Refrigeration Part 2 – How they work
4th Grade

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References:

- PBS Zoom into Engineering – "Keep a Cube"
- www.howstuffworks.com for explanation of how refrigerators work that was then put at a level that 4th graders can understand

Benchmarks:

SLC/GLI #: S&T-3, S&T-4

Objectives:

The objective of this lesson is to follow last week's lesson of why refrigerators are important and a look at bacteria. In this lesson, we'll discuss insulators and how refrigerators actually work to keep things cold through evaporation and pressure changes in the coolant. There will be a discussion on how they work with some demonstrations as well as an inquiry lesson about insulators and making a box that keeps an ice cube from melting.

Materials:

Demonstrations:

- rubbing alcohol and cotton balls
- liquid nitrogen
- pot of boiling water
- bottle with cork
- balloon or Ziplock bag filled with air

Keep-a-cube activity

- boxes
- 2 ice cubes of equal size
- newspaper
- rubber bands
- wax paper
- masking tape
- aluminum foil
- paper plate

Initial Demonstration:

We're actually going to do this lesson a little backward. We'll start with the Keep-A-Cube activity and while we're waiting the 30 minutes for the ice cubes to melt or "keep," we'll then do the demonstrations and discussion of how refrigerators work. So the initial activity will be "Keep-a-Cube." The initial introduction to this lesson will consist of handing out an ice cube

and paper towel to each student. Tell the kids to hold their cubes in one hand. Ask, "What happens to the ice in your hand? How does each hand feel? What makes Ice melt? What can you do to keep an ice cube from melting?" Have students throw the ice cubes away in a bowl or sink.

Procedure:

Show them the activity materials and introduce the challenge: Use these materials to make a container for an ice cube. Your goal is to have the ice cube melt as little as possible during 30 minutes. Give the students a time limit of about 20-25 minutes to complete their boxes. Use a timer if necessary to enforce the time limit. To expedite the materials gathering process, put a set of materials in a box for each pair or group of students before-hand, so you just hand out a box to each group. Keep extra materials on hand though if they need more. Once the students are done with their box, hand out two ice cubes of about the same size per group. Explain that one of the cubes is the "control" cube, and have them place it on a paper plate. They will compare the size of this cube to the size of the cube in the container at the end of 30 minutes.

As kids make their containers, visit groups and ask, "Why did you choose these materials? How do you think your design will keep out heat?" After the 30 minutes, ask the students to compare the ice cubes from their containers with the control cubes. Ask, "Which cube is bigger? What makes the ice cubes melt? What slowed the melting process? What might you do differently if you tried this again?"

Make a list on the board of the materials used by groups whose ice cubes melted the least. During the 30 minutes while they wait, you will have a discussion on insulators, so see if they can tell you which materials they used make the best insulators.

Target Observations:

- Students should notice that some materials work better for keeping the ice cube from melting than others.

Target Revised Model:

- Students should understand that insulators help to keep things cold because they are designed to allow only minimal heat transfer, so that cold things stay cold (and hot things stay hot.)
- Insulation is one way that refrigerators keep things cold.

Demonstration:

The demonstrations should come while the students are waiting for the 30 minutes to be up during the "Keep-a-Cube" activity. There is the possibility to have several demonstrations depending on your ability to get your hands on liquid nitrogen.

First, you should talk about insulation and different insulators because that's one point to emphasize about how refrigerators keep things cold. Bring in several examples of insulators – fiberglass insulation that is found in your walls at home, cooler, maybe some foam insulation, even wood – a piece of a board. You could also bring in a piece of metal, to show an example of a bad insulator. One quick demonstration you can do with this is point out that both materials,

the piece of wood and the piece of metal are both at room temperature, but have the students touch both objects. The metal will feel much colder than the wood because it is conducting the heat away from your hand, while the insulator doesn't transfer heat away as well, so it doesn't feel as cold (although you decide if that will be over the heads of your students or not).

Next, another way that refrigerators keep things cold is by sucking up the heat inside the refrigerator and depositing is on the outside of the refrigerator. It does this by having a material, the coolant, that passes through tubes that run both outside and inside the refrigerator. When the coolant is inside the refrigerator, it's at a low pressure, so is colder that the inside of the refrigerator, and absorbs heat from the inside of the refrigerator by evaporating. The demonstration that goes along with this is putting rubbing alcohol on a cotton ball and dabbing a little on each of the students' hands. When they blow on it, it feels cold on their hand. This is because the alcohol is evaporating and is absorbing heat from their hand in the process. To help them to understand and use another example they already know about, tie this back to the water cycle and the fact that water needs the sun's heat to evaporate. They should already know this.

The final demonstrations involve the connection between temperature and pressure. Temperature and pressure are directly proportional. This is the other way that refrigerators work. While the coolant is inside of the refrigerator, it's forced to being at a low pressure, which makes it colder, so it can better absorb the heat from inside the refrigerator. When the coolant travels to the outside of the refrigerator though, it is forced to be at a high pressure, and is better able to release the heat it absorbed from the inside to the air so it can start the cycle over again and be really cold when it passes back to the inside of the refrigerator.

To demonstrate this relation, you need a bottle with a cork in it, a pot and burner with water to boil. You cork the bottle at room temperature and then place the bottle into boiling water. The air inside the bottle will heat up, thus increasing the pressure, and the cork will pop out of the top of the bottle. You can demonstrate the opposite with a balloon or ziplock bag filled with air and something really cold – liquid nitrogen. Pour liquid nitrogen into a container and dip the balloon or bag into the liquid nitrogen, the balloon or bag should shrink because the air pressure inside goes down.

Target Observations:

- Students should notice that when air is heated, the air pressure goes up, so the cork pops off the bottle, but when air is cooled down, the pressure goes down too, so the balloon shrinks.
- Students should also notice that their hand feels cold when the alcohol is on it and evaporating because it sucks the heat out of their hand in order to evaporate
- Finally, the should notice that insulators such as fiberglass insulation and wood do not allow heat to move efficiently through them.

Target Revised Model:

- Students should understand that refrigerators also help keep things cold by having a coolant pass through them
    - The coolant absorbs heat as it evaporates inside the refrigerator and
    - The coolant is forced to be at a higher pressure outside the refrigerator so it can release its acquired heat into the air before going back into the refrigerator.

Summary:

This lesson was a sequel lesson to last week's lesson of why refrigerators are important. This week, the students learned how refrigerators work. This was done through an activity designed to teach them about insulators and through demonstrations to show them other aspects of how refrigerators work, using a coolant to pass through the refrigerator and absorb the heat on the inside and then deposit it into the air on the outside. Through this process the coolant changes pressure to change its temperature, so the students learned the relation between pressure and temperature.