In this investigation, you will experiment with the effect of nutrients on water quality.

Getting started

Can plants grow without nutrients? If having some nutrients is good for plants, is having more nutrients better? Can there be too much of a good thing? What happens to a body of water that contains a lot of nutrients?

Make a prediction

Your teacher will give you materials you can use to observe the effects of nutrients in water and compare the effects under different conditions. Write in your journal what you think you will observe in each sample.

Figure it out

① What variables should you test to observe the effects of nutrients on water?

② How can you adjust these variables using the material provided?

③ What can you do to keep the other variables constant?

④ How many samples do you need to test these variables? (Be sure to label them!)

⑤ How long should you leave the samples to observe meaningful results?

⑥ How often should you observe and record your results?

⑦ Write down your procedure in your journal, explaining each step you need to take. Include a method for recording your observations over the length of the experiment.

⑧ Set up your experiment.

⑨ Record your initial observations and maintain your records.

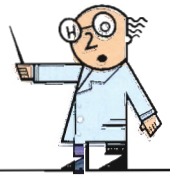
DEFINITIONS

Nutrients: Chemicals in water, mostly nitrogen and phosphate, that provide nourishment to algae and other plants.

Aerobic: Living in an environment that contains atmospheric or dissolved oxygen.

Anaerobic: Living in an environment without atmospheric or dissolved oxygen.

Eutrophication: A set of physical, chemical and biological changes caused by excess nutrients in the water. These nutrients stimulate plant growth and algal blooms that deplete the supply of dissolved oxygen and eventually kill aerobic life in the water.



What does it mean?

① What can you conclude about the need for nutrients in raw water and the need for controlling nutrients?

② Which of your samples is likely to produce an algal bloom? Why?

Make connections

Pretend that you've been invited to submit your research findings to a scientific journal. Write a "Research Paper" discussing your findings. Include these items in your paper:

- A description of your experiment.
- A description of its results.
- A theory about the effect of nutrients on water.
- A hypothesis about the effect of extra nutrients on other aquatic life.

Consider these issues in your report:

- What might happen to the oxygen levels?
- What might happen to the amount of biological decay, and how will that decay affect water conditions over the long term?

Conclude your report with a recommendation about controlling the plant and algae growth in a body of water.

Go further: Tracking pH and DO

① If you did the dissolved oxygen/pH investigation in this chapter, do it over again using different levels of nutrients. Track the changes in pH and dissolved oxygen in these samples. Do these findings reinforce or change your conclusions from the earlier investigation?

② Research and write a paper about how eutrophication can be caused by excess nutrients in natural bodies of water.

The Taste and Odor Game

DEFINITIONS

Taste and Odor:
"Aesthetic" concerns about how drinking water tastes and smells.

QUESTION

Can you identify qualities through taste and odor?

RESOURCE MATERIAL

Fact Sheet 6: Taste and Odor

Getting started

At the Metropolitan Water District, a panel of taste and odor experts taste and smell water samples and rate them every single day. How easy is it to tell the difference between different water samples based on only these two senses? It's harder than you may think!

The "Blind" Taste and Odor Game

Your teacher will provide you with samples of different kinds of water, but you will not know what they are. None of these samples has toxic or unhealthy ingredients, but to be safe, tell your teacher if you have any food allergies!

In the "taste" portion of the test, you will rate samples of hot, cold and room temperature water for their flavor. In the "odor" portion, you will try to identify common scents from their smell alone.

Guidelines for Taste and Odor Tests

You will use the techniques developed by wine tasters, perfume testers and water scientists: clear away other tastes/smells so your senses are fresh for the new sample. Then take only a small taste/whiff, because too much can overwhelm your senses.

Taste: "Clear your palate" by rinsing your mouth with distilled water. You may repeat this whenever you want. Taste the sample and complete the Taste Test Worksheet.

NOTE: In most laboratory practices, scientists do not taste samples.

Odor: Before smelling a sample, clear your nose and breathe in fresh, unscented air. Do not put your nose all the way to the cup. Hold the cup about 10 cm from your nose with one hand. With the other hand, wave the air above the cup toward your nose and take a few quick sniffs. Complete the Odor Test Worksheet.

Make a prediction

① Can you taste differences in tap water and bottled water?

② Does temperature affect flavor? If so, how?

③ Will you be able to identify various common smells?

④ What factors influence our ability to identify various tastes and odors?

Figure it out

① Taste the water samples one at a time and record your reactions on the sheet supplied by your teacher.

② Sniff the odor samples and record your findings.

③ If you overhear comments from others, ignore them. You may be surprised at how many different tastes people will identify for the same sample.

What does it mean?

① Once you have tried to identify the samples, your teacher will identify them for you. Are you surprised at the results? If so, why?

② Compare your results with those of your classmates. What were the similarities and differences in your findings? How do you explain these differences?

③ What impact did temperature have on your ability to identify the samples by taste? How can you explain this result?

④ Write your conclusions regarding the temperature, flavor and odor of drinking water in your journal.

Make connections

① Do you or does anyone you know drink bottled water? Why?

② Why do you think the Metropolitan Water District has a taste and odor panel?

③ Research ways that water agencies ensure that water tastes and smells good.

④ What factors besides minerals and temperature may affect the taste of water?

Microorganisms: Size, Scale and Filtration

DEFINITIONS

Filtration: Screening out the organisms and solids in water. The size of the filter's openings determines the size of the particles that are removed.

Microorganisms: Organisms so small they can only be seen through a mircroscope.

QUESTION

How fine a filter do I need to catch a germ?

RESEARCH MATERIALS

Fact Sheet 7: Microorganisms: Size, Scale and Filtration

Getting started

Why do we keep microorganisms out of our drinking water? Why do we need to use both disinfection and filtration to keep them out? How effective is a single filter? What will it filter, and what won't it filter?

Make a prediction

Could a filter remove disease-causing germs?

Figure it out

Sample Scales

Your teacher will give you a series of diagrams that were made at different scales, ranging from 1:1 to 1:10,000,000. Study these diagrams. How small would the pencil lead look on the 1:1 grid showing the penny? How large would the pencil lead look on the 1:100 grid showing the thickness of an index card? Would the molecule of cholesterol be visible on the diagram showing the penny?

What does it mean?

Indicate on the Microorganisms: Size, Scale and Filtration Worksheet, which items shown would fit through the openings of each scale diagram.

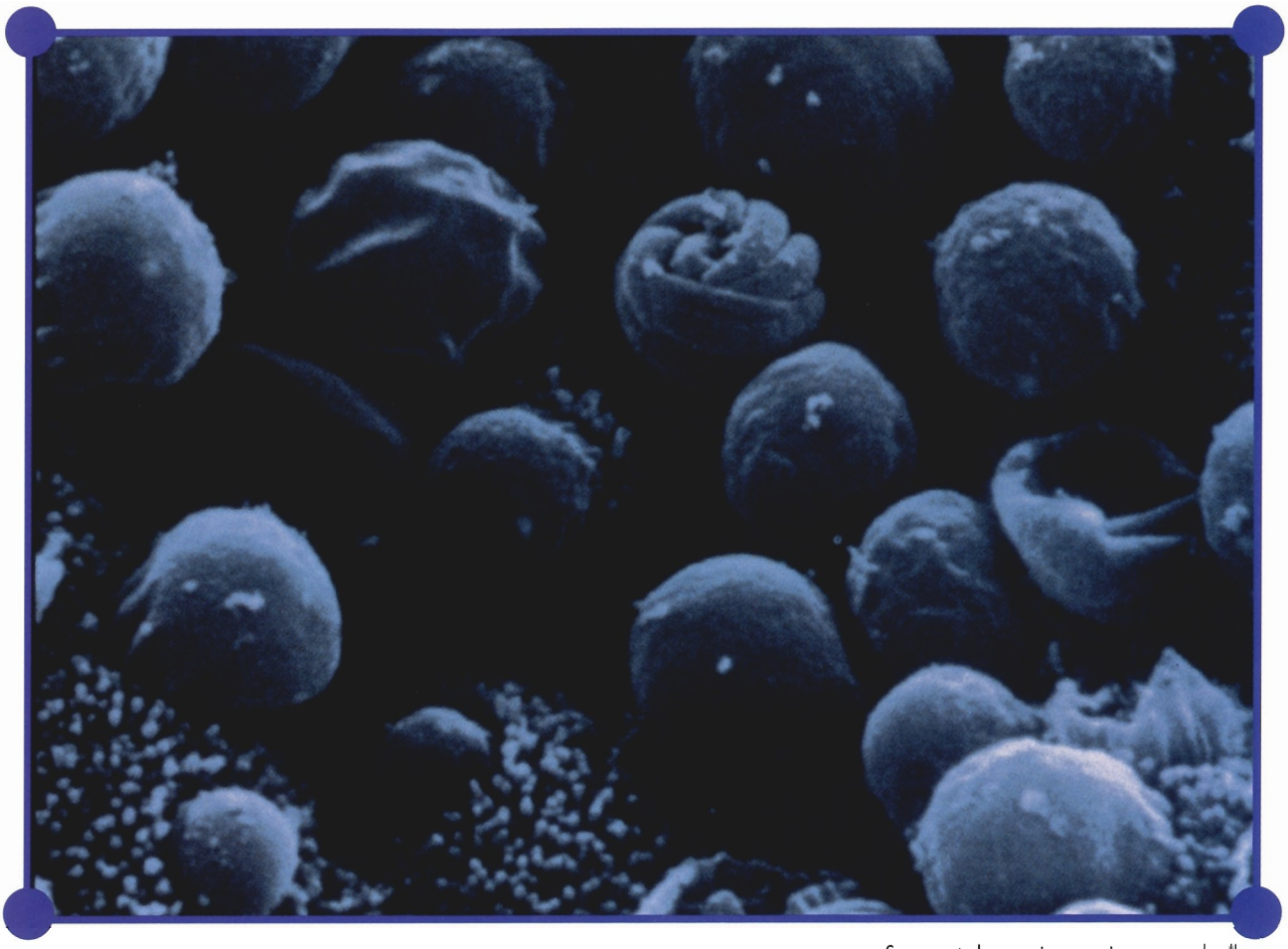
Make connections

① What size filter do you think a water agency should use to protect the water supply from disease-causing microorganisms?

② Why do water agencies filter water to remove microorganisms if they can kill them by disinfection?

③ Research the kinds of filters used by water treatment and wastewater treatment plants. What different kinds of technology do they use? What are the pros and cons of different filtration technologies?

④ Where else in your life might you be concerned with issues of scale?



Some waterborne microorganisms cause deadly diseases such as cholera and typhoid.

Go further

Microscopes and Filters

① With a microscope and knowledge of magnification, look at a coffee filter. Notice the wood fibers and the holes between them.

② Measure those holes and calculate what size particle would pass through them during filtration.

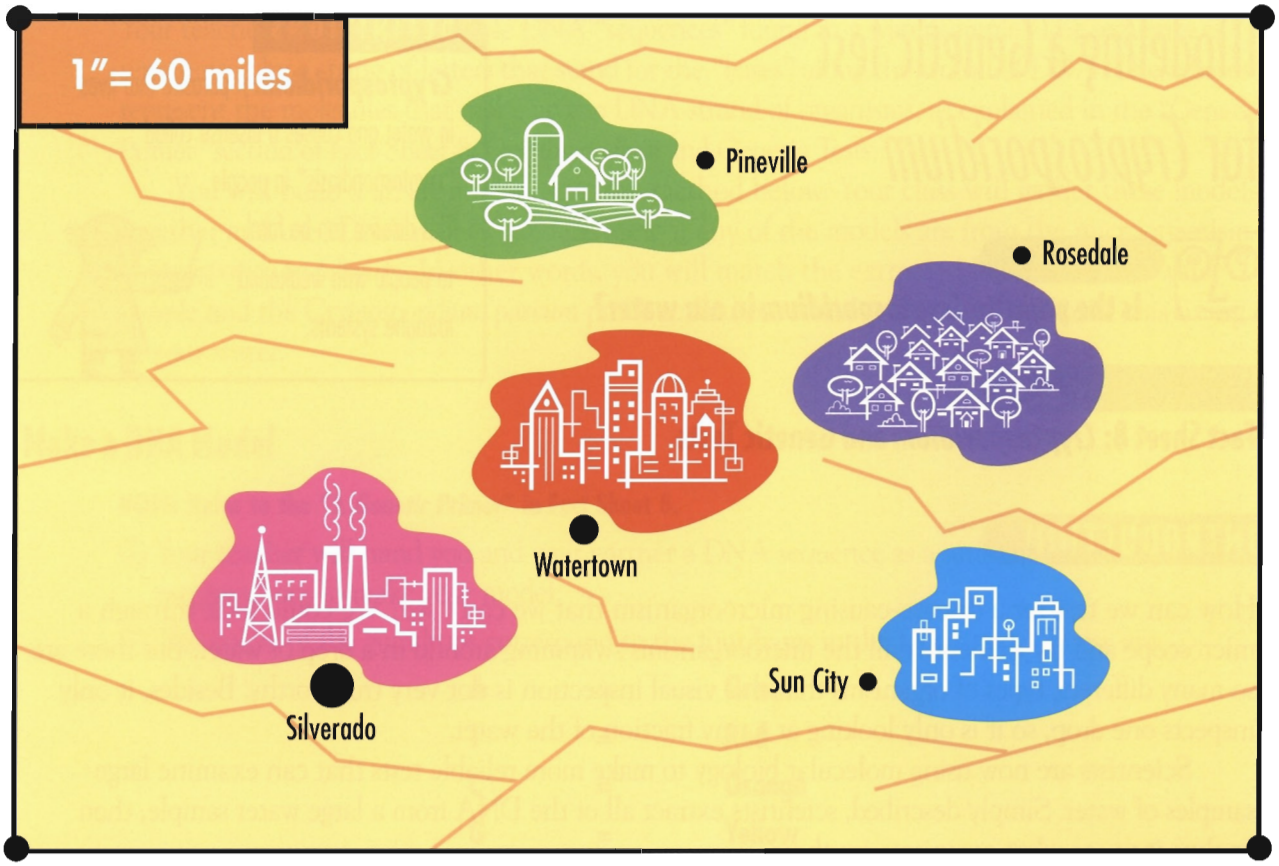
③ Could you use this paper filter to treat drinking water?

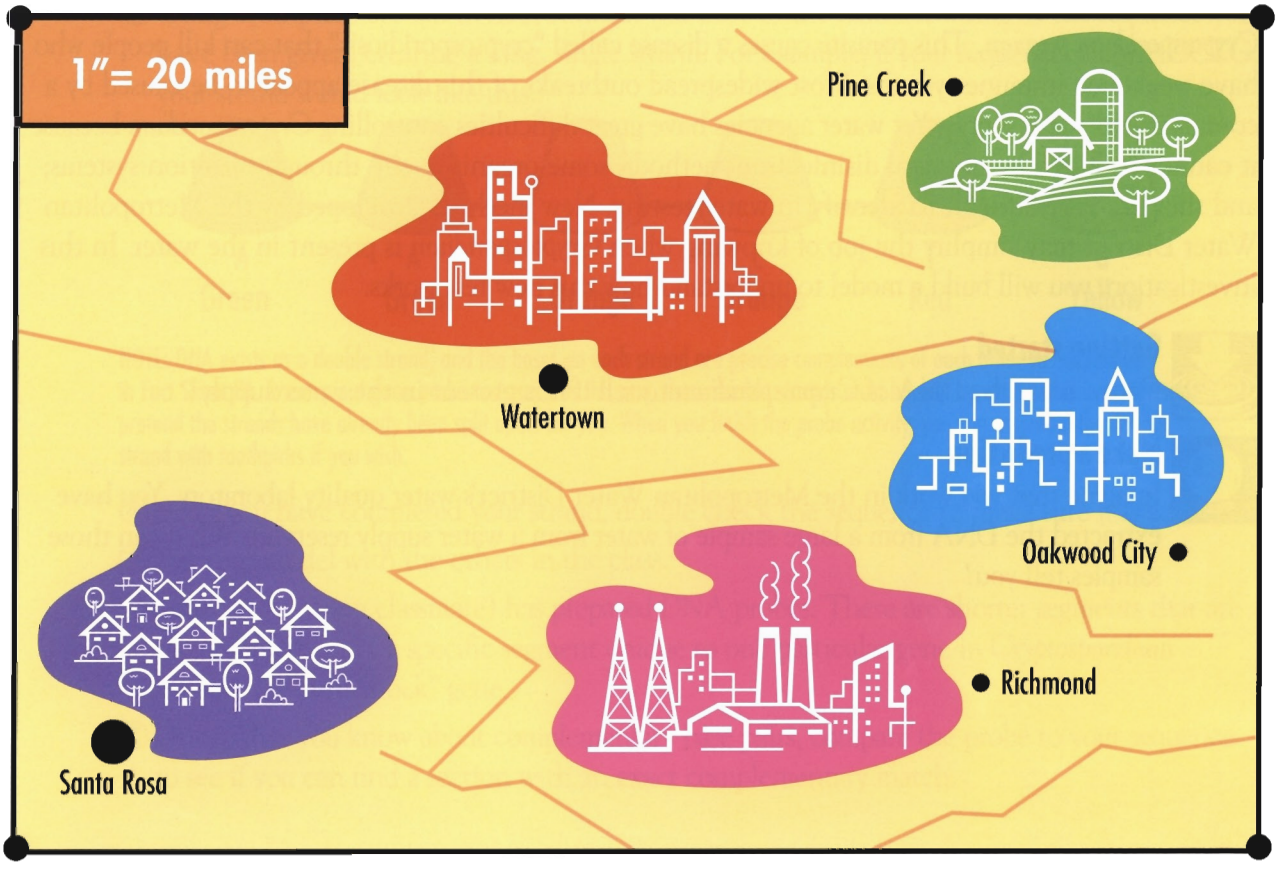
Map reading

When you look at a map, it is not drawn to actual size. All maps contain scale keys just like the drawings in this investigation. They are generally written as 1" = *x* miles or 1 cm = *x* km.

① Examine the maps on the next page. You have to walk from Watertown to the closest town. Which town will you be walking to?

② What is the actual distance to each of the towns shown?

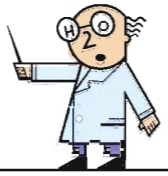

1″= 60 miles
Pineville
Rosedale
Watertown
Silverado
Sun City


1″= 20 miles
Pine Creek
Watertown
Oakwood City
Richmond
Santa Rosa

Modeling a Genetic Test for *Cryptosporidium*

DEFINITIONS

Cryptosporidium: A parasite that lives in water and causes a disease called "cryptosporidiosis" in people. This disease can be fatal to people with weakened immune systems.



QUESTION

Is the parasite *Cryptosporidium* in our water?

RESOURCE MATERIAL

Fact Sheet 8: *Cryptosporidium* and Genetic Tests

INTRODUCTION

How can we test for a disease-causing microorganism that we can't see? We could look through a microscope and try to identify all the microorganisms swimming around in a drop of water. But there are so many different types of organisms that this visual inspection is not very trustworthy. Besides, it only inspects one drop, so it is only looking at a tiny fraction of the water.

Scientists are now using molecular biology to make more reliable tests that can examine large samples of water. Simply described, scientists extract all of the DNA from a large water sample, then analyze it to see what organisms are there.

Water scientists have developed a technique using DNA to search for an infectious parasite called *Cryptosporidium parvum*. This parasite causes a disease called "cryptosporidiosis" that can kill people who have weakened immune systems. Most widespread outbreaks of this disease appear to be caused by a contaminated water supply. Yet water agencies have great difficulties controlling *Cryptosporidium* because it cannot be killed by standard disinfection methods; some organisms slip through filtration systems; and they are very difficult to identify in water testing. New methods developed by the Metropolitan Water District may simplify the job of knowing when *Cryptosporidium* is present in the water. In this investigation, you will build a model to understand how this new test works.

Getting started

Can you use the DNA of *Cryptosporidium* to tell if it is present in the water supply?

Make a prediction

Imagine that you work in the Metropolitan Water District's water quality laboratory. You have extracted the DNA from a large sample of water from a water supply reservoir. What can those samples tell you?

Your teacher will give you sample DNA "sequences" found in a water sample. The sequence is represented by a string of letters that stand for the "bases" along the strand of DNA. These bases represent the molecules that make up the DNA strand of organisms, as explained in the "Genetic Primer" section of Fact Sheet 8: *Cryptosporidium* and Genetic Tests.

You will build a DNA model using the method below. Your class will gather these models together and use "DNA probes" to determine if any of the models are from the microorganism *Cryptosporidium parvum*. In other words, you will match the extracted DNA from the water sample and the *Cryptosporidium parvum* probe to find out whether or not this parasite was living in your water.

Make a DNA Model

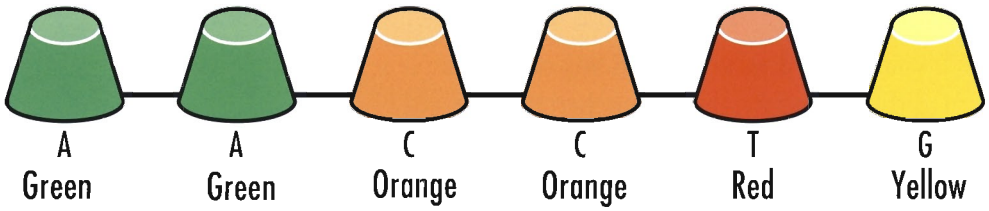
NOTE: Refer to the "A *Genetic Primer*" in Fact Sheet 8.

① Your teacher will hand you and your partner a DNA sequence as a series of letters. You will use gumdrops to make your model.

② The colors of the gumdrops correspond to the four bases in the DNA code. These are:

A	=	**Green**
T	=	**Red**
C	=	**Orange**
G	=	**Yellow**

③ Using toothpicks broken in half, connect one base to the next according to the sequence you have been given, creating a long, single strand. For example, if your sequence was AACCTG, your strand would look like this:



NOTE: DNA exists as a double strand, and the bases on each strand are precise complements of each other (as explained in Fact Sheet 8). To carry out gene probe tests such as this one, those double strands must be split apart. For this investigation, pretend the strands have already been split apart for you. When you finish the probe activity, you can assemble the double strand with toothpicks if you wish.

④ After you have completed your strand, double check the sequence to make sure it is accurate.

⑤ Put your model with the others in the class.

⑥ Your teacher (or a classmate) has prepared DNA probes. These are shorter segments that are the complement of a specific segment unique to one particular gene in *Cryptosporidium parvum:* its "heat shock" gene.

⑦ Using what you know about complementary base pairs, compare the probe to your sequence to see if you can find a section with an exact complementary match.

COMPLEMENTARY DNA BASE PAIRS:

A-T T-A C-G G-C

Practice linking colors with bases. If your DNA strand contained these bases, what colors would your model be? (Write the corresponding color in your journal.)

These colors and bases represent one-half of the DNA strand		What colors go along with the bases in the complementary strand of DNA?
Green	**A**	**T**
Green	**A**	**T**
Orange	**C**	**G**
Orange	**C**	**G**
Red	**T**	**A**
Yellow	**G**	**C**

⑧ If you find the complementary match to your probe, double check yourself, then attach it to the sample strand by sticking a half-toothpick between each of the complementary bases. You will end up with a short section of a "ladder" attached to the longer sample strand. Get a "*Crypto flag*" from your teacher and attach it to the probe after you have connected the probe and the sample. (This flag represents the "tag" or signal, such as a fluorescent glow, that is turned on when the probe binds to its complement in a laboratory test.)

⑨ If your probe does not match any of the sample segments, give it back to your teacher. (In the laboratory, the unmatched probes would be "washed" away in a chemical bath; only the attached probes stick and resist being washed away.)

What does it mean?

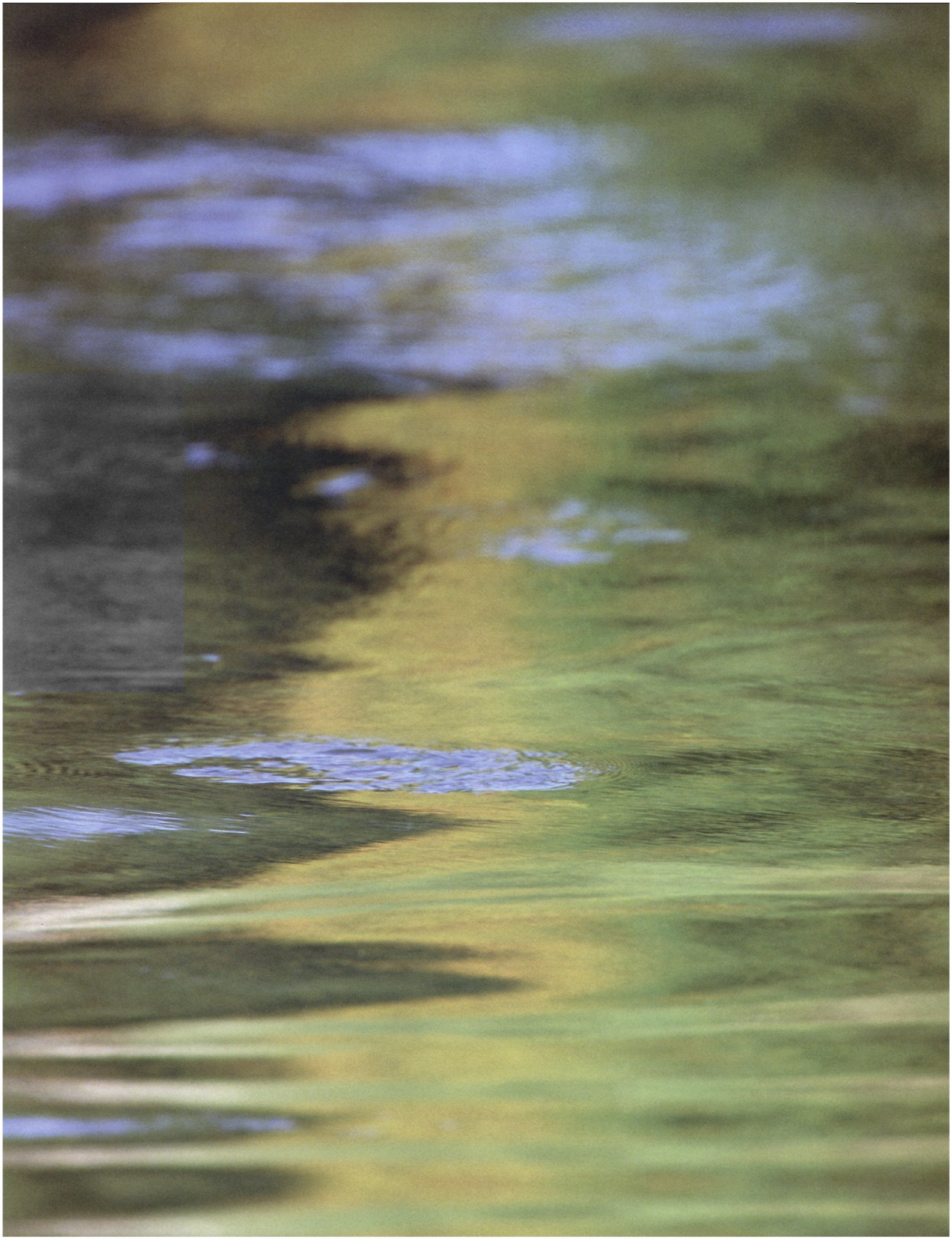
① After each probe has either been attached or discarded, inspect the sample as a class. What did you learn about the water supply? Is *Cryptosporidium* present?

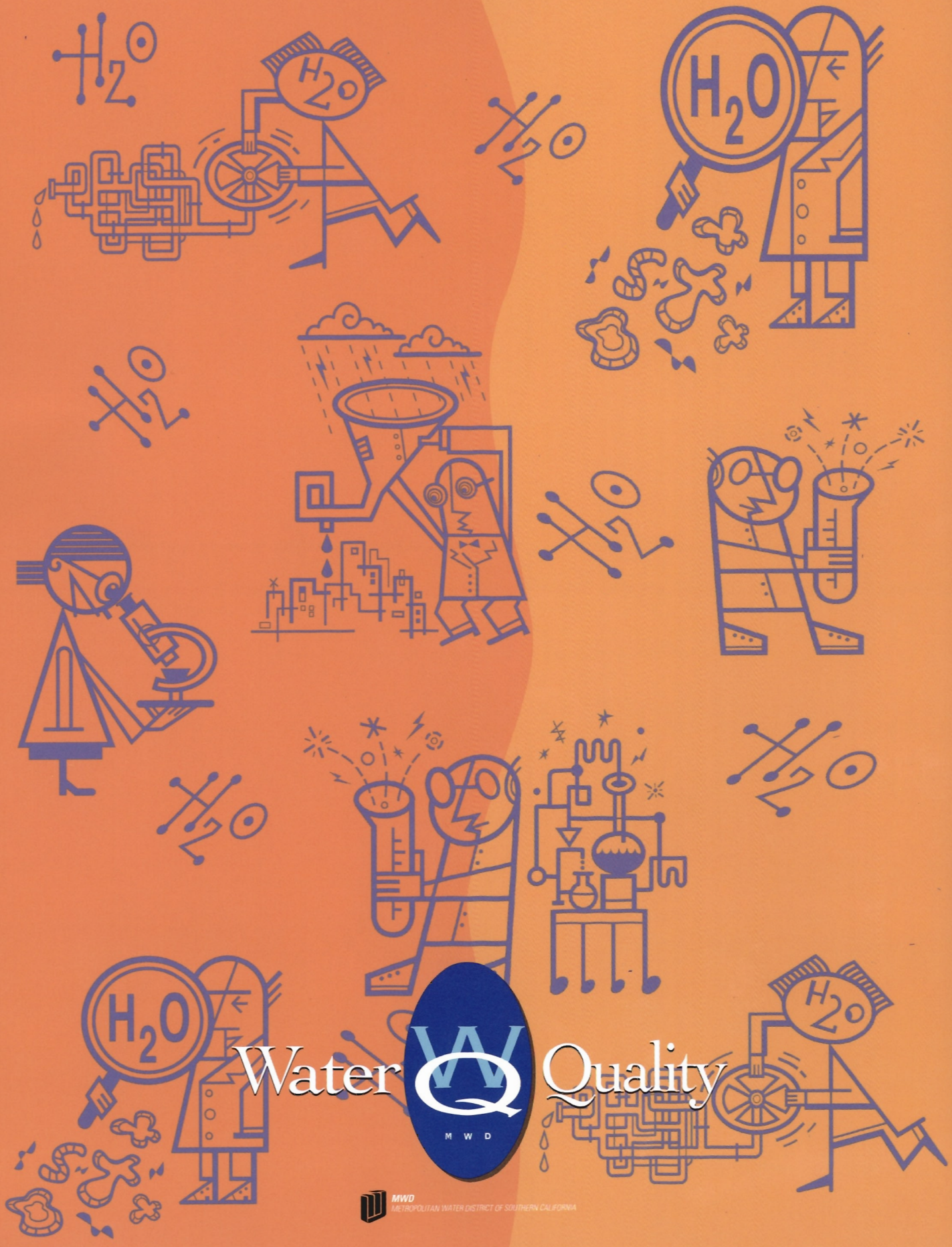
② What action should the water agency take to ensure public health? Give reasons for your answer.

Make connections

① Why would a water agency be interested in using a genetic test for *Cryptosporidium* and other disease-causing microorganisms?

② Look for news stories about how genetic tests are used for environmental testing and diagnostics.




Water Quality
MWD
MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA