

How Solar Energy Is Harvested

A Teaching Kit For

A Process of

Photosynthesis

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The dilemma of designing a good curriculum: Abstracted terms. A good curriculum is one that can be taught by ordinary teachers to ordinary students and that at the same time reflects clearly the basic or underlying principles of various fields of inquiry. Bruner (1960) explained that there are a number of problems that are encountered as we construct a curriculum of that kind. The major problem is to ensure that the pervading and powerful ideas and attitudes that are related to the underlying principles are given a central role. The most difficult decisions that have to be made in each unit have to do with the fact that some things can be discovered by children doing experiments, but some cannot (Karplus & Their, 1967). The latter are the man-made constructs (higher order concepts), what is thought about natural phenomena.

Driver, Asoko, Leach, Mortimer and Scott (1994) argued that even in the relatively simple domains of science, the concepts used to describe and model the domain of science are not revealed in an obvious way. They are, rather, constructs that have been invented and imposed on phenomena in attempts to interpret and explain them, often as a result of considerable intellectual struggles. Once such knowledge has been constructed and agreed on within the scientific community, it becomes part of the “taken-for-granted” way of seeing things within that community. As a result, the symbolic world of science is now populated with entities. These ontological entities, organizing constructs, and associated epistemology and practices of science are unlikely to be discovered by individuals through their own observations of the natural world (Driver, et al., 1984). While scientists use these terms to precisely communicate their findings to other scientists, they are taught as abstracted terms to students in order to understand important scientific concepts and principles, to become scientifically literate, or to lay a foundation for further learning in the sciences (Wandersee, 1988a). In the study of photosynthesis, such entities appear in the form of pigments, electron donor, electron flow, details of metabolic pathways, reducing power, and energy reactions, among others. Some laboratory experiences are means of relating these abstracts to the intuitive knowledge of the students. Wandersee (1983b) explained how a science educator can act as a biological membrane between science and society by regulating the flow of ideas and helping students decode the complex messages.

Obtaining Information About Students' Alternative Conceptions

The creator of a unit must clearly have in mind what constructs are already available to the

Pupils and what constructs must be introduced to enable the pupils make the discoveries potentially derivable from the experimental observations (Karplus & Their, 1967). Science education researchers are looking to the day when they will be able to develop a good curriculum after having studied by direct means what students already know about a given discipline. An indirect way of doing this is to evaluate students' intuitive knowledge. Intuitive knowledge is contrary to what they are expected to learn, hence the name alternative conceptions. Evaluation of students' alternative conceptions relating to the plant nutrition can be done by:

1. Conducting a pilot study with a large cross-section of students.
2. Thorough examination of the relevant literature dealing with the students' cognitive structures as they are documented in science education literature.

The findings obtained from the pilot study are matched with those documented in science education literature. A good curriculum can then be drawn in an attempt to deal with these two sources of information. Teaching or instruction based on this approach turns out to be “undoing” the intuitive concepts of the learner; hence the name, “conceptual change.”

Day One

Set the goals and objectives

1. Appreciate that all energy originate from the sun.
2. General understanding of photosynthesis, include brief details of the Calvin Cycle.
3. General understanding of respiration, include brief details of the Krebs Cycle.
4. Draw some similarities between photosynthesis and respiration. Consider aspects of energy transfer.
- 5.

Sun: The Source of All the Energy

Nuclear fusion is a nuclear change in which two isotopes of light elements such as hydrogen, are forced to unite together at an extremely high temperatures and pressure until they fuse to form a heavier nucleus. Temperatures of at least 100 million ° C are needed to force the positively charged nuclei (which strongly repel one another) to fuse. Fusion of hydrogen nuclei to form helium nuclei is the source of energy in the sun and other stars.

Laws of thermodynamics and interconversion of matter. The vital and much celebrated equation of Albert Einstein ($E=Mc^2$) comes into play when the fusion of elements at the sun takes place. Here, not all the mass (m) of hydrogen ($1.008 \times 4=4.032$) is converted into the mass of helium

(4.026), but a small amount of this mass (0.0006) is converted into some energy according to the equation of Albert Einstein $E=Mc^2$. The energy released is equivalent to $E=0.006 \times (3. \times 10^8)^2$. This amount is enormous. Some of it proceed to the earth in the form of the electromagnetic radiation. About 0.1% of that hits the earth is trapped by the plants. Only plants have the ability to capture that energy in the form of the chemical energy. As these processes continue, the two laws of thermodynamics continue to operate in regard to the flow of that energy. At the sun, where hydrogen is being converted into helium, the first law operates just as it continues to operate when the electromagnetic radiation is reconverted into the chemical energy during the process of photosynthesis. Only little of this electromagnetic radiation is converted into the chemical matter, thus obeying the second law of thermodynamics.

It is absolutely necessary for students to appreciate that solar energy can be used to do some work. Demonstrational experiments, like those done by Mr. Wizard can be used to illustrate this. One of them is shown below:

Effects of Different Colors on Reflection of Solar Energy.

Greater expansion of air in the black bag than that is the white bag. Some balloons were fitted in two different bags (see diagram below). One of the bags was black, the other was white. The two bags were exposed to the blight sunlight for a while (half an hour is sufficient to bring about the required changes). Changes in the volume of the air in the bags were monitored by the changes of the volumes the balloons.

Refer to Figure 1

Observations The balloon fitted to the black bag was inflated but the one fitted to the white bag remained flaccid.

Explanations The black bag did not reflect light. Instead, it absorbed it and converted it into some heat energy. This heat energy increased the kinetic energy of the molecules of the air causing its expansion. This forced the balloon to expand. It is worth noting that the principles involved, here, are the same that makes the hot air rise; the air in the black bag has fewer molecules, per given volume, than that of the surrounding air. As a result, the atmospheric air moves below the bag replacing the heated air in the black bag. It is necessary to note that the reverse is bound to happen if there is some very cold weather. The black bag will give away more heat energy to the surrounding air than the white bag would do.

(A class discussion; Energy as the force that moves matter and also required to maintain an order in any system. Any organism can be considered as a system and therefore energy is required for the processes that take place within it. This discussion can lead to the comparison of the black bag with the chloroplasts. An experiment to illustrate it can be set as follows.)

Materials needed: fresh healthy springs of elodea plant (*Anacharis*, an aquarium plant); microscopes, slides and cover-slips.

Procedures Students may proceed to make slides as directed. Afterwards they compare what they see under the microscope with chloroplasts shown in a standard textbook of biology.

Guiding questions, such as, what are the green bodies that you can see under the microscope?

Expected response is that of identification, *chloroplasts*;

Guiding questions, what gives the green coloring to the chloroplasts:

Expected response is that of identification, chlorophyll.

Day Two

Separation of the Leaf Pigment by Paper Chromatography

A technique called Chromatography may be used to separate the chlorophyll pigments in a leaf. Explain to the students that chromatography has been known for many years and that it can be done in a variety of ways. Some of these ways can be technologically sophisticated. The one that they would perform then; paper chromatography was very basic. Paper chromatography works on the principle that different pigments, when dissolved in a solvent (such as water or ether), will move (travel) through a piece of paper at different rates of speed. The rate is determined by:

1. Obtain a paper of filter paper long and narrow enough to fit inside a test tube. (*A standard diagram of chromatography is essential*).
2. Crease the paper lengthwise to make it more rigid. Some extract has been prepared by macerating leaves in a small volume of acetone. This can be done either with a mortar and pestle or in an electric blender. By paper chromatography, you can separate the different pigments out of the leaf extract.
3. Get a test tube and add to it a small amount of solvent (about 1 cm or so in depth). The solvent is a mixture of 95 parts ether and 5 parts acetone. Plug the tube and set it aside.
4. Obtain a strip of paper long and narrow enough to fit inside a test tube (See the figure below) and crease it lengthwise.

5. With a medicine dropper, apply a few drops of the leaf extract to the filter paper strip about 2 or 3 from one end. Allow the spot