WKS
Making Ice Cream

Name ________________________________
Period _____

Read the article, “Making Ice Cream,” from pp. 4-7 of the December 1995 issue of *ChemMatters* and answer the following questions.

1. [1 pt] How do colloids differ from solutions and suspensions?

2. [2 pts] What kind of colloid is ice cream? Describe what this means.

3. [4 pts] What are the four phases of ice cream and what are their purposes?

   a.

   b.

   c.

   d.

4. [1 pt] What is “heat shock” and how does it reduce the quality of the ice cream?

5. [2 pts] What is the purpose of “stabilizers?” How do they work?

6. [3 pts] What are the three sensations experienced when eating ice cream?

   a.

   b.

   c.

7. [1 pt] What does the sugar inside the ice cream mixture do to the freezing point of the mixture? (Read in "Homemade Ice Cream")

8. [1 pt] Explain the role that salt plays in making homemade ice cream.

Making Ice Cream

by Roberta Baxter

WHO MADE THE FIRST ICE CREAM? Historians can't say for sure. Some say that Marco Polo first tasted a soothing new food in the courts of Kublai and brought recipes for "milk ice" back to Italy. Later, Catherine de Medici's chef concocted delicious "fruit ices." Perhaps the first true ice cream made in the West was the "creme frez" served at the coronation feast of King Henry V of England.

For decades, ice cream was the rarest of treats because it was so difficult to make. Then, in 1846, Nancy Johnson invented the hand-cranked ice cream freezer that made it possible for anyone to make ice cream at home. Five years later, Jacob Fussell opened the first commercial ice cream factory in Baltimore, Maryland, and the rush for our favorite dessert was on.

Why is ice cream so popular? Probably because it combines the rich buttery taste of cream, the irresistible sweetness of sugar, and the soothing coolness of ice. The ingredients couldn't be simpler: cream, milk, sugar, air, and flavoring. But the problems start when the ingredients are mixed with cream.

Cool Chemistry

Cream consists of oily butter fat and water, with the remainder lactose, proteins, and minerals. Normally, oil and water refuse to mix, with the oil floating on top of the water. Cream does not separate this way because each microscopic droplet of butterfat is surrounded by a protein membrane that attracts water molecules.

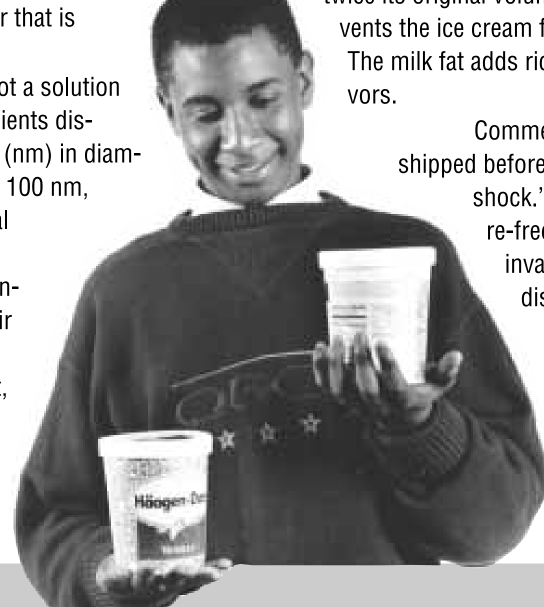
Sugar can easily be added to cream because it dissolves well in water. If cream is stirred very gently while sugar is added, it is possible to make a sweet, rich liquid. But to make ice cream, you must stir the mixture *vigorously* to fluff it up with air. Unfortunately, this breaks the protein membranes surrounding the butterfat droplets. The butterfat is set free and, if nothing prevents it, rises and forms an oily layer on the surface. Not a pleasant dessert. A remedy to this problem is to add an emulsifier—a chemical that helps oil mix with water. One natural emulsifier that is found in egg yolks is lecithin.

The liquid that is churned and chilled is not a solution but a colloid. In a solution, the different ingredients dissolve into tiny particles less than 1 nanometer (nm) in diameter. In a colloid, the particles are larger, up to 100 nm, though they are still invisible without an optical microscope. If you cool the colloidal liquid to about –10° C and make some provision for continuously adding air bubbles, you need only stir and stir and stir. A liquid that holds lots of trapped air bubbles is a *foam*. This means that, technically, when the ice cream finally freezes, you have made a frozen colloidal foam.

Under a microscope, frozen ice cream shows four distinct regions or phases:

- a syrup of sugar, salts, and proteins
- droplets of milk fat
- pockets of air
- tiny ice crystals

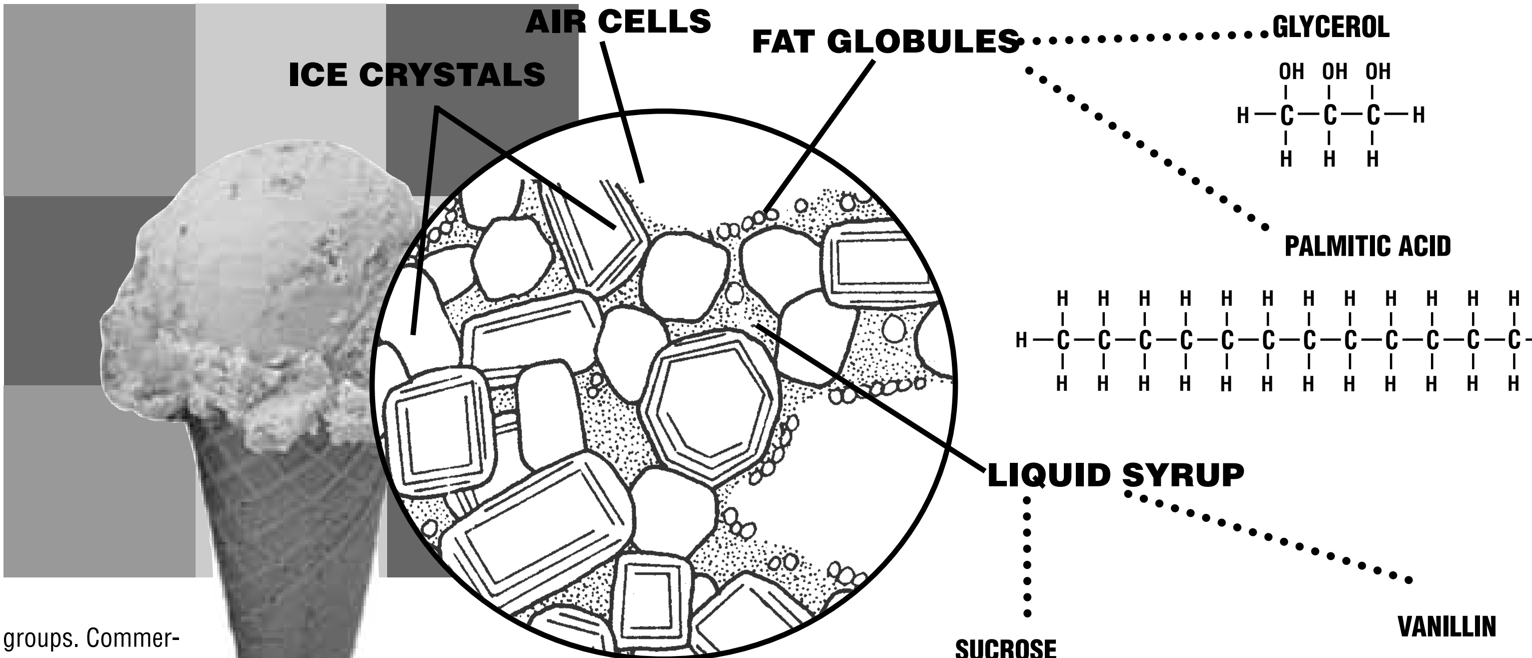
Each phase contributes to the taste and texture of the ice cream. The ice crystals stabilize the foam and and form a strong framework that holds the other phases in place. The air pockets interrupt the liquid and solid phases and make the ice cream smoother and lighter. Ice cream with no air is very hard to scoop and eat. The amount of air that is whipped into ice cream is called "overrun." A 100% overrun means that the air has expanded the ice cream to twice its original volume. The syrup, which remains liquid, prevents the ice cream from becoming as hard as a block of ice. The milk fat adds richness and carries some of the other flavors.

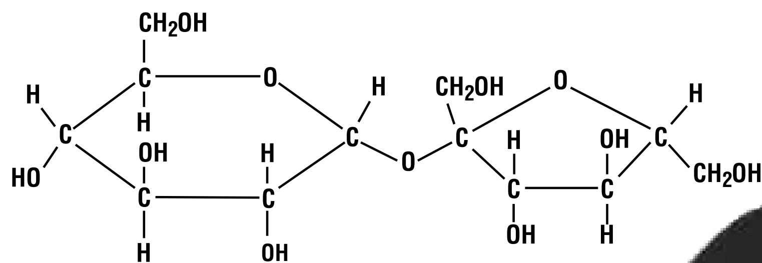


Commercial ice cream, which must be stored and shipped before being eaten, can suffer the dreaded "heat shock." If ice cream melts even partially and then re-freezes, the ice crystals grow larger and may invade the air pockets. This makes the texture distinctly grainy. To reduce this effect, manufacturers add stabilizers—compounds in the syrup that cling to the water molecules and keep them from attaching to the ice crystals. Some of the most effective stabilizers have long, chainlike molecules with water-attracting polar

Each gallon must weigh at least 4.5 pounds. Homemade ice cream usually weighs twice that amount. The weight reflects the amount of "overrun" or air added. The maximum amount allowed is 100%. Cheaper ice creams have smaller amounts of milk fat, larger overrun, and lower weight.

Federal regulations specify that ice cream must contain at least 10% milk fat and at least 20% total milk solids, including milk fat, proteins, lactose, and minerals. The maximum amount of stabilizer permitted is 0.5% by weight, and the maximum amount of emulsifier is 0.2%.



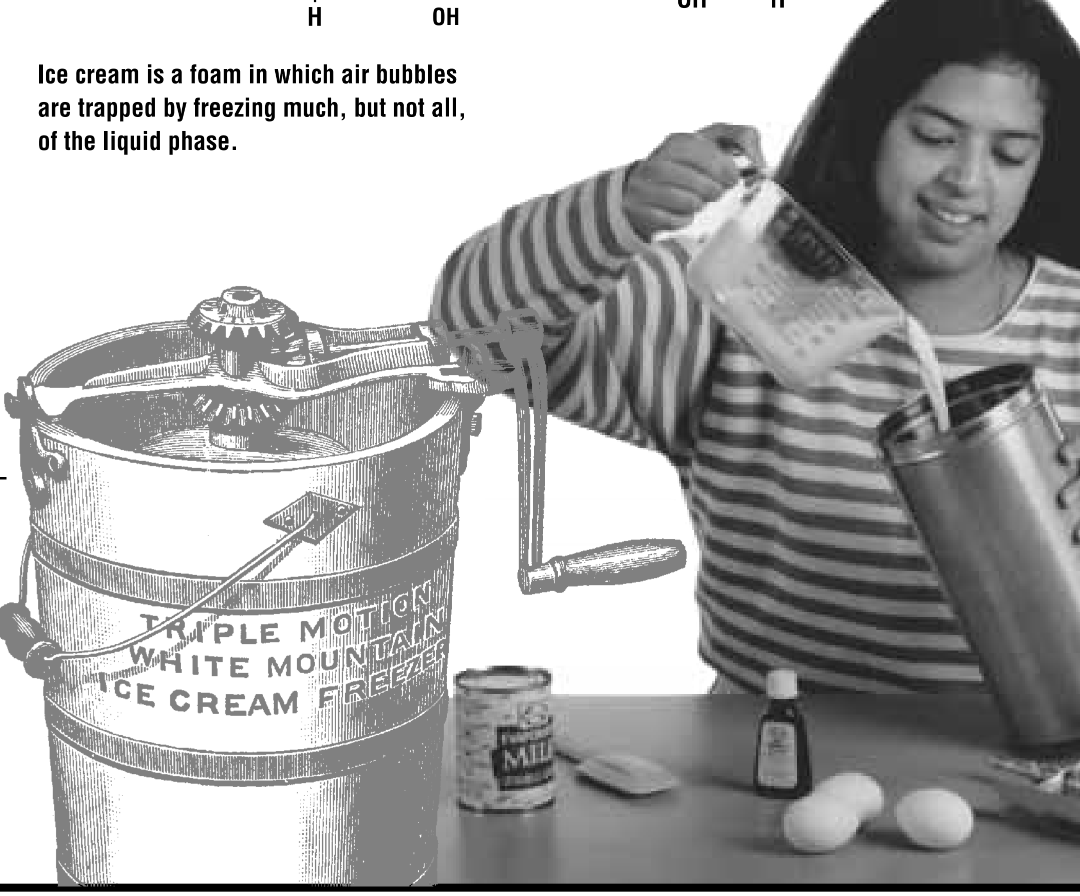


groups. Commercial manufacturers prefer vegetable gums, such as locust bean and guar gums. If you make ice cream at home, adding gelatin gives some of the same effect.

The most popular flavor of ice cream is vanilla. The flavoring is a minuscule fraction of the ingredients but a large part of the eating experience. Traditionally, vanilla was extracted from the beans of the plant *Vanilla planifolia*, a member of the orchid family. (See *Chem Matters* article "Vanilla," April 1988.) The compound that carries the distinctive vanilla flavor is known as vanillin. Vanillin is a volatile chemical that vaporizes readily when warmed.

It is easy not to appreciate our favorite dessert. When you take a bite of vanilla ice cream, you first experience a cool, sweet sensation from the ice and sugar. As the heat of your mouth warms the ice cream, it softens and you notice the second taste—the buttery-rich dairy flavor. Then as the vanillin vapor fills your nostrils with its familiar aroma, you enjoy the rich harmony of aromas, tastes, and textures that we know as vanilla ice cream.

Ice cream is a foam in which air bubbles are trapped by freezing much, but not all, of the liquid phase.

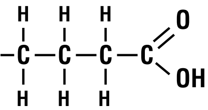


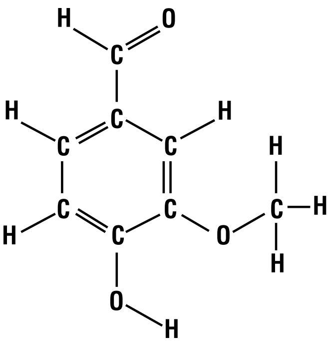
FOR FURTHER INFORMATION

Joseph, Lawrence E. "The Scoop on Ice Cream". Discover Magazine, August 1992.; page 69.

Lamb, William G. "What is a colloid?" The Science Teacher, September, 1985; page 49.

Martino, James. "Ice cream: Delicious chemistry." Journal of Chemical Education, volume 60, number 11, page 1004. November, 1983.



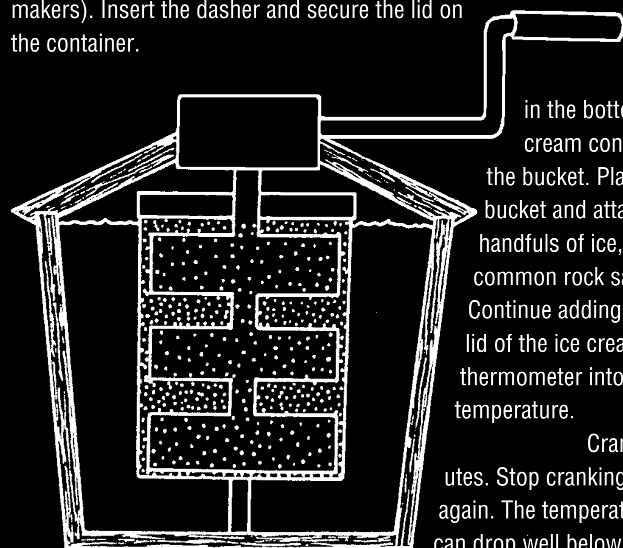


Homemade Ice Cream

You'll need an ice cream freezer, either hand cranked or motorized.

In a large bowl, mix 1 can condensed milk, 2 tablespoons vanilla, 6 eggs, and 2 cups sugar. Stir to dissolve the sugar. Pour the mixture carefully into the metal container that comes with the freezer.

Add whole milk up to the mark on the container (about 1/2 gallon milk) for most ice cream makers). Insert the dasher and secure the lid on the container.



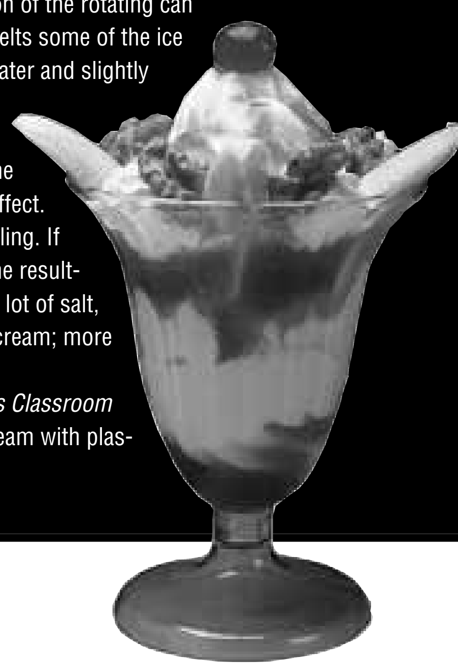
Put a small amount of water in the bottom of the ice bucket to keep the ice cream container from freezing to the bottom of the bucket. Place the ice cream container into the bucket and attach the motor or crank. Add about 4 handfuls of ice, then sprinkle about 1/2 a handful of common rock salt (sodium chloride) over the ice. Continue adding ice and salt to a level just below the lid of the ice cream container. If possible, insert a thermometer into the ice–salt mixture and record the temperature.

Crank (or turn on the motor) for 10 minutes. Stop cranking and measure the temperature again. The temperature of the brine (water–salt) solution can drop well below the usual freezing point of water. Continue cranking and taking temperature readings at 10-minute intervals. Stop when the crank becomes too hard to turn (or the motor bogs down). Scrape the ice off the lid and remove the dasher. If time permits, replace the lid and repack the freezer with more salt and ice to allow the ice cream to harden for about 30 minutes before eating.

Pure water freezes at 0° C, but the mixture used to make ice cream freezes at about –3° C. Water freezes at 0° C, which means that ice water is not cold enough to make ice cream. So how can we freeze ice cream with ice? By controlling the balance of freezing and melting. When a substance melts, it absorbs heat and cools the surroundings. When it freezes, heat is released to the surroundings. In a container of pure water and ice, there is a balance between freezing and melting that keeps the mixture at 0° C. But adding salt changes the balance.

When an ice cream freezer is started, friction of the rotating can as well as the warmer ice cream mixture in the can melts some of the ice packed around the can, realizing a small amount of water and slightly cooling the can. In a normal ice–water mixture, much of this water would refreeze and slightly warm the can. The salt, however, acts as an antifreeze for the water, blocking both the refreezing and its warming effect. Each gram of ice that melts causes 334 Joules of cooling. If you use one part salt to three parts ice (by weight), the resulting brine can drop to -21° C. A 1:3 mixture requires a lot of salt, so a 1:8 ratio is commonly used to start making ice cream; more salt may be added later.

The December 1995 issue of the *Chem Matters Classroom Guide* explains how to make a small amount of ice cream with plastic bags instead of an ice cream freezer.



***Roberta Baxter** is a freelance writer who lives in Colorado Springs, Colorado. Most recently, her article "Say Cheese" appeared in the February 1995 issue of* Chem Matters.