Teacher's Preparatory Guide
Water purity and filtration – Getting down to the nanoscale
Lesson 2: What Affects the Purity of Water?

Purpose This activity—in which students test a local water supply—is designed to be used as an extension to classroom activities related to treating foul water for consumption. This activity should be done after students have been introduced to the concept of nanoscale and before Lesson 2 - *Water Filtration and Nanoparticles* lab. Students should have a good grasp of how to convert the size of objects to the nanometer scale.

Level Middle school and High school – Biology, Chemistry, Physical Science, Environmental Science

Time required Two 50-minute class periods or one 90-minute block day

Safety Information Use care when collecting water samples from natural bodies of water—do not collect water during unsafe conditions, as during high winds or stormy conditions. Wear protective gloves to avoid contact with potential pathogens in the water sample. Use care when cleaning and working with knife and clipper blades—they present a cutting hazard.

Advance Preparation Locate a natural body of water near your school and arrange for a field trip for collection, or collect the water yourself beforehand. If collecting the water beforehand, be sure to use a container that is sterile (such as a very large water bottle, however you should dispose of the clean water just before collecting your sample for more accurate data collection. Do not use bleach to sterilize the container that you use—even small amounts could kill bacteria you are testing for in your sample water. Materials for testing the bacteria level in water can be found at www.hach.com/ or through Lifewater International (888)543-3426. Alcohol prep pads (those used to prepare the skin for an injection) can be purchased from a pharmacy (we used alcohol swabs from B-D Consumer Health Care brand, purchased at www.riteaid.com). Collect enough 1 L plastic bottles for each student group to have one and cut the top off of each bottle. Conduct this activity when the outside/room temperature is 75°F–95 °F to allow the bacteria to grow.

Materials per student group

- pathoscreen media, 100 mL 50/pack, Hach part #26106-96
- sterile whirl-pak bag with dechlorinating agent, Hach part# #2075333
- antiseptic alcohol prep pads (also called alcohol swabs/wipes)
- fine point permanent marker
- a 1 L plastic bottle, with the top cut off

Did You Know?

"A child dies every 15 seconds from diarrhoea, caused largely by unsafe water and inadequate sanitation."
—*World Health Organization*
Source: http://www.undp.org/water/
http://www.who.int/dg/lee/speeches/2005/ministerialmeeting_healthandenvironment/en/index16.html

"Currently, over 1 billion people lack access to water and over 2.4 billion lack access to basic sanitation."
—*United Nations Development Programme*

Source: http://www.undp.org/water/
Find out more about the global water crisis at the links

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National Science Education Content Standards

Content Standard A

- Abilities necessary to do scientific inquiry
- Understanding scientific inquiry

Content Standard B

- Structure and properties of matter

Content Standard C

- Interdependence of organisms

Content Standard E

- Abilities of technological design
- Understandings about science and technology

Content Standard G

- Science as a human endeavor
- Nature of scientific knowledge

Content Standard F

- Personal and community health
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Teaching Strategies

- Before this activity, review the concepts of size and scale (units available at http://www.education.nnin.org).
- Students may work in groups of 3–5 students.

Guided Dialog Use the guided dialog below to introduce this activity to students:

- Where might you find water that has bacteria? *Answers will vary. Examples: a pet's water bowl, a mud puddle, the kitchen sink*
- If you had to survive in your house for three days after an earthquake or other natural disaster, what device(s) in your home would probably have a reservoir of clean potable (drinkable) water? *The water heater and the toilet reservoir.*
- If you had to collect water from a river, creek or pond, how could you make sure the water was safe to drink? *boil it or pour water through sand to filter large particles*

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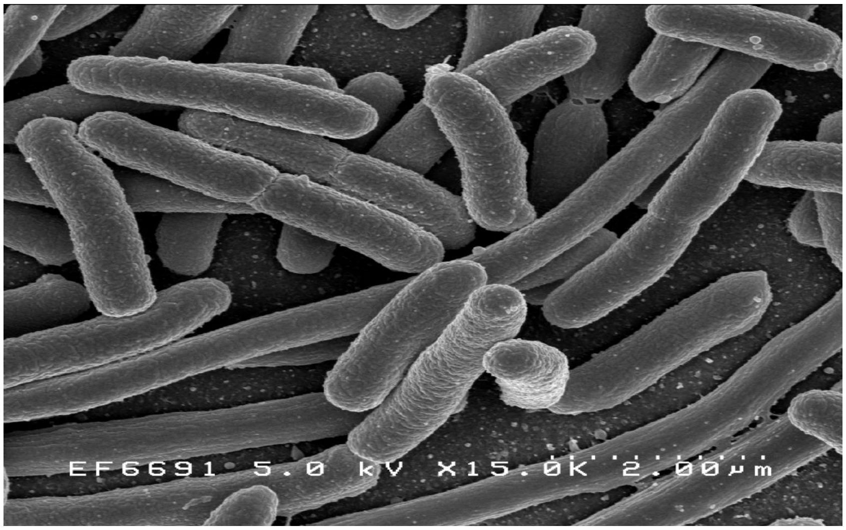
Power Point Slides (Nanofiltration)

Have students look at the picture of *E. coli*. Explain that these bacteria have sizes that are microscale and are NOT nanoscale.



Above: Scanning electron microscope image of *Escherichia coli*, grown in culture and adhered to a cover slip.
Credit: Rocky Mountain Laboratories, NIAID, NIH
Source: NIAID: *These high-resolution (300 dpi) images may be downloaded directly from this site. All the images, except specified ones from the World Health Organization (WHO), are in the public domain. For the public domain images, there is no copyright, no permission required, and no charge for their use.*
http://en.wikipedia.org/wiki/Image:EscherichiaColi_NIAID.jpg

Ask students to find different sources of water pollution from the picture. *Sample answers: bathing and washing in the river, trash and garbage dumped beside the river, people and animals defecating along the river, animal feces can be washed into the well, stored water is not protected from animals or industrial waste*

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What Affects the Purity of Water?

Student Worksheet with Answer Key

A ranch owner in Mexico is concerned that some of the people who live and work on his ranch have been getting sick. He suspects that the stream that serves as the water supply may be contaminated with disease-causing bacteria. Your team has been hired to investigate the stream to see whether the water is safe to drink and to make recommendations for further action if the water is unsafe.

Question How can you test whether this stream has disease-causing bacteria?

Make a Prediction *Sample Prediction: If the water in the sample bag changes from yellow to black, the water coming out or the filter is not clean. If the water does not change color after 48 hours, the water is probably free of disease-causing bacteria.*

Procedure

Safety Tip

Use care when cleaning and using blades—they are sharp and can cut.

Materials

- knife or nail clipper
- pathoscreen media
- sterile bag with dechlorinating agent
- 2 antiseptic alcohol preparation pads or alcohol swabs/wipes
- permanent marker
- 1 L plastic bottle, with the top removed

1. Wearing protective gloves, remove an alcohol swab from the foil pouch and use it to carefully clean the knife or nail clipper blade.
2. Place the swab atop a flat surface.
3. Use the knife or clipper to open the pathoscreen media and carefully place the media on top of the opened alcohol wipe. Make sure that the contents do not spill out!
4. Label the sterile bag with your name, date, and time.
5. Open the sterile bag by tearing off the top of the bag along the perforation. Be sure NOT to contaminate the inside of the bag. Leave the small tablet of sodium thiosulfate in the bag—it will remove any chlorine from the water.
6. Hold the bag by the wireless white strips at the top and pull. The bag will open.
7. If the water can flow, let the water run for about 30 seconds before collecting water.
8. Fill the bag to the 100 mL line with the water. If the bag fills above this line, pour out the excess water.
9. Add the pathoscreen media powder to the bag containing your water sample—this nutrient will help any bacteria present to quickly multiply and allow you to detect their presence. Be sure to add **all** of the powder to the bag.

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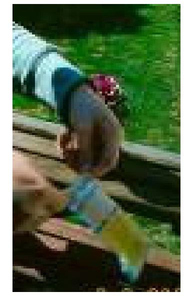
10. Pull the white wire strips taut to close the bag.

11. Firmly hold the wire strips, and carefully but quickly flip the bag 3 times so that the bag folds tightly over the wire to create a tight seal. Fold the wire strips over to seal the bag, as shown in the image at right.



12. Observe the contents of the bag. If the sodium thiosulfate has not fully dissolved, gently shake the bag. Prevent water from leaking out by not squeezing the bag.

13. Place the bag in the 1 L bottle with the top removed for safe transport. Store on a level surface where it will not tip.

Data

14. Record the color of the bag, the date, and time in the table below.

15. After 24 hours, observe the sample bag and record your observations in the table below. What color is the sample? If it is yellow, does it have black spots?

16. After 48 hours, repeat step 15.

Sample	Description at 24 hr	Description at 48 hr	Is bacteria present?	Conclusion
1	*black*	*black*	*yes*	*lots of bacteria in initial sample or these bacteria quickly grow*
2	*yellowish/cloudy*	*yellow with black percipitate or black dots*	*yes*	*not many bacteria in initial sample or these bacteria slowly grow*
3	*yellow*	*black*	*yes*	*not many bacteria in initial sample or these bacteria slowly grow*
4	*yellow*	*yellow with black percipitate or black dots*	*yes*	*not many bacteria in initial sample or these bacteria slowly grow*
5	*yellow*	*yellow*	*no*	*bacteria not detectable; water may be safe to drink*

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Disposal

Materials for disposal

- bucket
- bleach
- water
- straight pin
- spray bottle containing bleach and water in a 1:10 ratio
- paper towels

Safety Alert!
The contents of the bag may contain disease-causing bacteria that could cause diarrhea or other illness. Wear gloves and use caution at all times during disposal.

17. Wear a pair of protective waterproof disposable gloves.
18. Remove the sample from the transport bottle and have a lab partner hold the bag upright as you fill the 1 L transport bottle halfway with tap water.
19. Add bleach to the transport bottle until it is ¾ full. Gently shake the bottle to mix the bleach with the water.
20. Place the sample bag in the water bottle and push it down to submerge the bag.
21. Use the straight pin to puncture the bottom corner of the bag. Allow the contents of the bag to empty into the bottle.
22. Flush with tap water the fluid contents of the bottle. Do **NOT** flush the bag.
23. Repeat steps 20–22 to disinfect the inside of the bottle and the bag. You may open the bag and rinse the inside of the bag.
24. Dispose of the bag, pin, bottle, and gloves in a way that they cannot be recovered, such as placing them in a biohazard bin. Pins should be disposed of in a closed cardboard box before placing them in a biohazard bin. Be sure that pins do not go directly in a plastic bag—they can puncture the bag.
25. Use the spray bottle containing bleach water to disinfect any surfaces that might have come in contact with the sample.

Analysis

26. If the water sample in your bag is black or has black dots in it, then bacteria has been detected. If it is yellow with no trace of black, bacteria has not been detected. Is bacteria present in your samples? For each sample, record your answer in the table on the previous page.

27. Why was it important to leave the sodium thiosulfate in the bag? *Sodium thiosulfate removes any chlorine that may be in the sample water. This allows any bacteria that are present to grow.*

28. Why did you clean the cutting tools before testing the water for bacteria? *Dirty tools could contaminate the water sample.*

29. If you hadn't cleaned the tools, how would it have affected your results? *It might indicate bacteria is present in the water when they are really from the blade.*

30. Why do you think the sample needs to be at room temperature for 24 hours before you can expect a color change? *It takes time for bacteria to multiply and grow to detectable levels.*

31. How might doing this experiment on a very cold day affect the results? *Bacteria would not grow as quickly or would not grow at all to be at detectable levels. So, the bag might appear yellow even when bacteria is present.*

32. How might doing this experiment on a very hot day (over 90°F) affect the results? *The heat might kill bacteria present and result in a negative test, which would be inaccurate.*

Conclusion

33. In your data table, notice the trend of color throughout the period of time that you tested. What conclusions can you draw about how quickly or slowly the bacteria grew? What can you conclude about how much bacteria were initially present in the sample? Record these conclusions in the data table.

34. Is the water safe for human consumption? *No, my water was not safe for human consumption.*

35. Based on your water analysis, what would your team recommend to the ranch owner? Explain your answer. **(Hint:** review your answer in step 32.) *People should not drink the water right out of the stream. First, they should boil the water. Alternatively, a filter would probably remove disease-causing bacteria.*

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Inquiry-based interlude

Water Filtration and Nanoparticles

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Dear Team:

Thank you for your recommendation to get a filter for the stream on our ranch.

To save money, I would like to have you build a filter that will purify the water in the stream so that people on my ranch can drink the water.

Also, please test the filtered water to make sure that it is safe to drink.

Sincerely,

Manuel Ranchero
Ranch Owner
Rancho Felicidad

Teaching Strategies:
Ask:
How would you modify the procedure in this lab that would allow you to test the quality of the filtered water? Why would you make this change?
Example answer: I would also clean the filter faucet/tube with an alcohol swab to make sure that bacteria is not introduced to the water sample.
How would you modify the question?
Question: Does the filter remove disease-causing pathogens from the water?

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