C2.2 Cooling without electricity

Why do meat, milk, and vegetables have to be stored in a cool location? Bacteria and mold fungi already multiply in food at room temperature (around 20°C). At higher temperatures, they multiply even faster, which is why foods spoil more quickly in summer. These spoiled foods contain many bacteria that can cause food poisoning. Foods must be sufficiently cooled to prevent this. You can make a simple mini refrigerator without electricity or too much technical effort.

Find out how you could build a mini refrigerator in order to keep food cool.

Write down your ideas and guesses:

You need the following for the experiment:

- ☐ 2 cotton cloths
- ☐ 3 containers with lids, 100 ml
- ☐ 1 pail
- ☐ 1 clay pot
- ☐ 1 thermometer
- ☐ cold water

Figure 1: Required materials.

How to set up the experiment:

Lay out all the materials as shown in the photo.

How to conduct the experiment:

1. Fill all three containers to the top with water. Use cool water if possible.
2. Measure the temperature of the water in all three containers. Take turns with your team partners. Enter the results in the table below in the column labeled "Temperature at beginning".
3. Close the containers until you get to step 6 so that you don't spill any water.
4. Place the clay pot in a pail of water.
   Let the clay pot soak in the water until it is saturated with water. You can recognize this by the darker color of the clay pot.
5. Soak both cotton cloths in water and wring them out. They should be wet but not dripping.
6. Unscrew the lids from the containers and prepare three arrangements:
   - Arrangement 1: Place one container of water on a base in the sun. Place the moist clay pot upside down over the container and wrap the clay pot with one of the wet cotton cloths.
   - Arrangement 2: Place the second cup next to the clay pot. Wrap this container with the other wet cotton cloth.
   - Arrangement 3: Place the third container without anything next to the first two.
7. Now wait about 30 minutes.
8. Measure the water temperature in the three containers and write your results in the table.

Write your observations in the table:

Container	Temperature at beginning	Temperature after 30 minutes
Arrangement 1: with wet cloth and wet clay pot		
Arrangement 2: with wet cloth		
Arrangement 3: container without anything		

Evaluate your observations:

1. Summarize the results of the three arrangements: Did the temperature increase or decrease?

2. Decide which of the three arrangements is best suited for cooling foods and why.

3. Do you have an idea of how the cooling occurs?

Doing further research:

1. Together with your team partners, think about how you could change the experiment:
   What pots/containers could you use?
   What liquid could you cool?
   Make notes about your plans.
2. Now get one or two of these pots/containers and liquids and conduct the experiment again.

Tracking down technology

You are familiar with a refrigerator from home. It works according to the same principle as the mini refrigerator that you built in the experiment. Of course, a lot more technology is involved in a refrigerator.
The technology ensures that the coolant used doesn't leak into the surroundings, but remains in the refrigerator where it continuously flows through the cooling circuit.

Figure 2: What it looks like in the refrigerator.

In the experiment, it got cold in the clay pot when the water evaporated.
A refrigerator uses a specific coolant that absorbs a lot of energy when it evaporates and thus cools the surroundings.

1. Guess where this happens in the refrigerator.
2. Check your guesses. What places in the refrigerator feel particularly cold?

Take a closer look at the back of the outside of the refrigerator. You will notice that it is rather warm there.

3. Guess where this heat comes from.
4. Complete the following statement. Cross out the wrong terms.
   The refrigerator heats / cools the interior and simultaneously heats / cools the exterior.

Figure 3: This is what the back of the refrigerator looks like.

The following text describes how the coolant circuit works.

5. Read the text and then in your own words, explain to your classmate next to you how a refrigerator works. Where does the heat in the refrigerator's interior go when the refrigerator cools down?

a.	The coolant evaporates in a cooling surface inside the refrigerator.
b.	It gets cold in the refrigerator.
c.	The coolant vapor is compressed by a pump (compressor) and liquefied again. In the process it becomes warm, like air with an air pump when you pump up a tire.
d.	The warm liquid coolant flows through the pipes on the back of the refrigerator.
e.	The coolant releases its heat to the surroundings in the black cooling coils on the back.
f.	The liquid coolant, now cooled, flows back into the refrigerator.
g.	The cycle starts over again.

6. A refrigerator needs electricity to work. Look for the place in the coolant circuit where electricity is needed and write down the letters: _____
7. Why is electricity needed?
8. Explain why it is important that the refrigerator door always be closed tightly.
9. Why is it important that ice doesn't form on the cooling surface inside the refrigerator?
10. Start searching for all the places where the refrigerator principle is used in everyday life. Take notes.
    This photo shows one example: An air-conditioning system is located on the roof of a commuter train. It also works according to the refrigerator principle.

Figure 4: Air-conditioning system on a train roof.