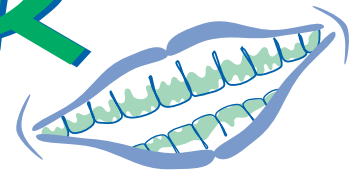


DEFEND YOUR SURFACE



Boat owners constantly fight a battle with microbes that settle on the bottoms of their boats. Any boat, float, or pier that stays in the water more than 24 hours is soon covered with a slime layer of bacteria. After that, even larger organisms find the surface a suitable home.

Goal

To design and test a surface that prevents harmless microbes from sticking to it.

Activity Time

Two 90-minute sessions

Time to Get Ready

90 minutes

What You Need

Have the following for the entire group:

- 4 clear, empty 2-L soda bottles
- 1 pair of scissors
- 1 hole punch

Have the following for the entire group only if using a small natural body of quiet water:

- 4 empty, washed liquid laundry detergent bottles with lids
- 4 lengths of rope or cord 30 cm longer than the water is deep
- 4 medium-sized rocks or similar weights

Have the following for the entire group only if using an artificial pond:

- 4 buckets at least 40 cm tall
- 4 sticks or dowels at least 25 cm long

Have the following for each group of 3 or 4:

- surface coating material such as petroleum jelly, nail polish, hot pepper sauce
- 2 medium-sized washers, fishing weights, or small stones
- 1 magnifying glass
- 1 bucket, pan, or bowl
- 2 1-meter (m) lengths of string
- 5 pieces cut from soda bottles, pennies or pieces of aluminum foil or wood
- 1 stereoscope or microscope

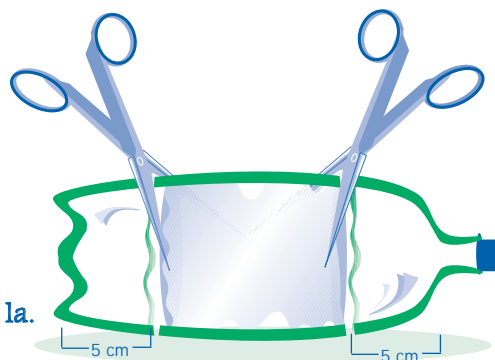
Getting Ready

Two weeks before

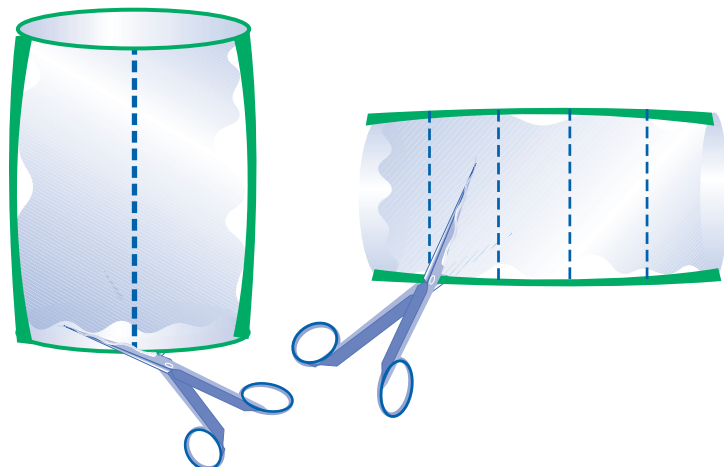
- Locate a quiet body of water at least 25 centimeters (cm) deep. Good sites include small ponds or lakes, quiet saltwater harbors or estuaries, quiet areas of streams, or drainage ditches with water in them. Be sure to obtain permission from the landowner if the water source lacks public access. Determine the depth of the water.
- If no natural water source is available, an artificial pond can be created. Two weeks before, obtain a bucket 30 to 40 cm deep. Fill it with water and let it sit at room temperature for 24 hours. After 24 hours, pour 2 cups of dirt or mud into the bucket. Make sure that the mud is as free of chemicals as possible.

One day before the activity

- Cut the top and bottom off soda bottles 5 cm from each extreme. See Figure 1a. The tops and bottoms can be discarded. Cut the remaining portion in half from top to bottom. Flatten the portion and then cut them into 5-cm x 15-cm strips. Cut 5 strips for each group. See Figure 1b. Punch a hole in each end of the strips cut from the soda bottle. See Figure 2.



1a.



1b.

Figure 1a. Cut the top and bottom off the bottle.
1b. Preparation of strips.





Figure 2. Hole placement for each strip.

- Cut 2 1-m lengths of string for each group.
- If the group's time will be limited, or you are working with younger students, you may want to assemble the ladders ahead of time.
- If you will be using a natural body of water, prepare floats by thoroughly washing 4 laundry detergent bottles and tightening the lids. Cut a piece of rope 30 cm longer than the water is deep for each bottle. Tie one end of the rope to the handle of the bottle. Tie the other end of the rope to a rock or weight. Repeat the process for each of the laundry bottles. See Figure 3.

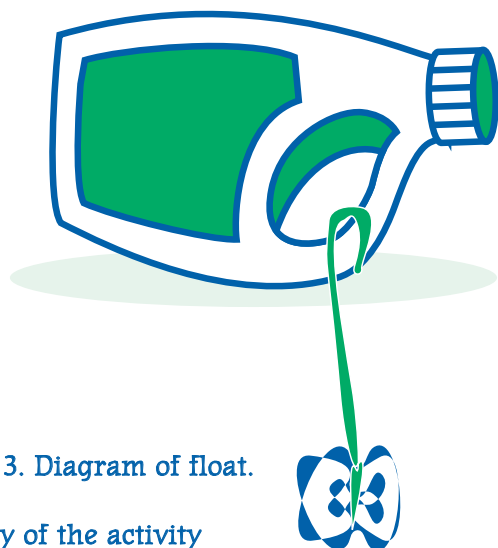


Figure 3. Diagram of float.

The day of the activity

- Lay out the materials required for each group's work in their separate areas. Each group should have 5 prepared pieces of soda bottle or other material; 2 1-m lengths of string; 2 washers, weights, or stones; and access to surface coating materials.

The second day of the activity

- Provide each group with a bucket, pan, or bowl and a magnifying glass.

Useful Information

All microbes need a place to live where they can be safe and find food. Most have developed ways to adhere, or stick, to the surfaces where they live. Adherence is a very important part of how some microbes live. Without being able to stick to a surface, they could not get food, or survive.

Frequently, microbes stick to surfaces in great numbers creating a coating known as a "biofilm." Sometimes, a biofilm can be very helpful. The rocks and decorations in both salt- and freshwater aquaria are usually covered with a biofilm of useful microbes. The microbes help convert ammonia and nitrates from waste products into less toxic substances. On the other hand, some biofilms are harmful. That slick feeling you get on your teeth when

they need to be brushed is caused by a biofilm of microbes that have attached themselves since your last brushing. If allowed to remain, they contribute to cavities.

The biofilm that builds up on the bottom of pools is sedentary protozoa and algae. The submerged surfaces of marine docks, floats, and boats support a variety of organisms. Growth of organisms on surfaces, called "fouling," can cause problems. Marine fouling on the bottoms of ships reduces the speed of the vessel and causes an increase in fuel consumption. In the Great Lakes, industrial and municipal pipelines become clogged with zebra mussel colonies.

Over the years, many products have been introduced to try to inhibit fouling. Municipalities use chlorine to control zebra mussels. Fungicides and algacides are used to control soft fouling organisms. Many boat owners coat the bottoms of their boats with paints to keep these organisms from growing. Often the paints are very toxic and dangerous both for the people applying the paint and for the environment. However, some bottom paints currently being manufactured contain extracts of hot peppers that may be safer.

If you use a freshwater body of water in your experiment, you will see protozoa. These are tiny, one-celled animals that are too small to be seen individually. See Figure 4. They are often sedentary, or live stuck to one surface and don't move around. Most are very important in breaking down dead plants and animals. Some eat bacteria and other protozoa. Others filter the water around them for food. If you use a saltwater body of water in your experiment, you will see tiny versions of marine "float animals." These organisms live underwater on mooring floats and pilings of docks and wharves. They include barnacles, bryozoans, tiny corals, sea squirts, and sea anemones. Some look like brown and red seaweed, but are actually animals. See Figure 5.

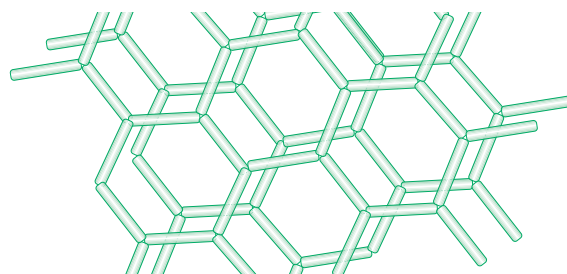


Figure 4. Freshwater protozoa.

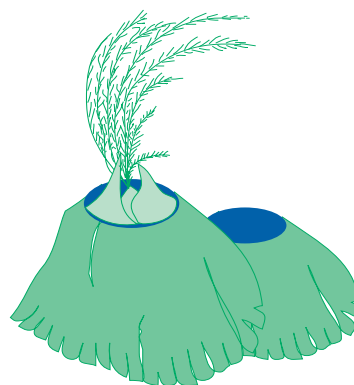


Figure 5. Marine organisms.



Suggestions to Modify the Activity for Those Who Are Exceptional

Specific modifications for this activity are found here. For common considerations when modifying activities for exceptional participants, see page V of the **Introduction**.

Blind or Visually Impaired

- Allow the participant to feel the difference between the coatings used for the activity. Comparing the petroleum jelly and the hot pepper sauce will reinforce the concept. Exercise care that the participant does not rub his/her eyes accidentally and that hands are washed after this step.
- Use cubed manipulatives to construct a bar graph that shows the growth progression of a biofilm.
- Build a tactile model of a protozoa if one is not available.
- Allow the participant to touch the slime.

Deaf or Hard-of-Hearing

- See the **General Modifications** for *Blind or Visually Impaired* listed in the **Introduction**, page V.

Mobility Impaired

- See the **General Modifications** for *Mobility Impaired* listed in the **Introduction**, page V.

Physically Impaired

- See the **General Modifications** for *Physically Impaired* listed in the **Introduction**, page V.

Cognitively Impaired

- See the **General Modifications** for *Cognitively Impaired* listed in the **Introduction**, page V.

For More Information

ADHA. Oral health FAQs <http://www.adha.org/blip/blip-faqs.html>. An American Dental Hygienists Association site that includes information on oral health, including a fact list and news briefs.

Jensen, M.N. (1998). Good health requires good gums. *Science News*, 153(19), 300-301.

Jones, M., et al. (1997). *Biofilms: Community Interactions and Control*. (Biofilm Club Publications.)

Lee, J. (1998). Bacterial biofilms less likely on electropolished steel. *Agricultural Research*, 46(2), 10-11.

Patients take notice of caries vaccine. <http://www.ada.org/adapco/daily/archives/9805/0505vacc.html>

An American Dental Association site that includes daily news articles in dentistry in addition to an archive of recent articles.

Scientists develop vaccine against tooth decay.

<http://www.ada.org/prac/position/vaccine.html>. An

American Dental Association site that includes daily news articles on technological breakthroughs in dentistry.

Teaching tools. Lesson plans. http://www.oralb.com/teaching/lesson/9_12/day1.html. This commercial site is a source of information on Oral-B. The site includes a section of teaching tools comprised of lesson plans on the importance of oral care for educators at various levels.

Tooth decay. Health library. <http://www.thriveonline.com/health/Library/illsymp/illness529.html>. A site that focuses on tooth decay: General information, what to expect, and how to treat.

Wu, C. (1997). Material gives bacterial films the heave-ho. *Science News*, 151(17), 253.

How to Start the Activity

Show the participants a jar of water collected from a pond or relatively clean ditch. Have them hold the jar up to the light and look for tiny organisms swimming in the water. Discuss the organisms. Explore the possibility that similar organisms are found in other bodies of water. Discuss what organisms need to live.

Let's Make a Hypothesis

Discuss the following questions to help guide the participants to make hypotheses.

- What kind of surface would be suitable for microbes to live on?
- What substances might inhibit the adherence of microbes?
- How can you test your hypothesis?

What the Data Mean

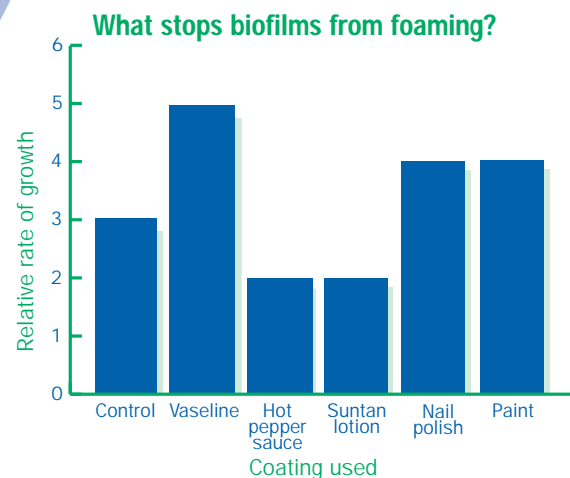
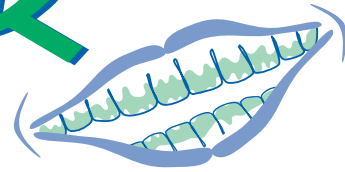


Figure 6. Sample graph of substances used to stop the formation of biofilms.



DEFEND YOUR SURFACE



Questions to Think About

How can microbes make you sick? When you sneeze or cough into your hand, why don't the microbes just fall off? Run your tongue over your teeth. What do you feel? Are there microbes on your teeth? If you look into a pool, you may see a green coating on the sides and bottom. These are biofilms made up of microbes. Do microbes stick better to some surfaces than others? Can you coat a surface with something to prevent microbes from sticking to it? Can you coat a surface to encourage microbes to stick to it? How can you find answers to these questions?

Safety Notes

- Wash hands before and after the activity.
- Make sure that all materials collected for surface coating are safe to handle.
- Food, drinks, and gum are not allowed.
- Life jackets should be worn by participants working near natural bodies of water.
- Care should be taken with scissors and hole punches.
- Avoid getting hot sauce on hands or in eyes.
- Closed-toe shoes should be worn at all times.

What to Do

Day 1 of the activity

1. Arrange your 5 soda bottle pieces in a row so that the long sides are parallel. Thread a piece of string through the hole in the end of one of the pieces. Leave 7 cm hanging, then tie the string to the piece. Thread the next bottle piece onto the string and tie it off 3 cm from the first. See Figure 1 for 2 strips that have been tied together. Continue to thread the bottle pieces onto the string and tie each piece 3 cm from the last. Repeat the process on the other side. When all the bottle pieces are threaded onto the strings, it should resemble a ladder. Tie washers, weights, or small pebbles to each of the 7-cm pieces of string hanging from the bottom. Tie the top pieces of string together as shown in Figure 2.

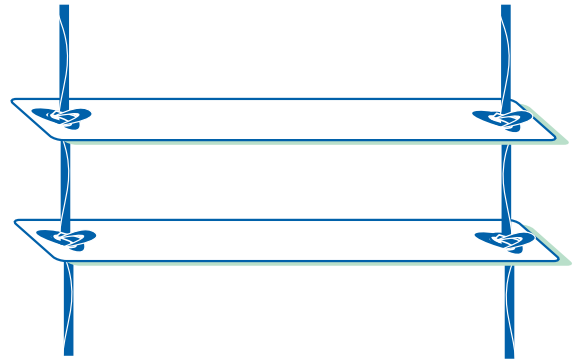


Figure 1. Shown are 2 of the 5 strips that have been tied together.

2. Leave the top rung of the ladder uncoated. It will serve as your control. Coat the remaining rungs with surface coating materials. Use a different coating substance for each rung. Be sure to coat both sides of the rungs. Make note of which substances are used on which rungs.

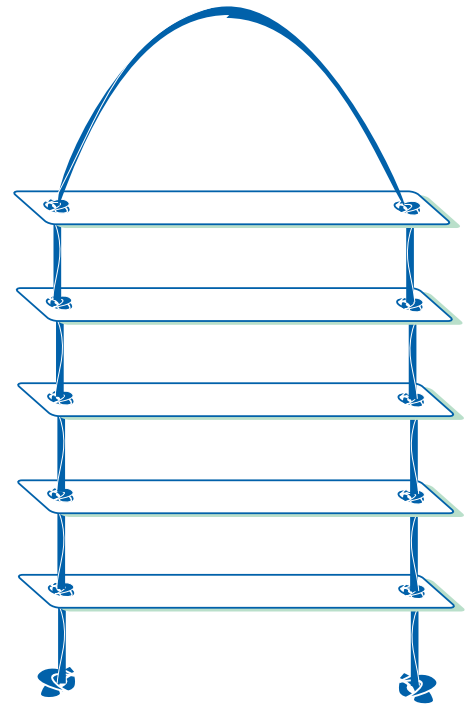


Figure 2. Diagram of setup.



3. If you are using a natural body of water for your experiment, place a float near enough to the shore for easy access, but far enough from shore so the ladders will hang without touching the bottom. Tie your ladder to a float. If several groups share a single float, try to arrange the ladders so they touch each other as little as possible. Leave the floats and ladders undisturbed in the water for 2 weeks.

4. If you are using an artificial pond, place a stick or dowel across the top of the bucket. Tie the ladders to the dowel. Try to position ladders so they touch each other as little as possible. Leave the ladders undisturbed for 2 weeks.

Day 2 of the activity

5. Fill a bucket or pan with water from the experiment site. Collect your ladder. Place it in the bucket or pan so it doesn't dry out.

6. Examine the surfaces of your ladder with a magnifying glass. Your microbes may look like green, brown, red, or pink spots. Rate the amount of growth on each rung on a scale of 1 to 5. Give the control a rating of 3.

7. Rungs with more growth should be rated 4, while those with much more growth should be rated 5. Rungs with less growth should be rated 2, and those with much less growth should be rated 1. Construct a bar graph that compares the data. The type of surface coating should be entered on the horizontal axis, and the growth rating should be entered on the vertical axis.

8. What other questions come from your results? To what other topics is this activity related? How does this activity relate to your life?

9. How can you learn more about microbe adhesion? Would the microbes' ability to adhere be the same on different surfaces? Is it the same in all temperatures? Could you design an experiment to test a new hypothesis or question? What procedures would you use? What would you use for a control? What variables are important? What would you measure? How many trials would you include? Could you graph the results?

What Did You Find Out By Doing the Activity?

Before doing "Defend Your Surface," did you know:

- if you had ever seen slime on a surface?
- if a slime layer is living?
- what the slime is that grows on boat bottoms?
- if there is a way to prevent a slime layer from growing?
- other places that slime appears?
- what slime needs to grow?
- if slime occurs in all water areas, such as pools and sinks?

From this activity, did you discover:

- how slime grows on boat bottoms?
- how slime growth can be prevented?
- why slime doesn't grow on surfaces in swimming pools?
- how the slime on boat bottoms is like the slime that can cover your teeth?
- why slime only grows on the bottom of the boat?
- if your individual tooth-brushing habits should change to reduce the chance of slime?
- if brushing is the only thing you need to do to prevent a slime layer from covering your teeth?

