TAPPING INTO MAPLE TRADITION

Lesson Title: **Maple Sugar Molecules and Crystals**

Submitted By: Christopher Szkutak

Email: crszku10@gmail.com

Grade Level:
☐ Early Elementary (K – 2nd)
☐ Upper Elementary (3rd – 5th)
☒ Middle School (6th – 8th)
☒ High School (9th – 12th)

What National Agriculture Literacy Outcomes does your lesson address?
http://www.agclassroom.org/get/doc/NALObooklet.pdf
T4.6-8b
T4.9-12e

What Common Core Standards does your lesson address?
MS-PS1-2.
HS-PS1-6
HS-PS2-6

Brief description of your lesson plan:
In this activity, students will learn about what sugar crystals look like on a larger scale and how removing water allows for crystallization by making rock candy.

Time:
Lesson Prep: 30 minutes
Inactive time: one week

Materials:
- Maple molecule poster
- For rock candy,
  - 4 cups sugar
  - 2 cups water
  - a small saucepan
  - a wooden spoon
  - a candy thermometer
  - a small, clean glass jar
  - a measuring cup
  - cotton string
  - a weight to hang on the string
  - waxed paper

a pencil

Vocabulary:
Crystal: a piece of a homogeneous solid substance having a natural geometrically regular form with symmetrically arranged plane faces.

Background:
Maple syrup is primarily composed of a mixture of sugars, water, and minerals. Maple sap is mostly 98% water and 2% sugars. Early season sap has higher concentrations of the disaccharide sucrose, while late season sap has more glucose and fructose, both monosaccharides.

Different maple products are made by heating maple syrup to a higher boiling temperature. Crystallization of the sugars in maple syrup will begin when enough water (solvent) is removed from the syrup so the larger sucrose molecules (solute) can begin to bond together. The more water removed, the tighter the crystallization bonding. Thus experienced sugarmakers can whip up smooth maple cream or rock hard sugar from the same high disaccharide maple syrup by boiling it to different temperatures. Since monosaccharides are smaller molecules, they will not crystallize as easily as a larger disaccharide.

Two different methods will contribute to the growth of the crystals on the string. You have created a supersaturated solution by first heating a saturated sugar solution (a solution in which no more sugar can dissolve at a particular temperature) and then allowing it to cool. A supersaturated solution is unstable—it contains more solute (in this case, sugar) than can stay in a liquid form—so the sugar will come out of solution, forming what's called a precipitate. This method is called precipitation.

The other is evaporation—as time passes, the water will evaporate slowly from the solution. As the water evaporates, the solution becomes more saturated and sugar molecules will continue to come out of the solution and collect on the seed crystals on the string. The rock candy crystals grow molecule by molecule.

Different sizes of crystals are preferred in different kinds of confections. Granulated sugar for instance is best with a fairly large crystal that can easily been seen and felt with the tongue. To make granulated sugar the syrup is evaporated to the desired temperature and is not cooled at all before stirring is started. For maple cream the desire is to have a smooth creamy texture where no crystals can be felt with the tongue. Here the supersaturated syrup is allowed to cool without stirring until it is somewhere between 50 and 90º F. Both the temperature at stirring and the method of stirring have an effect on the size of the crystals formed in the cream and the stability of those crystals over time. The cooler the temperature when stirring begins the longer, in weeks and months, the crystals will stay the same size and resist growing

The formation of sugar crystals in many confections and recipes is controlled by the temperature and stirring procedures. However the syrup chemistry is also an important factor. Controlling the size of crystals or preventing crystals with crystal inhibitors is used in making many sugar confections and candies. Large crystals of sucrose have a harder time forming when molecules of invert sugars are present. Crystals form something like building blocks locking together. If some of the molecules are a different size and shape, they won't fit together, and a crystal doesn't form or grows with much more difficulty. The influence of invert sugars, common in natural maple syrup, on crystallization should be well understood by maple confectioners.

(Adapted from WIlts)[1]

Interest Approach – Engagement:
Discuss with students about the formation of crystals. What other crystals exist and how do you think they are

formed?

Procedures:

1. Heat the water in the saucepan over medium-high heat until it comes to a boil.
2. Completely dissolve the sugar in the boiling water, stirring continuously with the wooden spoon until the solution grows clear and it reaches a rolling boil.
3. Remove the solution from the heat, and then carefully pour it into the jar. Cover the jar with a small piece of waxed paper.
4. Tie the weight to one end of the string, and then tie the other end to the middle of the pencil. The string should be about two-thirds as long as the jar is deep.
5. Gently suspend the prepared string in the solution and let sit at room temperature, undisturbed, for several days. You can check each day to see how much your crystals have grown. It's tempting, but don't touch the jar until the experiment is finished—it usually takes about seven days.
6. At the end of the week, the crystals on your string should be clearly defined, with sharp right angles and smooth faces of various sizes. In the field of crystallography, these are called monoclinic crystals. Their shape is determined by the way the individual sugar molecules fit together.
7. Discuss with students why maple syrup producers need to control the temperature in which they heat the syrup. (People do not want crystals in their syrup.)

Did you know? (Ag Facts):

Rock candy is one of the oldest and purest forms of candy. It was originally used by pharmacists to make medicines for many kinds of illnesses.[2]

Enriching Activities:

- Perform the same procedure with maple syrup and imitation maple syrup. Determine if the results are the same.
- How would other sugary liquids behave under similar circumstances?

Sources/Credits:

1. C.O. Willits and C.H. Hill 1976. Maple Syrup Producers Manual. USDA Agriculture Handbook No. 134 and North American Maple Syrup Producers Manual, 2nd ed, 2006
2. http://garrettamchenry.weebly.com/fun-facts.html