Lesson Plan: Now I Can Drink the Water!

Summary
In this lesson, students review important concepts of the water cycle and then design, test, and evaluate a working model of a desalination plant (a distiller). They extend their understanding of the critical need for desalination around the world as they research new and promising technologies.

Resource Type: Lesson plan  
Grade Level: Elementary school

Objectives
By the end of this lesson, students should be able to
- Diagram the water cycle.
- Cooperate within a team to design a working model of a desalination plant.
- Measure, record, graph, and analyze quantitative data.
- Communicate investigation findings.
- Research and describe new methods of desalination.

Chemistry Topics
This lesson supports students’ understanding of the following topics in chemistry:
- States of matter
- Solutions
- Mixture
- Separating mixtures

Time
Teacher Preparation: 30 minutes
Lesson: 3 class periods, 45 minutes each

Materials
For each group:
- Bowl or similar shaped container (capacity between 2 L and 3 L)
- Small and short cup (capacity about 100 mL; the heavier, the better)
- Clear plastic wrap (to cover the bowl)
- Small stones or weights (2)
- Salt water solution (about 1 L)
- Area outside that is exposed to the sun for several hours
- Small paper cups (one for each student)
- Graduated cylinder (about 20–30 mL in size)
- Clock or timer (optional)

Safety
- Remind students not to look directly at the sun when they are outside setting up their distillers.
- Remind students not to drink the water (unless instructed by the teacher).
Vocabulary Terms
- condensation
- evaporation
- solute
- solution
- solvent
- water cycle
- water vapor

Keywords
desalination, water cycle, model, salinity, system, distill, solar still, engineering, design

Teacher Notes
- If students already have a strong grasp of the water cycle, Explore 1 and Explain a can be skipped.
- To see what others have done to make a model desalination plant, explore one or more of the following Web sites.
  - Solar Still
  - Solar Still Part 1: Salt Water
  - Salt Water Distiller
  - How to Make a Solar Still
- Be aware that if there is too much water in the bowl and the cup inside is not heavy enough, the cup might float and move away from the center of the bowl. Be prepared to have students add a second rock or weight to the cup to weigh it down.
- Be prepared to mop up any water spills if the experiment is done indoors.
- If you can provide new small paper cups and feel comfortable having your students drink the fresh water their distillers will produce, let them taste this water. It will add to their engagement in the lesson. Make sure the collecting cup placed inside the distiller is sufficiently clean.
- Once students conduct the initial investigation, they may want to investigate the effects of other variables such as amount of time in the sun, location of the distiller (full sun vs. shade), or initial salinity of the water. Keep in mind, however, that all other variables, including the design of the distiller, would need to be controlled.
- Visit the following Web sites for additional information about desalination.
  - How Desalination Works
  - What if you drink saltwater?
  - Solar Still

Lesson

Engage
Hold up a container of water. Ask students if they’ve had a drink of water today and if so, where did that water come from? A brief discussion about drinkable water will probably include the relative ease and convenience of obtaining safe and drinkable water whenever they need it. Have you ever been in a situation where you did not have access to drinkable water? Why did it happen? How did you feel when this happened? How would you feel if it happened?

Next, ask students if they know how people in other parts of the world get their drinking water. Guide students to consider the broader issue of the importance of safe drinkable water to all
people around the world.

Use some of the water from the bottle to wet a sponge. Swipe the wet sponge across a blackboard or other smooth surface the students can see; it should leave a visible smear mark. Allow the smear to dry/evaporate as you ask students to carefully observe any change in the smear. (An alternative and quick way to demonstrate evaporation is to vigorously breathe on the blackboard and step away so students can observe a dark spot of moisture on the board. This is even something students could do themselves.)

Facilitate a brief discussion about the “disappearance” of the water and draw the students’ understanding of evaporation. Can they articulate the change of state from liquid water to water vapor? What do they understand about the particle nature of matter such as water? Do they use the term “water molecule”? As key concepts are brought up, write them on the board or chart paper: water, liquid, gas, water vapor, molecule, evaporate and others. You might even want to organize these concepts in graphical form in order to show relationships among the concepts.

Move on to pose the dilemma of being stranded on a small island somewhere in the middle of the ocean without having any fresh water to drink. How would students survive without any water to drink? Encourage students to brainstorm possible ideas they offer for survival. (This could be done in small groups, using Think-Pair-Share, or as a whole class. Ideas could be charted or diagramed on the board or chart paper and summarized with the class.)

Next pour some of the water from the bottle you have been using into a beaker or glass, add a small amount of salt and stir. Tell students you have just made a salt water solution, and that the water is called the solvent and the salt is called the solute. Write these three terms on the board. (If time and availability of materials permit, individual or pairs of students could be allowed to make their own salt water solution. Students should be cautioned not to drink their salt water.) Prompt students to make a connection between this salt water solution and ocean water, both of which contain salt. Is this salt water drinkable? Is the salt water from the ocean drinkable?

Tell students they are going to have an opportunity in this lesson to design, build, and test a device that can remove salt from water so the water is drinkable (and enjoyable to drink). Hold up your beaker of salt water. In theory, if they were indeed stranded on a small island, they should be able to obtain drinkable water by using such an apparatus. Why would such a device be helpful to populations around the world? What areas of the world might benefit from a device like this? (Save this beaker of salt water for later use.)

Explore 1
Ask students what they think happens to the water vapor that is naturally in the air or has evaporated from a source of liquid water, like the smear on the board or a puddle of water. Does it always stay as water vapor? Does it move around? Does the water vapor change form? Tell students they are going to view a video about the water cycle that can answer these questions and more. What do students already know about the water cycle? Do they know what ingredients or factors are necessary for the water cycle to work?

Show the video Bill Nye the Science Guy episode 47: Water Cycle. This video, 23 minutes long, nicely covers all aspects of the water cycle using entertaining visuals and models, among other techniques. If time is a concern, a shorter portion of the video, three minutes long, is available at
Bill Nye the Science Guy: Water Cycle - Video; it covers the basics of the water cycle. Key concepts addressed in the full video include:

- evaporation
- condensation
- precipitation
- water cycle
- solid
- liquid
- gas
- water vapor
- energy

You might choose to review and discuss these key concepts with students in a number of ways: pause the video at appropriate times and discuss each concept, ask students to take notes in their science journals as they view the video, after viewing the video ask students to list the important ideas they can recall from the video, list the key concepts above on the board and discuss each one, or some method of your own choosing.

It would be useful to discuss with students the penguin toy Bill Nye used to model the water cycle. (If you chose not to view the full-length video, you might want to show the portion [14:50–15:47] of the video that features the penguin toy.) This toy is appealing for students of all ages and can be a useful memory aid to conceptualize the different aspects of the water cycle. Ask students: What makes this particular toy a good model of the water cycle? Is there a way this toy does not model the real water cycle very well? Can you think of other ways [systems, mechanisms, or procedures] to model a cycle?

Another option is to have students explore the water cycle is this interactive water cycle diagram from the U.S. Geological Survey (USGS). Note that there are three versions available: beginner, intermediate, and advanced. Choose the one most appropriate for your students. Be aware of the link on those pages that takes you to the main USGS Water Cycle for Kids page, where you have the option of printing the water cycle diagram in several formats as well as selecting a different language.

**Explain**

For students to be able to demonstrate their conceptual understanding of the water cycle, choose from the following possible activities. Offer support and access to materials and resources as students undertake this essential component of the lesson.

- Students make their own water cycle diagram (chart, using a computer, index cards, cut out pictures from magazines, make a rotating wheel such as a bicycle wheel or round cardboard disk that displays the main components of the water cycle, etc.)
- Students write an essay or blog entry in which they follow a drop of water throughout the entire water cycle.
- Within a small group, students write and present a creative play that features or incorporates the water cycle.

Once students have completed this task, facilitate a means for them to share their understandings with others in the class or even with parents at home. This could take the form of a gallery walk, formal time in front of the class, a blog on a dedicated website, or another method of your choosing. Use this as an opportunity to interact with students to clarify possible misconceptions and assess their current level of understanding of the main concepts. In this
part of the lesson, you want students to broaden and deepen their understanding of the water cycle and related concepts. Review with and remind students of the function and utility of models to promote a better understanding of natural phenomena.

**Explore 2**

Hold up the beaker of salt water and remind students of the opportunity they were offered to build and test a device that can remove salt from water so the water is drinkable. Now present this opportunity as a challenge. *Can you complete such a task? How might you do it? Will it be easy to do? Can you do it quickly? What materials will you need? How would people who don’t have access to many materials make such a device?* Use the term “investigation” when talking with students about this challenge and their activities. Suggest that the device they will make could be considered a model of a much larger device—called a desalination plant or distiller—that can remove salt from salt water and make it safe for many people to drink.

Tell students they are going to have an opportunity in this investigation to design, build, and test a device that can remove salt from water so the water is drinkable. Specifically, their task will be to work in groups to:

- Clarify and agree on the challenge;
- Design a device that will remove the salt from a salt-water solution so that the water is drinkable;
- Document the design and procedures on paper with drawing and text;
- Build the device;
- Collect and measure the amount of drinkable water;
- Analyze and evaluate the design and results;
- Develop a report or presentation of their findings.

Show students the materials you have available for their use for this investigation. Allow the groups to begin work on the challenge and facilitate as necessary. Arrange for as much time as you feel students need to design, carry out, analyze, and report or present their findings. See the [Teacher Notes](#) section above for systems found on the Web that will desalinate salt water and other helpful tips.

**Explain 2**

Encourage students to make accurate labeled diagrams of their distillers. Allow time for students to analyze their results. There won’t be much quantitative data (the amount of water collected) unless you have chosen to have each group leave their distiller in the sun for different amounts of time. They can examine their design and compare designs with those from other groups. Encourage groups to consider ways their design could be improved. If you have class data, students could make a data table and then graph the data from each group.

Discuss with students how knowledge of the water cycle helped them design and understand how their distillers work. They should be able to identify where in their distillers evaporation and condensation occurred and the role of gravity played in producing fresh water.

Arrange for groups to share their design, experiences, and results with the rest of the class. Groups could be encouraged to create a multimedia presentation, write a report, a press release, a blog, or come up with another creative method.
Elaborate
After briefly reviewing the water cycle and applying its principles to the students’ distillers, ask students if they know of other ways to remove salt from a salt-water solution. After some discussion, allow students to research other methods to accomplish the same task.

As a way of extending and applying the concepts central to this lesson, the following references would be valuable for students to investigate.

- How Dean Kamen’s Invention Could Bring Clean Water to Millions.
- Portable Solar Desalination “Plant” That May Aid In Third World Water Woes
- How Oil Refining Works

Ask if any students have seen the movie Life of Pi in which the main character, adrift in a lifeboat, is able to capture drinking water with the help of 12 solar stills. Discuss the fact that a still would be a good item to have in an emergency kit on a boat.

Evaluate
Assess the quality of the student’s response to tasks you assigned in the Explain section for the water cycle. Additional assessment can be made using the group’s presentation of their design of and results for the model distiller they made. Further assessment can be made using any of the following items.

Discussion Questions
1. What happened to the salt in the salt water solution? [It stayed in the original container.]
2. If you could measure the salinity (saltiness) of the water that was left over in the original container after the investigation, do you think it would be more salty or less salty than you began with? Why? [it would be more salty; the concentration of salt would be higher because water was removed, but not the salt]
3. Do you think the total amount of salt and water was different after it went through the distiller than before? Why or why not? [the total amount of salt and water did not change, but the salt and water might have moved]
4. What could be done to increase the output (amount of fresh water collected) of a distiller? Explain the reasoning behind your response. [make it bigger or wider; change the materials used]
5. What factors, other than the design of the distiller, might have affected your results? [the weather (air temperature, cloud cover); the amount of time spent in the sun; ability to measure carefully]
6. If you could have any materials, what would you use to make your distiller work better? How would those materials help? [answers will vary]

Multiple Choice Items
1. Which process caused water droplets to appear on the plastic wrap?
   a. condensation *
   b. evaporation
   c. expanding
   d. freezing
2. What was the source of energy for the distillers?
   a. the bowl
   b. the salt water
   c. the salt
   d. the sun *

3. Over time, what is most likely to happen to a pond of salt water in a desert?
   a. It will become saltier. *
   b. It will become less salty.
   c. Its saltiness will not change.
   d. It will become less salty and then more salty.

4. Why is it important for some parts of the world to have machines that can desalinate water?
   a. Salt water is not as clean as fresh water.
   b. Many people like to put salt on their food.
   c. Salt water doesn’t taste as good as fresh water.
   d. Humans and many other animals need fresh water in order to live.*

Open-Ended Questions
1. Explain the meaning of the term “cycle” in water cycle.
   [The word cycle means something like an event or process repeating regularly in the same order. A bicycle wheel rotates and the same place on the tire, like the valve stem, appears at the same place on the wheel regularly as the wheel spins. In a water cycle, a particle of water can evaporate, condense, fall to the ground, and then evaporate again. So it’s called a water cycle.]

2. Compare the life cycle of a butterfly to a water cycle.
   [A butterfly’s life cycle begins with an egg, progresses to a larva, then a pupa, and finally an adult butterfly. The adult lays eggs and the cycle begins all over. Likewise, in a water cycle, a drop of liquid water evaporates into a small amount of water vapor. Upon contact with a cool surface, the water vapor condenses back into liquid water, which falls down and begins the cycle can begin all over.]

Other
1. Samantha’s group made their distiller using aluminum foil instead of clear plastic wrap. How would their results (amount of water collected) compare with Kristen’s group who made theirs with clear plastic wrap? Explain your response. [Students may infer that the foil reflects sunlight while the plastic wrap allows it to pass through. Therefore, the distiller with foil won’t work as well as the distiller with plastic wrap.]

2. Ask students to compare the diagram they made of the water cycle to the diagram they made of their distiller. [Students should compare both parts (ground, clouds, rain; cup, plastic wrap, water) and processes (evaporation, condensation, precipitation).]
Cross-Disciplinary Extensions

Connect to Math
Have students calculate the rate at which their distillers produced fresh water based on the volume of water collected and the time their distillers were in the sun. Can they calculate the time-in-the-sun necessary for a given volume of water, for example a liter?

Connect to Writing
Have students write a procedural narrative explaining how to make a sun-based distiller.

Connect to Social Studies
Have students look for articles that discuss how distillers would improve the lives of populations in third world countries.

Next Generation Science Standards
This lesson supports the following:

Practices of Science and Engineering
- Asking questions and defining problems
- Developing and Using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Crosscutting Concepts
- Cause and Effect: Mechanism and Explanation
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter: Flows, Cycles, and Conservation
- Structure and Function

Disciplinary Core Ideas, Grades 3-5

Physical science
- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model shows that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects. (5-PS1-1)

- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (5-PS1-2)

- No matter what reaction or change in properties occurs, the total weight of the substances does not change. (5-PS1-2)

Earth science
- Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things,
including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)

- Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)

- Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)

**Engineering Design**

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) (secondary to 4-PS3-4)

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)

- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)