Chicago del Sol:
An Innovative Solar Energy Education Pilot Program
Outreach Lesson 2

Lesson Introduction and Goals
This lesson is the second of two outreach lessons to be delivered during the *Chicago del Sol* project. The two outreach lessons will be supplemented by a museum visit and by online learning activities and Webcasts. This second lesson is intended to provide students with a basic introduction to electricity and to the how the solar cells on the roof of Reilly school actually work to supply energy to the school.

At the conclusion of this lesson, the students will be able to:
- Define electricity as the movement of electrons through a circuit
- Explain how solar cells are designed
- Understand how the rays of the sun make energy for the school

During the lesson, students will work to solve the "Solar Cell Mystery" using a number of clues; they will then make a human solar cell.

Time Allotment
50 minutes

Materials
- "Solar Cell Mystery" Clues: sample solar cell, sand, photos of local cells (on schools or museums if possible), solar cell calculators, batteries (these are just some suggestions—you can come up with your own clues)
- 20 red and 20 yellow balloons

Advanced Preparation
- Gather materials and inflate balloons

Procedure
A. Tap Prior Knowledge (10 min.)
Review the previous lesson: All energy comes from the sun. Energy is movement, sound, light, heat, growth. We are all connected in a web of energy. Ask the students to remember the web activity and to summarize one chain from it (e.g., sun to plants to cows to milk to cereal to dancing).

B. Share With Neighbor (5 min.)
Ask students the students what they know about solar cells and how they work, in particular what they know about the cells on the roof of the school. Write answers on the board.

Then pour sand on the table or ask the students to close their eyes and feel the sand in the container. Ask them where they find sand. Ask them what happens when it's very hot at the beach—do they like to walk in the sand?

Pass out to the groups of students the rest of the clues. Give each group of students 3-5 minutes to discuss its clue and how it relates to solar energy and solar cells.

Tell them that the same material that makes up sand, silicon, is what's used to make solar cells. Silicon is poured into thin layers and different chemicals are added to each layer. When the photons of the sun hit the layers, electrons move from one layer to the other, forming an electrical circuit.

After giving the students three or so minutes to discuss amongst themselves what their clues might have to do with the mystery object (solar cell) or with making energy from the sun, ask each group to tell you their ideas and write them on the board. As you write them on the board, tease out the key principles important to solving the mystery. For example, the sand is important because it attracts and holds heat (think of hot sand at the beach) and silicon—the main component of sand—is used to make solar cells. The batteries are important because they use a mix of chemical to generate energy—just like solar cells (for you teachers out there, boron and phosphorous are added to the silicon wafers to create positive and negative sides of the silicon "sandwich." The calculators are important because they show a solar cell at work.

C. Hands-On Activities and Explanations (25 min.)
By now, the students probably have guessed the "mystery object" is a solar cell. Congratulate them and then ask them how—really, HOW?—does the cell turn sunlight into electricity. Then tell the students that they're going to demonstrate how, that you're going to turn them into a "human solar cell!"

1. Have all the kids stand up and ask 5 or 5 of them to come to the front of the class—they are going to represent the sun. Give them each a yellow balloon to represent the radiant energy from the sun.

2. Arrange directly in front of the sun and perpendicular to it two rows of 5 or 6 students each (it helps to have the same number of students in each row as you have in the sun. These two rows of students represent the two layers of a solar cell (you describe this as a "sandwich" if it's helpful for them to visualize it—get it? "*sand*"wich? Silicon? Sand? :-).

3. Then have the balance of the students line up on either side of the sandwich cell, spanning out parallel to the sun and reaching out toward the walls of the classroom (toward electrical appliances such as a clock, computer, or pencil sharpener, or an outlet, if possible). Explain that they are the wires carrying the energy from the cell to the classroom.

4. Hand out to each student in only one of the rows of the solar cell line a red balloon. Explain to them that this represents bits of energy in the cell (electrons) from the chemicals (remember the batteries?) waiting to be released by the sun's rays.

5. Set the "human solar cell" in motion by asking the first representative of the sun to send down their ray of light in the form of the balloon. When the yellow balloon of the sun hits the red balloon in the solar cell, the yellow radiant energy of the sun breaks loose or releases the red energy (electrons) from the cell. Then have Student 1 in the first row with the red balloon pass the balloon (energy) to Student 1 in the row next to him/her. Now that this energy is moving, it is electricity! Then send the balloon into the wire and have it passed down through all the students until it reaches a use in the classroom (lights, computer, clock, etc.).

6. Have the last student in the wire row take the balloon and touch the appliance that's using the energy. Then ask him/her to give the balloon to the last person in the other wire row and have the energy passed down and back to the cell again. Explain the loop or circuit created and note that electricity must travel in a closed loop or circuit to be accessed.

D. Introduce Scientific Principles (5 min.)

Provide a brief introduction to electricity first. Everything is made up of atoms. Atoms have a nucleus of protons and neutrons, with electrons orbiting around them in a "cloud." The electrons are kept close by the positive force of the protons, but they can be knocked loose. When they fly loose and into a looped current, this is electricity.

The review how solar cells work. Y- and X-rays carry so much energy form the sun that their photons dislodge electrons from atoms in the solar cells. In this way, radiant energy turns into kinetic energy in solar cells.

Solar cells have two layers of silicon (which comes from sand, the second most abundant material on Earth), one with boron (positive layer that attracts electrons) and one with phosphorous (negative layer that gives up electrons). These layers are sandwiched together to create a circuit.

E. Relate Activity and Concept (5 min.)

Ask the students to summarize for you what they learned today. Write their answers on the board, organizing the concepts as you go. Ask the students to give you ideas for some of the ways solar energy could be used. Write these ideas on the board. Explain to the students how solar energy is renewable and relatively non-polluting. To wrap up, you might do one final demo. Many of the students will likely rub the balloons against their hair to create static electricity. This is a great way to point out what's happening in a solar cell. Just as with the balloon—where electrons are broken loose during the rubbing and they create static electricity that causes one's hair to stand on end—likewise in the solar cell where rays from the sun break loose electrons from the cells, generating electricity.

Finally, ask the students to draw pictures representing what they now know about how solar cells work and how solar energy is produced. (For the Chicago del Sol project, these drawings formed the basis of a sharing activity conducted with Ortiz de Dominguez students during International Public Science Day 2002).

Assessment

You can begin to assess student learning during this lesson by:

- Listening closely for accurate recollections from the previous lesson and for ideas during the Share with Neighbor portion of the lesson
- Observing the students during the "Human Solar Cell" activity to note whether they "get it"
- Making the "Scientific Principles" portion of the lesson more of a discussion and less of a lecture