# Sugar Crystallization

**Unit:** Culinary Science

**Problem Area:** Food Science

**Lesson:** Sugar Crystallization

## Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Explain the stages of sugar crystallization.**
2. **List food products created at each stage of sugar crystallization.**

## Resources.

The following resources may be useful in teaching this lesson:


Barham, Peter. *The Science of Cooking*. Springer, 2001.

Bullock-Prado, Gesine. *Sugar Baby: Confections, Candies, Cakes & Other Delicious Recipes for Cooking with Sugar.* Stewart, Tabori & Chang, 2011.

Culinary Institute of America. *The Professional Chef*, 9th ed. Wiley, 2011.

Greweling, Peter P. The Culinary Institute of America. *Chocolates and Confections: Formula, Theory, and Technique for the Artisan Confectioner*. Wiley, 2007.

"Making Candy & the Role of Sugar Crystals," *Baking 911*. Accessed Aug. 15, 2011. <http://www.baking911.com/candy/101_crystallization.htm>.

"Temperature & Stages of Making Sugar Syrup Chart," *Baking 911.* Accessed Aug. 15, 2011. <http://www.baking911.com/candy/chart.htm>.

"What Is Sugar?" *Science of Cooking*. Accessed Aug. 15, 2011. <http://www.exploratorium.edu/cooking/candy/sugar.html>.


## Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

## Key Terms.

The following terms are presented in this lesson (shown in bold italics):

- ➤ candy thermometer
- ➤ caramelized sugar
- ➤ cold water test
- ➤ corn syrup
- ➤ crystallization
- ➤ firm ball stage
- ➤ glucose
- ➤ hard ball stage
- ➤ hard crack stage
- ➤ humidity
- ➤ inversion
- ➤ invert sugar
- ➤ simple syrup
- ➤ soft ball stage
- ➤ soft crack stage
- ➤ sucrose
- ➤ syrup strength
- ➤ thread stage

## Interest Approach.

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

*Items needed:*

- ♦ *Granulated sugar*
- ♦ *Caramel*
- ♦ *Fudge*
- ♦ *Gummy-type candies*
- ♦ *Marshmallows*
- ♦ *Rock candy or other hard candies*

- *Toffee*
- *Other candies or syrups as desired*

*To introduce the concept of the variety of sugar crystallization, have sugars and several candies available for students to see, touch, and taste (e.g., granulated sugar, marshmallows, rock candy, toffee, caramel chews, gummy-type candy, maple syrup products, and fudge). Pictures of a variety of candy and sugar will work, but the real product is more fun!*

*Use VM–A to show pictures of various candies and confections. Allow students to feel and snack on the variety provided or, if using pictures, ask students to describe the taste and texture of the candies illustrated. Remind students that every item is based primarily on granulated sugar, but how can that be? The sugar is coarse, gritty, and white. How can that one substance be responsible for rock candy and marshmallows? A student may well answer that the sugar is cooked, and if that comes up, ask for more details.*

# CONTENT SUMMARY AND TEACHING STRATEGIES

**Objective 1:** Explain the stages of sugar crystallization.

**Anticipated Problem:** What are the stages of sugar crystallization?

I. Sugar crystallization stages

A. ***Crystallization*** is the formation of sugar crystals in sugar syrup. Crystallization can occur quickly and turn formerly smooth sugar syrup into a lumpy, dense, and gritty mass. Granulated sugar (a carbohydrate; sucrose) is always on a "mission" to return to its original crystalline shape rather than remaining dissolved in syrup.

1. ***Sucrose*** is the chemical name for granulated sugar (table sugar): a crystalline disaccharide made of fructose and glucose. (Both fructose and glucose are simple sugars or monosaccharides.)
2. Most sucrose is made from beet or cane sugar and is typically produced in fine granulated crystals. It is the main ingredient of most candies.
3. Heating sucrose melts its crystals into syrup. Depending on the final temperature of the syrup, what is added to it, and how it is handled, the melted crystals re-crystallize into different solid forms that result in a variety of final products.

B. Temperature, moisture, humidity, and altitude

1. Heat—The temperature of the cooking sugar syrup determines the level of crystallization taking place. A ***candy thermometer*** is a special thermometer designed to read the stages of cooked sugar via a clearly visible display of temperature readings. An instant read thermometer is not adequate for candy making.
   a. A candy thermometer registers temperatures up to 400°F.
   b. A candy thermometer has 1- or 2-degree graduations between 100° and 400°F.
   c. A candy thermometer should be tested for accuracy by placing it in a pan of warm water and gradually bringing the temperature of the water to 212°F. The thermometer should register 212°F.
   d. A candy thermometer should be warmed before inserting it into cooking syrup. Heating the thermometer in hot water helps ensure that the thermometer does not break in the cooking syrup.
   e. A candy thermometer should be inserted just above the bottom of the pan in which the sugar syrup is cooking to ensure accurate temperature readings.
   f. A candy thermometer should not "roll around" in the sugar syrup, as agitation can cause crystallization to occur.
   g. A candy thermometer should be cleaned by allowing it to stand in warm water. If syrup (or chocolate) dries on the bulb of the thermometer, accurate temperature readings are impaired.
2. Cold water test—Many candy makers use a thermometer and a ***cold water test*** (a measure of the density or concentration of sugar in the syrup) to determine the stage of sugar crystallization in a syrup. A thermometer is a good guide, but the cold water test confirms or disaffirms the thermometer's temperature reading. To perform the test:
   a. It is necessary to use a clean wooden or silicone spoon to drop about a half teaspoon of syrup into a small bowl of chilled, not ice, water. Each test should be conducted with a fresh bowl of chilled water.
   b. The sugar syrup should be collected quickly between thumb and forefinger. Its shape, resistance to pressure, and body should be judged. The candy syrup becomes increasingly stiffer as more and more water is evaporated.
3. Moisture—The temperature of the syrup indicates the temperature of the sugar and how much moisture is left in the sugar; this is a key factor in the resulting product. The more moisture in the syrup, the softer the final candy product. The hotter the syrup, the less residual moisture is left in the product, and the tighter the crystalline structure. Less moisture results in a harder candy.
4. ***Humidity*** is the degree of moisture (wetness) in the air. Humidity affects the amount of moisture in the syrup, too. Cooking or crystallizing sugar is never recommended on humid days. Sugar absorbs moisture, and cooking sugar reduces moisture in the syrup. However, humidity interferes with this process

and can make the final product sticky and cloudy. Humidity disrupts the crystallization process. Candy makers cook sugar to slightly higher than normal temperatures (about 2 degrees higher) to compensate for high moisture levels.

5. Altitude affects the cooking of candy syrups, so temperatures must be modified to accommodate the higher altitude. In general, for every 1,000 feet (300 meters) above sea level, it is necessary to subtract 2 degrees F (1 degree C) from the boiling point of the syrup.

C. Basic stages of sugar crystallization

1. ***Simple syrup*** is a mixture of sugar and water heated until the sugar dissolves to a temperature of no more than 212°F. Sugar is commonly dissolved in water to assist the breakdown and dissolving of sugar into a solution. Simple syrup mixtures remain a solution even when cooled; no re-crystallization takes place.
2. ***Thread stage*** is a string of candy that drips off the end of the spoon into the syrup pot in the form of a thread. The temperature range is from 215° to 234°F. (NOTE: Temperature ranges vary slightly depending on the source.)
3. ***Soft ball stage*** is candy that is more compact than thread stage; when a small amount is dropped into chilled water, it results in a soft, pliable candy that flattens into a disc if left on a flat surface. The temperature range is from 234° to 242°F.
4. ***Firm ball stage*** is candy that is stiffer than soft ball stage, and it holds its shape when a small amount is dripped into chilled water. It is still soft enough to flatten if pressed between a thumb and forefinger. The temperature range is from 244° to 250°F.
5. ***Hard ball stage*** is candy that is more rigid than firm ball stage, and the syrup forms thick threads as it drips from a wooden spoon back into the saucepan. The syrup easily forms a hard ball when dripped into chilled water, but it is pliable enough to compress when squeezed between a thumb and forefinger. The temperature range is from 250° to 266°F.
6. ***Soft crack stage*** is candy that is more brittle than hard ball stage candy. When a small amount is dropped into chilled water, the syrup breaks into bendable threads. The temperature range is from 270° to 290°F.
7. ***Hard crack stage*** is candy that is more brittle than soft crack stage candy. When a small amount is dropped into chilled water, the syrup separates into hard, brittle threads that break easily. The color of the syrup is that of weak honey. The temperature range is from 298° to 310°F.
8. ***Caramelized sugar*** is candy syrup that continues to cook to temperatures beyond 310°F; it turns from a honey color to a light brown to a dark brown. The browning of sugar adds depth of flavor and character. It will eventually turn black, bitter, and burned at about 400°F (a product often referred to as Black Jack). However, crystallization will not change structure beyond hard crack stage as virtually all of the water has been evaporated.

D. Cooking tips

1. Sugar syrup (candy) temperatures rise very slowly until the mixture reaches 220°F. The syrup "sits" at 220°F for a period of time, and then temperatures tend to rise quickly to 230°F. Again, the syrup "sits" at 230°F for a period of time and levels off at about 10-degree intervals.
2. It is important to read the candy thermometer at eye-level for accuracy.
3. Candy has a tendency to spurt or splutter as the temperature rises, so a person should keep his or her face away from the surface when reading the candy thermometer.

**Teaching Strategy:** *Use VM–B. Assign LS–A.*

**Objective 2:** List food products created at each stage of sugar crystallization.

**Anticipated Problem:** What is the food use at each stage of crystallization?

II. Food products created at each stage of crystallization

A. ***Syrup strength*** is a measure of the concentration of sugar in the mixture. As water evaporates from the sugar and water solution (syrup), the temperature of the syrup gradually rises. If all the water evaporates, melted sugar remains. At this point, the sugar will begin to caramelize. There are essentially two types of candies: crystalline and non-crystalline.

1. Crystalline candies are in two types:
   a. Candies may have visible crystals, such as rock candy.
   b. Cream candies have crystals that are too small to see, such as fudge and fondant.
2. Non-crystalline candies are simpler to make and include brittles and toffee.

B. Crystallization and inversion

1. Grittiness or graininess is a common problem with candies and desserts. Graininess results when cooked sugar crystals turn into smaller sugar crystals rather than remaining dissolved in the syrup mixture. Interfering agents (e.g., cream of tartar, lemon juice, corn syrup, molasses, or vinegar) are added to sugar syrup mixtures to prevent the formation of large crystals. To avoid crystallization in the early stages of sugar syrup development, tell your students to follow these steps:
   a. Wash down the sides of the pan with a brush dipped in water while the syrup is boiling. It is best to move the wet brush around the top interior of the pan and to let the water run down the sides of the pan. This action removes crystals that could potentially multiply and create a gritty mess in the cooking syrup.
   b. Cover the pan, and boil the syrup for a few minutes at the beginning of the cooking. Steam will wash down the sides of the pan. Uncover and continue cooking the syrup without stirring.

c. If the recipe calls for butter, one may lightly butter the inside of the saucepan before adding the remaining ingredients.
d. Avoid stirring the syrup once it begins to boil. (There are exceptions to this rule.)

2. ***Inversion*** is a chemical change in sucrose into another form of sugar. Syrups cooked to a high concentration of sugar sometimes crystallize after they are cooled. Inversion resists crystallization and is accomplished by the addition of an acid at the beginning or during the cooking that "inverts" the sugar. Common acids are:
   a. Cream of tartar
   b. Lemon juice
3. Invert sugar is created when a sucrose solution is heated with an acid. When heated, some of the sucrose breaks into equal parts of dextrose and levulose. A mixture of equal parts of dextrose and levulose is called ***invert sugar***. The result is a sweetener that is sweeter than sucrose was before the inversion. While re-crystallization still takes place with invert sugar, the ability to manipulate the cooling syrup into different candies makes it exceptionally useful.
4. Liquid sweeteners all contain small amounts of acid to invert some of the sugar. While sucrose is the main source of sugar used in crystallization, it is not the only choice. Sugars in liquid form are also used in candy making, including ***corn syrup*** (a thick liquid derived from corn and not as sweet as sucrose) and ***glucose*** (a very thick liquid form of sugar, sweeter than corn syrup but not as sweet as sucrose). These liquid sweeteners bring additional moisture to the products and have different molecular structures, resulting in different textures of the final products made from the cooked and cooled syrups.
5. Humidity and movement (stirring) during the cooking process can easily disrupt regular sugar syrup development. The use of liquid sweeteners or acids to invert cooking sugar syrups reduces the risk of poorly re-crystallizing candies. In fact, by inverting some of the cooking sugar, additional ingredients and motion can be added to create a variety of different candies and textures from the same syrup. For instance, marshmallows and gummy-type candies are made from the same syrup as rock candy.

C. Food use at each stage of sugar crystallization
   1. Simple syrup
      a. Food uses: sorbets; slushies and other flavored ices; dessert sauces; fruit punch; cocktails; to flavor and moisten cake layers or cookies; in the preparation of candied fruit; and to dilute fondant
      b. Sugar concentration: NA
   2. Thread stage
      a. Food uses: syrups of all types; glazes and icings; liqueurs; jellies and jams; candied orange peel and candied fruit; and for decorative spun sugar confections
      b. Sugar concentration: 80 percent

3. Soft ball stage
    a. Food uses: soft textured fudge; fondant; Italian meringue; some buttercream icing and candy truffle fillings; caramel corn; and pralines
    b. Sugar concentration: 85 percent
4. Firm ball stage
    a. Food uses: chewy and soft caramel products (caramel candies, fillings, and sauces at this stage use artificial flavors to attain the caramel taste) and marzipan
    b. Sugar concentration: 87 percent
5. Hard ball stage (a very versatile stage)
    a. Food uses: marshmallows, nougat, divinity, gummy-type candies, some peanut brittle, and some types of rock candy
    b. Sugar concentration: 92 percent
    c. Marshmallows are made by whipping egg whites into candy syrup as it cools. In a purely sucrose-based hard ball stage, the "whipping" would result in a re-crystallized mess. However, with invert sugar in the syrup, the egg whites are easily incorporated and allow the mixture to hold air, becoming marshmallows as it cools during whipping.
6. Soft crack stage
    a. Food uses: taffy and some nougat (both chewy textures)
    b. Sugar concentration: 95 percent
7. Hard crack stage
    a. Food uses: crunchy toffees, some brittles, butterscotch, and all hard candies
    b. Sugar concentration: 99 percent
8. Caramelizing sugar stage
    a. Food uses: hard caramel for crème caramel and flan deserts, spun sugar and caramel cages, and pulled sugar creations
    b. Sugar concentration: more than 99 percent

**Teaching Strategy:** *Assign LS–B.*

**Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used in the Review/Summary.

**Application.** Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

## Evaluation.

Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

## Answers to Sample Test:

### Part One: Short Answer

1. When sugar inverts, an acid causes the sucrose to break apart into glucose and fructose. This leaves the sugar sweeter than it was prior to inversion and less susceptible to unwanted crystallization.
2. No level of new crystallization takes place in simple syrup; it is not cooked to a high enough temperature to elicit a change in crystallization.
3. Humidity interferes with the crystallization process by adding moisture to the sugar when it should be losing moisture. The result is a sticky, cloudy, poorly crystallized product.

### Part Two: Multiple Choice

1. c
2. c
3. d
4. b
5. c
6. a

### Part Three: True/False

1. T
2. F
3. T
4. T
5. T
6. F

**Sample Test**

Name _____

# Sugar Crystallization

## Part One: Short Answer

***Instructions:*** **Answer the following.**

1. What happens when sugar “inverts”?

2. What level of crystallization occurs in simple syrup?

3. How does humidity effect the crystallization of sugar?

## Part Two: Multiple Choice

***Instructions:*** **Circle the letter of the correct answer.**

1. The temperature range for the “soft ball” stage is _____.

   a. 200 to 212°F
   b. 244 to 250°F
   c. 235 to 242°F
   d. 220 to 235°F

2. Sugar begins to burn at _____.

   a. 300°F
   b. 350°F
   c. 400°F
   d. 450°F

3. Gummy-type candies are made from sugar at the _____ crystallization stage.

    a. soft ball
    b. hard crack
    c. hard thread
    d. hard ball

4. At temperatures above 310°F, sugar _____.

    a. crystallizes into different forms or stages
    b. stops reaching new crystallization stages and begins to caramelize
    c. crystallizes into new stages and begins to caramelize
    d. None of the above

5. A candy thermometer is used when crystallizing sugar because it is _____.

    a. unbreakable
    b. usually digital
    c. capable of registering temperatures as high as 350°F
    d. safe to use in chocolate

6. The products of soft ball stage sugar crystallization include _____.

    a. soft textured fudge, fondant, Italian meringue, caramel corn, and pralines
    b. hard caramel for crème caramel and flan deserts, spun sugar and caramel cages, and pulled sugar creations
    c. sorbets, slushies, dessert sauces, and fruit punch
    d. crunchy toffees, some brittles, butterscotch, and all hard candies

## Part Three: True/False

***Instructions:*** **Write *T* for true or *F* for false.**

_____1. The hotter sugar syrup gets, the less moisture is left in the syrup.

_____2. Hard candies are made from sugar crystallized to the soft crack stage.

_____3. Adding cream of tartar to cooking sugar is one way to form invert sugar.

_____4. Sugar at the soft ball stage is commonly used for making fudge and Italian meringue.

_____5. Introducing granulated sugar into cooking sugar syrup at 235°F will likely cause a reaction that would make the entire syrup batch re-crystallize.

_____6. Problems with cooking sugar on humid days can be avoided by cooking the syrup to a slightly lower temperature than required.

VM–A

# CANDY VARIETIES

*Describe the taste and texture of the candies illustrated.*

Sugar crystallization in candy making begins with granulated sugar—sucrose.

Caramel toffee

Caramel chew

Chocolate fudge

Marshmallows

Gummy candy

Ribbon and other hard candies

# SUGAR CRYSTALLIZATION STAGES

- **Thread:**
  **215° to 234°F**
- **Soft Ball:**
  **235° to 242°F**
- **Firm Ball:**
  **244° to 250°F**
- **Hard Ball:**
  **250° to 266°F**
- **Soft Crack:**
  **270° to 290°F**
- **Hard Crack:**
  **298° to 310°F**
- **Caramelization:**
  **310° to 375°F**
- **Black Jack (burned):**
  **400° to 410°F**

This French macaroon has a chocolate ganache filling made by heating the sugar syrup to the soft ball stage.

These caramel-colored sugar strings are brittle and have a rich, dark flavor. To achieve these characteristics, sugar syrup must be heated to the hard crack stage.

Name _____

# Sugar Crystallization Worksheet

## Purpose

The purpose of this activity is to identify and describe stages of sugar crystallization and related factors in the crystallization process.

## Objectives

1. Identify stages of sugar crystallization.
2. Describe stages of sugar crystallization.
3. Explain related elements of sugar crystallization.

## Materials

- lab sheet
- writing utensil
- computer with Internet access and/or text material access

## Procedure

1. Work independently to answer each of the following questions. Use complete sentences.
   a. Table sugar or granulated sugar is known by another name. What is its scientific name? From what two other sugars is it made?

   b. How does humidity affect crystallizing sugar?

c. Define “crystallization” in your own words.

d. What tool is essential when cooking sugar to different stages? Be specific. What is the companion “tool” to verify the stage of sugar crystallization?

e. What sugar syrup crystallization point is cooked to between 298° and 310°F?

f. What sugar syrup crystallization point is cooked to between 244° and 250°F?

g. What sugar syrup crystallization point is cooked to between 235° and 242°F?

h. Describe what happens to sugar crystallization after syrup reaches 325°F.

i. Describe the appearance of sugar syrup cooked to 250° to 266°F and tested with the cold water test.

2. Participate in a class discussion of your responses to the sugar crystallization questions.

3. Turn in your completed lab sheet to your instructor.

# Sugar Crystallization Worksheet

1. a. *Table sugar's (granulated sugar) scientific name is sucrose. It is made from glucose and fructose.*
   b. *Humidity interferes with the crystallization of sugar, resulting in sticky, cloudy candy.*
   c. *Crystallization is the formation of sugar crystals in sugar syrup. (Crystallization can occur quickly and turn formerly smooth sugar syrup into a lumpy, dense, and gritty mass.)*
   d. *A candy thermometer is an essential tool in candy making to help gauge the stages of sugar crystallization. The companion process to verify the candy thermometer's reading is the cold water test.*
   e. *The hard crack stage occurs between 298° and 310°F.*
   f. *The firm ball stage occurs between 244° and 250°F.*
   g. *The soft ball stage occurs between 235° and 242°F.*
   h. *Crystals stop changing form after 310°F. The only change that occurs at higher temperatures is caramelization and finally burning.*
   i. *Syrup at this stage (250° to 266°F), when dripped into cold water, readily forms a hard ball that will still compress if squeezed between a thumb and forefinger.*

Name _____

# Crystallization Experiment

## Purpose

The purpose of this activity is to observe the stages of sugar crystallization.

## Objectives

1. Observe the stages of crystallization and caramelization.
2. Record the cooking temperatures.
3. Describe each stage's texture, color, and flavor.

## Materials

- lab sheet
- VM–B
- writing utensil
- 6 small glass or metal bowls (or Styrofoam cups) each half filled with cold water
- 1 small heavy bottom saucepan
- 1 candy thermometer
- 1 metal pan (cookie sheet) lined with silicone or parchment paper (or well greased)
- 1 c. of granulated sugar
- ½ c. + water
- 1 T. light corn syrup, honey, or glucose OR ½ t. cream of tarter
- 7 wooden or silicone spoons (or a towel so you can clean and dry a spoon between cold water tests)
- 1 natural bristle pastry brush and extra water
- pot holder or oven mitt
- stovetop or tabletop burner

## Procedure

1. Work in groups of three to four students.
2. Mise en place: Collect the items shown in the "Materials" list.

3. Read the experiment through before beginning any cooking. Follow the instructions **exactly** during this exercise. Remember to keep a towel or potholder ready to hold or lift the pan's handle because it will be very hot. **The syrup will be exceptionally hot during the cooking process. Exercise caution throughout the experiment!**

   a. STEP 1. Place the pan on the burner, and pour the sugar in the middle of the pan. Leave the sugar in a mound.

   b. STEP 2. Pour the ½ cup of water **around** the mound of sugar. Jiggle the pan slightly to bring down the mound, but **do not stir**! If there still seems to be a large amount of dry sugar in the middle, add another tablespoon or two of water to the center of the pan, but do not add more than that.

   c. STEP 3. Set the burner heat to medium or medium high. You can jiggle the pan slightly if necessary to mix the water and sugar. In general, however, just leave the pan alone. **Do not stir**. Allow the mixture to come to a boil; there should be no crystals of sugar visible. If there are, dip the pastry brush into some extra water and touch the sides of the pan, along the top edge, with the brush, allowing a small amount of water to drip into the pan and "wash" away the crystals. Wash the pan sides with water only if crystals are visible in the pan.

   d. STEP 4. Place the thermometer in the syrup and leave it there; **do not stir**.

   e. STEP 5. At each temperature range, from the thread stage through the hard crack stage, perform a cold water test. To perform the test: Dip a **clean wooden or silicone spoon** into the syrup, and drip about ½ teaspoon of the syrup into the cold water.

      (1) Observe and describe what happens to the syrup in the cold water.

      (2) Then use your fingers to feel the cooked syrup in the water. Describe the experience.

      (3) Record your notes on the back of this sheet. Additionally, record the stage (or temperature) at which you are able to pull a solid from the water.

   f. STEP 6. At the hard crack stage, be prepared to continue cooking the syrup to caramelize the mixture. At five or six intervals, drip a bit of syrup from the pan onto the lined metal pan as the sugar caramelizes. Keep tabs of the temperature of the syrup for each little "drip" example. **DO NOT TOUCH THE SYRUP!** Record the temperature of each drip sample.

   g. STEP 7. After the caramelized samples cool, record the texture, color, and taste of each sample. Compare it to the corresponding temperature.

      (1) At what temperature did the sugar begin to get too dark to be palatable?

      (2) Describe how each caramelized sugar sample tastes. Did the samples remind you of any flavor you have tasted before?

4. Clean your saucepan, spoons, and thermometer carefully. You may wish to soak all equipment in warm water before washing it in the sink.

5. Participate in a class discussion of the results of your crystallization experiment.

6. Turn in your completed lab sheet to your instructor.

# Crystallization Experiment

1. Safety precautions:
   a. This lab is **NOT recommended for students under 16 years of age.** Consider completing the activity as a demonstration for younger students.
   b. **Encourage safety throughout the exercise. The hot syrup and pan can cause serious burns!**
   c. Avoid this experiment on a humid day. Wait for a dry, sunny day.
2. Troubleshooting:
   a. Student groups that follow directions exactly should not encounter sugar syrups that improperly crystallize into a grainy mass. Students will find that the candy closely follows the temperature guidelines for each crystallization stage.
   b. If the sugar crystallizes into a grainy mess while cooking, have the students determine what went wrong. Perhaps the sugar crystals mixed into the syrup and/or the syrup was stirred during the cooking process.
3. Provide each group with a copy of VM–B, or a projected image, to assist in recording observations.
4. STEP 7. Students should see an amber color appear at about 310°F. The syrup will continue to get darker and more intensely flavored as it cooks. By 360°F, the syrup will be dark (but not black) and will take on a burnt flavor. By 400°F, the syrup will be black and virtually inedible. Note whether students pick up on the taste of molasses at the 350° to 370°F range.