PHASE TWO: BUILD UP
LEMON FREEZE



Mission: How can different processes affect final properties?

Age: 8+
Materials: $8

Time: 4 hours (1 hour active)
(Set-up: 15 min Activity: 30 min Clean-up: 15 min)

What you need:

Materials:
- Masking tape
- 3-4 lemons
- 4 cups hot water
- 1 cup sugar

Equipment:
- 1/2 cup measuring cup
- Grater or lemon zester
- Ice cube tray or muffin pan
- Mixing bowl
- Small stirring spoon
- Knife
- Pen

What to do:

1. First prepare the ingredients. With help from a grown-up, mix the hot water and sugar in a mixing bowl, stirring with a spoon until all of the sugar is dissolved. Put this mixture in the refrigerator for about one hour. While your sugar water is chilling, use a grater to grate 1 teaspoon lemon rind. Be sure to grate only the outer yellow surface of the lemon, the white stuff below tastes bad! Then cut the lemons in half with the knife and squeeze them over a measuring cup to make 1/2 cup of juice. Be sure to remove any seeds that sneak in. Add the grated rind to this lemon juice.

2. Prepare your ice cube trays or muffin pan. You will make two types of lemon ices: "A – Still" and "B – Stirred". Use the masking tape and pen to label half of your tray or pan with an "A – Still" and the other half with a "B - Stirred."

3. After an hour, add the lemon mixture to the cooled sugar water and stir. Pour the mixture into your prepared tray or pan, filling each compartment about 3/4 full. Save any leftover mixture in the refrigerator for further experiments!

4. Put the tray in the freezer and wait 30 minutes. While you're waiting, write down what you think you'll see when you remove the tray.

What to do:

5. Now remove the tray and observe what has happened. Has anything changed? Write down your observations, and then use the spoon to stir each of the compartments on the "B – Stirred" side, scraping the edges of the compartment as you stir. Do not disturb the "A – Still" side. Place the tray back into the freezer for 30 minutes.

6. Continue stirring the "B – Stirred" side every 30 minutes for approximately 3 hours, or until both types are frozen. Make observations each time you take the tray out. When do the ices start to become solid? What changes occur? Which completely freezes first?

7. Now eat your ices. How do they taste?

Clean-up:

After enjoying your lemon desserts, wash your dishes and tray or pan.

What's Happening?

You may have noticed that you made two completely different consistencies of dessert! Although you used the exact same materials, the different processes you used caused a big change in their properties. When the lemon mixture is in its liquid form, its molecules are free to move. As it freezes, the water molecules slow down and start to form tiny ice crystals. The crystals get bigger as more molecules join them, and eventually you get one big block of ice, like a popsicle. Stirring the lemon mixture during the freezing process changes how the molecules are arranged, resulting in smaller crystals and a softer texture like a slushy. While we cannot see these atomic structures with our eyes, the different textures show us the behaviors they cause.

So What?



Materials scientists are always experimenting to find new properties of materials. As we saw in our experiment, sometimes you can find new properties from the same materials just by changing how you put them together. For example, scientists build solid structures of special types of atoms called semiconductors, because they conduct electricity when they are all packed together. If you put the same atoms together as tiny particles—thousands of times smaller than a grain of sand—they act very differently. Called "quantum dots," these semiconductor particles glow different colors depending on their size.

MISSION: MATERIALS SCIENCE

DATA SHEET

LEMON FREEZE

	SIDE A - STILL	SIDE B - STIRRED
Which side will freeze first? Check the box to make your prediction.		
30 Minutes		
1 Hour		
1 Hour 30 Minutes		
2 Hours		
2 Hours 30 Minutes		
3 Hours Final Observations		

NGSS Alignment of Lemon Freeze Activity

The information below may not include every area that this activity can be linked to NGSS concepts

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- **Grade 2**
  - ◇ Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.
  - ◇ Different properties are suited to different purposes.
- **Grade 5**
  - ◇ 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 showing 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 and the effects of air on larger particles or objects.
- **Middle School**
  - ◇ Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
  - ◇ Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Performance Expectations

2-PS1-1: Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

2-PS1-2: Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.

MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.

Crosscutting Concepts:

Patterns

- Grade 3-5
  - ◇ Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.
- Middle School
  - ◇ Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

Crosscutting Concepts:

Cause and Effect

- Grade 3-5
  - ◇ Cause and effect relationships are routinely identified, tested, and used to explain change.
- Middle School
  - ◇ Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Engineering and Science Practices

Planning and Carrying Out Investigations

- Grade 3-5
  - ◇ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
  - ◇ Make predictions about what would happen if a variable changes.
  - ◇ Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.
- Middle School
  - ◇ Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
  - ◇ Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.