Plants

Grade Level: 5th Grade
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Length of Unit: Five weeks (four lessons)

I. ABSTRACT

This is a 5th grade unit on Plant Structures and Processes, part 1. These lessons will incorporate the topics outlined in the science strand of the *Core Knowledge Sequence* and content standards topics in scientific investigation covering the plant kingdom, vascular/nonvascular plants and photosynthesis. Students will develop strategies for learning and questioning that follow best science practices. The unit is comprised of four lessons that are designed to be taught in a five-week period. These lessons can be broken up throughout the week to fit your schedule.

II. OVERVIEW

A. Concept Objectives (Colorado State Standards: CSS)
   1. Understand the processes of scientific investigation (CSS Science 1).
   2. Understand the characteristics and structure of living things (CSS Science 3).
   3. Understand that science involves a particular way of knowing and understanding common connections among scientific disciplines (CSS Science 6).

B. Content from the *Core Knowledge Sequence*
   1. Plant Kingdom, page 126
   2. Nonvascular plants, page 127
   3. Vascular plants, page 127
   4. Photosynthesis, page 127

C. Skill Objectives
   1. Students will list three characteristics that all plants share.
   2. Students will list all the things plants need to live successfully.
   3. Students will understand why scientists believe all plants come from algae.
   4. Students will understand characteristics that nonvascular plants share.
   5. Students will describe structure of a moss plant.
   6. Students will understand characteristics that vascular plants share.
   7. Students will describe structure of a fern.
   8. Students will ask questions and state predictions that can be addressed through scientific investigation.
   9. Students will explore the process of photosynthesis.

III. BACKGROUND KNOWLEDGE

A. For Teachers
   1. "Introduction to Plants," Chapter 4, *From Bacteria to Plants (FBtP),* Teachers' Edition, Science Explorer Series, Prentice Hall, New Jersey, 2000, pages 108-137. This volume of a science textbook series is a perfect complement to the 5th Core Knowledge content and state standards for science. The teachers' edition provides ideas for many activities that reinforce inquiry and science process skills, quick and easy experiments, study skills and assessments. Highly Recommended. For a free preview copy call 1-800-848-9500.
   2. *Biology for Every Kid*, by Janice Van Cleave, provides numerous experiments with very accessible materials to demonstrate both the vascular system and photosynthesis.

3. *Photosynthesis*, by Alvin Silverstein, provides an in-depth yet easy to understand description of the process of photosynthesis. This book is very comprehensible for fifth grade students.

B. For Students
   1. Safe lab procedures (Appendix A)
   2. Knowledge of Science Process Skills (Appendix A) and Scientific Method (Appendix B) (or go to *Steps in Doing an Experimental Science Project* website)
   3. Background knowledge: life cycles and seasons (2nd grade), light (3rd grade), cells (5th grade)

IV. RESOURCES

A. "Introduction to Plants," Chapter 4, *From Bacteria to Plants (FBtP)*, Teachers' Edition, Science Explorer Series, Prentice Hall
B. *Plants*, by Tricia Ball
C. *Plants*, by Alvin Silverstein, et al.,
D. *Photosynthesis*, by Alvin Silverstein
E. *Life Science Homework Booklet*, by Daryl Vriesenga
F. *Top Secret*, by John R. Gardiner (A great read-aloud book for the elementary/middle school grades. Written at about a fourth grade level, the book tells the story of a boy who decides to solve the mystery of photosynthesis for a school science project. Students learn all about photosynthesis from the book.)
G. *Studying Plants*, Milliken Publishing Co.
H. *Plants* http://pittsford.monroe.edu/jefferson/calfreri/plants/plantsmain.html Short descriptions of plant parts and functions. Quizzes, links and activities on each.
I. *Steps in Doing an Experimental Science Project*, is a great web guide to the Scientific Method. http://www.isd77.k12.mn.us/resources/cf/SciProjInter.html

TEXT NOTE: While at the 5th grade level the Core Knowledge Science Sequence encourages hands-on learning experiences, book learning is also stressed. "While experience counts for much, book learning is also important, for it helps bring coherence and order to a child's scientific knowledge... a systematic approach to the exploration of science, one that combines experience with book learning, can help provide essential building blocks for deeper understanding at a later time." Get your class a text.

MATERIALS NOTE: Many teachers may not have the science equipment called for in these activities. Schools should attempt to acquire proper science equipment to provide real science experiences. However, in the meantime, feel free to adapt with materials that are accessible and affordable. Many local science companies offer free equipment and materials as a community service. Ask, they can only say no.

V. LESSONS

Lesson One: The Plant Kingdom

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Understand the characteristics and structure of living things.
   2. Lesson Content
      a. Plant Kingdom, page 126
      b. Nonvascular plants and vascular plants, page 127
   3. Skill Objective(s)
      a. Students will list three characteristics that all plants share.
      b. Students will list all the things plants need to live successfully.

B. *Materials*

Planting Seeds Activity

For each student (and several extras for those that don't sprout):

1. One container (small milk carton, paper cup, etc. Ideal would be the plastic partitioned sprouting containers that come with a holding tray and lid that can be found in gardening centers at Walmart or Kmart.)
2. Labels for containers
3. 3/4 cup potting soil
4. Plastic trays large enough to hold eight of the containers for watering and moving during experimentation
5. Sphagnum moss (enough to examine and put a little on top of container)
6. Three seeds, pea or bean (two to plant now and one to dissect in Lesson Three), you can buy a bag of different dry beans at the grocery store

Comparing Leaves Activity

For each pair of students:

7. Leaves from two plants that grow in two very different environments (e.g., jade plant (desert) and local deciduous tree; if winter, use fresh leaves in a bag (e.g., spinach) from grocery store)
8. Hand lens
9. OPTIONAL: microscope with samples of leaf cells
10. Science Notebook (Teacher should decide how they wish students to keep notes.)
    a. Appendices A-F; you may use these worksheets or create your own
    b. Binder paper and blank paper for notes and drawings
11. 6-12 collegiate dictionaries that have root etymology and definitions

C. *Key Vocabulary*

1. Cellulose: a chemical that makes the cell walls of plants rigid and strong
2. Cuticle: the waxy, waterproof layer used to retain moisture that covers the leaves and stems of some plants
3. Autotrophs: an organism that makes its own food
4. Photosynthesis: the process by which plants and some other organisms capture light energy and use it to make food from carbon dioxide and water
5. Chlorophyll: a green pigment found in the chloroplasts of plants as well as in algae and some bacteria
6. Adaptation: the ability to change in order to survive
7. Vascular tissue: the internal tissue in some plants that is made up of tubelike structures that carries water and nutrients throughout the plant
8. Nonvascular: a low-growing plant that lacks vascular tissue

D. *Procedures/Activities*

Two Weeks Before You Start Lesson One: Plant seeds (30 minutes)

1. Each student will need a plant to experiment on in future lessons. In order for the plant to be big enough, plant the seeds two weeks before you start Lesson One. (Alternatively, you can purchase seedlings for each student at a local market. Seasonal and budget restrictions should be considered.)
2. Review safe lab techniques and procedures with students. (Appendix A)
3. Germinate 2/3 of the seeds by placing them in water and out of direct light until a "hook" or root appears (2-3 days). Now the seeds are ready to plant into a container. (The remaining ungerminated seeds will be used in Lesson Three.)
4. Students should gently poke a couple of small holes (pencil) in the bottom of their containers to allow drainage. After labeling the container with their name, have students fill containers with ½ cup of potting soil.
5. Place two germinated seeds carefully on top and cover with ¼ - ½ inch more soil.

6. Sprinkle water over top of the soil until well saturated but not soggy and place on communal tray to catch drainage.
7. Cover each container (plastic wrap, close the milk carton, place lid tray, etc.) to retain moisture until you see green. If mold appears, place some sphagnum moss on top to absorb water from the surface.
8. Once seedlings appear, place in a well-lit place and continue to keep moist until you are ready to start your experiments (2-4 weeks).

Prepare science notebooks

9. Science notebooks will be used for the remainder of the unit. The notebook can be a pocket folder with prongs or 3 ring binders. Notebooks will hold handouts, binder paper, and blank paper for drawing. Pass out Science Notebooks to each student.
10. Hand out and briefly go over the outline of the Core Knowledge Content on Plant Structures and Processes (Appendix C). Ask students what they already know about any of this information. What do they remember from their 2nd grade unit on life cycles and seasons? Recall parts and functions of plant cells, e.g., chloroplast, chlorophyll, eukaryote.

Comparing Leaves Activity

11. Give pairs of students one of each leaf. (Students can break leaf apart.)
12. Using the hand lens, have them describe and record characteristics of the leaves in their Science Notebook (Appendix D). How are the leaves alike and how are they different? Infer what these characteristics are for. (15 minutes)
13. Optional: If you have a microscope, view a slice of each type of leaf.
14. Group discussion: What can students infer about the environment of these plants? (e.g., fat leaves store water – desert; broad leaves have more surface area to collect light and allow excess water to escape– northern climates). Brainstorm what characteristics students believe all plants share (autotrophs-photosynthesis, eukaryotes-specialized cells). Accept all answers and say you will be investigating these claims in this unit and the one on plant reproduction. (10 minutes)
15. Students should throw away all leaves and wash their hands after observation.
16. Introduce key vocabulary as students bring up characteristics and have them note definitions in their notebooks using "Science Word Roots" (Appendix E). Being able to decode a word using knowledge of its root etymology is very useful. Have pairs of students use a dictionary that has Greek and Latin roots to look up commonly used science roots. Tell students that the root is usually italicized with the letters *L* or *Gr* and in [brackets]. (15 minutes)
17. If you have a science text, have students read a general overview of characteristics all plants share, adaptations of plants to their environment, photosynthesis, reproduction. Plant Kingdom text, Ch.4.1 *FBtP* is excellent. See also Background Knowledge. Other sources for teacher background are cited in Resources. (15 minutes).

E. *Assessment/Evaluation*

1. Activities and discussion
2. In class or for homework have students respond: Consider the plants you had for lunch and dinner. They may look different after processing (wheat now looks like bread and tomatoes are a sauce). Pick three very different ones and describe them as they were before harvesting. Give three characteristics they all share. Give an adaptation for each one.

Lesson Two: Nonvascular Plants

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand the characteristics and structure of living things.
2. Lesson Content
   a. Plant Kingdom, page 126
   b. Nonvascular plants, page 127
3. Skill Objective(s)
   a. Students will understand why scientists believe all plants come from algae.
   b. Students will understand characteristics that nonvascular plants share.
   c. Students will describe structure of a moss plant.

B. *Materials*

1. Venn diagram to compare simple and complex plants (Appendix G)
2. Green algae samples or quart of drink found in grocery stores for students to taste (little paper cups)

Will Mosses Absorb Water?

For each group of four students (or can be done as a class activity):

3. 20 mL peat moss
4. 20 mL sand
5. Dropper
6. Water
7. Hand lens
8. Three plastic graduated cylinders (work best, but clear plastic cups could work with more sand and peat moss)

Masses of Mosses

For each student:

9. Small clump of peat moss
10. Hand lens
11. Toothpick
12. Water to moisten drying moss
13. Piece of white paper as work surface
14. Science Notebook to draw specimen

C. *Key Vocabulary*

1. Bog: a wetland where sphagnum moss grows on top of acidic water
2. Liverwort: liver-shaped bryophyte
3. Nonvascular: without the tissues necessary to get water from soil
4. Peat moss: compressed sphagnum moss found in bogs
5. Rhizoids: the thin rootlike structures that anchors a moss and absorbs water and nutrients
6. Spore: tiny cell that is able to grow into a new organism
7. Sporophyte: part of the plant that produces spores
8. Gametophyte: part of the plant the grows from spores

D. *Procedures/Activities*

1. Show students algae: pictures (website *Natural Perspectives* http://www.perspective.com/nature/plantae/), sides of a fishbowl, sample from a pet store, or green algae drink from grocery store. (They will love this, but it is a little pricey!)
2. Compare simple vs. complex plants. During the brainstorming in Lesson 1 #14 students may have stated that all plants produce seeds or make fruit. Tell them this is not a common characteristic between all plants. Only complex plants

produce embryos (seeds and fruit). Simple plants reproduce asexually and are found everywhere in nature. Often protists like algae, autotrophic bacteria and fungi are lumped into this category but recently fungi have been split off into its own kingdom. Algae are unique because they live in both freshwater and seawater, can live alone or in colonies, in moist soil or on animals. They are autotrophs using chlorophyll.

a. 400 million-year-old fossils show that early plants resembled small algae. Scientists have found that plants and algae contain the same kind of chlorophyll used in photosynthesis. For these reasons biologists infer that ancient green algae were the ancestors to today's plants.
b. Simple plants are nonvascular, they do not have the tissues necessary to get water from soil and so they grow close to the ground in moist environments. They grow close together in mats or clumps. Simple plants grow to maturity quickly and are not as specialized as complex plants.

3. Hand out Venn Diagram (Appendix G) or have them draw one for their Science Notebook. Discuss characteristics that are alike and those that are different.

Will Mosses Absorb Water? (taken from *FBtP* page 125)

4. In groups or as a whole class activity, prepare the graduated cylinders so that one has 20 mL of sand, the second 20 mL of peat moss, and the third 20 mL of water.
5. Ask students to predict what will happen when we pour 10 mL of water into each of the two cylinders and wait. (This would be a great opportunity to teach writing up an experiment in their Science Notebook, but it depends on the time you have to spare.)
6. Perform the experiment by slowly adding water with a dropper (allows the moss to absorb).
7. Have students record their observations.
8. Discuss results and conclusion. What characteristics does moss have? (Peat moss absorbs much more water than sand.) Tell students that gardeners mix peat moss in with poor soil to loosen the soil and help it hold moisture a long time after it is watered.
9. If you have a science text, have students read about mosses. Plant Kingdom text, Ch.4.3 *FBtP* is excellent. See also Background Knowledge. Other sources for teacher background are cited in Resources. (15 minutes). Like fungi and algae, bryophytes (mosses and liverworts) do not have vascular tissue for transporting food, water, and minerals. They do not have true roots, stems and leaves because these plant parts do not have tubes for moving nutrients. They need to live in moist, shady environments because their biggest problem is getting and keeping water. They use rhizoids to anchor the plant in the soil and absorb moisture and nutrients. Their little leaf like parts are thin and small. Since these structures do not have tubes, water and nutrients must slowly seep from one cell to the next.

Masses of Mosses (taken from *FBtP* page 129)

10. Hand each student a small clump of peat moss. They should examine it with a hand lens on a background of white paper.
11. Using toothpicks, gently separate individual moss plants from the clump. If they dry up, moisten them with a drop of water.
12. In their notebook have students make a life-size drawing of a moss plant. Label the parts, give their sizes and record the color of each part. If you find a moss with stalks and capsules, use toothpicks to release some of the spores that can be as small as dust particles. (Many of the resources have great diagrams of a moss plant to help students identify the parts.)

a. Ask students to notice the capsule at the tip of each stalk of moss (sporophyte). New mosses will be grown from the spores encased in this capsule. Once the spore is released and begins to grow, it produces a long runner or protonema. From this the rhizoids, stemlike and leaf like structures grow (gametophyte). A more complete description of the reproduction of spore bearing plants can be found in part 2 of this unit, Plant Reproduction.

13. Optional: Examine spores under microscope.

E. *Assessment/Evaluation*

1. Analysis: Have students write a paragraph that describes the typical size of the leaf like portion, the typical height of the stemlike portion, the typical length of the rootlike portion of their mosses. In which part does photosynthesis occur? How do you know? Why are mosses unable to grow tall?

Lesson Three: Vascular Plants

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand the characteristics and structure of living things.
   b. Understand the processes of scientific investigation.
2. Lesson Content
   a. Vascular plants, page 127
3. Skill Objective(s)
   a. Students will understand characteristics that vascular plants share.
   b. Students will describe structure of a fern.
   c. Students will ask questions and state predictions that can be addressed through scientific investigation.

B. *Materials*

1. Potted fern
2. Design an Experiment worksheet (Appendix H)
3. Science Notebooks

Capillary Action Activity

<u>For each pair of students</u>:

4. Plastic petri dish
5. Narrow glass tube that is open on both ends (fragile, treat carefully)
6. Water
7. Food coloring
8. Goggles

Examining a Fern Activity

<u>For each student</u>:

9. Fern leaf
10. Hand lens
11. Dropper and water
12. Assortment of plants to examine and compare: fern, horsetail, liverwort, hornwort, clubmoss

Root, Stem or Leaf? Activity

<u>Whole class or group</u>:

13. Assortment of vegetables: celery, broccoli, potato, onion, carrots, parsnips, cabbage, lettuce, parsley; no fruits as they are seed/flower parts

Xylem or Phloem? Activity

<u>Whole class</u>

14. Large tree leaf (or one from nursery if out of season)

15. Scissors
16. Food coloring, blue
17. Large test tube, or small narrow vase
18. Water

Seeds Activity

19. Seeds remaining from Lesson One soaked overnight
20. Six clear plastic cups, black construction paper cut to line cups, and paper towels
21. Samples of plants with fibrous root (most potted flower plants) and tap root (carrot, garden weed)

Examining a Leave Activity

For each student:

22. Large leaf
23. Hand lens
24. Explicit diagram of a leaf's structure to compare to real leaf (science text; *Life Science Homework Booklet*, or other source)

C. *Key Vocabulary*

1. Vascular tissue: tubelike structures that allows transport of water and nutrients throughout a plant
2. Roots: hairlike structure that provides an anchor while absorbing water and nutrients from the soil to maintain the plant
3. Xylem: the vascular tissue through which water and nutrients move upwards from the roots to the stem and leaves
4. Phloem: the vascular tissue through which food made by photosynthesis moves downwards from the leaves to the stem and roots
5. Stomata: small openings on the underside of most leaves through which carbon dioxide enters and oxygen and water vapor move out; *stoma* means mouth
6. Fronds: the leaf portion of a fern
7. Capillary action: the phenomenon of a liquid spontaneously seeping up thin tubes due to adhesive and cohesive forces and surface tension

D. *Procedures/Activities*

1. Prior Knowledge. Ask students to draw and label in their Science Notebook a plant that includes leaves, stems and roots. Use a potted plant (a fern, for example) to point out these parts afterwards. Ask them to explain how these parts function in a plant. How does the plant get water and food?

Capillary Action Activity (taken from *FBtP* page 130)

2. Pass out petri dishes to each pair of students and fill half full of water. Add drop of food coloring. (You may want to color water before passing out to students.)
3. Pass out goggles and glass tubes to each student.
4. Students should stand tube on end in water and hold upright. Caution them that these tubes are very fragile.
5. Students should observe what happens and record observations in their Science Notebook.
6. Ideas to think about: What would happen if you stopped the top hole with your finger before putting the tube in the water? What if the tube had a kink in it? (Don't kink the tube, it will break!)
7. Pass out Design an Experiment handout (Appendix H) and model on the board or overhead as you take your students through the steps of writing up the Capillary Action experiment. Encourage students to be specific and write sentences that would allow another person to duplicate the experiment exactly. What is the advantage for the transporting cells of plants to be arranged in a tubelike way?

8. If you have a science text, have students read about ferns and seedless vascular plants. Plant Kingdom text, Ch.4.4 *FBtP* is excellent. See also Background Knowledge. Other sources for teacher background are cited in Resources. (15 minutes).
    a. Importantly, vascular tissue provides support and transport for the plant. A plant needs support to allow tubes to remain straight to enhance the capillary action of water and nutrients throughout the plant. It also provides access to the sun for photosynthesis, and gives greater a opportunity for successful reproduction. Capillary action is when water wicks, or spontaneously seeps up thin tubes, due to adhesive (water molecules are "sticky" and are attracted to other water molecules) and cohesive forces and surface tension (water wants to stay together).

Examining a Fern Activity (taken from *FBtP* page 132)

9. Give each student a fern leaf to examine. Draw a diagram and label the structures in their notebook.
10. Using a hand lens, look at the top and lower surfaces of the leaf. Feel the leaf with your finger. Does your frond have spores? Add to your diagram.
11. Seedless vascular plants have vascular tissue and use spores to reproduce. They grow taller than nonvascular plants but they need to live in moist places. Their reproductive cycle includes the sporophyte stage and the gametophyte stage. Ferns have true stems, roots and leaves. Their stems are underground while their leaves, called fronds, grow above. Roots grow from the stem to anchor the plant and absorb water and nutrients. Developing leaves of a fern are called fiddleheads. (Why do you suppose?) As they mature, the fiddleheads uncurl.
12. If you were able to gather samples of ferns, horsetails, clubmosses, etc. have students examine and create a table to compare these plants. Category ideas could be: vascular, moist environment, spores.

Root, Stem or Leaf? Activity (taken from *FBtP* page 140) (10 minutes)

13. Tell students: Not all food we eat is fruit. Give me examples of roots, stems or leaves that we eat daily.
14. Pass around vegetables and ask students to decide whether these are roots, stems or leaves. (Potatoes and onions are underground stems, Broccoli-stem; carrots and parsnips – roots; lettuce and cabbage – leaves; and celery is not a true stem but a leaf stalk.)

Xylem or Phloem Activity (taken from *FBtP* page 141) (15 minutes)

15. Carefully cut the end of the stem of the leaf. Fill a large test tube with water and add 15 drops of blue food coloring. Put the stem in the water.
16. Observe the stem/leaf over three days looking for movement of the dye through the leaf. Replenish colored water in the test tube as needed. Is the dye moving through the xylem or the phloem? (Through the xylem with the water.)
17. Two types of vascular tissue occur in plants. Phloem allows food produced by photosynthesis in the leaves to travel <u>down</u> to the stem and roots. Xylem allows water and nutrients to flow the other way – <u>up</u> from the roots to the stem and leaves. (Mnemonic: **Ph**otosynthesized **f**ood **f**lows through **ph**loem) Have students create a flow chart in their Science Notebook demonstrating the direction of these two vascular systems.

leaf → stem → root	root → stem → leaf
Phloem	Xylem

Seeds Activity (20 minutes)

18. Soak overnight all the remaining pea and bean seeds leftover from Lesson One. Pass <u>one seed</u> out to <u>each pair of students</u> to examine with a hand lens. Before

they touch the seeds, ask each pair to discuss what they think the inside of the seed looks like.

19. Student pairs should notice that the seed has two sections. After separating sections, students should see the tiny leaves and roots of the embryo plant. Seeds are the ovule of the plant that has been fertilized by pollen that can grow into a new plant. A more complete description of seed fertilization can be found in part two of this unit, Plant Reproduction.
20. Have the students draw and label these seeds including: seed coat, embryo, cotyledon, stored food.
21. Have students plant the remaining, undissected, seeds in a clear plastic cup, lined with black construction paper cut to fit and stuffed with paper towels to hold the lining in place and absorb water. The seeds should be wedged between the black paper and the top edge of the cup so that students will be able to observe the roots and two seed leaves (cotyledons) emerge over the next few days. Keep paper toweling moist, not soggy, as there is no drainage. Four to six seeds can be positioned in each cup.
22. If you have a science text, have students read about plant parts and their functions. Plant Kingdom text, Ch.5.1 *FBtP* is excellent. See also Background Knowledge. Other sources for teacher background are cited in Resources. (15 minutes).

Root Activity (10 minutes)

23. Class discussion. Have you ever weeded your garden or repotted a plant? Are some plants harder to remove than others? What kind and why? What is the function of roots? (anchor, absorb water and nutrients.) There are two types of roots, tap roots and fibrous, or diffuse, roots. *Show example of each to class*. Tap roots have a thick long main root that grows deep in the soil. Trees, carrots, dandelions. Fibrous roots have several main roots that repeatedly branch. When you pull them out they take soil with them. Grasses, corn, geraniums have fibrous roots. Root systems can be far larger the above ground parts of the plant. They tend to grow in length rather than width. The roots contain a cap at their end that is replaced periodically as the root grows through the soil.
24. Have students draw both tap roots and the fibrous, or diffuse, roots.

Examining a Leaf Activity (taken from *FBtP* page 145) (15 minutes)

25. Give each student a large leaf and a hand lens. Let them examine it without instruction for a minute.
26. Pass out a diagram, or have one on the overhead of the structure of a leaf. A good copy is on page 145 of *FBtP* or *Life Science Homework Booklet*, IF. Many other resources will have it also. Ask students to try to find the structures in their real leaf (external: cuticle, veins, stomata; internal: cells, chloroplasts).
27. Optional: Examine leaf under a microscope. Prepared slides from a biological supply house showing leaf tissues would be ideal.
28. Leaves come in all shapes and sizes but their role is the same – photosynthesis – turning the sun's energy into food. Although they appear thin, there are many layers in a leaf. The top and bottom layers are protective layers. They sandwich the chloroplasts and veins that contain the xylem and phloem. On the top layer is a waxy waterproof cuticle that prevents water loss. Why do you suppose the underside of the leaf does not have a cuticle layer? (clog stomata). On the bottom layer are stomata (stoma, singular), tiny pores that allow CO_2 to enter and H_2O and O_2 to exit.
29. **Extensions:** Other well-known experiments that demonstrate vascular tissue can be found in many of the resources mentioned. These can be done as whole class

or small group activities and may better fit your circumstances than the activities I have given here. Some examples are:

a. Cross sections of celery left standing in colored water can show arrangement of tubes as a supporting structure, tubes can also be stripped out of the celery stalk. Have a celery race, whose celery can transport the most colored water in two hours.
b. Carnations will show color at the tips of their petals proving that the colored water traveled up through the vascular system. Split the stem and dip each part into different colored water. The bloom will display both colors.
c. Examine the rings of cross sections of a tree to identify the xylem, phloem and other parts of the vascular system. Syrup is the food sap flowing through the phloem.

E. *Assessment/Evaluation*

1. Notebook activities: Ask students to choose a structure found in a leaf and explain the function of that structure. Students should be able to identify parts of growing beans.

Lesson Four: Photosynthesis

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand the characteristics and structure of living things.
   b. Understand the processes of scientific investigation.
   c. Understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
2. Lesson Content
   a. Photosynthesis is an important life process that occurs in plant cells, but not animal cells, page 127
   b. Role in photosynthesis of: energy from sunlight; chlorophyll; carbon dioxide and water; xylem and phloem; stomata; oxygen; sugar (glucose), page 127
3. Skill Objective(s)
   a. Students will explore the process of photosynthesis.
   b. Students will ask questions and state predictions that can be addressed through scientific investigation.

B. *Materials*

What Do Plants Need?

1. Science Notebook
2. Design an Experiment handout (Appendix H)
3. Plants grown from seed or purchased seedlings for each student
4. Labels for plant containers
5. Four trays that will hold up to eight plant containers during experiments
6. Reading selection, "Photosynthesis," Chapter 4.2, *FBtP* or other source
7. Scientific Method (Appendix B)

Eye on Photosynthesis (taken from *FBtP* page 118)

8. Elodea plants (or other water plants from a tropical fish supply store)
9. Wide-mouthed container
10. Sodium bicarbonate solution (0.5 g of sodium bicarbonae for each 100 mL of water)
11. Two test tubes or clear plastic vials labeled 1 and 2
12. 500 mL water that has been boiled to release gases, then cooled

Assessment

For each student

13. 12" x 18" white construction paper
14. 9" x 12" construction paper (three colors e.g., green, yellow, orange)
15. Glue stick
16. Scissors

B. *Key Vocabulary*

1. Photosynthesis: *photo* = light, *synthesis* = to put together; the process of using the sun's energy to create food, oxygen and water out of carbon dioxide
2. Pigment: a chemical that produces color
3. Chlorophyll: a green pigment which gives leaves their color; chlorophyll absorbs energy from sunlight
4. Chloroplast: a plastid that contains chlorophyll and is where photosynthesis occurs
5. Light spectrum: colors of the rainbow which appear when light passes through a prism

C. *Procedures/Activities*

What Do Plants Need? Designing Experiments

1. Say to students: *Have you noticed our little seedlings are growing. What do you think caused those plants to grow?* Write down all their ideas on the board. Common ideas will be sunlight, soil, water, fertilizer, air.
2. Ask students*: Are these facts, theories or hypotheses? Do you know the difference?* Discuss the difference and have students define them in their Science Notebook.
    a. **What is the difference between a fact, a theory and a hypothesis**? In popular usage, a theory is just a vague and fuzzy sort of fact and a hypothesis is often used as a fancy synonym to 'guess.' But to a scientist a theory is a conceptual framework that explains existing observations and predicts new ones. For instance, suppose you see the sun rise. This is an existing observation that is explained by the theory of gravity proposed by Newton. This theory, in addition to explaining why we see the sun move across the sky, also explains many other phenomena such as the path followed by the sun as it moves (as seen from Earth) across the sky, the phases of the Moon, the phases of Venus, and the tides, just to mention a few. You can today make a calculation and predict the position of the sun, the phases of the Moon and Venus, the hour of maximal tide, all 200 years from now. The same theory is used to guide spacecraft all over the Solar System.
    b. A hypothesis is a working assumption. Typically, a scientist devises a hypothesis and then sees if it "holds water" by testing it against available data (obtained from previous experiments and observations). If the hypothesis does hold water, the scientist declares it to be a theory. -Jose Wudka.
3. Tell students that they will turn their ideas on the board into hypotheses and then design experiments to test them. Have students pick two different ideas from the board and write them as hypotheses. Share some of the hypotheses, redirecting where needed. **[Ultimately the class will be using these seedlings to perform different experiments testing what plants need or how they behave. As students begin to design their experiments, it would be most effective if no more than four students perform the same experiment. This way everyone will benefit from the knowledge gained from the various hypotheses.]**

4. Tell students: When you think you know what variables may be involved, think about ways to change only one at a time. If you change more than one at a time, you will not know what variable is causing your observation. Sometimes variables are linked and work together to cause something. At first, try to choose variables that you think act independently of each other. A hypothesis is a question which has been reworded into a form that can be tested by an experiment. e.g., The hypothesis "My dog barks every time a stranger throws a newspaper at the door at 5 am" is not very good. There are three variables here: stranger, paper thrown at door, and early morning hour. Might the dog be barking because it is a stranger? Or might it bark because a newspaper hit the door? If a stranger threw the paper at the door at noon, would the dog still bark? There are too many variables to know why the dog barks. How could we test for one variable?
5. Design an experiment to test each hypothesis. Make a step-by-step list of what you will do to answer each question. This list is called an experimental procedure. For an experiment to give answers you can trust, it must have a "control." A control is an additional experimental trial or run. It is a separate experiment, done exactly like the others. The only difference is that no experimental variables are changed. A control is a neutral "reference point" for comparison that allows you to see what changing a variable does by comparing it to not changing anything.
    a. Dependable controls are sometimes very hard to develop. They can be the hardest part of a project. Without a control you cannot be sure that changing the variable causes your observations. A series of experiments that includes a control is called a "controlled experiment." What would be the control for our barking dog? (Observe if the dog barks at 5 am when no stranger appears and no paper hits the door?)
    b. Experiments are often done many times to guarantee that what you observe is reproducible, or to obtain an average result. Reproducibility is a crucial requirement. Without it you cannot trust your results. Reproducible experiments reduce the chance that you have made an experimental error, or observed a random effect (coincidence) during one particular experimental run.
6. Have students write up their experiments in their Science Notebook or on copies of APPENDIX H. They should circle the variable. They should also include their idea for the control. Mention that students should design simple, plausible experiments that can be performed within the constraints of their classroom and materials available.

    If you have time constraints, consider assigning students variables to test. For example, assign four students to test for water, four to test for light, four to test for soil, four to test for phototropism, etc. They can work as a team designing their experiment and control. The fact that all of a group's plants will be placed in the same testing situation will strengthen the results.
7. Have students switch experiments with another and peer evaluate. Ask students to look for one variable and a control.
8. The teacher should review experiments and group like procedures together. For example, students who want to test for whether light is important should all place their seedlings on the same tray to go in the dark.
9. Before the experiment begins, have students draw a "before" picture of their plant on the top half of the back of their Design an Experiment handout. Students should label their plant with the variable for which they are testing.

10. Each day students should have time to tend to their plant denying them only the variable. Extra plants can serve as controls.
11. After one week students should compare their plant to the control, others in their group and to those in other groups. Have students draw the "after" picture below their "before" picture. Have them record observations.
12. Ask your students: What were your results? How will you collect data? Will you measure the height or weigh your plant? Note the color and health, number of leaves? What are your conclusions? Have them fill out the rest of their experiment worksheet.

Eye on Photosynthesis Activity (taken from *FBtP* page 118)

This activity should take place during **What Plants Need** experiments are in progress.

13. Prior Knowledge. Have students recall anything they know about photosynthesis. Also recall study on light done in third grade. You may need to reteach about the nature of light: light travels in a straight line unless it is reflected off an object, refracted as it passes through a transparent or translucent object or absorbed into an object. Visible light is made up of many colors as seen in the light spectrum. Ultraviolet, x-ray, microwave and gamma rays are examples of light that we cannot see but still affect us. The light that is reflected is the color we see and it is not absorbed. Therefore green leaves reflect, and do not use, light with a green wavelength. Because light is a form of energy (microwaves can cook food), a substance that absorbs light absorbs energy. Once light strikes a leaf, the power is turned on.
14. Tell students: I am going to perform an experiment but you are going to tell me what I am testing for.
15. I fill the large container ¾ full with sodium bicarbonate solution, which provides a source of carbon dioxide.
16. Then I fill test tube #1 to the top, place my thumb over the mouth of it. I turn the test tube over and lower the tube to the bottom of the container. Notice that I do not let in any air. (If necessary, repeat this step so that test tube 1 contains no air pockets.)
17. Now I fill test tube #2 to the top, but this time I place an Elodea plant in the tube with the cut stem at the bottom. I will place tube #2 the same way next to tube #1. Any ideas?
18. Let's place this container in bright light and look at it in a couple of minutes. (After a few minutes, examine both test tubes for bubbles.) Why are there bubbles in #2 but not in #1? What do you think is happening? (If bubbles form in test tube #2, observe the Elodea stem to see if it is producing the bubbles. The bubbles are oxygen bubbles. The production of oxygen signals that photosynthesis is taking place. Check back in thirty minutes and see what happens to any bubbles that form.)
19. Tell me about my experiment. What is my variable? (Elodea plant.) What is my control? (Tube without Elodea plant.) What was my question? (Do Elodea plants produce oxygen?) What could be my hypothesis? (Accept possible answers) Say: My hypothesis was really "Elodea plants will produce oxygen when carbon dioxide, water and light is present." Is this a good hypothesis? Why or why not? Could it have been just the CO_2 or the water or the light that allowed oxygen to be produced? Are we even sure that the bubbles were oxygen? (No, not really. We would have to test it. But theory says plants give off oxygen.)
20. I would like you to design an experiment to now test whether carbon dioxide is needed for photosynthesis. Talk to your neighbor for a minute to see if you can

come up with a way to do this. (Give one minute or so and then share a few ideas.)

21. Pass out Design an Experiment worksheet (Appendix H.) Say: I will give you water that has been boiled and then cooled. Boiling drives off gases that are dissolved in the water, including carbon dioxide. Based on what you learned from my experiment, design an experiment to show whether or not CO_2 is needed for photosynthesis. Fill in all the sections up through Observations. Walk around the room and review students' experiments.
22. Ask two students to come up and perform the experiment using the boiled, cooled water. Ideally every pair of students should perform their experiment but time and materials may prevent this in your class.
23. While you are waiting for the experiment to be completed, ask student to brainstorm a list of any other factors that they think may affect photosynthesis. (light, size of plant, number of leaves, bacteria or disease on plant, age of plant)
24. Have students observe the CO_2 experiment and write down their observations and conclusions.
25. HOMEWORK: Students should now choose one of their factors and design another experiment to show how the factor affects photosynthesis. What will your variable be? What will your control be?
26. If you have a science text, have students read about photosynthesis. Plant Kingdom text, Ch.5.2 *FBtP* is excellent. See also Background Knowledge. Other sources for teacher background are cited in Resources. (15 minutes).
    a. Carbon dioxide enters the leaf through open stomata. Water, which is absorbed by the plant's roots, travels up the stem to the leave through the xylem. During photosynthesis, chlorophyll absorbs light energy and produces sugar and oxygen from the carbon dioxide and water. Oxygen passes out of the leaf through the open stomata. The sugar enters the phloem and then travels through out the plant. Have students write this equation in their Science Notebook:
27. carbon dioxide + water → light energy → sugar + oxygen

$$CO_2 + H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + O_6$$

D. *Assessment/Evaluation*

1. **Photosynthesis Poster**: Students create a poster representing chemical process of photosynthesis by cutting out colored squares that represent carbon (say, orange marked with a C), hydrogen (yellow marked with an H) and oxygen (green marked with an O). Fold a 12" x 18" piece of construction paper in half "like a hamburger." On the left half have students write the formula for six molecules of water plus six molecules of carbon dioxide, $6\ H_2O + 6\ CO_2$, on the top or bottom margin. These are resources that a plant uses to photosynthesize.
2. Ask students how many squares of hydrogen will they need to represent this formula? (12). How many oxygen? (18). How many carbon? (6). Using these numbers have students glue the squares to show six water molecules and six carbon dioxide molecules. For example, they should place two yellow H squares next to a green oxygen square in a triangle and connect them with lines.
3. On the right side of the 12" x 18" construction paper have students write the result of photosynthesis, $C_6H_{12}O_6 + O_6$, on the same margin. How many squares will they need? (Exactly the same as on the left hand side!) Have them cut and paste these molecules on the right hand side. (They should have one large molecule of sugar and six molecules of oxygen, O_2.) Pretty neat!

4. Finally, what powered this change? The SUN! Students should draw an arrow from the formula on the left hand side to the formula on the right hand side and write the word Sun Energy or Sun Light above the arrow to show the interaction.
5. Give the Poster a title. Draw some appropriate pictures or labels and voila.
6. An alternative or additional assessment would be the write-up of each student's seedling experiment.

VI. CULMINATING ACTIVITY

A. Circuit Folder Game: Adapted from *#232 TCM - Inventions*. Students will create a question game for others in their class to play. Questions should reflect understanding of concepts and knowledge. (The electrical circuit format reinforces the 4th grade's concepts! Cool!)

1. **Materials per student**:
   a. One 10" x 12" sheet of aluminum foil or 5' insulated wire
   b. One 9" x 12" file folder (no pockets)
   c. Masking tape
   d. 50 brads 1/4"
   e. Scissors
   f. Markers
   g. AA battery
   h. Electrical tape
   i. Section of holiday lights w/bulb

B. **Directions**: Assemble the bulb, battery and brads.

1. Cut holiday lights so that there is about 6" of wire attached to the bulb on either side.
2. Carefully cut away 1/2" of the insulation from each end without cutting the wire.
3. Using electrical tape, attach one end of the wire to the flat end of the AA battery. Securely wrap halfway up the battery so that the wire will not come loose.
4. Wrap the bare wire of the other end between the prongs of a brad. Secure with electrical tape, leaving the head of the brad exposed.
5. Test the circuit by touching the brad to the positive end of the battery. The bulb should light. If not, recheck connections or replace the bulb.

C. **Create the board game**.

1. Have students research 10 facts about Plants or Photosynthesis. Students can use their notebook to come up with ideas, or challenge them to come up with extensions. Questions should not be impossible or too easy. Each question should have three plausible answers including the correct one.
2. On the folder front, students should write the question and the three possible answers leaving enough room for a brad to be positioned before each one.
3. On the back side of the folder place a strip of aluminum foil connecting the prongs of the question brad to the prongs of the correct answer brad. The foil will then need a strip of masking tape covering it to prevent tearing or connecting with other foil. Instead of foil, thin insulated wire can be stripped and wound around the prongs of the question brad and the correct answer brad. This does not need to be masked.
4. Students should write neatly and make their folder attractive. They may use the computer to print out their questions and answers, or to research questions. The teacher should set expectations for quality of work before students begin.
5. Students need to trouble shoot their folder, making sure answers are correct and the wiring works before trading with another student.

VII. HANDOUTS/WORKSHEETS

A. Appendix A: Safe Lab Procedures; Scientific Process Skills
B. Appendix B: Scientific Method
C. Appendix C: Core Knowledge 5th grade sequence: Plant Structures and Processes
D. Appendix D: Comparing Leaves
E. Appendix E: Word Root Activity
F. Appendix F: Plant Kingdom Outline Activity
G. Appendix G: Simple Plants vs. Complex Plants Venn Diagram
H. Appendix H: Design an Experiment Worksheet
I. Appendix I: Some Guidelines for Experimental Procedures

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O. *Plants* http://pittsford.monroe.edu/jefferson/calfreri/plants/plantsmain.html Short descriptions of plant parts and functions. Quizzes, links and activities on each.
P. *Plants and Our Environment* http://tqjunior.thinkquest.org/3715/ Created by Hinkle Creek Elementary School. Fun web page, worth a look.
Q. *Natural Perspective*, http://www.perspective.com/nature/plantae/ Great pictures of different kinds of plants, algae, mosses, liverworts, ferns, etc.
R. *GardenWeb Glossary of Botanical Terms* currently contains 4400 terms relating to botany, gardening, horticulture and landscape architecture and is regularly updated. http://glossary.gardenweb.com/glossary/

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APPENDIX A-PLANTS

SAFE LAB PROCEDURES

1. Wait until all directions have been given before you begin science activities.
2. Never put anything in your mouth or near your eyes unless it is required by the experience.
3. Wear safety goggles.
4. Have respect for the lab equipment and use only as intended.
5. Dispose of waste and recyclables in proper containers.
6. Follow classroom rules of behavior at all times.
7. Wash your hands with soap after handling chemicals or organisms.

SCIENTIFIC PROCESS SKILLS

Even the youngest students blossom in their ability to make sense out of their world and succeed in scientific investigations when they learn and use the inquiry process skills. These are the tools that help children think and act like professional scientists. The first five process skills on the list below are the ones that should be emphasized with young children, but all of the skills will be utilized by anyone who is involved in scientific study. Every science text has their version of these skills. Adapted from *Plants*, TCM #629, 1994.

Observing: It is through the process of observation that all information is acquired. That makes this skill the most fundamental of all the process skills.

Communication: Humans have developed the ability to use language and symbols which allow them to communicate not only in the "here and now" but also over time and space as well. The accumulation of knowledge in science, as in other fields, is due to this process skill.

Comparing: Once observation skills are heightened, students should begin to notice the relationships between things that they are observing. Comparing means noticing similarities and differences..

Ordering: Other relationships that students should be encouraged to observe are the linear patterns of seriation (order along a continuum: e.g., rough to smooth, large to small, bright to dim, few to many) and sequence drawings, and by putting many objects in order by a variety of properties.

Categorizing: When students group or classify objects or events according to logical rationale, they are using the process skill of categorizing.

Relating: Relating, which is one of the higher-level process skills, requires student scientists to notice how objects and phenomena interact with one another and the change caused by these interactions. An obvious example of this is the study of chemical reactions.

Inferring: Not all phenomena are directly observable, because they are out of humankind's reach in terms of time, scale, and space. Some scientific knowledge must be logically inferred based on the data that is available. Much of the work of paleontologists, astronomers, and those studying the structure of matter is done by inference.

Applying: Even very young, budding scientists should begin to understand that people have used scientific knowledge in practical ways to change and improve the way we live. It is at this application level that science becomes meaningful for many students.

APPENDIX B-PLANTS

The Scientific Method

1. Make an **OBSERVATION.**
2. Select a **QUESTION** to investigate.
3. Make a **PREDICTION** (Hypothesis).
4. Develop a **PROCEDURE** to test the hypothesis.
5. Record the **RESULTS** of the investigation in written and picture form.
6. State a **CONCLUSION** that tells what the results of the investigation mean.
7. Record **QUESTIONS**, **OBSERVATIONS**, and **SUGGESTIONS** for future investigations.

The Scientific Method can be found in most science texts and experiment books. For one detailed explanation, look in *Plants*, TCM #629, 1994, pp. 5-6.

APPENDIX C-PLANTS

Ill. Plant Structures and Processes (taken from Core Knowledge 5th grade Science Sequence)

A. STRUCTURE: NON-VASCULAR AND VASCULAR PLANTS

- Non vascular plants (e.g., algae)
- Vascular plants
  - Vascular plants have tubelike structures that allow water and dissolved nutrients to move through the plant
  - Parts and functions of vascular plants: roots, stems and buds, leaves

B. PHOTOSYNTHESIS

- Photosynthesis is an important life process that occurs in plant cells, but not animal cells (*photo* = light, *synthesis* = putting together). Unlike animals, plants make their own food through the process of photosynthesis.
- Role in photosynthesis of energy from sunlight; chlorophyll; carbon dioxide and water; xylem and phloem; stomata; oxygen; sugar (glucose)

C. REPRODUCTION

- Asexual reproduction
  - Example of algae
  - Vegetative reproduction: runners (e.g., strawberries) and bulbs (e.g., onions); growing plants from eyes, buds, leaves, roots, and stems
- Sexual reproduction by spore-bearing plants (e.g., mosses and ferns)
- Sexual reproduction of non-flowering seed plants: conifers (e.g., pines); male and female cones; wind pollination
- Sexual reproduction of flowering plants (e.g., peas)
  - Functions of sepals and petals; stamen (male), anther, pisffl (female), ovary (or ovule) Process of seed and fruit production: pollen; wind, insect and bird pollination; ferfilization; growth of ovary; mature fruit

Seed germination and plant growth: seed coat embryo and endosperin; germination (sprouting of new plant); monocots (e.g., corn) and dicots (e.g., beans)

APPENDIX D-PLANTS

Comparing Leaves Science Process Skills: Observation and Inference

Objectives: 1. Plants have common characteristics

2. Plants adapt to their environment

Discover: Carefully observe leaves from plants that grow in two very different environments. Touch the surfaces of each leaf. Examine each leaf with a hand lens. Record your observations below.

	Leaf 1	Leaf 2
Color		
Size		
Shape		
Texture		
other observations		
Your drawing		

Inferring: Use your observations to determine which plant lives in the desert and which does not. Give reasons to support your inferences.

APPENDIX E-PLANTS

Plant Word Roots

Dictionary: Look up these words in the dictionary and unlock the meaning of the terms.

autotroph self (auto) + nutrition (troph)

definition: an organism that makes its own food.

eukaryote _____ (eu) + _____ (karyote)

definition: _____

photosynthesis _____ (photo) + _____ (synthesis)

definition: _____

cellulose _____ (cellul) + _____ (ose)

definition: _____

chloroplast _____ (chloro) + _____ (plast)

definition: _____

chlorophyll _____ (chloro) + _____ (phyll)

definition: _____

cuticle _____ (cutis) + _____ (-le)

definition: _____

vascular _____ (vas) + _____ (-cule)

definition: _____

APPENDIX F-PLANTS

The Plant Kingdom Outlining

Background knowledge: Overview of characteristics that plants share. More detailed information can be found in almost any text or book on plants. See Resource.

I. Plants Share Characteristics
- A. Plants are autotrophs that use photosyntnesis to make food.
  - 1. Photo = light, syntnesis = to make
  - 2. Plants use Carbon dioxide gas and water to make food and oxygen
  - 3. Food is made in structures within cells called chloroplasts
  - 4. Chlorophyll is important pigment in making food.
- B. Plants are eukaryotes that contain many cells.
  - 1. Plants have a cell wall.
  - 2. The cell wall is made of rigid substance called cellulose.
  - 3. Vacuoles are large sacklike storage areas in the cell.
  - 4. Cells are organized into tissues that perform a specific function.

II. Origin of Plants
- A. Plants and green algae contain same kind of chlorophyll

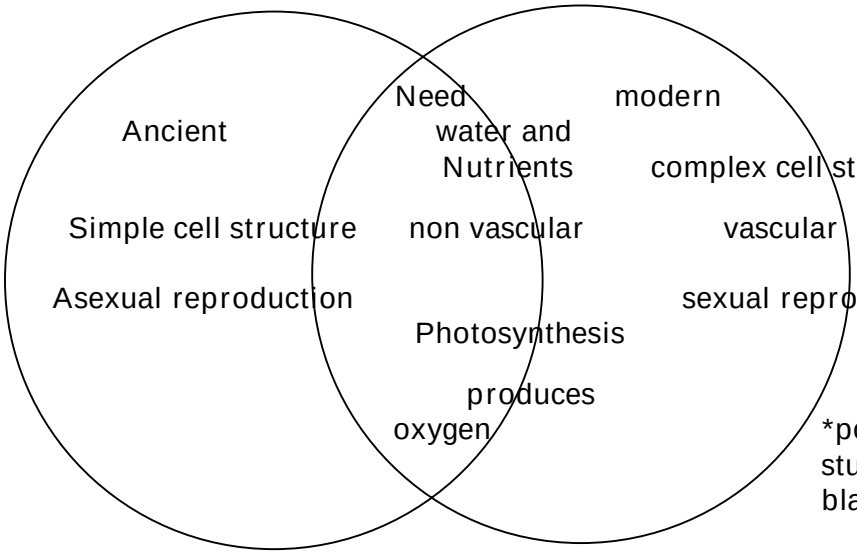
III. Plants Have Adaptations That Help Them Live On Land.
- A. Plants need ways to obtain water and nutrients from surroundings
  - 1. retain water: cuticle
  - 2. transport materials throughout the plant: vascular tissue
  - 3. support their bodies to receive sunshine: vascular tissue
  - 4. reproduce: fertilization without water
- B. Plants have Complex Life Cycles
  - 1. sporophyte stage: produces spores to create gametophyte
  - 2. gametophye stage: produces two kinds of sex cells or gametes
  - 3. gametes: sperm cell and egg cell
  - 4. Zygote: sperm cell and egg cell join, develops into sporophyte

You can use this format to teach your students outlining. Webbing can also be demonstrated. Model on a blank outline how to organize information from their text or your classroom discussions. This outline was created using text from *FBtP* Ch 4.

APPENDIX G-PLANTS

The Plant Kingdom Science Process Skills: Comparing

Venn diagram: show the similarities and differences between green algae and complex plants



*possible answers students should get blank diagram

APPENDIX H-PLANTS

Design an Experiment

Scientists _____

Title of Activity _____

Observation: What caused us to ask the question?

_____

_____

Question: What do we want to find out?

_____

_____

Hypothesis: What do we think we will find out?

_____

_____

_____

Procedure: How will we find out? (List step-by-step.)

1. _____
2. _____
3. _____
4. _____

Results: What actually happened?

_____

_____

_____

Conclusions: What did we learn?

_____

_____

_____

APPENDIX I-PLANTS

Some Guidelines for Experimental Procedures

- Select only one thing to change in each experiment. Things that can be changed are called variables.
- Change something that will help you answer your questions.
- The procedure must tell how you will change this one thing.
- The procedure must explain how you will measure the amount of change.
- Each experiment should have a "control" for comparison so that you can see what the change actually did.