

# We Scream for Nano Ice Cream

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**ABSTRACT** There is a wide range of new products emerging from nanotechnology, and “nano ice cream” is an easy one that you can use to teach topics from surface area to volume applications. In this activity, students learn how ice cream can be made smoother and creamier tasting through nanoscience. By using liquid nitrogen to cool the cream mixture, students can sample nano ice cream and investigate how decreasing the size of the ice crystal affects the taste and texture of the ice cream.

**KEYWORDS** engineering, food science, nanotechnology

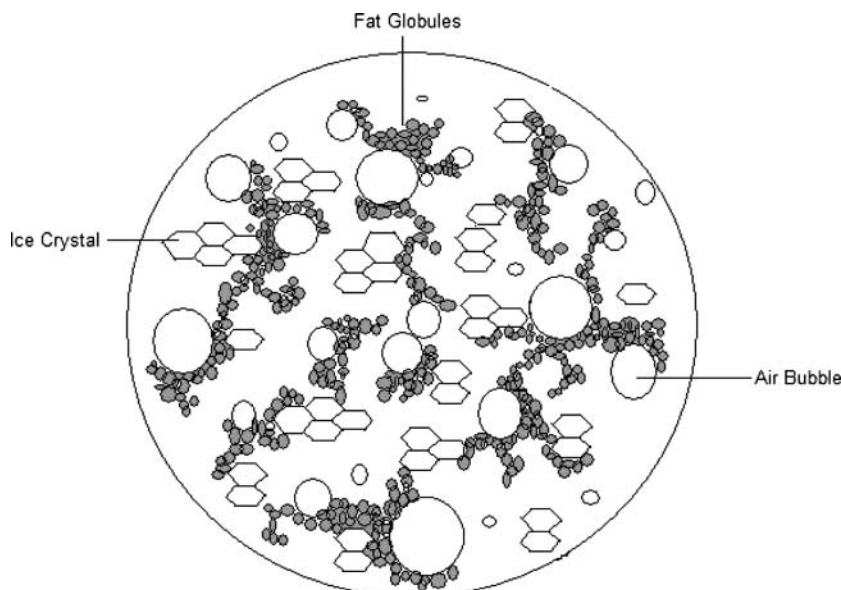
## BACKGROUND

One of the best ways to motivate high school students to learn science is to build lessons on everyday applications of science, such as a lesson on the science of food. There are several scientific principles that are involved in the making of ice cream, and high school science teachers often use it as a fun and tasty way to teach students about colligative properties, heat transfer, and emulsification (Gable 1999; Gibbon et al. 1992). Now those lessons can be extended to include nanoscience. Nanotechnology is becoming increasingly prevalent in our society, and new applications using nanotechnology are appearing in medicine, cosmetics, food preparation, and environmental applications. Using nanoscience to make ice cream is an interesting way to incorporate this new topic into a science lesson that students find motivating (see Table 1 for standards and key concepts addressed).

So, how is nanoscience related to ice cream? Nanoscience is the study of very small materials that exist at the nanoscale (a billionth of a meter). When ice cream is made so that the crystals are only a few nanometers in diameter, they are considered to have “nanoparticles.” Normally, the cooling process involves large vats of ice cream that are slowly and continuously stirred. As the mixture cools, the particles of sugar and fat are coated with water that crystallizes when it gets cold enough. Because this cooling process is slow, the crystals end up being relatively large in size (see Figure 1).

Salt is often used in high school classrooms to lower the freezing point of ice enough to make ice cream. However, instead of using ice and salt, liquid nitrogen can be used. Due to its extremely cold temperature (approximately  $-196^{\circ}\text{C}$ ), it freezes the water much faster, and the crystals end up being only a few nanometers in diameter, which makes the ice cream texture much creamier.

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**FIGURE 1** Representation of the makeup of ice cream.

“Nano ice cream” is also tastier because there is less surface area of water to melt on the tongue before tasting the sugar and fat. Nano ice cream can be made in the classroom if liquid nitrogen is available. Because liquid nitrogen is extremely cold, proper safety measures must be followed (see Safety section), and the teacher should practice the procedure before it is done in front of a class.

Liquid nitrogen has been used in cryotherapy for many years, frequently to remove skin growths (Kee 1967). The use of liquid nitrogen to remove growths should serve as a caution to teachers for the judicious handling of the liquid as it is poured into the cream mixture (Figure 2). Through the use of insulated gloves, long sleeves, and goggles by the person stirring the cream, any damage to skin that might occur as the nitrogen is added is easily avoided.

- Heavy cream or half-and-half (use twice as much cream as milk)
- Real vanilla (8 tsp for each gal. of liquid)
- Sugar (1 cup dry per gallon of liquid for really sweet ice cream)
- Liquid nitrogen (about 4 L for each gallon of ice cream): Liquid nitrogen is often donated by nearby universities to science teachers. It can also be purchased in farm supply stores and welding supply shops.
- Flavorings (candy, flavored syrups, etc.)
- Stainless steel bowl (Glass or ceramic bowls should *not* be used because of the extreme temperature change. Stainless steel or wooden bowls work best.)
- Long wooden spoon
- Heavy insulated gloves (e.g., fireplace gloves)
- Goggles

## ABOUT THE ACTIVITY

This lesson makes a great hook to engage your students in learning about nanoscience. Begin by asking: (1) What is nanotechnology? and (2) What are some ways that scientists are currently using nanotechnology? Discuss students’ ideas and then explain that they will be making ice cream that contains nanoparticles.

## MATERIALS

- Milk (a pint will make enough for 20 to 30 small servings)

## SAFETY

*Keep in mind: The liquid nitrogen should only be handled by teachers.*

Liquid nitrogen should always be handled with care because it is extremely cold! Simply to exist in the liquid state, it has to reach temperatures below  $-195.8^{\circ}\text{C}$  ( $-320.5^{\circ}\text{F}$ ). Skin contact and inhalation should be avoided, and thick gloves and goggles are necessary. Liquid nitrogen is best stored in a Dewar flask. Dewar flasks are well-insulated containers and can be purchased from many suppliers (Flinn, Cole-Parmer, etc.).

**TABLE 1** Integrating Nano Ice Cream into the Curriculum

National Science Education Standard	Key Ice Cream Concepts
Life and physical sciences	Examples of ice cream concepts
<ul style="list-style-type: none"><li>• Structure and properties of matter</li><li>• Interactions of energy and matter</li><li>• Matter, energy, and organization in living systems</li></ul>	<ul style="list-style-type: none"><li>• <i>States of matter</i>—Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together.</li><li>• <i>Colligative properties</i>—Properties that depend on the number of molecules or atoms rather than on their nature</li><li>• <i>Heat transfer</i>—The total energy of the universe is constant. Energy can be transferred by collisions in chemical reactions, by the light waves and other reactions, and in many other ways.</li><li>• <i>Emulsification</i>—The process of making any colloidal suspension of a liquid in another liquid</li></ul>
Science and technology	Nanotechnology
<ul style="list-style-type: none"><li>• Abilities of technological design</li><li>• Understandings about science and technology</li></ul>	<ul style="list-style-type: none"><li>• <i>Nanomaterials</i>—Ability to controllably synthesize small materials means new functionality, improved material properties, and revolutionary technology.</li><li>• <i>Nanomanipulation</i>—Ability to manipulate matter at the nanoscale opens up new possibilities of science and engineering.</li></ul>

The 1-L flasks cost approximately \$120, so the purchase of a Dewar flask may be limited owing to school budgets. However, most colleges, universities, and research laboratories have them in their inventory and

are frequently willing to loan the flasks to teachers for short periods of time. The flasks are reasonably rugged but, like any well-insulated vessel, can be damaged by dropping. Tops for Dewars fit loosely to allow for the



**FIGURE 2** Making the ice cream (color figure available online).

evaporation of the liquid as it slowly warms. Storing liquid nitrogen is not hazardous as long as it is kept covered. Because of its extremely low temperature, liquid nitrogen can cause oxygen from the surrounding air to liquefy. Liquid oxygen is hazardous. This hazard is altogether avoided by keeping the Dewar covered.

## PROCEDURE

This should be done under a hood, in a large sink, or on a wide counter. Also, students should be moved back from the demonstration.

1. Mix the milk, cream, vanilla, and sugar in the stainless steel bowl. Continue mixing until the sugar has dissolved into the milk and cream.
2. Add in desired flavorings (candy or flavored syrups).
3. Put on thick gloves and *slowly* add the liquid nitrogen. Use the wooden spoon to stir it until frozen (about 5 to 10 min). *Note:* As the liquid nitrogen boils off, excessive foaming and bubbling will occur.
4. Provide samples of ice cream to students. Ask them to make observations about the ice cream and to note how it may differ from regular ice cream. Are there differences in how it looks, smells, or tastes?

## POSTACTIVITY QUESTIONS

1. How small is a nanometer?
2. What is meant by the term *nanotechnology*?
3. How was nanoscience used in this activity to make ice cream?
4. What role did the liquid nitrogen play in making the ice cream?
5. List and describe five current applications of nanotechnology.
6. What kind of risks may be associated with nanotechnology?

While students sample the ice cream, introduce the scientific principles involved in making ice cream (heat

transfer, colligative properties, etc.). The postlab questions may need some additional research for students to answer them.

Nanoscale science is one of the fastest growing areas of science and has been predicted to be the next great science revolution. Futurists predict that nanotechnology will profoundly alter our world through innovative products, more efficient and abundant sources of energy, and new forms of medical care (Maynard 2007; Shea 2005). Therefore, it is important for students to be introduced to the topic as early as is practical, and making ice cream is the perfect way to incorporate it.

## INSTRUCTIONAL ICE CREAM RESOURCES

- Helmenstine, A. n.d. Make ice cream in a baggie: Freezing point depression and colligative properties. *About.com Chemistry*. <http://chemistry.about.com/cs/howtos/a/aa020404a.htm>.
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