Hold the Salt

Section **THE CHEMISTRY OF LIFE & EARTH SCIENCES**

Estimated Time Setup: 10 minutes; Procedure: 4+ hours

OVERVIEW

Transform saltwater into pure drinking water using knowledge of separation techniques, states of matter, and physical changes.

In this activity, students create their own solar sill: a low-cost device that can be used to purify water. Through their understanding of how water can change from liquid to gas and back again, and how mixtures can be separated through the process of distillation, students engineer their own solution to the problem of dirty drinking water.

INQUIRY QUESTIONS

Getting Started:

- Where do we find fresh water on Earth, and how is this water used by humans, and other plants and animals? What are the problems with other sources of water that make them unusable?

Learning More:

- What physical or chemical properties can be used to separate a saltwater solution into water and salt?

Diving Deeper:

- How can a sample of saltwater be purified into fresh water through distillation?

CONTENT TOPICS

This activity covers the following content topics: states of matter, physical changes, condensation, vaporization, mixtures, solution, separation techniques, distillation, desalinization

This activity can be extended to discuss: human impact on the environment, fresh water scarcity, water purification methods, water cycle, precipitation, pollution, physical properties, intermolecular attraction, solutions

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **K-PS3-1:** Make observations to determine the effect of sunlight on Earth's surface.
- **2-PS1-4:** Construct an argument with evidence that some changes caused by heating or cooling can be reserved and some cannot.
- **MS-PS1-4:** Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- **MS-ESS2-4:** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MATERIALS

For one setup:

- Large bowl
- Heavy glass cup (shorter than the bowl)
- Teaspoon
- Clear plastic food wrap
- 1 coin
- Clear cellophane tape
- Food coloring - blue
- Spoon
- Water
- 3 tablespoons table salt
- Ruler

Optional materials:

- Dry erase marker

ACTIVITY NOTES

This activity is good for:

- Small groups
- Large groups
- Demonstrations

Safety Tips & Reminders:

- Even though the product of this experiment is clean water, we do not recommend drinking it since the equipment might not be sterilized beforehand.
- Review the Safety First section in the Resource Guide for additional information

Fun Fact **#1**

About 6,800 gallons of water are required to grow a day's worth of food for a family of four!

ENGAGE

Use the following ideas to engage your students in learning about the chemistry of life and Earth sciences::

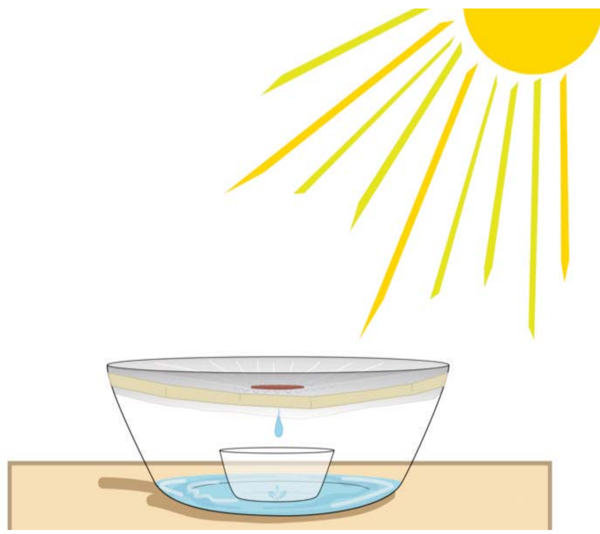
- Start with a problem: how would students get fresh water if they were stranded at sea and surrounded by only salt water? Or what if they were lost in the desert? Students can brainstorm strategies in groups and share with the class before trying the activity.
- Make this activity into an engineering task! Pose the problem of how to make pure water from saltwater, and provide the materials listed here, along with any others you have available to add more of a challenge and diversity to the solutions. Lead students through the Engineering Design Process to ensure they tackle the problem like a real-life engineer would.
- Begin the lesson with a deep dive into the challenge of humans' high demand for freshwater, including local activities and industries that require this resource (i.e. farming, drinking, plumbing in homes, etc.). Discuss how water is unequally distributed around the world, largely inaccessible, expensive to source, energy-intensive to clean, and how pollution makes even our natural freshwater systems unusable at times. Students can conduct their own local research into this problem, and this activity can be used as an example of a simple, low-cost way to get pure water.
- This activity can be connected to learning about the water cycle, since this is a small, simple way to represent the processes of vaporization and condensation in a closed system.

See the Elaborate section of this activity for more ideas to engage your students.

EXPLORE

Procedure:

1. Pour water into a bowl to a depth of around 5 cm. Either write down the depth or mark it on the bowl using tape or a dry erase marker.
2. Add 10 drops of blue food coloring and 2-3 teaspoons of salt. Mix until the salt dissolves.
3. Place the glass cup in the center of the bowl with the opening facing up, so the base is in the blue saltwater solution. (If the cup floats try to find a heavier cup or put something in the cup to weigh it down.)
4. Loosely cover the bowl with plastic wrap and tape it to the side of the bowl securely so no air can get in or out. The plastic wrap should not be pulled tight, but should sag slightly in the middle.
5. Place a coin on top of the plastic wrap, directly over the cup.
6. Put the bowl on a flat surface in a warm place, like near a windowsill, outside, or under a heat lamp.
7. Wait at least 4 hours, then observe the height of the water and see if there is anything in the cup.
8. Remove the plastic wrap and lift the cup out of the bowl to observe the results.



DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Describe the problem posed in this activity.
- Brainstorm some ways you might solve the problem posed in this activity. Draw or describe your thinking and solutions.
- Using the materials supplied, discuss with your group how you could build a device that would transform saltwater into pure water. After coming to a consensus, draw your idea and label the parts and their purpose. Or, if your educator has shown you one way to do this, describe how you think it will work.
- After a few hours or the next day, describe what you notice in the device that was built. Did you successfully make pure water? How do you know? If not, what might have gone wrong?
- Describe or draw how you think water is made from saltwater in this experiment.

EXPLAIN

What's happening in this Activity?

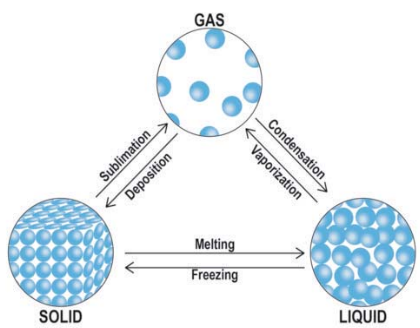
First review the Chemistry of Life & Earth Sciences Background section to gain a deeper understanding of the scientific principles behind this activity.

Plants and animals need fresh water to survive, but in many places fresh water is not easily available. Around 72% of the earth is covered in water, but 97% of that water is in our oceans. Ocean water is not pure water. It is mixed with many different substances, some of which—for example, salt—are unsafe to drink. We need some salt in out diet, but too much salt can dehydrate our cells and damage our kidneys and blood cells. To make ocean water safe to drink, we must purify it to remove the salt and other unsafe materials. Water in lakes, streams, and other bodies of water are also often mixed with unhealthy materials, and have to be treated to get clean, fresh water.

The combination of water and salt is a mixture. A **mixture** is two substances that are physically combined. The parts of a mixture retain their own properties, so they can be separated from one another based on differences in their physical or chemical properties. In this mixture, the solid salt is dissolved in the liquid water. Salt is very **soluble** in water, meaning that a lot of salt can be added to water and it will easily dissolve.

Distillation is the process by which a liquid is isolated based on its **boiling point**, which is the temperature at which it turns from a liquid to a gas. The phrase "distilled water" comes from this separation technique. As an example, when a mixture of water and other impurities – like salt – is heated, the liquid water will easily boil. As the water turns from liquid to gas, the water vapor gas produced is funneled through a tube. The tube then cools the water vapor, and it **condenses** back to liquid water in a separate container. With the water boiled and condensed into another container, eventually the only material left in the original container will be the solid impurities .

Water turns from liquid to gas at 100 °C. Salt takes a huge amount of energy to turn into a gas, and only does so at 1,413 °C! This means that if we take a solution of saltwater and let it warm in the sunlight, the water should easily vaporize over time and turn to gas, and the salt will remain behind. (Hint: remember phase changes between states of matter from the previous activity, Dew Drops!)



Now that we understand how pure water can vaporize from a solution, we have to find a way to turn the water back into a liquid again so it can be used. We seal our contraption so no water vapor escapes. When then water vapor touches the cool plastic wrap, it condenses into liquid water once more. Since the plastic wrap is weighed down in the middle over the cup, the water drops are directed right into the cup, where they can be collected and used!

Why is the water in the cup clear and not colored blue like it was originally? Food coloring also has a higher boiling point than water so more energy is needed to make it into a gas. Therefore, the water collected in this experiment should be pure H_2O – with no salt or coloring!

Notes

EXPLAIN continued

Any method that removes the salt from water is called **desalinization**. Desalinization is important for making pure water for human to use and drink. The contraption built in this experiment is a solar still. A solar still uses energy from the sun to heat and evaporate water, and then cools and collects the purified water vapor as a liquid. There are many types of solar stills and they are used around the world as a simple, low-cost way to obtain **potable** (drinkable) water.

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED	DIVING DEEPER
For younger students, emphasize the following concepts: • Matter can be found in three states: solid, liquid, or gas. As temperature changes, matter can change between these states. • A mixture can be separated into its components through different techniques.	**For more advanced students, emphasize the following concepts:** • A substance undergoes each phase change at a specific temperature, and substances can be identified based on these temperatures. • Distillation is a technique that separates liquids based on their boiling points.

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- Does the type of bowl used affect the results? Try the experiment with a metal, glass, and plastic bowl. Which worked best? Why?
- Does the location of your experiment affect the results? What if it was done on concrete? Grass? Outdoors? Indoors? See where you get the best results!
- Can you distill water out of other solutions? Try juice, sodas, or anything else that contains water.
- As recommended in the Engage section, you can pose this as an engineering problem for students to solve. Alternatively, if they do the experiment first, see if they can optimize the design to get the most water in a 24-hour period.
- Lead a discussion about the real-world feasibility of using this type of device to purify water. What are the limitations? What are the benefits? Would this be something that could be adopted in your community? Why or why not?

Fun Fact #2

By 2025, the United Nations projects that 2/3 of the world's population will face water scarcity. Finding inexpensive, simple ways to produce and clean fresh water for a growing population is important.

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

On a very small scale, this activity also demonstrates how water moves through its natural cycle. Processes like condensation and evaporation happen on a large scale, along with other complex phenomena which cause the weather and earth formations we see in the world around us .

Solar stills can be used on land and in the water to get water through natural processes of evaporation and condensation.

Careers in Chemistry

- Food chemists perform distillation on a massive scale to ensure they are working with the purest, safest products, and also to isolate specific liquids from a mixture. When oil is refined, it also goes through a process of distillation to separate the crude oil into its components for use .
- Techniques like the one used in this experiment are useful in areas of the world without infrastructure for plumbing, sufficient rainfall to provide drinking water, or dependable power sources. Low-tech ways to get clean water and food are also useful for people who do adventure sports or travel to remote areas of the world. There are many companies that sell inexpensive products to generate portable water using the power of the sun.

Notes

EVALUATE

- What changes in state occurred during this experiment and how? Ask students to write a report of what happened in this experiment using their new vocabulary words, such as evaporation, condensation, liquid, gas, desalinization, mixture, and more!
- There are many solar still designs, and even more devices for desalinization. Task students with researching a desalinization device either on their own or in pairs. What are the pros and cons of the system? How does it purify water? Where can we find it? Is it sustainable?
- If students are familiar with other separation techniques (hint: check out the Separations Techniques Activity Guide set!), provide a complex mixture for them to separate. What techniques would they use? Is a perfect separation possible? Students can write or draw their solutions, or test them out.