Figure 1. Crystals grown on the International Space Station Laboratory.

Figure 2. Crystals that can be grown in your classroom laboratory.

National Science Content Standards:

Science as Inquiry
Physical Science

Science Activity 2

Crystal Growth in Space

Objective

Investigate how crystals form when materials transition from their liquid to their solid state.

NASA Challenge

You are a scientist astronaut working in the laboratory of the International Space Station. Use the materials below to grow the largest crystal you can to help scientists on earth design a new medicine!

Materials

□ Hot water
□ Table sugar (sucrose) or other crystalline materials (See Table 1. for other options)
□ Clean glass jars/cups (at least 3 inch diameter opening at top)
□ Pencils or sticks
□ Cotton or wool string
□ Bowls for hot water and making solution
□ Spoons or stirring rods
□ Magnifying glass
□ An adult to help
□ Optional: Food coloring, Tape, Coffee Filter, Two sheets of black construction paper

Management

This activity can be conducted in a classroom environment. This activity can be done in teams composed of at least three (3) students: the mixer (chemist), the string designer (materials engineer), and the pourer/safety watcher (safety and mission assurance officer).

Vocabulary List

Gas, Liquid, Solid, Crystal, Dissolve, Saturated Solution, Protein

Background

Astronauts on the space station get to do a lot of science experiments growing crystals. When certain materials 'freeze' from a liquid to a solid their special growth patterns appear. These materials that group together in a repeated pattern are called crystals. You see crystals every day such as in salt, sugar, gemstones, and medicine!

Most new medicines are designed by scientists using special crystals called proteins. Proteins play a key role in the living world around us. They are the building blocks for humans and other animals. Knowing exactly how a protein crystal is shaped helps scientists design new medicines to combat diseases.

Growing some protein crystals here on earth can be extremely difficult, or even impossible, because gravity causes the delicate crystals to grow with imperfections. Studying crystals in space, where gravity does not get in the way, allows space scientists to grow big and almost perfect crystals!

Space scientists on the space station are helping find out how to grow the best quality crystals with protein crystals, like insulin (used to help people with diabetes). Bigger and better protein crystals made in space are a tremendous opportunity to design new medicines in the future!

Procedure:

The instructor should go through this activity a week before the teaching session to produce finished example crystals for the discussion and assessment portion of the lesson.

1. Gather your materials.

2. Break off into teams.

3. Tie the string to a pencil or stick. Make sure you are using a rough string or yarn.

4. Set the pencil or stick across the top of the glass jar and make sure that the string will hang into the jar without touching its sides or bottom. However, you want the string to hang nearly to the bottom. Adjust or cut the length of the string, if necessary.

5. Get hot water (faucet, boiled, or heated in the microwave), be very careful to avoid getting splashed! The instructor may want to go around and pour the water into the bowls for the students.

6. Stir in the sugar, a teaspoonful at a time. Keep adding sugar until it starts to accumulate at the bottom of the container and won't dissolve even with more stirring. This means your sugar solution is saturated. If you don't use a saturated solution, then your crystals won't grow quickly. On the other hand, if you add too much sugar, the crystals will grow on the sugar at the bottom of the jar and not on your string!

7. If you want colored crystals, stir in a few drops of food coloring.

8. Dip the string into the solution so that half of the string is coated. Take the string out and let it dry.

9. Pour your solution into the clear glass jar. If you have undissolved sugar at the bottom of your container, pour very slowly to avoid getting solid sugar pieces in the jar. Fill the glass about 2/3 full. The instructor may want to go around and pour the finished solutions into the jars.

10. Place the pencil over the jar and allow the string to dangle into the liquid. Make sure the string does not touch the glass.

11. Optional: You can tape the pencil/stick to the jar to keep it from moving

12. Set the jar somewhere where it can remain warm and undisturbed. If you like, you can set a coffee filter or paper towel over the jar to prevent dust from falling into the jar.

13. Finish lesson for the day with prepared example crystals using the discussion and assessment sessions.

14. Check on your crystals after a day. You should be able to see the beginnings of crystal growth on the string.

15. Let the crystals grow until they have reached a good size or have stopped growing. At this point, you can pull out the string and allow the crystal to dry. You can keep them. Have fun!

16. Keep your crystal beautiful by storing them in a dry area or in a closed container.

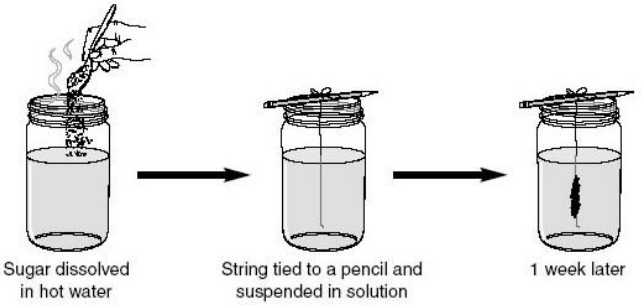

Figure 3. Diagram on experiment setup.

Discussion

Material phases

Mention 3 items: water, ice cubes, and steam. Ask the students what the water, ice, and steam have in common (they are all forms of water). Explain to students that these familiar water forms exemplify the three states of matter: liquid, solid, and gas.

What are crystals?

When water freezes into ice, like a snowflake, it becomes a solid with a pattern. Crystals are materials that solidify together into an orderly repeated pattern, like snowflakes. Sugar and salt are also crystals and you can grow these patterned materials in class!

Why you used hot water

In step 6 you made a saturated solution. The sugar dissolved or 'melted' into the water at first. When sugar started appearing at the bottom of the bowl, it meant that the water could not hold any more sugar. The water did not have room to dissolve anymore! Hot water was used because hot liquids can hold/dissolve more than cold liquids; this is called super-saturation!

Growing the crystal

In step 8 you dipped the string into the solution. Some of the dissolved sugar already stuck to the string. Once the sugar water started to cool off, the sugar in the water started to join the sugar on the string. When the water started to dry up into the air (evaporate), the sugar was left behind. The sugar joins the sugar on the string and starts growing a crystal! Because the jar only has sugar, all the sugar forms the same sugar crystals shape, making a big chunk of crystals that are pretty to look at.

Salt and sugar crystals (If different crystals were made in class)

- Ask students how they can tell the difference between the sugar and salt crystals just by looking at them!?
- Put the pre-made example crystals over sheets of black paper, to see them better.
- Use the magnifying glass to look closely at the crystal grains and compare how they look.

● Do they notice any differences? What shape are they? Have them draw the shapes.
● Since crystals grow in patterns, they grow to always have the same shape. The salt crystals are cube shaped (like dice) and have six sides. The sugar crystals are very rough looking and are shaped more like rectangles with pointed ends. The string crystals are actually just a bunch of the little cubes or rectangles stuck together! Some crystals might look different because pieces have broken off. Sugar crystals also look very clear and sparkly while salt looks more white-colored or frosted.

Assessment

1. What crystal was grown?

2. What was your Hypothesis on how the crystals would look? Were your results different?

3. What Are Crystals?

Answer: Crystals are materials that group together in a repeated pattern**.**

4. Can you identify other crystals you see every day?

Answer: Snowflakes, ice, baking soda, baking powder, geodes, etc.

5. Is glass a crystal?

Answer: No, glass doesn't freeze in any specific pattern, is has no order.

6. How are sugar and salt crystals alike? How are they different?

Answer: Both materials are crystals and they look very similar – they are both white colored, small grains. The salt crystals are cube shaped while sugar crystals are rectangle shaped and rough. Sugar crystals are clear while salt is looks more frosted.

7. Is a rough or smooth surface better for crystals?

Answer: A rough surface tends to be better for growing crystals. The students should notice that the crystal grows on the rough piece of string and not on the smooth sides of the glass.

Figure 4. Example images of salt and sugar crystal shapes.

Table 1. Crystal Growing Options

Jar	Ingredients	Observation
#1	1 3/4 cups regular salt 4 cups hot water	It grew fuzzy, white, frost like crystals
#2	1 3/4 cups brown sugar 1 cup hot water	It formed a crust over some slime
#3	1 3/4 cups white sugar 1 cup hot water	It grew a crust over the top
#4	1 3/4 cups iodized salt 4 cups hot water	It grew fuzzy frost like crystals.
#6	1 lb powdered sugar 1 cup hot water	It grew a crust