Super Cooling Activity Sheet
Info Sheet

***Materials Needed**:*

Measuring Spoons
Measuring Cup
*½ cup milk**
1 Tbsp sugar
¼ tsp vanilla extract
1 small Ziploc bag (sandwich or quart sized)
1 gallon sized Ziploc bag
½ cup Table/Rock salt
4 cups of ice cubes
Oven mitts or small kitchen towel
Timer

Heavy whipping cream works best. If you don't have that, whole milk and 2% milk are good too. 1% and skim will work, but gives more of a slushy consistency. We haven't tested non-dairy milk for this experiment, but the higher the fat content in the milk, the better.

Background Information

1. Organ preservation and transplantation can save lives.
2. Our organs contain about 70% water.
3. Currently organs are preserved in static storage, which means they are flushed with a solution and preserved on ice. This slows the metabolic activity allowing survival outside a human body.
4. To preserve organs for longer durations, we need to avoid 'ice formation'. Ice formation can damage the tissues.

   Show the students the video of greens gone soggy due to ice formation.

   Frozen Greens Video: In this video talk about the before and after differences. What happened to the greens after it was taken out of the freezer and thawed? Where did the water on the plate come from?

5. One way to do that is to add solutions in the organ that lower the freezing point of water this is called **Freezing Point Depression**. You cool it extremely rapidly below the Glass transition temperature. **Glass transition temperature** is defined as a temperature where the viscosity of the solution is extremely high (~10^{12} Poise). Due to this extremely high viscosity, the molecules of the solution cannot align themselves in a crystalline form and remain trapped in an amorphous (glassy) state.

6. This ensures water remains amorphous (glassy) and does not crystallize. This is called vitrification.

Ice Cream Activity Instructions

1. Prepare a small bag with the following ingredients:
    - ½ cup milk
    - 1 Tbsp sugar
    - ¼ tsp vanilla extract
2. Add four cups of ice cubes to the large, gallon-size bag. Then add one half cup of salt to the bag.
3. Put the small bag you prepared into the large bag with the ice cubes. Be sure both bags are sealed shut. Be careful to not squeeze the smaller bag too much or else it could be punctured by the ice.
4. Put on oven mitts or wrap the bag in a small towel and then shake the bag for five to ten minutes until you have more of a solid consistency. Feel the smaller bag every couple of minutes while you shake it and observe it.

    Show the students the video of our ice cream experiment, two bags, one of which did not have salt added to ice.

Super Cooling Background

- *Answer to Question 1*: 0°C
- *Answer to Question 2:* A water molecule is made up of two hydrogen atoms and one oxygen atom. The hydrogen and oxygen atoms of different water molecules are attracted to each other, and so they will stick to each other by forming bonds. When you cool water down to 0°C, the bonds become stronger and organize themselves in a crystal structure. This crystalline structure is ice. This process releases heat.
- *Answer to Question 3:* Ice formation in the cell caused the cell well and internal structures of the greens to burst. The water is from the vacuoles within the cells rupturing and then leaking out.
- *Answer to Question 4:* Adding salts or solutions to water can lower its melting temperature. This is called Freezing Point Depression. This means that water will exist in its liquid form at lower temperatures.
- *Answer to Question 5:* Lowering the melting point will allow the solution to freeze at lower temperatures. So, we can preserve the organ without ice formation inside it.

Ice-Cream Making Experiment

- Answer to *Question 6:* Open ended question based on what students think.
- Answer to *Question 7:* Ideally, they should. If not, discuss what possibly could have gone wrong.
- Answer to *Question 8:* Bag A had salt added to the larger bag. Bag B did not have salt in it.
- Answer to *Question 9:* The ingredients in Bag B did not turn into ice-cream.
- *Answer to Question 10:* The ice-cream could be potentially be made faster with metallic containers as the thermal conductivity of metal is higher than that of polymers (Ziploc bag).
    - **Mentors:** Talk about thermal conductivity here. Thermal conductivity: How fast can I cool or heat the organ. This property is also considered when we decide what container to cool or rewarm the organ in.
- *Answer to Question 11:* Insulators are bad conductors of heat. This will slow drown the process of making ice cream.
- *Answer to Question 12:* Salt on roads

After the experiment, show the students the Flash Freezing Water and Super Cool Ice videos.

Flash Freezing Water Video: The water in the bottle was filtered water and left in a car over night in winter when the temperatures dropped below freezing.

- *Answer to Question 13:* **Supercooling** is cooling of a liquid below its melting point while avoiding ice formation. This is done by avoiding ice nucleation (impurities, shaking all cause ice nucleation).

Super Cool Ice Video: Point out that the water in 2 of the bowls (middle and on the right) is now colder than the ice because we've added salt.

Sources

https://www.scientificamerican.com/article/scrumptious-science-making-ice-cream-in-a-bag/