Science Unit: ***Matter***

Lesson 13: ***States of Matter in Food***

Summary:	In this lesson, students explore the concept of **state change,** using various food and drink, in three activities: (1) Students observe **ice, water and steam** and then do a **movement activity** to illustrate water molecules in each state. (2) Students observe popcorn popping and discuss how a state change **causes popcorn to pop**. (3) Students add baking soda to orange juice to observe a **gas** and use a molecular model to visualize the chemical structure of baking soda.
Science skills:	Close observation, careful observation, technical manipulation, comparison, inferring, concluding, verbally summarizing, reporting results.
School Year:	2013/2014
Developed for:	Champlain Heights Annex Elementary School, Vancouver School District
Developed by:	Ingrid Sulston (scientist); Mona Francis and Ramona Smith (teachers)
Grade level:	Presented to grades 2/3; appropriate for grades 2 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Notes:	The popcorn activity is also in Lesson 3 (Physical Changes to Matter) in the "Matter" unit of the Scientist in Residence Program: www.scientistinresidence.ca/pdf/physical-science/Matter/SRP_Matter_Lesson%203%20F.pdf

Objectives:

Students will be able to:

Model the spacing and activity of the molecules in the three states of matter.

View and understand state changes in a familiar context (food).

Relate observed state changes to the underlying molecular changes.

Background Information

States of matter can be an abstract concept for many students. This lesson uses sensory experiences to approach the topic. Modeling the states of matter with their own bodies can help students visualize what is happening at the molecular level. Making snacks are fun and memorable activities on which to scaffold understanding the states of matter and state changes in molecular terms.

Vocabulary

States of matter:	The distinct physical forms that matter can take: solid, liquid or gas (plasma is also a state of matter, but not dealt with in this lesson).
Molecules and atoms:	Tiny particles that make up everything around us. Molecules and atoms are too small to see individually, but with enough of them together they make objects we can see. Two or more atoms are bonded together to make a molecule.
Model:	A representation of an object to help understand it. In this case the model (students themselves) are much larger than the real object (molecules), so that the arrangement and movement of molecules can be visualized.
Solid:	A state of matter. The molecules in a solid are packed tightly together. Solids keep their shape (even in a granular solid, the individual grains keep their shape).
Liquid:	A state of matter. The molecules in liquids are free to move but remain close to each other. Liquids can change shape, but always take up the same amount of space.
Gas:	A state of matter. The molecules in gases are free to move apart from each other. Gases spread out to fill the container they are in.
State change:	A change between any of the states of matter e.g. liquid to gas.
Chemical reaction:	A chemical reaction occurs when molecules break apart and their atoms rearrange to make new molecules. Sometimes the new molecules are a different state of matter, so the chemical reaction involves a state change.

Materials

- Ice cube
- Small dixie cups, one per student
- Coffee stirrers, one per student, at each table in the baking soda cup
- Kettle to boil water, preferably with clear sides
- Orange juice, about 40ml or half a Dixie cup per student; about one litre for a class
- Molecule model kit, one per student pair: Ziploc bag containing three red clay balls “oxygen”, two white clay balls “hydrogen”, one black clay ball “carbon” and six toothpick “bonds”. Clay balls should be about 1cm diameter.
- Materials to make popcorn
- Baking soda, distributed as about two Tbsp. in a Dixie cup per table

In the Classroom

Introductory Discussion

1. Ask students if they are familiar with the states of matter (solid, liquid and gas). If they are not, introduce the states of matter using examples from around the classroom. Use ref. 1 to teach and review states of matter concepts. Inform students that they will model the states of matter with their own bodies, then explore states of matter in food.
2. Processes of science that the students will focus on: close observation, careful observation, technical manipulation, comparison, inferring, concluding, verbally summarizing, reporting results.

Safety guidelines: caution is required when handling boiling water.

Science Activities

(1) Activity Title: Modeling States of Matter

Purpose of Activity: To model the relationships between the molecules in the different states of matter, while watching water change state.

Methods and Instructions:
Set-up prior to experiment: boil a kettle of water, so that it is quick to boil again.
Students work as one large group for this activity - space in the classroom (or gym) is needed.

a. Tell students that they each represent a molecule. Molecules are way too small to see, so by making a model of molecules, we can visualize better what molecules are doing in solids, liquids and gases.
b. Show students an ice cube and tell them that in a solid, like this ice cube, the molecules are packed tight, held together by strong bonds. Ask students to model a solid by linking arms with their neighbors, so that they are packed tight together in a group. The individuals can jiggle a little, but the group maintains its shape.
c. Show students how as the solid ice cube gets energy from the air and a warm hand, it starts to melt and become a liquid. As the molecules gain energy, they are still bonded to each other, but more loosely, so they can move around more. Ask students to model a liquid by spreading apart and moving around more, but always touching at least one other student with an outstretched arm. The bonds between molecules break and form continuously, so that the group stays together but can move and change shape, as a liquid does.
d. Show students water boiling in a kettle. As the liquid water gets even more energy the molecules gain enough energy to move completely apart and evaporate to a gas, which we see as bubbles in the liquid water. A gas fills the container it is in. Ask students to break all bonds with each other and run around the room, spreading out to fill the room.
e. Students can be asked to become a liquid again “condensation”, then a solid “freezing”.

(2) Activity Title: Popcorn

Purpose of Activity: To show how state changes in water can produce a familiar snack food.

Methods and Instructions:
Set-up prior to experiment: set up the hotplate, or microwave, ready for making popcorn.
Students will do this activity as one group.

a. Make popcorn on a hot plate, or make microwave popcorn.
b. While the popcorn is popping, explain that there is a little water inside the popcorn kernel. As the kernel heats up, this water turns to a gas. The gas molecules inside the kernel move around more than the liquid water and bump against the inside of the kernel so hard that they exert pressure on it. Eventually the pressure is so high that the kernel bursts. Relate the activity of the molecules to the previous activity where the students modeled the states of matter.
c. Students can examine popcorn kernels before and after popping, to see how the kernel turns inside out from the force of the explosion. The white part of popcorn was on the inside of the kernel. The remains of the brown husk can be found hidden inside.
d. Optional: watch a video of what happens to popcorn in slow motion (ref. 2). This can be done while the popcorn is heating up if necessary.

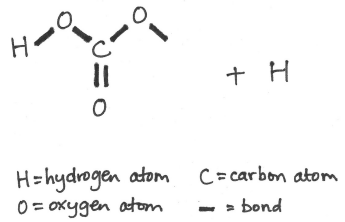
(3) Activity Title: Soda Drink

Purpose of Activity: To observe a chemical reaction and understand the molecular mechanism underlying the reaction.

Methods and Instructions:
Set-up prior to experiment: Pour a splash of juice into a Dixie cup for each student. Add the baking soda to one Dixie cup for each table. Give each student a coffee stirrer.

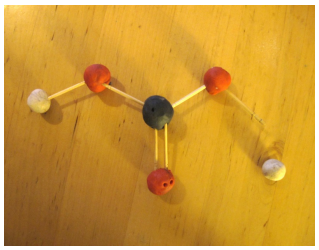
Students will work individually to make the soda drink, then in pairs to assemble molecule models.

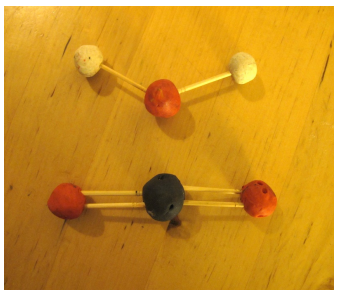
1. Introduce soda drink activity: we made popcorn by changing liquid water into a gas. Now we will make a gas in another way to make a soda drink.
2. Make soda: distribute a Dixie cup of orange juice to each student and a cup of baking soda and stir sticks to each table group. Ask the students to taste a little of the orange juice in their cup. Now ask the students to scoop some baking soda on the tip of a coffee stirrer, add it to their orange juice, and stir.
3. Ask students to watch and listen to what happens. (White with little bubbles; hear bubbles popping).
4. Ask students to taste the drink again. Ask students if the orange juice tastes different. (It should be fizzy on the tongue. Some students may also comment on it being sweeter or having another change in taste.)
5. Ask students about the states of matter and the state changes observed:
   - Q. What states of matter did you start with? A solid (the baking soda) and a liquid (the orange juice).
   - Q. What new state of matter was made? A gas (bubbles were observed).
6. Explain that a *chemical reaction* occurred between the solid and liquid, creating a new gas.



Molecular modeling of the soda drink activity:

1. Distribute one "molecule model kit" to each pair of students.
2. Show students a model of HCO_3 (the molecule in baking soda). See photo and drawing.
3. Show students a model of hydrogen (H) - (the chemical in the juice that takes part in this chemical reaction). See photo and drawing.
4. Ask students to use the materials in their kits to make their own models of HCO_3 and H.
5. Tell students that when the baking soda (HCO_3) and juice (H) were mixed, their atoms rearranged as they chemically reacted. Explain that new molecules were formed as a result:
   - One of the new molecules is a gas (seen and tasted as the bubbles and fizz in the soda).
   - The other new molecule is water.
6. Ask students to pull apart their HCO_3 and reorganize the molecules to make the water molecule (H_2O).

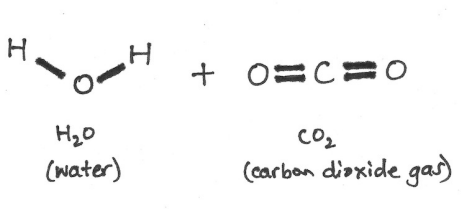




7. Then, ask students to use the remaining atoms (coloured balls) and bonds (toothpicks) to make the new gas molecule. They must combine the atoms according to the following rules (write rules on the board for reference):
    - Each oxygen atom (red ball) must have two bonds (toothpicks)
    - Each hydrogen atom (white ball) must have one bond only (toothpicks)
    - Each carbon atom (black) must have four bonds (toothpicks)

    The angle of the bonds is not important.

8. Students should, given time, create the following two molecules:
    (1) H_2O (water)
    (2) CO_2 (carbon dioxide), "the new gas molecule"



9. Discuss and summarize the soda activity:
    - The baking soda and the orange juice chemically reacted.
    - The reaction caused the molecules to reorganize. Two new molecules are created.
    - One new molecule was *water* (which mixes in with the other water in the juice and disappears).
    - The other new molecule was *carbon dioxide* (CO_2), which is a gas. You saw the CO_2 gas as little bubbles in the orange juice, heard the CO_2 gas bubbles popping, and also tasted the CO_2 gas as the "fizz" in your new drink.

Closure Discussion

This lesson involves a fair number of complex ideas, so review is maybe best done with the students taking turns to describe and explain parts of the lesson, with clarification by the teacher.

References

Bayrock, Fiona. 2006. States of Matter: A question and Answer book. Capstone Press.

<https://www.youtube.com/watch?v=NCSr18vtjeo> You tube video of popcorn popping slow motion. Accessed May. 12, 2014.