

Lesson 3



Wastewater treatment facility

Working with Wastewater

Students learn that human demand for fresh water is greater than the capacity of natural systems to produce it. While the water cycle cleans water and removes pollutants, it cannot do so at a rate, or the level, that meets human needs. Students examine a diagram to learn the basic methods involved in primary, secondary, and tertiary, or advanced wastewater treatment.

They use a second diagram to review the water cycle and see where water is cleaned in that ongoing process. In small groups, students create Venn diagrams that compare and contrast the natural and human processes for removing pollutants and providing fresh water. This activity helps them realize that some steps in our wastewater treatment systems

mimic steps in the natural water cycle. A homework assignment reinforces this and other lesson concepts. This lesson builds on students' understanding of potable and non-potable water quality levels, and establishes a foundation for upcoming lessons in which students explore water conservation methods, including reclaiming water for human use.

Background

Water covers approximately 70% of Earth's surface, but only about .003% of that water is both fresh and available to people, animals, and plants. The water cycle naturally cleans water, but the world's growing population influences the natural water cycle in two ways. First, we pollute more water, compromising the quality of our freshwater supply,

Learning Objectives

Recognize that the supply of fresh water is limited at any given time, and discuss how some resources within an ecosystem are finite in supply, while others are less limited.

Describe the methods by which wastewater can be treated and cycled back into the environment.



micro-filtration, reverse osmosis, desalination, and ultraviolet light.

Some wastewater treatment plants use nature to assist them. They guide sewage and partially treated wastewater through a series of settling ponds, where the sediment and nutrients in the water settle to the bottom and are filtered out by plants and other organisms before the water is released.

The Orange County Water District completed an ambitious project in January 2008, in which wastewater was rigorously treated and then reintroduced into reservoirs and aquifers. This water recycling project is called “indirect potable use.” In 2010, the largest ocean-water desalination plant in California will begin serving residents in San Diego County, converting sea water to fresh water.

and second, we use more fresh water than is readily available through the natural water cycle. Advances in technology have helped mitigate the challenge of a limited clean freshwater supply, but not all communities have such systems in place.

Water that has been used in homes, factories, and industry is called wastewater. Wastewater pipes carry contaminated water to treatment plants, which clean the water prior to sending it back to a natural system. Primary treatment is a mechanical process that filters the water to remove trash and then allows heavier particles to settle to

the bottom of a holding tank for removal. Secondary treatment uses microorganisms to consume dissolved biological matter, followed by mechanical filtration and settling processes to separate the solids and microorganisms. Adding chlorine to kill most of the remaining disease-causing microorganisms (bacteria, viruses, protozoa) finishes the second treatment stage.

Some communities add tertiary, or advanced wastewater treatment to rid the water of salts, certain volatile organic compounds, bacteria and viruses, and nitrates. Advanced wastewater treatment can include

Key Vocabulary

Evaporation: The process by which a liquid changes to a gas.

Filter: (verb) To pass a substance through a material, such as screen or fabric, to remove particles or other substances.

Percolation: The movement of water into the ground through soil, sand, and gravel.

Pollutant: A waste produced by human activity that contaminates the environment.

Settling: The sinking of heavier particles to the bottom of a liquid.

Storage: (noun) The place where something is kept.

Wastewater: Used water from homes, businesses, and industries.



Settling pond

Toolbox



Summary of Activities

Students discuss why humans need to clean wastewater. They study diagrams of the natural water cycle and the wastewater treatment process to learn how nature and humans clean water. They complete a Venn diagram to compare and contrast these two methods.



Instructional Support

See Extensions & Unit Resources, pages 34–35.

Prerequisite Knowledge



Students should know that:

- most of Earth’s water is present as salt water in the oceans.
- when liquid water evaporates, it turns into water vapor in the air and can reappear as a liquid when cooled, or as a solid if cooled below its freezing point.
- water vapor in the air moves from one place to another, can form fog or clouds, and can fall to Earth as rain, hail, sleet, or snow.
- living things cause changes in the environment they live in—some of these changes are detrimental, some are beneficial.

Advanced Preparation



Gather and prepare Materials Needed.

Add new vocabulary to Word Wall.

Create a Cleaning Water Venn Diagram:

- On the board or on chart paper, make a Venn diagram like the one on **Cleaning Water** (Student Workbook, page 5).
- Post the **Cleaning Water Venn Diagram** in a location that is visible to all students.



Materials Needed



A-V Equipment:

- projection system, screen

Class Supplies:

- chart paper
- colored markers
- pencils
- tape or thumbtacks

Student Edition:

- Wastewater Treatment, pages 7–8
- Water Cycle, page 9

Student Workbook:

- Cleaning Water, pages 5–7

Audio-Visual Materials



Visual Aids:

- Water Cycle, Visual Aid #9

Duration



Preparation Time

15 min.

Instructional Time

50 min.



Safety Notes

None

Procedures

Vocabulary Development

Use the **Dictionary** and the vocabulary **Word Wall Cards** to introduce new words to students as appropriate.

Step 1

Have several students volunteer to share why they think our supply of fresh water is limited. (*Fresh water is trapped in ice at poles, in glaciers, in the atmosphere; most of water on Earth is salt water in the oceans.*) (Note: You may want to mention that in some developing countries, some water is too polluted to use, and it is too expensive to clean it. Use the Lesson Background information to supplement students' knowledge as needed.)

Step 2

Ask students what they think happens to water once we have used it in our homes, factories, restaurants, and industries. (*Accept any answer.*)

Review the term “wastewater” with students.

Step 3

Remind students that the water cycle helps clean water naturally. Ask students, “Why do people need to clean wastewater if the natural water cycle already does this?” (*We use more fresh water than the water cycle can produce; it helps to prevent disease and reduce pollution.*)

Tell students that they are going to learn how wastewater is treated and cycled back into the environment. Tell students that they will also compare and contrast wastewater treatment to the parts of the water cycle that naturally clean water.

Step 4

Review the terms “filter,” “pollutant,” and “settling” with students. Distribute a **Student Edition** to each student. Tell them to turn to **Wastewater Treatment** (Student Edition, pages 7–8). Review the diagrams, briefly describing three methods of water treatment. Be sure students understand that primary treatment happens first, followed by the secondary and advanced treatments, so water gets progressively cleaner with each type of treatment.

- **Primary treatment:** Wastewater is pushed through a filter. This filter catches and removes large particles from the wastewater. The filtered wastewater then enters a big pool, called a settling tank. Chemicals are added to the wastewater in the tank and these chemicals cause the remaining particles in the wastewater to clump together. When clumped, the particles are heavy and settle to the bottom of the tank. The water above the settled particles is drained off into ponds.
- **Secondary treatment:** Air is pumped into the wastewater in the ponds. Tiny organisms (bacteria) are put into the wastewater. The bacteria eat the organic particles that are still in the wastewater. Then, a chemical (chlorine) is added to the water to kill the bacteria.
- **Advanced treatment:** The water from the ponds is pushed through another filter with smaller holes than the one used in the primary treatment. This micro-filter traps very tiny particles, as well as the particles that the bacteria did not eat. The water may also be boiled at this step. When the water evaporates, any remaining particles stay behind. The water vapor is cooled and collected. Chemicals to disinfect the water are added, and then the water is ready for use.

Tell students that the advanced treatment is an expensive process. Water treatment plants in different communities may or may not use advanced treatment to treat their wastewater.



Step 5

Tell students to turn to **Water Cycle** (Student Edition, page 9). Project **Water Cycle** (Visual Aid #9) and review the diagram and the following terms with students: “evaporation,” “storage,” and “percolation.” Briefly describe the parts of the water cycle that naturally remove pollutants from water.

- **Evaporation:** When water evaporates, it leaves behind some of the heavy pollutants. The water vapor is cleaner than the liquid water.
- **Storage:** When water collects in one place, heavier pollutants sink to the bottom. This helps clean the water.
- **Percolation:** (Also known as infiltration) When water soaks into the ground through sand and gravel, some pollutants are left behind.

Step 6

Redistribute students’ individual **Student Workbooks**. Tell them to turn to **Cleaning Water** (Student Workbook, pages 5–7). Ask students to compare and contrast the ways in which the processes described in **Wastewater Treatment** and **Water Cycle** clean water. Have them focus on finding the similarities between the two processes.

Review the instructions for completing the Venn diagram on **Cleaning Water**. Organize the class into groups of three and tell students that they can discuss their ideas within their groups, but that each student is responsible for completing **Cleaning Water**.

Allow approximately 15 minutes for students to complete the Venn diagrams.

Step 7

Bring the class back together and call students’ attention to the **Cleaning Water Venn Diagram**. Have one group share one similarity or difference between the ways in which water is cleaned through wastewater treatment and the natural water cycle. Write the idea in the appropriate space on the diagram. Ask each group to add one idea from their diagram until the class diagram includes all the similarities and differences identified by the groups. Encourage students to modify their Venn diagrams as necessary to reflect accurate and thorough information. (*Note: An Answer Key and Sample Answers for the **Cleaning Water Comparison Venn Diagram** are provided on page 71, as part of the **Sample Answers for Cleaning Water**.*)

Step 8

Tell students to answer the questions in Part 2 of **Cleaning Water**.

Gather **Student Editions**.

Collect **Student Workbooks** and use **Cleaning Water** for assessment.

Lesson Assessment

Description

Cleaning Water (Student Workbook, pages 5–7) assesses students’ achievement of the learning objectives: “Recognize that the supply of fresh water is limited at any given time, and discuss how some resources within an ecosystem are finite in supply, while others are less limited” and “Describe the methods by which wastewater can be treated and cycled back into the environment.” To demonstrate what they have learned, students complete a Venn diagram and provide written responses to questions.

Suggested Scoring

An Answer Key and Sample Answers for **Cleaning Water** are provided on pages 71–73. There are 8 total points possible.

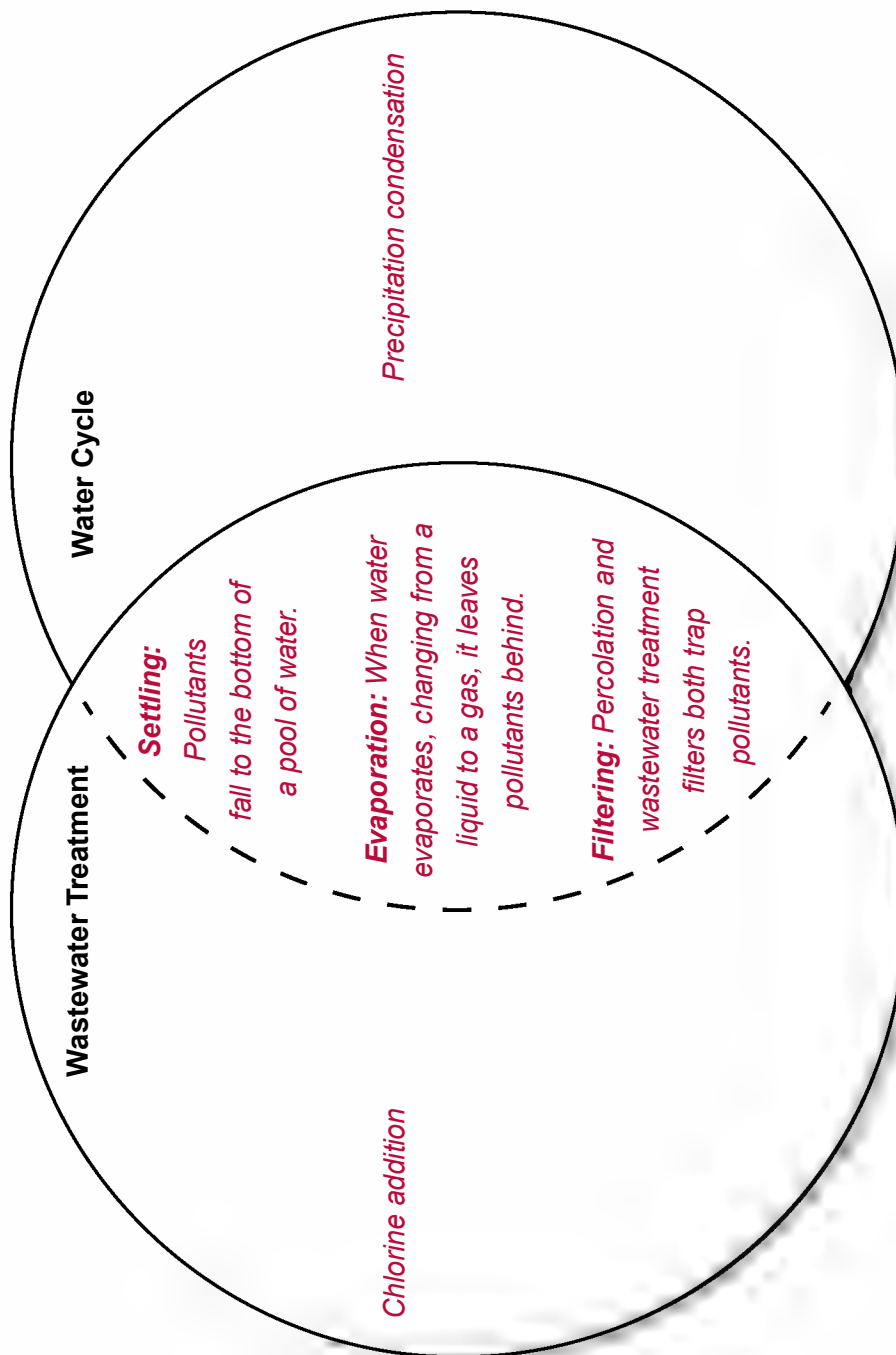
Answer Key and Sample Answers

Cleaning Water

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Name: _____

Part 1
Instructions: Think about how the natural water cycle and wastewater treatment plants make water clean. If both systems have something in common, list it in the area where the circles overlap. If only one system has a feature, list it in the outer part of the correct circle.



Cleaning Water

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Name: _____

Part 2

Instructions: Complete the tasks below in the spaces provided.

1. Write one paragraph that explains and gives at least two reasons why fresh water is a limited resource. (2 points)

Fresh water is a limited resource because the amount that it rains and snows in many populated regions is not always sufficient to meet all the human needs for fresh water; also, some of it is stored permanently in the ice at the North and South Poles. It is also stored in glaciers. Water is also in clouds in the atmosphere. Some fresh water is polluted so we cannot use it. The water cycle cleans water, but it cannot clean it fast enough for all the people that need it. That is why we have to clean the water ourselves through wastewater treatment plants.

2. Describe the primary, secondary, and advanced methods used in wastewater treatment systems. (3 points)

Primary treatment: Involves mechanical processes. Wasterwater passes through a filter, which traps large-sized pollutants. It then enters a big pool where heavy pollutants “settle,” or fall to the bottom for removal.

Secondary treatment: Involves biological and chemical treatment. Tiny organisms are put into the water. They eat some of the harmful pollution in the water. Then a chemical, like chlorine, is added to the water. This kills some of the bacteria in the water.

Advanced treatment: Involves mechanical and chemical processes. The water passes through a filter with tiny holes. This traps some of the pollutants. Then sticky chemicals that

Answer Key and Sample Answers

Cleaning Water

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Name: _____

cause some pollutants to clump together are added to the water. The clumps are then removed. Water can also be boiled. When the water turns to vapor, the heavy pollutant particles stay behind. Step 3 is an expensive process. Water treatment plants in different communities may have slightly different steps.

3. Describe how wastewater treatment methods are similar to some ways natural systems clean water. (3 points)

Both result in heavy pollutants sinking to the bottom of a pool of water. Both can result in certain pollutants “sticking” to things like plants or chemicals, allowing cleaner water to flow past them. Natural percolation and treatment filters both trap pollutants. Both use evaporation, because when the water evaporates the pollutants are left behind.

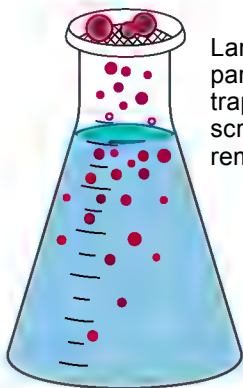
Wastewater Treatment

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Primary Treatment

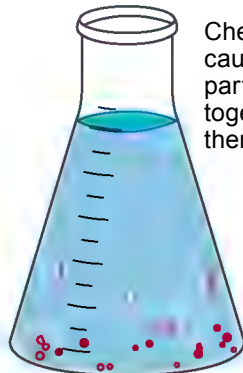
The first step in wastewater treatment uses mechanical processes (filters and settling).

Trapping

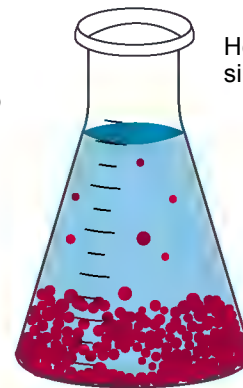


Large-sized particles are trapped in the screen and removed.

Chemicals cause small particles to clump together, making them heavier.



Settling

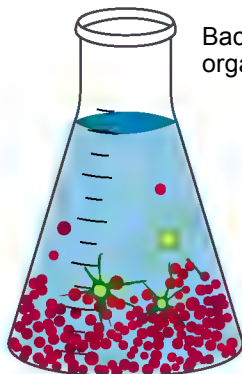


Heavy particles sink.

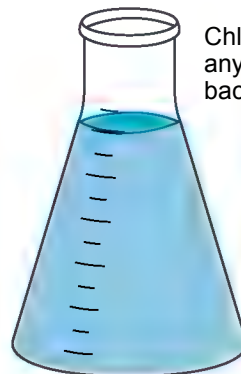
Secondary Treatment

The second step in wastewater treatment uses biological and chemical processes (bacteria and chemicals).

Bacteria digest organic matter.



Chlorine kills any harmful bacteria.



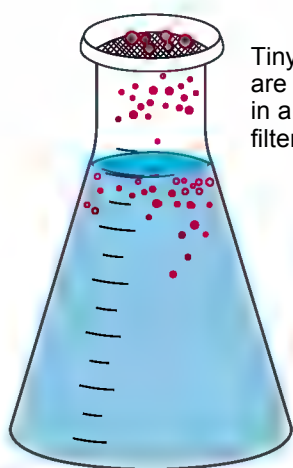
Wastewater Treatment

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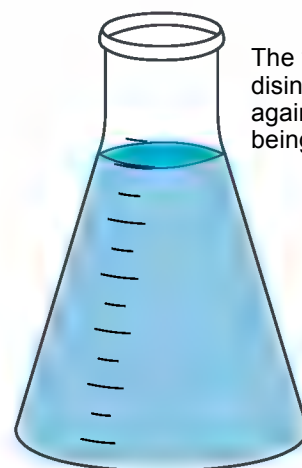
Advanced Treatment

These two steps follow primary and secondary wastewater treatment and use additional mechanical and chemical processes.

Micro-Filtration



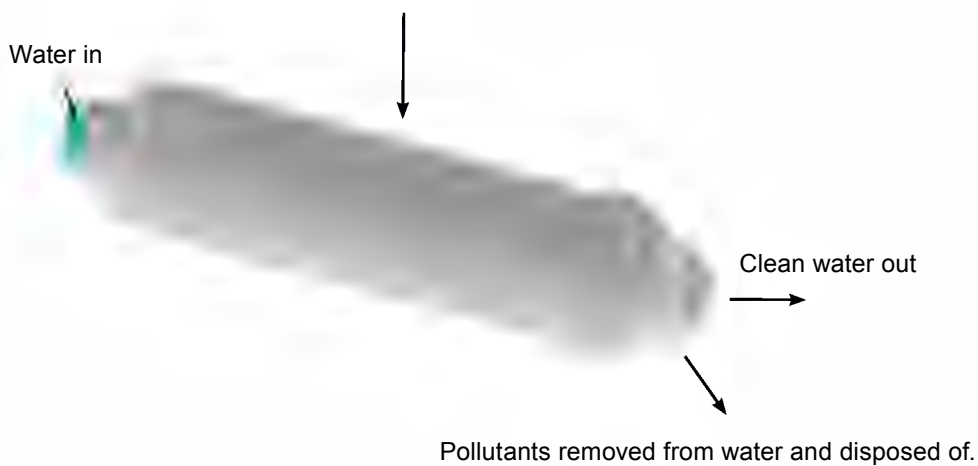
Tiny particles are trapped in a very fine filter.



The water is disinfected again before being used.

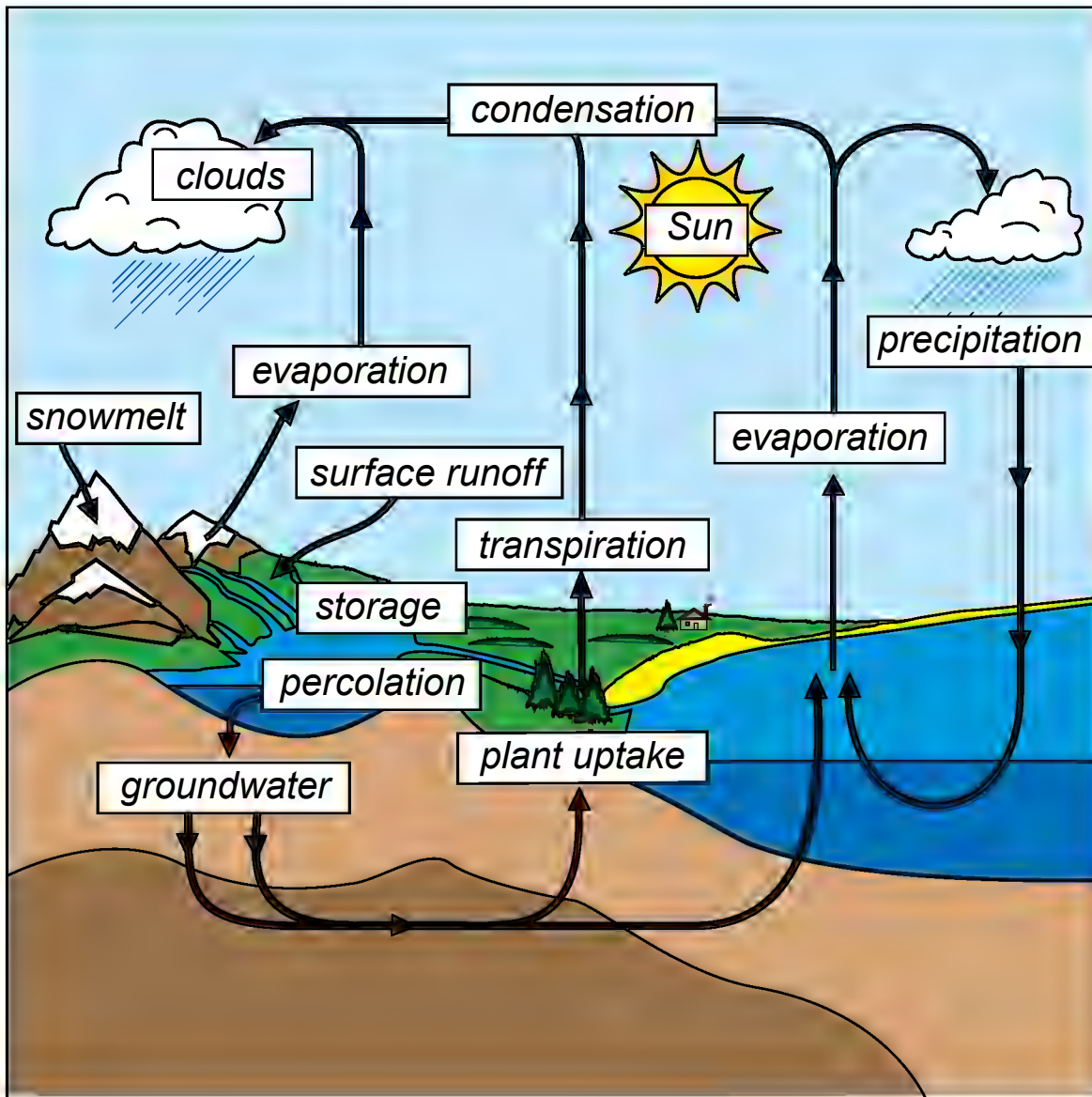
Reverse Osmosis

A tube containing a reverse osmosis membrane collects pollutants.



Water Cycle

Lesson 3



9

Water Cycle

Visual Aid

VA #9 Water Cycle

