ACTIVITY 3

HOW TO COOK AN EGG USING THE SUN'S ENERGY?

EXPERIMENT OBJECTIVES AND CONTENT

In this activity, students learn about the notion of solar energy and get a chance to design and build a functioning solar cooker.

ESSENTIAL KNOWLEDGE

Energy:

- Transmission of energy (radiation)

Techniques and instrumentation:

- Use of simple measuring instruments
- Design and manufacture of prototypes

Appropriate language:

- Terminology related to an understanding of the Earth and the universe
- Drawings, sketches

SUGGESTED MATERIALS

Scientific equipment:

- Thermometers
- Solar cooker (optional)

Perishable non-scientific materials:

- Eggs
- Water

Household materials:

- Aluminum plates
- Shoe boxes
- Plastic wrap
- Aluminum foil
- Oven cooking bags
- Empty potato chip bags
- Clear 2-litre plastic bottles
- Canning jars
- Aluminum cans
- Various shaped aluminum containers
- Oven mitts

School supplies:

- Scissors, glue, adhesive tape
- Black paint
- Paint brushes
- Black construction paper
- Rigid cardboard
- Precision knives
- Transparencies

School equipment:

- Sunny school yard

CONTEXT: SITUATIONAL PROBLEM OR RESEARCH QUESTION

The city is doing repair work in your neighborhood and they require the electricity to be shut off for a time. Your parents had planned to make egg salad sandwiches for lunch, but the eggs are not cooked, and without electricity, you can't use the stove. Since it's a sunny day, you decide to make a cooker that will use the Sun's energy. How will you go about it?

SUGGESTED PREPARATORY ACTIVITIES (INTRODUCTION)

The teacher could show a documentary about solar energy or collect examples of how we use solar energy in our daily lives, for example to warm up after going swimming, lighting a fire with a magnifying glass, heating a pool, or recharging batteries using solar panels.

Note: You could show students a manufactured solar cooker. They can be purchased from educational science materials suppliers.

INITIAL IDEAS AND HYPOTHESES

Here are a few examples of hypotheses the students might formulate based on their initial ideas:

Example 1
I predict that I can cook an egg using aluminum foil and black construction paper. I predict this because aluminum foil reflects light like a mirror, and black materials easily absorb heat from the sun, like when asphalt gets very hot in summer.

Example 2
I predict that I can boil water to cook an egg using an oven cooking bag and potato chip bags. I predict this because the inside of potato chip bags shine like a mirror and reflect light well. In addition, the clear plastic bag works just like a greenhouse, letting heat enter but preventing it from leaving.

Example 3
I predict that I can cook an egg using aluminum foil and a clear soft drink bottle. I predict this because aluminum foil reflects light, while the clear plastic bottle traps heat like a little greenhouse. I know this because when I leave a bottle of water in the sun, it soon becomes very warm.

WORK PLAN AND EXPERIMENTATION

Here are a few examples of experiments the students can carry out to verify their hypotheses:

Example A
The students line the sides of a shoe box with aluminum foil and the bottom with black construction paper. They also glue an aluminum plate, which they have previously painted black, to the bottom of the box. They place the egg inside and cover it with a piece of plastic wrap, which they hold in place with adhesive tape. Next, on the top of each side of the box, they position four rigid cardboard panels covered with aluminum foil (the shiny side exposed toward the sky). The four panels should be inclined about 120 degrees. They then place their oven in the sun and wait for the egg to cook.

Note: the students can add a second piece of plastic wrap to cover the opening of the box to increase the greenhouse effect inside the box.

RECORD ALL YOUR IDEAS AND OBSERVATIONS IN YOUR EXPERIMENT WORKBOOK.

AVOID STARING INSIDE THE COOKER SO YOU ARE NOT DAZZLED. THE COOKERS AND THEIR CONTENTS SHOULD BE HANDLED WITH OVEN MITTS.

Example B

The students make five reflective panels out of rigid cardboard covered with potato chip bags (shiny sides exposed to the sky). They place one on the ground with the shiny side facing the sky and they attach the other four panels to the sides of the central panel with adhesive tape. Each of the sides should be inclined about 120 degrees. They then paint the outside of a canning jar black, place an egg in it and fill it half full of water. They place the jar inside a plastic oven cooking bag and seal it, making sure to leave some air inside. They place the bag with the jar inside in the aluminum "oven" and orient the side panels so they capture as much light as possible.

Note: Put the flat cover on top of the canning jar but not the tightening ring. The cover will help keep heat in the jar but will be able to move if the water starts boiling.

IT TAKES ABOUT AN HOUR TO COOK AN EGG THIS WAY. REASSURING FACT: THESE TYPES OF OVENS DO NOT CATCH FIRE BECAUSE THEY REACH AN AVERAGE MAXIMUM TEMPERATURE OF 120°C, WHILE PAPER BURNS AT 233°C.

Example C

The students make a large cone out of cardboard and line the inside with aluminum foil. They then cut off the top of an aluminum can and place an egg inside, then cut the neck of a soft drink bottle and place the can inside it. They can seal the bottle with plastic wrap. Finally, they place the bottle (with the can inside) inside the cone and expose the whole structure to the Sun. They can place the cone in a box or a bucket to stabilize it.

Note: A kitchen thermometer can be placed inside the oven, or a thermocouple thermometer can be placed on the surface of the egg. By measuring the temperature, students will be able to observe how it changes depending on the amount of sun and the various cooker designs. They will also be able to determine what temperature is needed to cook an egg.

EXPERIMENTAL FACTORS

To ensure scientific rigor, the students should evaluate the experimental factors that might influence the experimental results.

- Quality and duration of sunlight
- Time of day
- Time of year
- Combination of techniques to capture and store heat
- Orientation of cooker to Sun
- Duration of exposure to Sun
- Color of materials used

DISCUSSION: SUGGESTED INTEGRATION ACTIVITIES (CONSOLIDATION)

The teacher leads a discussion and reviews the activity's key concepts. Which teams were able to cook their egg? Which cooker was the most efficient and why? The students could also present the design particularities of their cooker to the rest of the class.

SUGGESTED ACTIVITIES FOR APPLYING KNOWLEDGE (APPLICATION)

The teacher could have the students compare solar energy to other types of energy (fossil fuels, electricity) and list the advantages and drawbacks of each. It is also suggested to initiate a discussion on the importance of using renewable energy sources. The students could draw plans for a house that uses renewable energy sources.

SCIENTIFIC CONCEPTUAL CONTENT

Solar radiation

The Sun emits light (visible light), infrared rays, ultraviolet rays, and other electromagnetic radiation. Ultraviolet and infrared rays are invisible to the naked eye. Ultraviolet rays are what give us a tan and can also cause cataracts and skin cancer. Infrared rays, visible light and ultraviolet rays all contain energy and contribute to heating the cookers. Most of the energy from the Sun that reaches the Earth's surface comes from visible light and infrared rays.

Solar energy

Solar energy is energy transmitted by the Sun by way of radiation. This energy is what creates the Earth's water and wind cycles. It is also what plants use to carry out photosynthesis. Solar energy can also be converted into other forms of energy useful to humans such as electricity, through photovoltaic arrays, or heat, through solar cookers.

Greenhouse effect
Phenomenon through which heat rays (thermal radiation) are trapped in a medium. This happens when thermal radiation and light pass through a transparent medium and some of the radiation does not leave the medium. These rays are therefore stored, increasing the medium's temperature. The phenomenon is used in farming, in the form of greenhouses, to grow exotic plants or fruits and vegetables in winter. This same phenomenon can be observed on a planetary scale.

Albedo effect
Different surfaces reflect and absorb radiation from the Sun differently. Dark colors, for example, absorb more thermal radiation and light than light colors. As a result, they store more heat and their surface is said to have a low Albedo (near 0). Inversely, light surfaces and mirrors reflect light and absorb very little of the Sun's rays. These surfaces are said to have a high Albedo (near 1).

Focal point
Curved concave mirrors and convex lenses have the special ability to concentrate thermal and light radiation they receive into a single point, called the focal point. It is the focal point that allows us to light a fire with a magnifying glass.

Principle of the solar cooker
An efficient solar cooker can be made by combining the following three principles: the principle of the focal point, which concentrates the Sun's rays into a single point; the greenhouse effect, which traps the Sun's rays; and the Albedo effect, which helps maximize the absorption of infrared rays on a given surface.

CULTURAL REFERENCES

The tactics of Archimedes
Legend has it that during a war with the Romans, this great Greek scholar of antiquity developed giant mirrors that could reflect and concentrate the Sun's rays onto the sails of the enemy ships to set them on fire. However, many scientists today believe this is only a myth, since Archimedes would have needed mirrors much more powerful than those available at the time. In addition, Archimedes' town faced the sea eastwards and was therefore exposed to the Sun's rays in the morning, when they are much less powerful than at noon. This would have greatly reduced the amount of energy that could be concentrated with the mirrors.

Mont-Louis solar furnace
The first modern solar furnace was built in 1949 in Mont-Louis, France by professor Félix Trombe and two collaborators. The furnace can reach temperatures from 250°C to 3,000°C. Initially, the furnace was used as an army laboratory. Later, after having been abandoned for decades, it took on a completely different purpose. In 1993, it was used to fire artisanal ceramics. It is hoped that it will soon be used to melt bronze and aluminum.

FOR MORE CULTURAL REFERENCES,
VISIT THE ÉCLAIRS DE SCIENCES WEBSITE:
www.eclairsdesciences.qc.ca

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PROCESS OF ACTIVE DISCOVERY

GENERAL LEARNING PROCESS IN SCIENCE AND TECHNOLOGY (IN ELEMENTARY SCHOOL)

Context related to everyday life

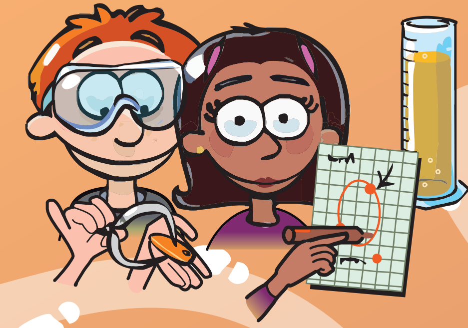
- **Situation problem** or
- **Discovery question** or
- **Need to be fulfilled**
- **Question related to the operation of an object** (how does it work?)

Initial ideas and hypothesis

My initial ideas:
- I share my own ideas.

My hypothesis:
- I predict that...
  I think that because…
- I imagine my prototype.
- I think it works like this…

Planning and carrying out



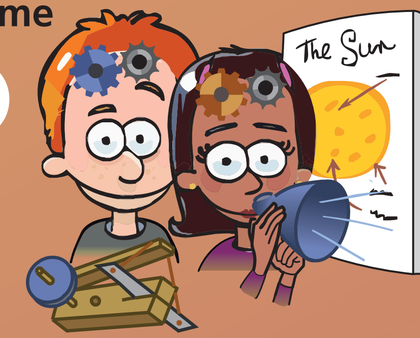
My equipment:
- I observe and handle the equipment.
- How could this equipment be useful to me?
- I choose my equipment and my materials.

Carrying out my process:
- What will the steps be?
- What precautions should I take?

My actions:
- I carry out the steps of my protocol.
- I note or draw what I observe, what I do and what I discover.

My results:
- What is my answer to the problem, question or need?

Outcome



My outcome:
- Do my results confirm my hypothesis or not?
- Are my results similar to those of the other teams?
- Can the other teams' results help me to find answers to my problem, my question or my initial need?
- What could I communicate concerning my discoveries?

New question?

What I learned:
- What do I retain from this activity?
- What could I communicate concerning my results or my discoveries?

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