

STEAM Subject: Chemistry

Lab: Sugar Solubility

Grades: 5th-8th

Learning Objective:

Students will be able to explain some chemical properties of water and sugar. Students will also be able to compare the solubility of sucrose in different liquids.

ENGAGE:

Ask the students the following questions:

- What do you think an M&M is made out of?
 - *Food coloring, sugar candy coating, chocolate*
 - They will write their ideas in a science notebook.
 - Break an M&M in half and show them the inside. Explain that the white layer is the sugar coating.
 - Ask them what is the science word for sugar? *Sucrose*.
- What do you think will happen to an M&M when placed inside water?
What about with oil or alcohol? Will all liquids have the same effect on the M&M?
We will conduct an experiment to find out!

EXPLORE:

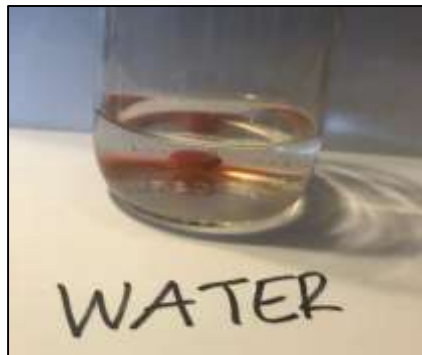
Sugar Solubility Experiment

Materials:

- 1 package of M&M's
- Water
- Vegetable/Canola oil
- Rubbing/Isopropyl alcohol (70%)
- 3 clear cups
- 3 pieces of white paper (large enough to place cup on)
- Marker/pen/pencil

Directions:

1. Pour enough regular tap water into a clear cup to completely cover an M&M (approximately 1 inch deep) and place this cup on a piece of white paper labeled as “water” (to better see the M&M). Repeat this step with both the rubbing alcohol and the vegetable oil.
2. Place 1 M&M in the center of each cup. Be careful to keep the liquid and M&M’s as still as possible. Observe each cup for about 1 minute.



Write your Results in your science notebook.

Below some of our results

- Water: The coloring and sugar coating dissolve from the M&M.
- Alcohol: The color dissolves only slightly and the sugar coating doesn’t seem to dissolve.
- Oil: Neither the color nor the sugar dissolves

Discuss observations and ask students the following questions:

- What do you notice about the M&M and the water? *The color comes off and moves through the water in a circular pattern.*
- What do you think is happening when the color and sugar come off the M&M? *Point out to students that because the water makes the colored coating come off the M&M and mix into the water, the water is dissolving the sugar and color.*
- Do you think different types of liquids (oil, alcohol) can also dissolve sugar like water can? Which liquid is better at dissolving the color and sugar coating? *Students may have originally thought that all liquids can dissolve sugar. They may also have seen before that water and oil do not mix. The water worked best for dissolving the color and sugar coating. The oil had little to no effect on the M&M.*

EXPLAIN:

Chemical properties of sucrose (sugar)

- The **chemical formula** for a sugar molecule (sucrose) is $C_{12}H_{22}O_{11}$, which means that it is made up of 12 carbon atoms, 22 hydrogen atoms and 11 oxygen atoms.

Water is a Polar Molecule

- Basically, the **hydroxyl group** (O-H) present in the **sucrose molecule** is **polar** like the H-O bonding present in water (H₂O), and because the bonds are both polar, they are attracted to each other and come between each other. The **polar** areas in a sugar (sucrose) **molecule** cause it to dissolve in water.
- The polar water molecules attract the negative and positive areas on the polar sucrose molecules which makes sucrose dissolve in water. Water is known as the universal solvent due to having the two hydrogen atoms, situated on one side of the oxygen atom (positive charges), while the oxygen atom retains a negative charge. Each substance dissolves in water to a different extent. **Solubility** is usually measured by the number of grams of a substance that dissolves in 100 mL of water at a particular temperature.

Show the students the molecular structure of each compound: sucrose, water, alcohol, and oil.

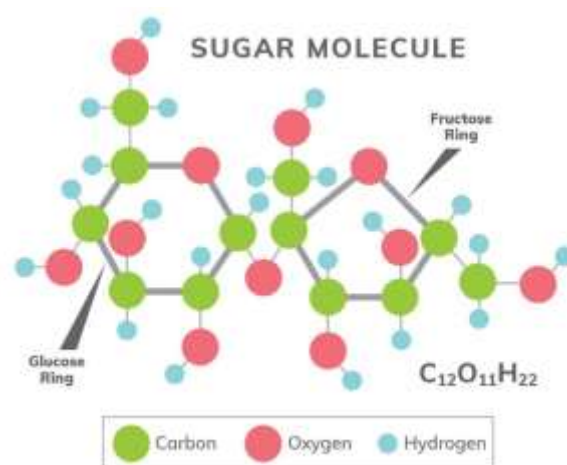
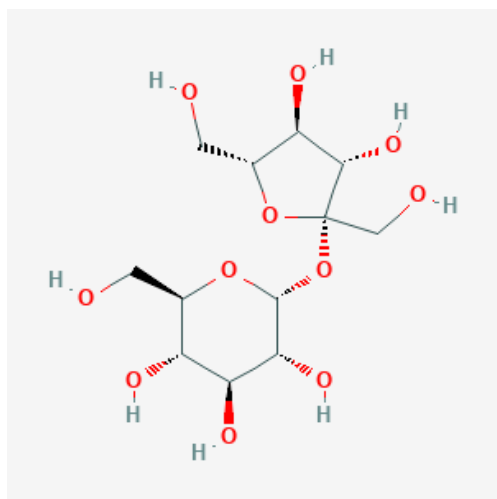
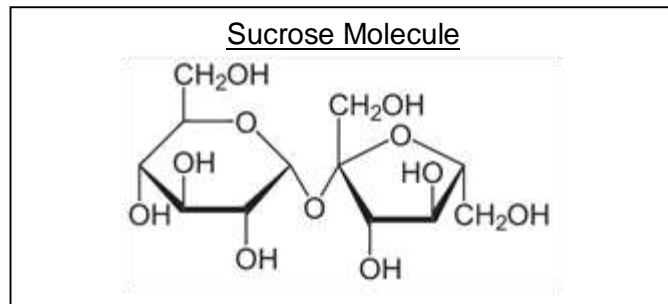
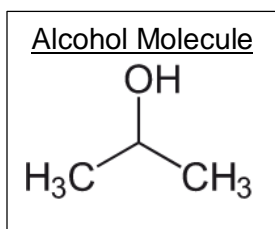
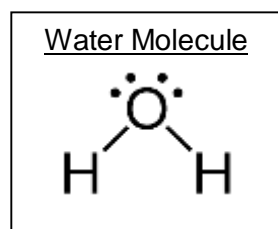
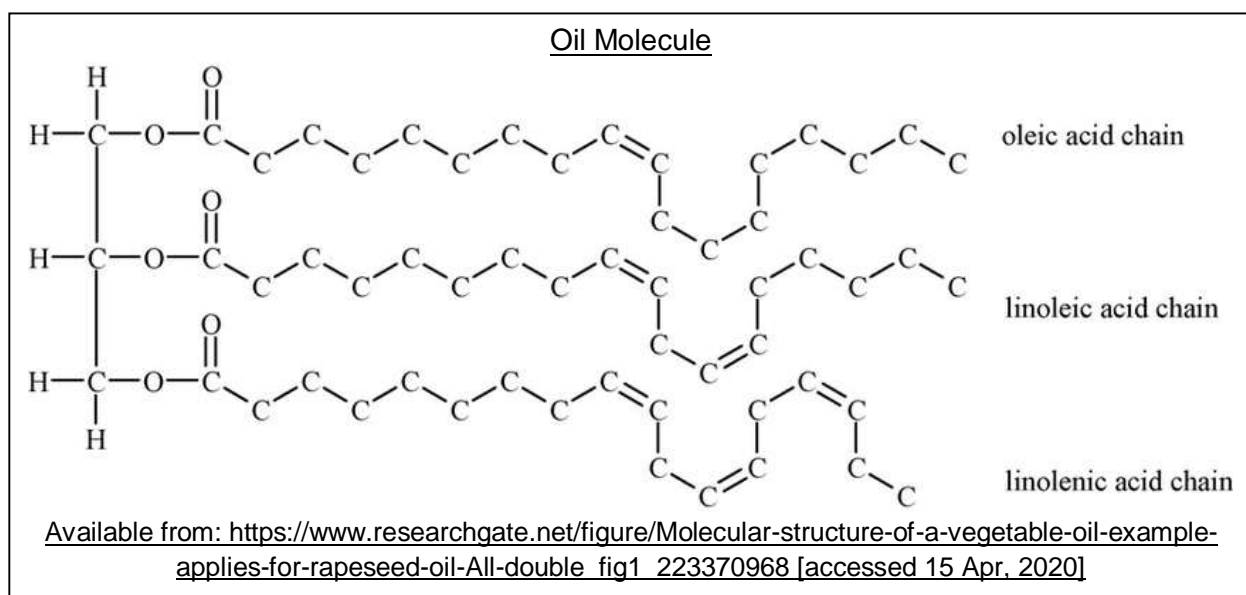


Image left: <https://pubchem.ncbi.nlm.nih.gov/compound/Sucrose>

Image right: © 2020 The Sugar Association, Inc.





What about the other molecules. What did you notice?

- Alcohol is not as good at dissolving sugar because while it is polar (it has a hydroxyl bond, O-H), it also has large non-polar sides (C-H bond).
- Oil is the worst at dissolving sugar because it is very non-polar with its long carbon chains (C-H bond), it is unable to dissolve sugar.

Lets' watch some videos about water molecules and sugar solubility

- Pop Up Science: Sugar and Water
<https://www.youtube.com/watch?v=ZmWYG7qh0QA>
- Bozeman Science "Water a Polar Molecule". Great info about water, make sure to watch the part in 7:00 "Like Dissolves Like" <https://youtu.be/iOOvX0jmhJ4>

EVALUATE:

- What happened in our experiment when we put a solid (M&M) in different liquids? For a liquid to dissolve a solid, the molecules of the liquid and solid must have similar polarity.
- Is water a polar molecule?
- The bond between the oxygen and hydrogen atoms (O-H bond) gives the polarity in sugar (sucrose).

- Sucrose is a polar molecule. The polar water molecules attract the negative and positive areas on the polar sucrose molecules which makes sucrose dissolve in water.
- A nonpolar substance like oil (many C-H Bonds) does not dissolve a polar substance like sucrose.

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