Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2000 Volume VI: The Chemistry of Photosynthesis

Ph-ocusing on Photosynthesis In and Out of the Garden

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by Francine C. Coss

Science is a highly neglected subject in the elementary grades. Most elementary students are steered toward less complex topics than those discussed in science class. This could be due to the lack of appropriate resources or curriculum available to elementary students. However, it could also be due to the lack of personal understanding and comprehension of science topics experienced by the classroom teachers. I find it extremely necessary to fill this void of science resources for elementary students and for elementary level teachers. Through participation in 'The Chemistry of Photosynthesis' seminar I will pave an avenue of resources and age/grade level appropriate curriculum that will increase awareness of problems, solutions and general information regarding photosynthesis. I also expect to encourage the study of sciences simply through exposing other teachers and students to the activities and experiments conducted in my own classroom.

Introduction

Primary and elementary grades encourage the use of hands on activities in the classroom curriculum. Science yearns for the opportunity to relate its topics in a hands-on fashion. The constant encouragement of active, subject manipulation found in the elementary grades sets the stage for success in the study of science. Planning and structuring a full-bodied, hands-on curriculum unit for the study of photosynthesis in grades 1-3 will increase student and teacher understanding of the subject. I plan to implement many hands-on projects, experiments, units and mini-units involving such sub-topics as "Plants and What They Need", "Growing Seeds", and "The Ways of Plants."

Preparing your Classroom for this Unit

To prepare your classroom for this unit it is recommended that you do the following:

Make a newsletter to send home with your students to tell their family members about your classroom activities. (See *A Garden Newsletter* below).

Provide a journal for each child to use with this unit or let the children make their own. Journals can be made easily by stapling together several sheets of lined paper with a construction paper cover. You may want to make the journals an interesting shape that relates to the garden/plant theme. (See *Flower Journal* below)

Flower Journal:

Cover and Interior Page(s) @Text:Flower Journal: Copy the cover and interior pages of the Flower Journal on 8.5x11" copy paper, enlarging by 23% to fill the entire sheet of paper. Instruct students to cut each sheet around the perimeter of the flower illustration. Assemble the cover and interior pages and bind with staples, yarn, etc. Use the reverse sides of the interior pages for illustrations that support journal writings.
(available in print form)

How to keep a journal is important. When doing a science project, such as growing plants from seeds, there should be dated entries that describe the procedures used (i.e., how many seeds were planted, how much water was added, where the pots were placed). The daily observations including descriptive information (the leaves wilted or the root pointed down) and quantitative information (the leaves measured 1 inch or the root was 1 inch long), as well as pictures or drawings of results and observations should be included in a science journal.

Gather books that relate to gardens/plants/photosynthesis to share with the children. Display the books conspicuously in the library area of yourclassroom. (See Annotated Bibliography).

Plants and What They Need:

Before diving into the scientific needs of specific plants, poll the class for their knowledge of general plant care. To enhance this knowledge, you should keep plants in your classroom beginning in September. This will insure a foundation of plant-keeping information for the students.

Reading About Plants:

To encourage further learning about the care of plants, read "The Amazing Beans." This story is appropriate for grades 1 through 3 and will be a good impetus for plant-care discussion. The book tells about two brothers who sow seeds and grow two plants in their home. One brother follows the directions for care found on the seed packet, while the other brother loses his seed packet and devises creative ways to 'feed' and care for his plant. The two brothers and the two plants cause mischief for the family.

Art Project:

The premise of the fictional story "The Amazing Beans" will whet the appetite of the class, encouraging them to plant, grow and care for their own seeds (See Lesson 1). Research in nonfiction books will begin the garden/photosynthesis project in the classroom. Creative writing will follow with a seed packet project allowing the students to invent their own seed/plant, listing appropriate care information on a seed packet.

Display commercially prepared seed packets and seeds of various plants and/or vegetables for all students to view during the reading of "The Amazing Beans." Utilizing the information found on each seed packet, set the guidelines for creating a student-made seed packet. Discuss and define terms found on the commercially prepared seed packets (i.e., germination, sowing, thinning). Determine what terms are common to most seed packets and encourage the use of those terms when creating the student-made packets.

Using the research information found in the nonfiction books and the information accumulated in the Flower Journal booklet, the students will select a seed or invent a seed to be packaged in their student-made seed packets. Distribute white art paper cut into rectangles approximately the size of a commercially prepared seed packet, markers and several commercially prepared seed packets. Encourage creating the packet's layout on scrap paper as well as the composition of the various categories containing written information. Once the layout and written information are complete, instruct the students to transfer that information to the white art paper rectangle. Discuss what an appealing seed packet looks like and the information it contains. Display the seed packets on popcicle sticks on a bulletin board that resembles a garden. As a follow-up art project, have the students 'plant' their seeds and display their growth on the bulletin board. Update the seed/plant growth as often as necessary, allowing the students to create a fully mature plant with flowers and/or vegetables! This follow-up will also attract the attention of other students/faculty in the school as they watch the growth of the fictional garden.

Classification of Seeds:

Seed classification on various levels from color and size to growth pattern and sun or shade tolerance will be incorporated into the mathematics curriculum. With the discussion and accumulation of information from the seed packet art project (above), the students should be aware of the many sizes, colors and shapes of plant/vegetable seeds. The characteristics of the seeds/plants will also be available to them from their research and completion of the seed packet art project. This information can be applied to the classification of seeds.

General categories taken from the seed packet information can encompass shade/sun tolerance, planting requirements, and the like. These categories do not require viewing the actual seeds. This aspect of seed classification should be the first or whole-class example, following the rules of classification according to the characteristic(s) listed. Chart paper and markers can be used for this whole-class exercise, however, actual seed packets glued to chart paper or stapled to a classification bulletin board may be more effective. Once this first classification exercise is complete and the students have a displayed example to follow, other categories involving the actual seeds can be defined by individual or small groups of students. The independent classification projects can also be displayed similarly to the whole class project, offering glued seed packets, seeds and maybe even plants as props to the displays.

Since planted seeds are ever-changing as they grow, classification exercises can continue on a multitude of levels. Simple classification using obvious characteristics will lend to more complex classification projects/discussions involving plant growth rates, watering rates, fertilization requirements, etc. These higher

order classification exercises will provide ample practice in the mathematical concept of classification/grouping and may assist the students in their success with the Connecticut Mastery Test.

The freedom necessary for the higher level classification exercises is the responsibility of the classroom teacher. If a student is interested in plant growth rates or plant characteristics in general, the classroom teacher must be prepared to offer space/time to the student(s) for planting their seeds of choice. Although a supervised, whole class planting project is planned for this unit, student interest in research and classification should be encouraged as appropriate.

Growing Seeds:

The class will read books like "Pumpkin, Pumpkin" and "Growing Vegetable Soup" before and during the period of actual seed planting. Art projects mimicking the illustrations in "Growing Vegetable Soup" will be completed and alternate vegetables will be described in book form following the story pattern in "Pumpkin, Pumpkin."

Growing seeds will be the next logical step in this garden/photosynthesis unit. The use of a Root Vue Farm for planting beans will allow the students to observe the growth above and below the soil. An alternative to this method is having the students plant their own seeds on a moist paper towel laid in a petri dish. To measure root and stem growth, copy a sheet of graph paper onto a piece of acetate or an overhead projector sheet. The students could then cut the clear plastic graph to the size of the dish and lay it behind the seed and moist paper towel for a more accurate record of root and stem growth. The clear plastic graph can also be made for the Root Vue Farm.

At least two different types of beans should be planted side by side: a bush bean and a pole bean. The comparison of the two (or more) varieties will continue throughout the germination and growth of the seeds. First leaves will be compared to true leaves. Information gathered earlier on plant nutrition will be reviewed and utilized. The students will observe similarities and differences among the bean varieties planted and will record their observations in their journals.

The nutrients housed in a seed will be the next researched topic. Seeds will be planted under two opposite conditions: seeds placed in a lighted area and seeds placed in a dark area or closet (Use the procedure for Lesson 2, replacing the two potted plants with potted seeds). This experiment will show that light is not needed for seeds to germinate. However, an experiment with plants under the same conditions will yield different results (See Lesson 2).

The story "Jack and the Beanstalk" will be read. The purpose of this story is to further discuss the differences in growth patterns of plants. Following the story, beans can be germinated under varied conditions such as lack of light, lack of water, indoors, outdoors, and with or without fertilizer. Plant growth in each of these conditions would then be compared to the plant growth of the same type of bean seeds in the Root Vue Farm or petri dishes. Environmental conditions would then become the topic of discussion. Predictions could then be made about the growth pattern of Jack's beans in the story "Jack and the Beanstalk." Creative journal writing will connect the beanstalk story to a real or fictitious plant described by the student. A reading beanstalk could be drawn and displayed, listing every book read during the garden/photosynthesis unit. Each leaf would represent one book. The beanstalk would continue to grow as more reading is completed.

Following the observation of root and stem growth for beans, the Root Vue Farm plants (or the petri dish plants) should be transplanted into regular pots or containers. The Root Vue Farm could then be reused for displaying the growth of others vegetables, such as carrots, radishes and onions. The roots of these

vegetables will then be compared to the roots of the bean plants.

A garden project could begin with an indoor greenhouse or an outdoor area for planting. The original bean plants could be transplanted once again to the indoor or outdoor garden. Plant needs would be re-discussed as the soil is prepared for the transplants. Compost, soil, water and light will all be related as the plants are moved. Plant environment and conditions would be revisited and earlier discussed concepts would be reinforced. A computerized garden design could be created using a simple drawing program like KidWorks2, KidPix, or HyperStudio.

The Ways of Plants:

Beginning the garden project and continuing the journal writings and observations, the inside functions of a plant can be discussed. Plant illustrations would begin this aspect of the garden/photosynthesis unit. Labeling the exterior parts of a plant and defining the purpose of each part will lead to a lesson of the workings of the plant's

interior. The flow of nutrients from a plant's roots to its body and leaves will be illustrated with the celery experiment. This experiment will help demonstrate that water is absorbed by plants and travels to all parts of the plant. (See Lesson 3 below). Photosynthesis will be in the spotlight during this section of the unit.

Below is a glossary of terms related to seeds, plants and photosynthesis.

anther: the male part of a flower which produces the pollen

carbon dioxide: a gas green plants use to make food; plants get this from the air

carpels: the female organ of a flower; they have three parts: 1) an ovary, holding one or more egg cells, 2) style and 3) stigma which is at the tip of the style and receives the pollen.

cells: one of the building blocks of which living things are made; plants consist of many cells; some may be specialized for particular jobs

chlorophyll: the green matter that is needed to make food for the plant

chloroplasts: the part of plant cells where photosynthesis occurs

cortex: in the root, it is the layer of cells between the center and the edge

dicot (dicotyledon): a flowering plant that has 2 cotyledons in the embryo; the bean seed is a dicot

dissemination: the act or process of scattering or the state of being scattered widely; the process of seeds traveling from one place to another

dormant: when a seed falls to the ground and may lie there "asleep"

embryo: the developing life of a new plant or animals, due to the combining of male and female reproductive cells; the part of a seed that develops into a new plant

endosperm: the part of monocot plants that store food

epidermis: the outer layer of cells on a plant; it protects the inside parts; it is like our skin

fats: found in cell membranes; also used to store energy

fertilize: to put manure or certain chemicals in the soil as food for the plants

germination: a seed begins to grow; the growth of a seed

gamete: the egg or the sperm in the flower

monocot: a plant that has only one cotyledon; the corn (monocotyledon) seed is a monocot

ovary: the female part of a flower which produces the eggs that are needed for making seeds

oxygen: a gas that has no color or smell; oxygen makes up one-fifth of the air; living things need oxygen to live and fires need it to burn; oxygen is a chemical element; green plants make this gas when they make food

petal: one of the parts of a flower that is arranged in a circle; they are the colored part of the flower

photosynthesis: the process by which green plants use carbondioxide, water and sunlight to make their own food; made up of two words: photo, which means light and synthesis, which means put together; a plant puts water and carbon dioxide together; it uses light and chlorophyll as helpers; when these things are put together they make sugar and oxygen

pistal: the female seed-producing part of a flower

pollen: the fine powder produced by the anther inside a flower that contains the male sperm cells

pollen tube: a tube that grows from a pollen grain on the stigma of a flower down through the style into the ovary

protein: a substance that is found in all living cells of animals and plants; it is necessary for growth and life

root hairs: they look like hair; they come out of the root like a branch; they absorb the water and food for the plant

seed coat: the outer covering of a seed

sepal: the outer green parts of the base of the flower; they protect the flower bud before it opens; inside the sepals are the colored petals

stamen: the male organ inside the petals; the part of the flower that produces pollen

starch: a white food substance (made of sugar) that is made and stored in most plants

stele: the center of the root; it holds the veins that carry water and sugar

stigma: the tip of the female part of the flower which receives the male pollen grains

stomata: tiny pores on the underside of the leaves (stomata is plural for stoma); carbon dioxide and oxygen enter and leave the plant through these tiny pores

vascular rays: cells in the root that carry water sideways

veins: tubes which take water to each and every cell of the plant; the veins help to strengthen and support the plant

xylem: veins that carry water and food to the plant

The following are illustrations that may aid in the implementation of this unit.

Illustration 1: The Parts of a Flower

(available in print formf)
Illustration 2: The Four Main Parts of a Flower
(available in print form)
Illustration 3: Photosynthesis (leaf)
(available in print form)
Illustration 4: Photosynthesis (plant)
(available in print form)
Illustration 5: Pollination
(available in print form)
Illustration 6: Germination
(available in print form)

Conclusion:

My photosynthesis curriculum unit will be used in my own classroom as I use all my other planned curriculum units. One month or more will be devoted to the study of photosynthesis. All classroom subjects (i.e.: Language Arts, Mathematics) will be integrated into the science subject matter. Full days will be spent discussing and actively participating in the topics of photosynthesis. A specific section of each day will be devoted to science experiments and activities. Concept awareness will be shared with the entire student body and encouraged future study will begin.

With hope, the science void will disappear as other students notice the new-found knowledge displayed by fourth grade students in their own school. Other teachers will become more interested in studying science topics with their own classes simply due to the enthusiasm shown by my grade four students.

The appropriate resources and curriculum will then be available and easily located. Primary (and possibly even secondary) teachers will no longer opt to avoid science subject matter; they will encourage its use and implement the activities found in the science unit(s) available to them. The science void will be filled, the neglect will disappear and all interested teachers will feel at ease teaching science in their classroom.

Lesson 1: Growing Plants

Experiment A: Plants Need Water

Materials:

two potted plants
masking tape
marker
water

Procedure:

1. Take two potted plants.
2. Use masking tape and a marker to label one potted plant 'watered regularly' and the other 'not watered regularly.'
3. Put them next to one another on a windowsill.
4. Water the plant labeled 'watered regularly' every three days. Water the plant labeled 'not watered regularly' very rarely and very little.
5. After several weeks, ask children to describe what happened. Then have children draw a conclusion. (Plants need to be watered regularly to grow well).

@2H(after1H):Lesson 2: Growing Plants

Experiment B: Plants Need Light

Materials:

two potted plants
masking tape
marker
water
closet

Procedure:

1. Take two potted plants.
2. With masking tape and a marker, label one plant 'in light' and the other 'no light.'
3. Put the plant labeled 'in light' in a sunny window.
4. Place the other plant in a closet.
5. Water them both regularly.
6. After two weeks, ask children to describe what happened and then come to a conclusion. (Plants need light to grow/plants need light to make chlorophyll).

Lesson 3: Where Does the Water Go?

Experiment C: Colored Celery

Materials:

tall, clear glass or jar
water
red food coloring
knife
celery stalk with leaves

Procedure:

1. Fill a tall, clear glass or jar half full with water.
2. Add a few drops of red food coloring and mix well.
3. Trim the bottom edge of a large stalk of celery. Leave the leaves on.
4. Put the celery stalk in the glass or jar. Leave overnight.
5. The next morning, observe what has happened. Let the children tell you where the water has gone.(The water has been absorbed into the celery stalk, tinting the stem and leaves red).
6. Ask: Does the whole plant get water for food? (Yes). Why does the color move to the leaves? (Water flows up the stem to replace water evaporated from the leaves).

Follow-up Activity:

Take a celery stalk that has leaves. Trim the bottom. With a knife, make aslit up the middle of the celery stalk,

stopping an inch below the leaves. Fill two tall, clear glasses or jars half-full with water. Add a few drops of food coloring to one glass or jar. Place several drops of a different food coloring in the second glass or jar. Mix the food coloring in each glass or jar well, and place the glasses next to each other. Put one half of the celery stalk in one glass or jar, and the other half of in the other glass or jar. Leave overnight. Observe what happens. (Each half of the celery stalk will have absorbed the colored water, and two colors will have blended together as they moved up inside the stalk).

Annotated Bibliography

Student Resources

de Bourgoing, Pascale and Gallimard Jeunesse. Vegetables in the Garden. New York: Scholastic, Incorporated, 1989.

This book shows root, bulb, vine and other types of vegetables. Plastic overlay pages show interior and exterior views of the vegetables. Ehlert, Lois. Growing Vegetable Soup. San Diego: Harcourt, 1991.

The illustrations lend to a simple and fun art project.

Kellogg, Steven. Jack and the Beanstalk. New York: Morrow/Avon, 1997.

This book tells the well-known tale of Jack and the magic beans. This story can be used to discuss growth patterns of plants.

Jeunesse, Gallimard and Pascale de Bourgoing. Fruit. New York: Scholastic, Incorporated, 1989.

This book shows different types of fruits and the ways they grow. Plastic overlay pages show interior and exterior views of the fruits.

Teacher Resources

Apple Early Learning. (CD-ROM) Apple Computers, (1993).

This computer software package is available in most K-1 classrooms in the city of New Haven. It contains games, word processing programs, drawing programs and other electronic resources used in this unit.

Bielitz, Joan and Marilyn LaPenta. MacMillan Early Skills Program: Nature and Science. New York: MacMillan Educational Company, 1984.

This resource is found in card form with each 8.5 x 11" card containing an experiment, game or classroom activity for a specific sub-topic. The activities are easily adapted to many grade levels, however they are intended for grades Pre-K through 2.

Strickland, Dorothy, ed. The Amazing Beans. New York: Harcourt Brace Jovanovich, 1993.

The Amazing Beans is a chapter book that compares two brothers through the care of their seeds/plants. The beans planted are cared for differently between the two brothers and strange events occur because of their care habits. Good for reading aloud to younger students or reading independently for older students.

Titherington, Jeanne. Pumpkin, Pumpkin. New York: Scholastic Incorporated, 1999.

This book tells a simple story in a form that can be easily read by young readers. The style of the book encourages similar creative writing by students.

Walker, David. Energy, Plants and Man. Brighton, England: Oxygraphics Limited, 1992.

This book is a textbook-style source of detailed information on photosynthesis. It contains in-depth descriptions of the chemistry of photosynthesis.