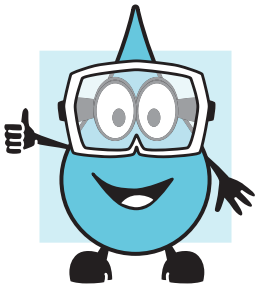


Lesson 2

Treatment of Water

Teacher's Guide

In this lesson, students will investigate how water is made safe to drink in a modern water treatment facility. They will work as teams of engineers to study one step in the water treatment process: filtraton. In an inquiry-based activity, they will design, build, test, and evaluate a water filter capable of being used in the process to produce clean drinking water.

This lesson is appropriate for students in grades 5-8 working in a cooperative learning environment in teams of four students each and will take approximately two 50-minute class periods to complete.

SafeWaterScience
lessons for life

National Science Content Standards: Grades 5-8

Content Standard A: Science as Inquiry
Abilities necessary to do scientific inquiry
Understandings about scientific inquiry

Content Standard B: Physical Science
Properties and changes of properties in matter

Content Standard D: Earth and Space Science
Structure of the earth system

Content Standard E: Science and Technology
Abilities of technological design
Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
Risks and benefits

Content Standard G: History and Nature of Science
Science as a human endeavor

Teacher Materials

The following materials are needed by the teacher:

- 1 L of dirty water (mix 1 teaspoon of finely pulverized soil/dirt in 1 L of tap water in a large container)
- 2-3 drops of food coloring (red or blue)
- 1 large plastic spoon
- Scissors
- Coffee filter
- Rubber band
- 9oz. plastic cup
- 16oz. clear plastic water bottle, with bottom cut off
- 1 domed "slushie" lid (can substitute another 9oz. plastic cup, with a hole cut in the bottom)
- 1 permanent marker*
- Approximately ½ cup of aquarium pebbles, washed (refill: can be purchased at discount pet store)
- Approximately ½ cup fine aquarium sand, washed (refill: can be purchased at discount pet store)
- Approximately 2-3 tablespoons of activated granular charcoal (refill: can be purchased at discount pet store)
- 1 plastic colander for separating filter materials to reuse in future labs
- Supply of fresh tap water*

Student Materials

Each team of 4 students should have:

- 100 mL of dirty water in a plastic cup
- 1 clear 16oz. water bottle with the bottom cut off*
- 1 9oz. plastic cup (to collect filtered water)
- 1 domed "slushie" lid (can substitute another 9oz. plastic cup, with a hole cut in the bottom)
- 1 coffee filter
- 1 rubber band
- 1 sheet of plain white paper*
- Supply of paper towels for potential spills*
- 4 copies of the Student Activity Packet
- 4 pairs of safety goggles*

Access to the following filtering materials for use in their filter apparatus:

- Cheese cloth
- Cotton balls*
- Cotton cloth*
- Panty hose*
- ScotchBrite pad* (or any flat green scouring pad)
- Supply of aquarium pebbles, washed
- Supply of fine aquarium sand, washed
- Supply of activated granular charcoal

*Not supplied in kit

Lesson 2

Treatment of Water

The students will work within their teams to complete Warm Up activity, learn how to construct a water filtration device, and individually complete a set of Cool Down questions.

I. Warm Up

Hand out a copy of the Student Activity Packet to each student. Ask the students if they know where their drinking water comes from and how it is made safe to drink. As a class, have students share and discuss their responses.

Just listen to their ideas; do not correct their answers. Tell students they will discover more about their drinking water, a valuable resource, during this lesson.

You may contact your local water treatment facility for a set of brochures, usually free for educational purposes, to share with your students.

Read instructions for the Warm Up activity with the students, answer any questions, and then allow the teams to work cooperatively for 10-15 minutes on this activity. Students should discuss answers within their teams. Discuss the answers as a class. Suggested responses are as follows:

Possible Contaminant	*Stage(s) of Water Treatment*
Bacteria	Disinfection and Storage
Hydrogen Sulfide Gas	Aeration
Gravel	Coagulation, Sedimentation, Filtration
Viruses	Disinfection and Storage
Sewage	Aeration, Coagulation, Sedimentation, Filtration, Disinfection and Storage
Fertilizers	Aeration, Coagulation, Sedimentation, Filtration
Methane gas	Aeration
Sand	Coagulation, Sedimentation, Filtration
Leaves	Coagulation, Sedimentation, Filtration
Parasitic Worms	Coagulation, Sedimentation, Filtration, Disinfection and Storage
Pesticides	Aeration, Coagulation, Sedimentation, Filtration

II. Activity: Design And Build The Best Filter

This is a guided inquiry activity in which students will work as teams of engineers to design, build, test, and evaluate a filter for cleaning dirty water. As teacher, you will act as a facilitator, being careful not to influence the student's choice of materials to build the filter.

Students will be studying only one of the five stages of the treatment process: filtration. The other stages will be examined in lesson 4. If you choose to do this activity as a demonstration and not an inquiry-based lesson, see Advance Preparation, section E, page 5.

Pre-Session Preparation

A. Prepare enough dirty water for each class (see Teacher Materials). To make the dirty water visible during the filtering process, add 2-3 drops of red or blue food coloring to the container of dirty water.

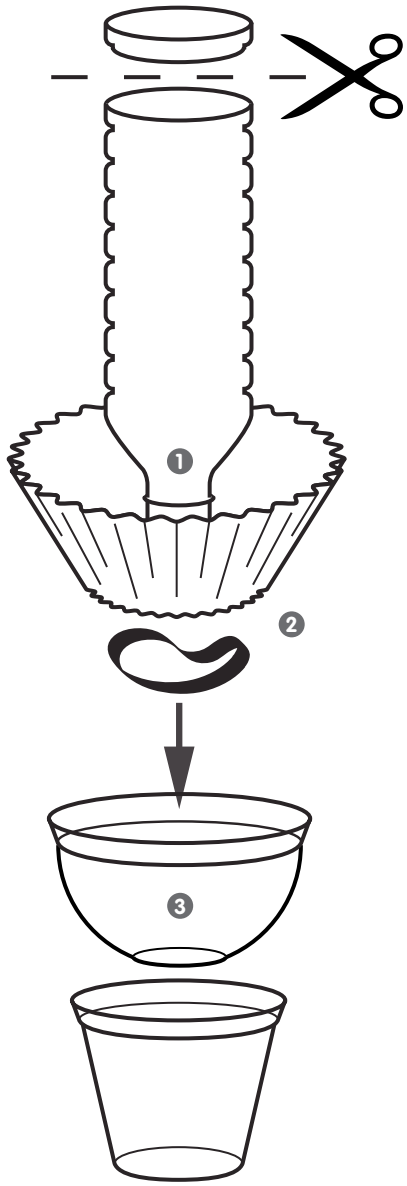
B. Prepare the water bottles that will hold the filters (one for each team of 4 students, one for the sample filter apparatus, and one for an "ideal" filter prepared by teacher): remove the lids, and cut the bottom off of each clear 16-oz water bottle. On each bottle, draw a line with a permanent marker 8 cm from the opening of the neck of the bottle. Students will fill the bottle with their choice of filtration materials up to this mark.

C. Prepare **two** sample filter apparati as examples for the students. Do not add the filtration materials to the first, so as not to bias the student's choices. Use the second to create the "ideal" filter (see step E below).

1. Take one of the prepared water bottles and cover the neck opening with a small piece of coffee filter.

2. Secure the coffee filter to the bottle neck with a rubber band.

3. Insert the neck of the bottle (now covered with a coffee filter and rubber band) through the hole in the "slushie lid" so that it stands upright. Place the whole structure into the clear 9oz. plastic cup.



D. Set up a station in your classroom where student teams will collect the materials they need: cheese cloth, activated charcoal, sand, and pebbles, etc. You may include additional materials, or have students bring materials of their choosing from home.

E. Build and test an "ideal" filter capable of removing the contaminants from your dirty water. You will use this filter as an example of an "ideal" filter at the end of the lesson, after the students have completed their filters.

1. Fill the inverted bottle 7 cm high with a mixture of equal amounts of fine aquarium sand and aquarium pebbles. Add another 1 cm of activated granular charcoal to the top of the sand and pebble mixture.

2. Be sure to test the operation of this "ideal" filter before demonstrating it to the students. To test, slowly add 100 mL of the dirty water to the filter, covering the entire surface of the charcoal.

3. Observe as the particulate matter and food coloring are filtered from the water. It is not necessary to filter the entire 100 mL of dirty water to determine that the filter is capable of producing clear water. Note: you must use "washed sand" to produce clear water.

F. Prepare a large container in which students may dispose of their wet materials at the end of class.

Student Lab Roles

This lesson provides a good opportunity for students to assume roles within the team. Possible roles could be as follows:

Team Coach

- Keep the team on task at all times.
- Make sure that others are performing their roles and that safety guidelines are followed.
- Be the main assistant to the Equipment Manager in performing lab procedures.
- Make sure that lab clean up is complete by assigning tasks to all team members.
- Motivate the team to do a good job

Data Manager

- Record all observations and data as the lab is being performed. Other team members will record data later on their own papers.
- Record any data that are to be reported by teams on the board, overhead, or marker board, etc.
- Watch the clock for the team for all timed observations.

Equipment Manager

- Be responsible for obtaining all materials for the lab.
- Perform most of the lab procedures for the team. If more than one person is needed to perform the procedures, assign tasks to the other group members with the Team Coach as primary assistant.
- Work with the Team Coach to make sure that the group is observing all safety guidelines.

Procedure Manager

- Read and interpret the procedures and other instructions for the team.
- Direct all team questions to the teacher during the lab.
- If one team member is absent, also act as Team Coach.

Classroom Procedure

A. Show the class the liter of dirty water you prepared. Ask the group if they would be willing to drink this water.

B. Ask them what steps they think are necessary to make this water safe to drink. They may refer to the Warm Up questions they completed together. Students may suggest getting rid of the dirt, some may suggest filtering, and some may even suggest that there are bacteria in the water that need to be killed.

C. Read together the introduction to the Design & Build The Best Filter section of the Student Activity Packet. Discuss with the students their roles as engineers and answer any questions they may have. Depending on your time constraints, you could have each team create an engineering company name and logo to display at their lab stations.

D. Discuss the required and optional materials used for construction of the filters. At this time, show the students the sample filter apparatus you prepared. Be sure not to influence their choice of optional materials.

E. As a class, discuss student procedure step 1, and allow the teams 10-15 minutes to design their filters. After each team's design is complete, approve the procedure by signing each team member's Student Activity Packet. Only sign if ALL students in a team have the design diagram and explanation completed to your satisfaction.

   If the activity cannot be completed in one class period, stop at this point. If you want students to bring in additional materials from home, include this in their homework assignments for the day.

F. After all teams have had their filter designs approved, allow the teams 25-30 minutes to build, test, and evaluate their filters (student procedures step 2-4). Only a small amount of filtered water (approximately ½ to 1 cm) needs to be collected before students may evaluate the effectiveness of their filters.

G. When all teams are finished, direct them in proper cleaning and disposal of the lab materials. Be sure to have students rinse and dry the water bottles and cups for the next class.

Evaluation of Results
Any team that did not use activated granular charcoal in their filter will have food coloring come through in the filtered water. The idea is not to have all teams build the perfect filter, but rather to learn and draw good conclusions from the various team results as to what materials work best. Evaluation for grades should not be based on how clear the filtered water came out, but on how well a student demonstrates his/her learning based on written observations and responses in the Student Activity Packet.

Cleanup
Separate the wet pebbles and charcoal from the fine sand by putting the wet materials into a colander/strainer and allowing the water and sand to pass through the colander. Decant the water from the sand, and spread out the materials to dry. The materials can then be used again.

III. Cool Down

Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion.

1. **Will your filter help improve the quality of water available to citizens in the developing world? Explain.**

   Answers will vary. Students are expected to reflect on their lab results and what they learned in the Warm Up activity.

2. **Would you drink the water that passed through your filter? Why or why not?**

   Answers will vary. Many students would not choose to drink the water without some kind of disinfection process due to the risk of being exposed to harmful microorganisms.

3. **In addition to your filter, what other treatment processes may be required to make drinking water safe?**

   Students should realize that although the filtered water looks clean, it may contain harmful microorganisms. Because of this, the water should be disinfected using a chemical treatment such as chlorine or should be boiled.

4. **Whose responsibility is it to make sure that your personal drinking water is safe? Explain.**

   Most students of this age have not thought about who is responsible for ensuring safe drinking water for their community. Many will realize that the government is responsible; however they should realize their personal role in this process by becoming an informed and educated citizen.

5. **Whose responsibility is it to make sure that people in developing countries have safe drinking water? Explain.**

   Again, answers will vary. Students may suggest that it is the responsibility of the government of the developing country. However, some may feel a personal responsibility to reach out to those who are less fortunate. It is a goal of this curriculum to help direct young people to be more involved in this important and worthy endeavor.

Optional Extension

Water Treatment

Visit a water treatment plant or have a professional from your local water treatment facility come and speak to your class. Contact your local water treatment facility for free materials or to obtain more ideas for teaching about the water treatment process.

Visit the following USEPA website for many games and activities related to water quality:
http://www.epa.gov/safewater/kids/kids_4-8.html.

Helpful Websites

http://www.epa.gov/safewater/kids/kids_4-8.html
This website contains links to many games, printable activities, and other lessons about water quality, with many activities geared toward high school and elementary school students.

http://www.epa.gov/safewater/kids/gamesandactivies.html
At this website, kids can participate in interactive on-line learning games about all aspects of water quality. For example, in one interactive game, kids control the water cycle while they learn about it.

http://www.epa.gov/safewater/kids/flash/flash_filtration.html
This is the direct link to a water filtration activity kids can do at home. The animated video shows the steps outlined in the Warm Up questions and includes explanations of materials and vocabulary.

http://www.epa.gov/safewater/kids/watertreatmentplant/index.html
This website has the water treatment diagram included in the Student Activity Packet. Students can click on different parts of the diagram to learn more about each stage of the process.

http://www.flowthefilm.com/
Irena Salina's award-winning documentary investigation into what experts label the most important political and environmental issue of the 21st Century - The World Water Crisis. Salina builds a case against the growing privatization of the world's dwindling fresh water supply with an unflinching focus on politics, pollution, human rights, and the emergence of a domineering world water cartel.

Glossary of Key Words

Aeration
the process of supplying with air or exposing to the circulation of air. Synonyms: airing, ventilation, breathing.

Bacteria
any of the unicellular prokaryotic microorganisms of the class Schizomycetes, which vary in terms of morphology, oxygen and nutritional requirements, and motility, and may be free-living, saprophytic, or pathogenic in plants or animals.

Chlorination
the process of treating or combining with chlorine or a chlorine compound. Most often the purpose is to disinfect of harmful microorganisms.

Coagulation
the transformation of a liquid into a soft, semisolid, or solid mass. Synonyms: clotting, congealing, curdling

Developing country
a developing country has a relatively low standard of living, an undeveloped industrial base, and a relatively low Human Development Index score (HDI). In developing countries, there is low per capita income, widespread poverty, and low capital formation. Some examples are Algeria, Botswana, Armenia, Azerbaijan, Guatemala, Brazil, and Paraguay. (http://en.wikipedia.org/wiki/developing-country)

Disinfect
to cleanse so as to destroy or prevent the growth of disease-carrying micro-organisms. Synonyms: decontaminate, sterilize, sanitize, clean.

Fertilizer
any of a large number of natural and synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its capacity to support plant growth.

Filtration
the act of passing a gas or liquid through a porous material in order to separate the fluid from suspended particulate matter.

Pesticide
a chemical used to kill pests, especially insects.

Sedimentation
the act or process of depositing sediments.

Virus
any of various simple submicroscopic parasites of plants, animals, and bacteria that often cause disease and that consist essentially of a core of RNA or DNA surrounded by a protein coat. Unable to replicate without a host cell, viruses are typically not considered a living organism.

resource: http://education.yahoo.com/

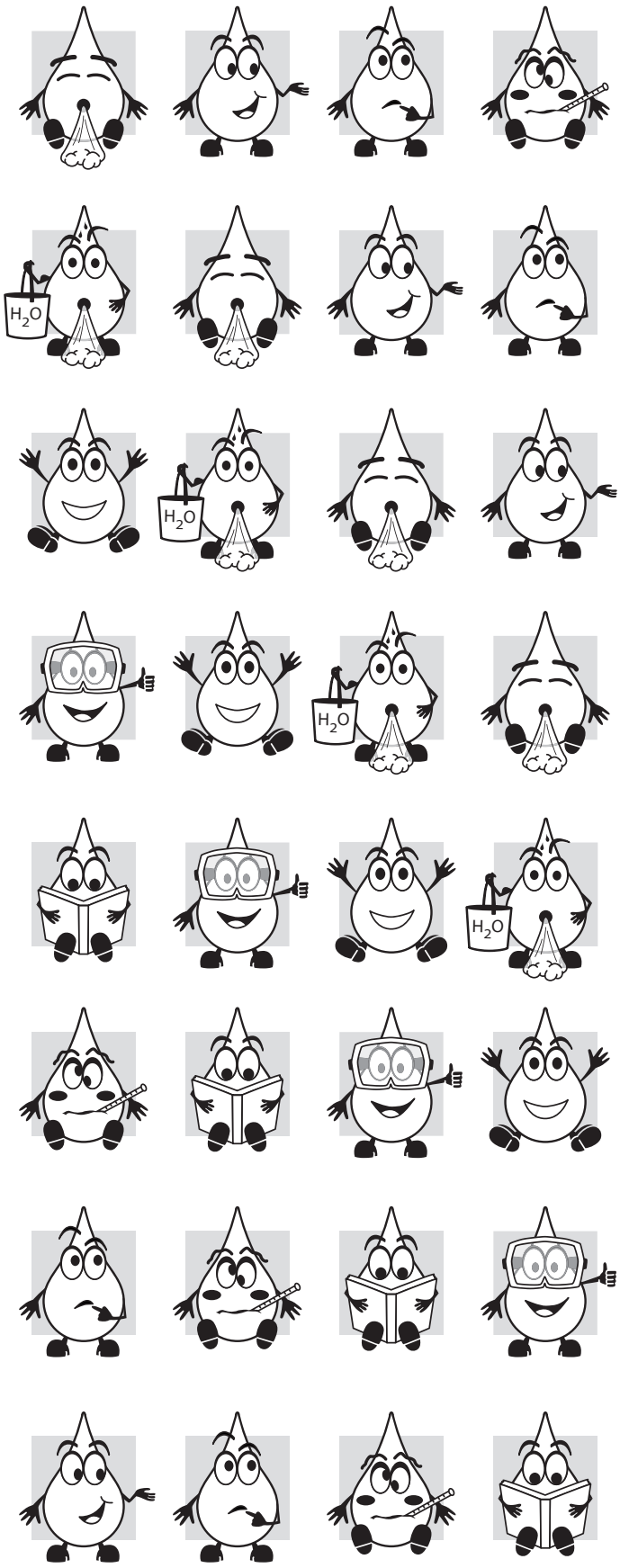
Acknowledgements

Many of the resources used for these lessons were provided through websites sponsored by the US Environmental Protection Agency: http://www.epa.gov/ow/.

Need help?

For assistance with chemistry and other scientific concepts, please contact Martha Brosz (martha.brosz@cincinnatistate.edu) or Mary Repaske (mary.repaske@cincinnatistate.edu) – Chemistry Instructors at Cincinnati State Technical and Community College.

For assistance with the structure of the lesson plans, help with materials, or classroom management techniques as they relate to the lessons, please contact Teresa Null (teresa.null@gmail.com) – Middle School Educator.



Lesson 2

Treatment of Water

Student Activity Packet

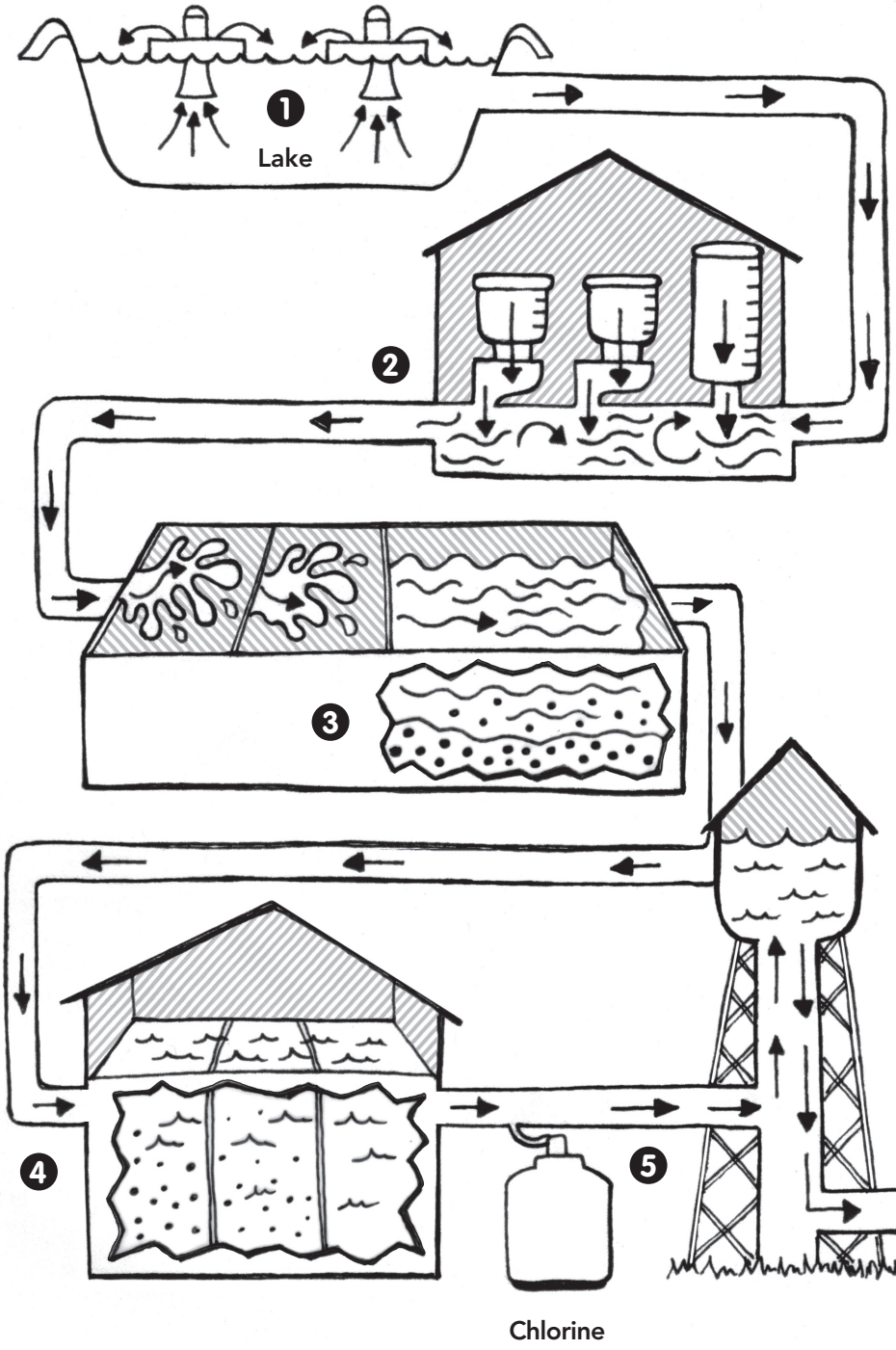
Name _____

Treatment of Water

Lesson 2
Warm Up

Challenge: Design, build, test, and evaluate the effectiveness of a water filter used to change dirty water into safe and clean drinking water.

With your team, examine the following diagram of a typical water treatment plant in the United States. Read the descriptions of the stages.



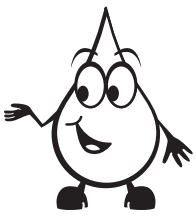
1. **Aeration**
   An initial process by which air is added to water and gasses that are trapped in water are allowed to escape.

2. **Coagulation**
   The process by which chemicals are added so that dirt and other suspended solid particles chemically stick together into "floc" (clumps of dirt and sediment) and can easily be removed from the water.

3. **Sedimentation**
   The process that occurs when gravity pulls the particles of floc to the bottom of the container.

4. **Filtration**
   The process that removes most of the impurities remaining in water after coagulation and sedimentation have taken place.

5. **Disinfection & Storage**
   The final process in which chemicals such as chlorine are added to water to kill harmful micro-organisms. The water is then stored in large quantities to be used by the community.

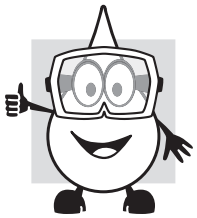


Lesson 2
Warm Up

Name _____

For each possible contaminant in the table below, list the stage in the treatment process in which the contaminant would be removed from water, making it safe to drink. More than one stage may be listed for any contaminant.

Contaminant	Stage(s) of Water Treatment
Bacteria	
Hydrogen Sulfide Gas	
Gravel	
Viruses	
Sewage	
Fertilizers	
Methane Gas	
Sand	
Leaves	
Worms	
Pesticides	



Lesson 2
Activity

Name _____

Design & Build The Best Filter

In the United States we are fortunate to have some of the best water treatment systems in the world, which use the five treatment stages discussed in the Warm Up activity.

Many people in developing countries, however, lack access to safe drinking water. Often, the only stage available to them is the filtration stage, in which they filter large particles out of the water using a cloth. However, for the water to be safe to drink additional stages of the treatment process are needed, especially the disinfection stage.

This activity will focus on the filtration stage. Your job is to become an engineer and design a better filter for the citizens in developing countries. You will construct your filter, test it, and evaluate how effective it could be for supplying clean drinking water.

General materials:

- 1 sheet of plain white paper
- Supply of paper towels for potential spills
- 4 copies of the Student Activity Packet
- 4 pairs of safety goggles

Filter apparatus materials:

- 100 mL of dirty water in a plastic cup
- 1 clear water bottle with the bottom cut off*
- 1 9oz. plastic cup (to collect filtered water)
- 1 domed "slushie" lid
- 1 coffee filter
- 1 rubber band

Filtering materials:

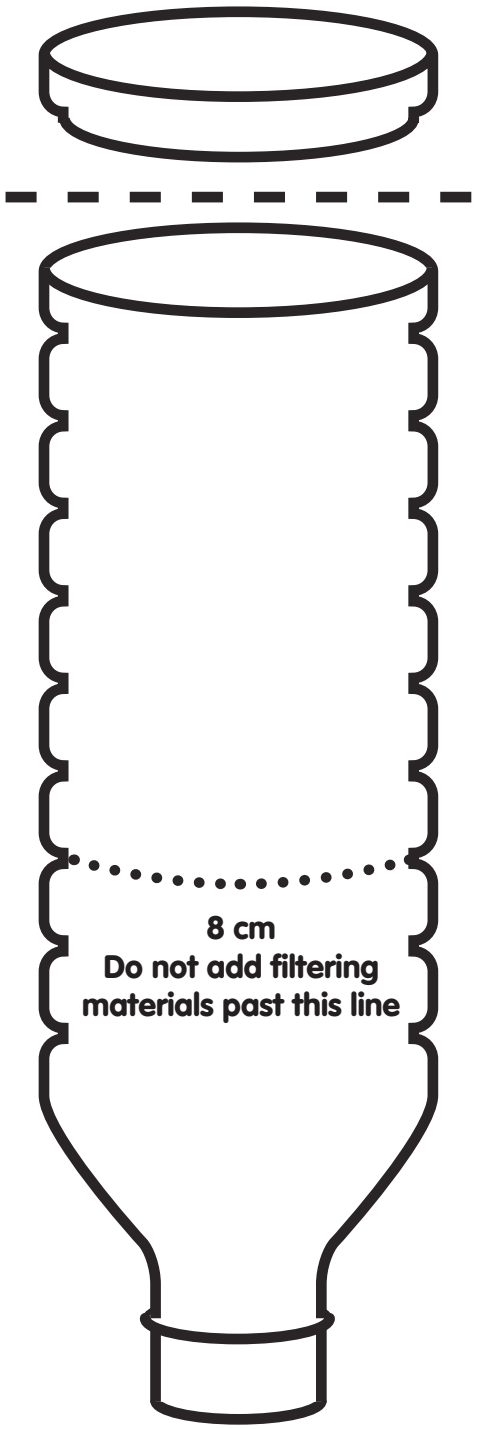
- Cheese cloth
- Cotton balls
- Cotton cloth
- Panty hose
- ScotchBrite pad
- Supply of aquarium pebbles, washed
- Supply of fine aquarium sand, washed
- Supply of activated granular charcoal

Lesson 2
Activity

Name _____

Procedure Step 1: Design Your Filter

Discuss with your team the materials available for building your filter. Build your filter apparatus according to the plan (next page) and select **some or all** of the available filtering materials to use inside the apparatus.



The filtration materials will be layered inside the bottle. Use the digram (left) to design your filter. Draw in and label which Filtration materials you think will best filter the dirty water. Remember, you may use **some or all** of the available filtration materials.

Describe how each material you use in your filter will help clean the water and why you think your filter will work.

_____

_____

_____

_____

_____

_____

_____

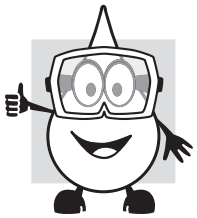
_____

_____

Share your design with your teacher, and obtain your teacher's signature of approval before you continue.

_____

Teacher Signature



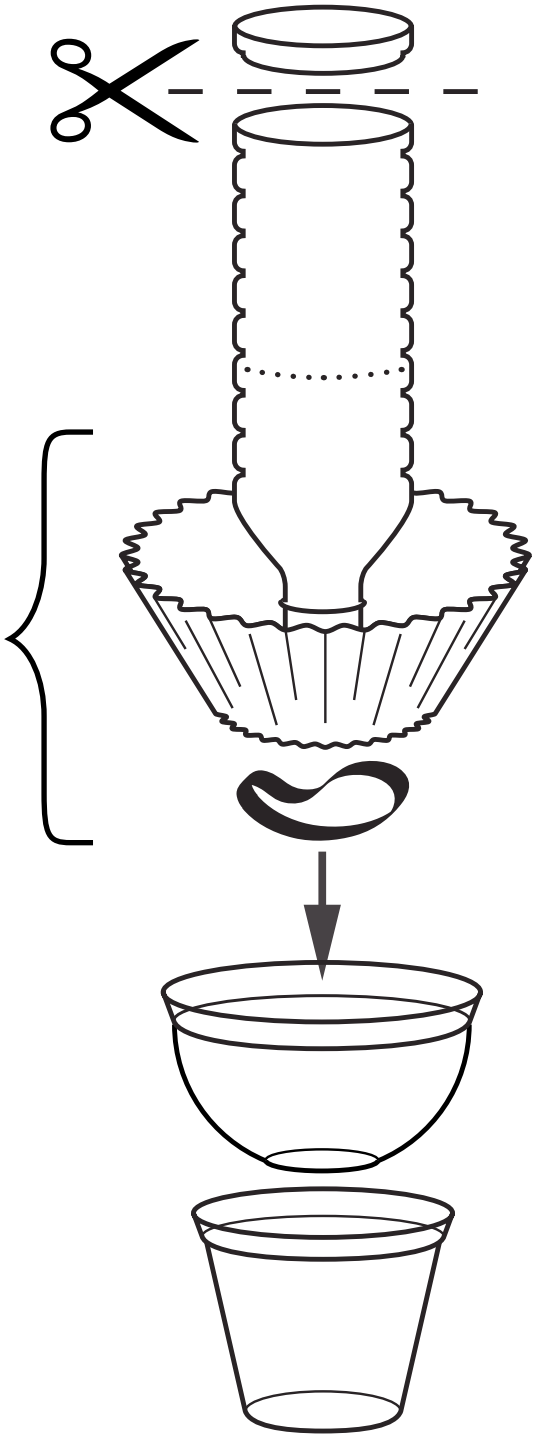
Lesson 2
Activity

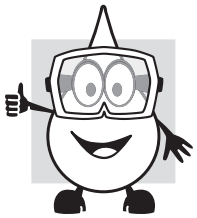
Name _____

Procedure Step 2: Build your filter

Have one or two team members obtain the Filtration and Structure materials needed to build your filter. Build your filter according to your approved design from Step 1. Be careful not to fill the bottle higher than 8 cm from the mouth of the bottle with the Filtration materials.

Wear your safety goggles at all times.





Lesson 2
Activity

Name _____

Procedure Step 3: Test your filter

A. Obtain 100 mL of dirty water in a plastic cup from your teacher and a piece of plain white paper. Observe the appearance and smell of the dirty water, and record your observations.

Appearance of dirty water:

_____

_____

Smell of dirty water:

_____

_____

B. Place your filter apparatus on the plain white sheet of paper so you will be able to see clearly the water as it filters through the bottle, and slowly pour the 100 mL of dirty water over the entire surface of the filtering materials in the bottle.

C. Watch carefully for the first drops of filtered water to appear in your collection cup. When about ½-1 cm of filtered water has collected in the cup, observe the appearance and smell of this water, and note any changes in appearance and smell from that of the original dirty water.

Appearance of filtered water:

_____

_____

Smell of filtered water:

_____

_____

D. Pair up with a member of your team and visit at least two other teams in the room to observe the results of their filters. Take notes comparing your results with those of the other teams.

Observations of the first team: Did this team's filter work better than yours? Why or why not?

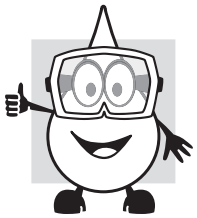
_____

_____

Observations from second team: Did this team's filter work better than yours? Why or why not?

_____

_____



Lesson 2
Activity

Name _____

Procedure Step 4: Evaluate your filter

Rejoin your team and discuss the results collected from other teams. Answer the following questions:

1. What worked well with your filter?

_____

_____

_____

_____

_____

2. What did not work as well as you had planned with your filter?

_____

_____

_____

_____

_____

3. How could you improve your filter if you built it again? You may discuss adding materials that were not available to you in this lab.

_____

_____

_____

_____

_____

4. Clean up all of your materials according to your teacher's instructions.

Lesson 2
Cool Down

Name _____

Treatment of Water

Answer the following questions on your own using complete sentences.

1. Will your filter help improve the quality of water available to citizens in the developing world? Explain.

_____

_____

_____

2. Would you personally drink the water that passed through your filter? Why or why not?

_____

_____

_____

3. In addition to your filter, what other treatment processes may be required to make your water safe to drink?

_____

_____

_____

4. Whose responsibility is it to make sure that your personal drinking water is safe? Explain.

_____

_____

_____

5. Whose responsibility is it to make sure that people in developing countries have safe drinking water? Explain.

_____

_____

_____