

# Tapping the Sun's Power

## Instructional Objectives

After viewing the program and participating in the accompanying activities, the student will be able to:

1. explain the source of energy for the Hubble Space Telescope and the scientific instruments on board,
2. diagram or in some way explain the role of valence electrons in electricity, and
3. state at least one accomplishment of students who have worked with solar energy.

## Synopsis

This program begins with "HST Data Stream" with Dr. Eric Chaisson. Eric shares with us the meaning of the images we see from HST.

Solar power has operated human-built satellites for nearly thirty years. This "Science Links" segment focuses on solar energy and its potential for use by the people on earth. Common examples of how we use solar power are shown. The Hubble Space Telescope's use of solar cells is described, and students' work with solar collector panels is shown. These applications are used as the motivator to understand how solar cells work.

The camera takes us to a manufacturer of photovoltaic cells, Solarex Company in Frederick, Maryland. There the students see and hear how the silicon-based solar cells are made and why they are the most viable and least costly method known today of producing solar electricity.

The role of atoms and in particular valence electrons in solar energy is explained. Electricity as the product of a flow of electrons is depicted.

The person behind the HST in this program is Pierre Bely. Pierre explains his role in designing solar panels and gives us a sense of what it is like to work at the Space Telescope Science Institute.

## Vocabulary

*Electricity* - A property of nature that we usually recognize as an electric current. The electric current is produced by a flow of electrons. Electrons are small particles that carry a negative charge.

*Ingot* - A mass of metal cast into a convenient size or shape for later storing or use.



*Semiconductor* - A substance that has different resistances to the passage of an electric current under different circumstances. How well a semiconductor conducts electricity depends on temperature. When a semiconductor is heated, its resistance decreases. (This is opposite of a metal.) Semiconductors are also sensitive to the energy of light. The greater the intensity of light that shines on a semiconductor, the better it conducts electricity; that is, its resistance decreases. Semiconductors are used in photovoltaic cells and in solar batteries.

*Silicon* - The second most abundant element found in the earth's crust. It has some metallic and some non-metallic properties. At room temperature, it is solid. Silicon has an atomic mass of 28 (neutrons + protons) and an atomic number of 14 (number of protons in the nucleus). Silicon always occurs in compounds. It is present in quartz, sand, flint, agate, amethyst, jasper, onyx, and opal. Silicon can be made in a factory by heating sand and coke in a furnace. The pure crystalline form of silicon is a semiconductor.

*Globular Cluster* - A tight knit collection of many thousands, sometimes even millions, of old stars usually spread throughout a ball about 10-20 light-years in diameter.

*Messier Catalog* - One of the earliest star catalogues, compiled by Charles Messier in 1781. Many star clusters, nebulae, and galaxies are referred to by their entry numbers in the Messier Catalogue. For example, the Andromeda Galaxy is referred to as M31, meaning it was the 31st entry into the Messier Catalog.

*M-14* - The fourteenth entry into the Messier Catalog. M-14 is a globular cluster located in the constellation, Ophiuchus. Scientists believe they saw evidence of a nova, or exploding star, in the upper left quadrant of M-14 in 1938.

*Nova* - A star that rapidly brightens while expelling a small fraction of its matter, after which it slowly fades back to normal.

*Solar Cell* - A device that can convert sunlight into electricity. Solar cells commonly power calculators and outside lights. When sunlight strikes a solar cell, it sets off a chain of events that produces electricity.

*Solar Collector* - A device for collecting solar energy and converting it to heat.

*Solar Energy* - Energy from the sun.

*Valence Electron* - Electrons in the outermost shell from the nucleus. Valence electrons play an essential role in the creation of an electric current.

## Previewing

Ask students to list sources of energy and the by-products of using the energy. What do the students note about using solar energy? Ask students to list examples of products that are powered by solar energy.

If available, bring in brochures from a manufacturer of solar cells. Show students the appearance of solar cells.

Ask students how satellites operate? From where do satellites get their power?

Have the students discuss why research into solar energy becomes popular or unpopular. What are the social or economic factors influencing change in the use of solar energy?

Have students create a timeline of the use of solar power in the United States.

Take students on a field trip to visit a solar powered home and a passive solar home. Discuss the differences in techniques and the reasons why people may choose one over the other.

## Postviewing

Discuss the latest images sent back to us from the Hubble Space Telescope. What do these images tell us about our universe?

Have the students diagram or sketch the role of valence electrons in electricity. Encourage students who are interested to create a sequenced cartoon explaining valence electrons.

Have the students contact their local utility company to see if the utility company supports student or student-teacher projects. Follow through with a class proposal to do an experiment with solar energy.

Discuss with students why the solar panels of the Hubble Space Telescope had to be rolled up prior to deployment and why the panels need to rotate in space.

## Active Involvement

On a cold, dry day, try some demonstrations or encourage class participation with experiments in static electricity. A few examples follow to get you started.

- Bring in a piece of wool (a wool sweater would do nicely). Rub a plastic comb against the sweater, then hold the comb near different objects. What is observed? Try objects such as hair, scraps of tissue paper, or a balloon.
- Rub the comb against the sweater again. Turn on the tap so that the water runs in a thin stream. Hold the comb near the water. What is observed?
- Bring in polystyrene (often referred to as peanuts and used in packing boxes). Place a handful of peanuts in a thin plastic bag. Shake the bag. Now try turning the bag open side down. What do you observe?

Have the students measure the change in temperature of the water in two plastic bottles, one left clear, the other painted black. Students should measure the temperature throughout the day and record results. Note when the sun is directly hitting the bottles. Have the students research and build a solar collector. Students can design and carry out their own experiments.

Have the students research the cost of using the various types of energy sources. Besides the dollar cost of production, ask students to include less quantifiable costs such as damage to environment, risk in obtaining materials, and location and transport of materials.

## Bibliography

*For high school readers:*

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Savon, Karl. "New high-efficiency photovoltaic solar panels bring everyday applications closer to reality." *Radio-Electronics*, Vol. 51, November, 1980, pp. 98-100.

*For middle school readers:*

Mohr, Merilyn. *Sunwings*. Buffalo: Firefly Books Ltd., 1985.

Spooner, Maggie. *Sunpower Experiments: Solar Energy Explained*. New York: Sterling Publishing Co., 1980.

Weiss, Malcolm E. *Far Out Factories: Manufacturing in Space*. New York: Lodestar Books, 1984.

# Science Career Profile

**PIERRE Y. BELY**

Head of Engineering Support Branch

Space Telescope Science Institute

Education: Engineering Diploma, Ecole Centrale de Paris

M.S.Engineering



## **Chief Responsibilities**

Pierre Bely and his team of engineers are responsible for providing engineering support for the day to day operation of the Hubble Space Telescope (HST). This includes monitoring the performance of the science instruments and of the pointing and guiding systems of the spacecraft, analyzing problems, and studying possible improvements and workarounds to failures.

In addition, Pierre takes an active part in the conceptual studies for the next generation space telescope which will replace HST around year 2005.

## **A Typical Day**

Pierre's day starts with a status meeting which is done in phone conference ("telecon") with the Goddard Space Flight Center. He confers about the problems and successes of the last 24 hours, and about the telescope scheduling for the coming days. There is also often another coordination meeting with the rest of the staff at the Institute.

The rest of the day is dedicated to the "auscultation" of HST, which is a little like checking the telescope's "heartbeat" and other vital signs. On a satellite, one cannot of course just plug in a meter or use a test instrument to check up on the health of the equipment or diagnose problems. One has to rely on "telemetry", a radio link which keeps scientists informed on what is happening with the spacecraft second by second, just as dials and gauges do in a lab or a factory.

Fortunately, HST is very well instrumented, with a total of about 4000 measuring points: voltages, current, temperature, vacuum, gyroscope indications, mechanism positions, starlight intensity, etc. One has to collect the data, analyze it, and often play "Sherlock Holmes" to understand what is happening without the use of the eyes or of a screwdriver.

At home, in the evening and often on weekends, Pierre toys with concepts for future telescopes. Two recent projects that he has worked on are a space-based interferometric array dedicated to the discovery of extra-solar planets, and a large optical telescope on the moon.

## **Career Viewpoint**

Scientists used to design and build their own experiment apparatus, and of course analyze their results themselves. Nowadays, scientific research has become very complex and relies heavily on technology. Very often a new technology will even spur scientific discoveries. This is especially true of astronomy. Astronomy would not be where it is now without photography, radio, television, computers and satellites.

Scientific research is certainly now a team work between scientists, engineers and technicians. Pierre has been on the "technical side" of astronomy for essentially all of his career, and finds that applying his engineer's skill to the benefit of human knowledge has been extremely rewarding.

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The Educational and Public Affairs Office of the Space Telescope Science Institute has compiled a *Glossary of Astronomical Terms for the Hubble Space Telescope*. Teachers interested in receiving the glossary, or a color poster of the Electromagnetic Spectrum, may send a written request to:

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# See for Yourself: Experiments/Projects

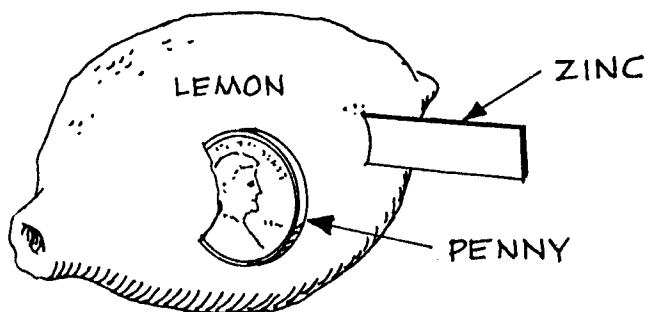
## Pennies and Lemons

### ► MATERIALS:

- wires of various types
- copper penny
- piece of zinc
- sliver of wood
- paper clip
- other items as available
- small utility knife or kitchen paring knife
- fresh lemon
- litmus strip

### ► DIRECTIONS:

1. Cut a small hole in the lemon. Squeeze out a couple of drops of lemon juice onto your litmus paper. Is lemon juice acidic or alkaline? Record your answer and how you know this.



2. On the other side of the lemon from the hole, insert the copper penny and the piece of zinc so that they are roughly 1/2" apart (see diagram). Raise the lemon to your mouth so that the zinc and copper touch your tongue. What do you feel? Record your sensations.
3. Repeat step 2 using different kinds of substances. Record the substances used and your sensations.
4. How would you explain what you felt? Record your answer.
5. Look up how a battery is made. Using this information, explain the sensation you felt. Record your answer.
6. Explain the results of the experiment for the different pairs of substances with which you experimented.

# STARFINDER

PROGRAM 12

## Fuses

### ► MATERIALS:

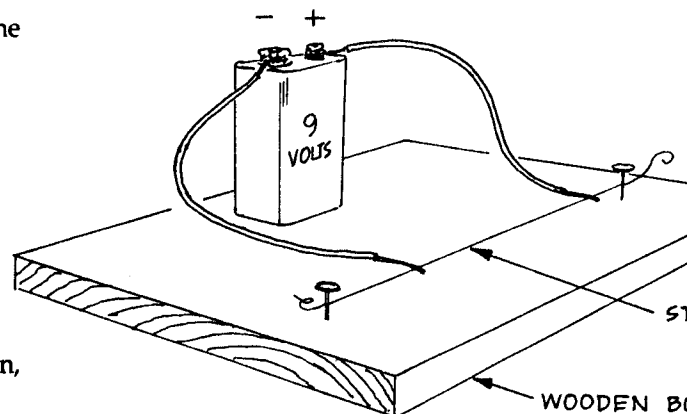
- paring or utility knife
- 9 volt battery
- steel wool (not too fine)
- insulated wire (2 pieces)
- wooden board or other surface to stick pins into
- 2 straight pins or thumb tacks

### ► DIRECTIONS:

1. Look up the definition of resistance. Write down the explanation. Look up fuses. How do they work in your home?

Steel wool has a greater resistance to the electrical current flow than does the wire.

Prepare the wire to be hooked to the battery by removing 1/2" of insulation from both ends of both pieces of wire. Attach one wire to the battery. Then pull a single strand of steel wool loose. Place the steel wool on top of the wire. Use pins to hold the wires in place (see diagram). When the steel wool is in place, touch the second wire to the battery, be sure to hold the insulated portion of the wire.



2. Observe the steel wool and record your observations. Detach the second wire. Put in another strand of steel wool and repeat the experiment.
3. Observe and record.
4. Explain how what you observed would function as a fuse in your home.
5. Why are fuses a safety device?

## **Capturing the Sun**

### **► MATERIALS:**

- paintbrush
- different color paints (dark colors)
- plastic bottles
- water
- thermometers
- graph paper

### **► DIRECTIONS:**

Paint each plastic bottle a different color. When they are dry, fill each bottle with an equivalent amount of cool tap water. Place the bottles in the sunlight and put a thermometer in the water. It is important that you do this experiment on a sunny day.

1. At intervals of 10 minutes, record the temperature of the water for each colored bottle. Continue the measurements until the temperature stabilizes, remaining the same for several readings.
3. Chart your results.
4. What conclusions can you make?
5. How does this influence the building of solar collectors?