

Build, Test, Improve: a Solar Distiller That Runs on Sunlight and Gravity

Investigation question: How can you change a simple solar still so it turns more salt water into fresh water in a day, and how will your test data tell you whether the change helped?

Engineering design challenge

Groups of 4

3 sessions

Setup 10 · Activity 120 · Cleanup 10 min

MS-ETS1-4 · assesses

MS-ETS1-3 · practice

MS-ESS2-4 · practice

Name _____

Group _____

Date _____

Your role today

- ☐ **Builder:** Assembles the still exactly as the design sketch shows, seals the cover, places the weight, and sets the still in the agreed light position without moving the bowl afterward.
- ☐ **Measurer:** Pours the salt water in with the measuring cup, draws the collected water out with the syringe or pours it into the cylinder, reads the volume to the nearest 0.5 mL, and runs the salt-residue test.
- ☐ **Data lead:** Keeps the design log, records every prediction before the test and every result after, and copies the group's numbers to the class comparison table.
- ☐ **Design lead:** Reads the data after each run, proposes the single change for the next version with a reason in water cycle terms, and makes sure only one feature changes at a time.

Safety

- Lamp bulbs get hot enough to burn skin and to melt or ignite plastic wrap and paper. Keep every part of the still at least 30 cm from the bulb, never touch the bulb, switch lamps off before adjusting anything, and never leave lamps on unattended overnight; use the window for overnight runs.
- Never drink or taste any water in this lab, including the collected water. The still is a model, the equipment is not food-safe, and the salt-residue test is the only way you will check the water.
- Wipe spills at once; water on a hard floor is a slip hazard. Keep cords along the wall.
- Handle glass bowls with two hands and carry them only when nearly empty. Report any chips or cracks.
- Food coloring stains clothing and skin; wash hands after handling the salt water.
- If a group tests warm starting water, the teacher prepares it from warm tap water no hotter than 45 °C and checks it with a thermometer; anything above 50 °C is handled only by the teacher.

Procedure

1. Session 1. Sketch version 1 on the recording sheet: the basic still is the bowl with 300 mL of salt water, the empty cup standing in the middle (its rim above the water), plastic wrap sealed tight over the bowl, and a pebble on the wrap directly above the cup so the cover sags to a point. Label where light enters, where water evaporates, where vapor condenses, and how the drops reach the cup.

2. Build version 1 exactly as sketched. Measure the inside diameter of the bowl and record it. Write a prediction of how many milliliters you expect in the cup after the run and why.
3. Place the still in your marked light position and note the start time. Over the next 15 minutes, watch the cover and record the time the first fog appears and where the first drops gather.
4. Session 2 (after the agreed run time). Without tilting the bowl, peel back the cover, lift the cup out, and measure its contents with the syringe or cylinder to the nearest 0.5 mL (or weigh it). Record the volume, the hours the still ran, and whether the collected water is colored or clear.
5. Run the salt test: put three drops of the collected water on the black lid and three drops of the original salt water beside it, label both with the marker, and leave the lid to dry until the next session.
6. Design lead proposes one change for version 2 based on the data and the water cycle (for example a black liner under the water, a taller or shorter cup, warm starting water, a tighter seal, a steeper cone). Change only that one feature. Write the prediction and the reason in the design log, rebuild with fresh salt water, and restart in the same position for the same run time.
7. Session 3. Measure version 2 the same way, record it, and read the dried salt test: a white ring or crust means dissolved salt was in the drop; little or no residue means the water left its salt behind.
8. Copy your feature change and both outputs to the class comparison table. As a class, look for features that raised output in more than one group and features that lowered it.
9. Answer the analysis questions individually. If time allows, propose and sketch a version 3 that combines the two most promising features from different groups.

Record your observations

Lab 1 recording sheet: Build, test, improve a solar distiller

Fill in each prediction before the still runs. Record every measurement to the nearest 0.5 mL. Change only one feature between versions, and write down why you chose it.

-  Sketch version 1 from the side. Label: where light enters, where liquid water evaporates, where vapor condenses, the path the drops take to the cup, and the one place gravity is doing the work.



Design log (one row per version)

Version	What is different from the last version	Prediction (mL) and reason	Run time (hours)	Water collected (mL)	Color of collected water	Salt test result	Keep this feature? (yes/no and why)
1 (basic)	nothing: this is the starting design						
2							
3 (if built)							

First 15 minutes of version 1

Minutes after start	Fog on the cover? (none / patches / all over)	Drops forming? where?	Other observations
5			
10			
15			

Class comparison table (copy from the wall chart)

[illegible]

1. Describe what you saw on the cover in the first 15 minutes. Where did fog appear first, and where did the drops collect? Explain both using the words evaporation, condensation and gravity.

2. What color was the collected water, and what did the dried salt test show for each drop? What do those two results tell you about what did and did not travel from the bowl to the cup?

Analysis questions

3. Trace one water molecule from the salt water to the cup. For each step, name the change of state (if any), say whether the water gained energy, gave energy off, or just moved, and name what drove the step.

4. Explain why the water in the cup has no dye and little or no salt even though it came from dyed salt water. Then explain what this means for rain that falls from clouds formed over the ocean.

5. Use your bowl's inside diameter to find the area of the water surface (area = $3.14 \times \text{radius} \times \text{radius}$, in cm^2). Divide your best output by that area to get mL per cm^2 per run. Then estimate how many square meters of still ($1 \text{ m}^2 = 10,000 \text{ cm}^2$) you would need to make 2,000 mL of fresh water per run. Show your work.

6. Did your version 2 change help, hurt, or have no clear effect? Compare the numbers to your prediction and explain the result with the mechanism (light absorbed, evaporation rate, condensation on the cover, drops reaching the cup).

7. Two groups each found a change that helped. Describe the test you would run to find out whether combining both changes gives an even larger output, and name two things you would keep the same.

8. Match the parts of the still to parts of Earth's water cycle (the salt water, the lamp or sunlight, the cover, the cup, the drops running down). Then name two real water cycle processes the still does not model at all.

9. Using the class comparison table, choose two features from different groups to combine in a version 3. Justify each choice with the numbers, and name one reason the combined output might not simply add up.
