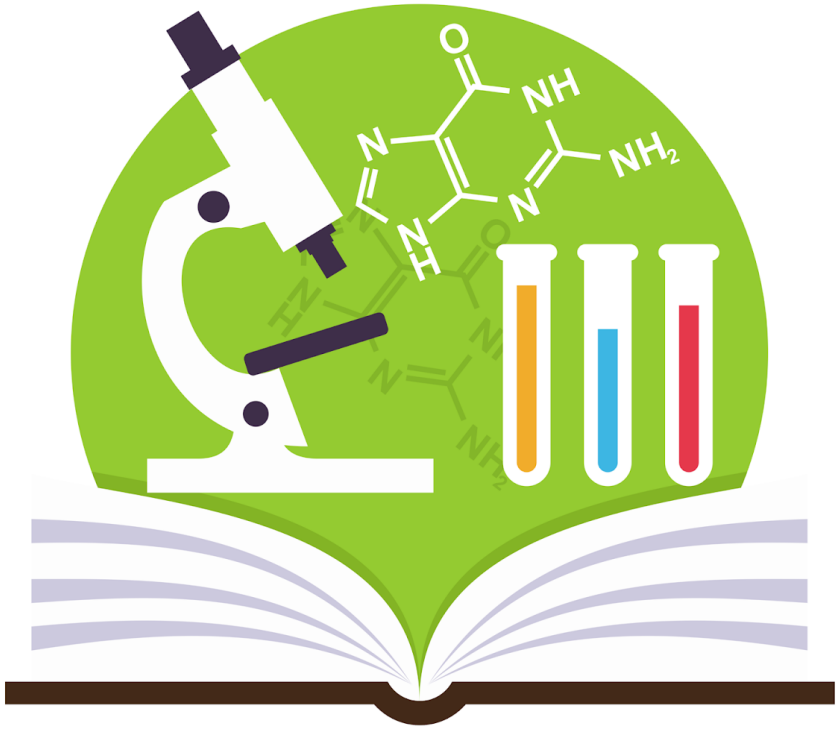
Sabbath Mood Homeschool Presents

LIVING SCIENCE STUDY GUIDES

A Charlotte Mason Resource for Exploring Science, a Vast and Joyous Realm



BOTANY: FORMS 3-4

First Studies of Plant Life

George Francis Atkinson

Sabbath Mood Homeschool Presents

Living Science Study Guides

A Charlotte Mason Resource for Exploring
Science, a Vast and Joyous Realm

Botany: Form 3-4 (grades 7-9)
Using the book *First Studies of Plant Life* by George Francis Atkinson

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"*But for the most part science as she is taught leaves us cold; the utility of scientific discoveries does not appeal to the best that is in us, though it makes a pretty urgent and general appeal to our lower avidities. But the fault is not in science—that mode of revelation which is granted to our generation, may we reverently say?—but in our presentation of it by means of facts and figures and demonstrations that mean no more to the general audience than the point demonstrated, never showing the wonder and magnificent reach of the law unfolded. The Hebrew poet who taught us that '*Breadcorn is bruised . . . because his God doth instruct him and doth teach him*,' glorified life. Coleridge has revealed the innermost secret, whether of science or literature: speaking on the genesis of an idea, he says, '*When the idea of Nature (presented to chosen minds by a Higher Power than Nature herself),*' etc. The man who would write for us about the true inwardness of wireless telegraphy, say, how truly it was a discovery, a revealing of that which was there and had been there all along, might make our hearts burn within us. No doubt there are many scientific men who are also men of letters, and some scientific books as inspiring as great poems—but science is waiting for its literature; and, though we cannot live in shameful ignorance and must get what we can out of the sources open to us, science as it is too commonly taught tends to leave us crude in thought and hard and narrow in judgment.*" (Mason, Charlotte M. *Towards A Philosophy Of Education*. Wheaton: Tyndale House Publishers, Inc., 1989. p. 318)

Introduction

In this Form 3-4 (grades 7-9) study guide, students will study the physiology of plants, including their structure, the way they function, some classification, and sensitivity. The following items are included:

- Reading assignments
- Activities based on the readings
- Recommended supplemental books, videos, and articles
- Notebooking prompts
- Discussion prompts
- Suggested biographies for students who take a particular interest in this topic
- Links to current events
- Supply lists and printable resources
- Exam questions

Spine Text:
This study guide accompanies the living book *First Studies of Plant Life* by George Francis Atkinson. (Yesterday's Classics, 2017) It is available on Amazon or Archive (with some missing pages,) or for a more extensive used-copy search, try used.addall.com.

- 280 pages, 33 chapters
- Reading Level: Grade 7 and up
- Prerequisites: none

Links Page:
You can access any of the links included in this guide at the following address:
http://sabbathmoodhomeschool.com/plant-links/
Password: starch

Schedule:
This study guide includes 33 lessons, each requiring approximately 30-40 minutes. It is scheduled once a week for an entire year, allowing time for exams at the end of each term and including other science subjects on the other days of the week.

Special Studies
- This study requires a student to observe seedlings and plants on almost a daily basis. It is suggested, therefore, that one of his special studies be to focus on the plants he is growing in this course.

Optional Biographies:
Your student may enjoy one of the following books during their leisure reading time:

- *Wicked Plants: The Weed That Killed Lincoln's Mother and Other Botanical Atrocities* by Briony Morrow-Cribbs (236 pp.)
- *Luther Burbank: Plant Magician* by John Beaty (251 pp., Messner Biography)
- *Leaves: their amazing by lives and strange behavior* by James Poling (103 pp.)
- *The Self-Made Tapestry: Pattern Formation in Nature* by Philip Ball (456 pp.)
- *Look at a Flower* by Anne Ophelia T. Dowden (120 pp.)
- *The Secret Life of the Flowers* by Anne Ophelia Dowden (96 pp.)
- *The Clover & the Bee: A Book of Pollination by Anne Ophelia Dowden* (90 pp.)
- *The Man Who Planted Trees* by Jean Giono (74 pp.)
- *Beloved Botanist: The Story of Carl Linnaeus* by Adrien Stoutenburg (192 pp.)
- Gregor Mendel: Planting the Seeds of Genetics by Simon Mawer (176 pp.)
- Monk in the Garden by Robin Henig (Gregor Mendel, 304 pp.)
- The Friar Who Grew Peas by Cheryl Bardoe (Gregor Mendel, PB)
- The Voyage of the Beagle by Charles Darwin (488 pp.)
- Darwin: With Glimpses into His Private Journal and Letters by Alice B. McGinty (48 pp.)
- Dr. George Washington Carver by Shirley Graham and George Lipscomb (248 pp.)
- Naturalist's Apprentice series (all approximately 4-6 grade level and 48 pp.):
    - Wildlife Watching with Charles Eastman by Michael Elsohn Ross
    - Bird Watching with Margaret Morse Nice by Michael Elsohn Ross
    - Bug Watching with Charles Henry Turner
    - Pond Watching with Ann Morgan by Micheal Elsohn Ross
    - Flower Watching with Alice Eastwood by Michael Elsohn Ross
    - Fish Watching with Eugenie Clark by Michael Elsohn Ross
    - Lady With a Spear by Eugenie Clark (fish)
    - Nature Art with Chiura Obata by Micheal Elsohn Ross
- Find more books on the botany page at SabbathMoodHomeschool.com.

Exams:
Exam questions have been organized for use depending on whether you complete this study in one term or over a whole year. They are available in a separate document that can be accessed through the email you were sent when you completed your purchase.

Current Events:
Each week, students should read a scientific current event. ScienceNewsforStudents.org is an excellent resource. Also, NewsELA, one of the best general news options for students, includes many scientific articles and allows you to change the difficulty of the text to your student's reading ability. You must create an account to view the articles on this site, but it is free and easy.

Science Notebook:
Students should write narrations in their science notebook, including drawings where appropriate to better show what they have learned. This is not a test, so if they need to look at a diagram in order to copy it into their notebook, that is acceptable. All reading, experiments, activities, and current events should be included, and each item should be dated. Students may also include quotes which they particularly like from the reading. Learn more about keeping a science notebook here.

Nature Notebook:
"*In connection with the Natural History every child in the P.U.S. keeps a Nature Book in which he paints from nature: flowers, birds, insects, animals—in short any natural object which takes his fancy—and he writes his own descriptions and notes, not those dictated by his teacher. ... Older children make lists of birds and flowers—and sometimes of mosses, fungi, seaweeds, etc.—with their English and Latin names.*" (The Work and Aims of the P.U.S.)

If you have not already begun a flower list, or possibly a moss or fungi list, this would be a good time to start keeping one.

Supply Lists

TERM 1

- Lesson 1
  - Masking tape
  - Marker
  - 6 small flower pots or yogurt cups with holes in the bottom
  - Saucers to put under the pots or a baking dish to set them all in
  - Seed-starting mix
  - 4 seeds of each: bean, pea, corn, pumpkin, sunflower, and buckwheat
  - Plastic wrap
- Lesson 3
  - Quart size wide mouth Mason jar
  - Cardstock
  - Peat moss or sawdust (option 1)
  - Paper Towels (option 2)
  - 6 small bowls
  - Water
  - several of each seed: bean, pea, corn, pumpkin, sunflower, and buckwheat
  - Scissors
  - Knife (optional)
  - Blunt wire, such as a straightened coat hanger
  - Plastic wrap
- Lesson 4
  - 6 small bowls
  - Water
  - several of each seed: bean, pea, corn, pumpkin, sunflower, and buckwheat
  - Knife (optional)
- Lesson 5
  - Seeds in the Mason jar from Lesson 3
  - Seedlings planted in Lesson 1
  - Fine tipped permanent marker
  - Ruler
- Lesson 6
  - Seeds in the Mason jar from Lesson 3
  - Seedlings planted in Lesson 1
  - Fine tipped permanent marker
- Lesson 9
  - Pin
  - Sharp knife
  - A tree shoot (branch) two or three feet long, branched if possible

- Lesson 10
    - Locate a mature hardwood shrub or tree in your neighborhood that you have permission to take cuttings from. (See suggestions below)
    - Pruning shears
    - Sharp knife
    - Rooting compound (liquid or powder)
    - Flowerpot or a sandy garden plot
    - Sand
    - Peat moss

TERM 2

- Lesson 12
    - A medium size organic potato that has begun sprouting (76% of conventional potatoes have been treated with chlorpropham, a herbicide that inhibits sprouting. You want a potato that will sprout.)
    - Toothpicks
    - Jar, a bit larger than the diameter of the potato.
    - Water
    - Ziplock bags (optional)
    - Masking tape
    - Marker
    - 8 small flower pots or yogurt cups with holes in the bottom
    - Saucers to put under the pots or a baking dish to set them all in
    - Seed-starting mix
    - 4 seeds of each: bean, pumpkin, sunflower, and buckwheat
    - 4 boxes which a pot of growing seedling can fit into, or 1 large box that 4 pots of growing seedling can fit into
- Lesson 13
    - Corms, such as crocuses, gladioli, or cyclamens
- Lesson 14
    - The seedlings you planted in Lesson 12
    - Carefully dig up various plants retaining their root system for observation
    - Poison ivy (optional), Please don’t touch poison ivy. If you would like to bring it indoors for observation, wear rubber gloves and set it on a surface that can be thrown away, such as a sheet of tin foil.
- Lesson 15
    - Gather several varieties of leaves. It is possible that you are doing this lesson at a time of the year when gathering leaves are difficult or impossible. If that is the case, gather what you can, and then you will have to rely on the observation of house plants.
    - The seedlings you planted in Lesson 12
- Lesson 16

    - The seedlings you planted in Lesson 1
    - 5 small bowls
    - Water, room temperature
    - Water, boiling
    - Rubbing alcohol
    - Beets
    - Salt
    - Knife
- Lesson 17 - part 1
    - Dialysis tubing (HomeScienceTools.com, Item# BE-MEMBRLG; you can use this rather than sheep bladder as it is a semi-permeable membrane tubing that can be used to demonstrate diffusion and osmosis.)
    - String, dental floss, or the rubber bands that come with your dialysis tubing
    - Pipette (HomeScienceTools.com, Item# CE-PIPET)
    - Small jar or beaker
    - Large jar or beaker
    - Sugar
    - Water
    - Scale
    - Needle
- Lesson 17 - part 2 (optional)
    - Compound microscope
    - Fresh leaf specimen (use one without many holes or blemishes)
    - Plain glass microscope slide
    - Slide coverslip
    - Sharp knife or razor blade
    - Water
- Lesson 18
    - Rhubarb, called pie plant in this section, or a piece of celery
    - Knife or scissors
    - 2 small bowls
    - Water
    - Salt
    - Dandelion stalks (if available this time of year)
    - Soft wood, such as a popsicle stick
    - Stapler
- Lesson 19 - part 1
    - Plants begun in lesson 1
- Lesson 19 - part 2 (optional)
    - Fully grown balsam plant started in Lesson 7 or a similar plant with a long thick stem

    - Glass or vinyl tubing, several feet long and about the same diameter as that of the stem of the plant to be used (HomeScienceTools.com, Item# CE-TUBEPLS)
    - A short piece of rubber tubing that can slip over the end of the glass tube (You might search for this in a local hardware store or automotive store.)
    - Wrapping cord (HomeScienceTools.com, Item# MC-STRING)
    - Water
    - Tall stake, such as a 3' bamboo stake
    - Sharp knife
- Lesson 20 - part 1
    - Thistle tube (HomeScienceTools.com, Item# BE-THISGLS)
    - Large jar or beaker
    - Dialysis tubing (HomeScienceTools.com, Item# BE-MEMBRLG)
    - String, dental floss, or the rubber bands that come with your dialysis tubing
    - Water
    - Molasses or sugar solution.
- Lesson 20 - part 2 (optional)
    - Cork Borer (HomeScienceTools.com, Item# CE-CORBO15)
    - Potato
    - Sugar
- Lesson 21 - part 1 and 3
    - 2 large glass bowls
    - Handful of fresh leaves or several leafy shoots from fresh plants
    - Paper towel
    - Rubber gloves
    - Safety glasses
    - Cobalt Chloride Test Paper (Amazon)
    - If you intend to make your test paper, you will need the following items:
        - Cobalt chloride (HomeScienceTools.com, Item# CH-COCL2)
          Please note—This chemical is moderately toxic and therefore should not be inhaled, ingested, or come in contact with eyes or skin. Store it in a cool, dry, well-ventilated area, and keep it out of reach of children.
        - Water
        - Filter paper (HomeScienceTools.com, Item# CE-FILTPAP)
        - Oven set at 200°F or a hair dryer
    - Potted plant
    - Bell jar or Mason jar that will fit over the potted plant
    - Plastic wrap
    - Popsicle stick
- Lesson 21 - part 2 (optional — you can skip this section if you are short on time.)
    - Potted plant
    - Bell jar or Mason jar that will fit over the potted plant

    - Plastic wrap
- Lesson 22
    - Seedlings from Lesson 12
    - Fresh leaves from other plants
    - Cobalt chloride paper from the last lesson
    - 2 panes of glass (I purchased two 4x6 glass clip picture frames from a craft store for $2.50 each, and removed the glass for this activity.)
    - A dry but fresh leaf

TERM 3

- Lesson 23
    - Celery stalks
    - White carnation
    - Cut a shoot from any other plants you have on hand
    - Red food coloring
    - Water
    - Vase
- Lesson 24
    - Iodine solution (HomeScienceTools.com, Item# CH-IODINE)
    - Cornstarch
    - 2 test tubes (HomeScienceTools.com, Item# CE-TTUBELG)
    - Test tube clamp (HomeScienceTools.com, Item# CE-TUBHOLD)
    - Cup of water
    - Pipette (HomeScienceTools.com, Item# CE-PIPET)
    - Potato
    - Knife
    - White plate
    - Lighter
    - Two plants, one must be placed in the dark and one placed on a windowsill for 24 hours before this experiment.
    - Jar or beaker
    - Saucepan on the stove
    - Ethyl alcohol (HomeScienceTools.com, Item# UN-ETHYALC)
    - Tweezers (HomeScienceTools.com, Item# DE-FORPLAS)
    - Wax paper or a shallow dish
- Lesson 26
    - 8-10 sprigs of an aquatic plant, such as E. densa, E. canadensis, or Chara (Elodea, live culture, pack of 12, HomeScienceTools.com, Item# LD-ELODEA)
      Please Note—Live cultures can be difficult to sustain. The culture will come with care instructions but plan to use it within 1-2 days of arrival for best results.
    - Large clear jar or beaker

    - Clear container, large enough to fit the funnel inside
    - 1 g Sodium Bicarbonate (HomeScienceTools.com, Item# CH-NAHC100)
    - Stirring rod (HomeScienceTools.com, Item# CE-STIRROD)
    - Large funnel (HomeScienceTools.com, Item# CE-FUN120G, 12 cm wide x 22 cm long) The outside diameter of the funnel stem is about 14 mm.
    - Test tube (HomeScienceTools.com, Item# CE-TTUBELG)
    - 20-W fluorescent light source
    - Dechlorinated tap water
    - Test tube stopper (HomeScienceTools.com, Item# CE-STOP0XC)
    - Matches
    - Wood barbecue skewer
    - Safety glasses
- Lesson 27
    - 1 cup of pea seeds
    - Water
    - 3 large jars or beakers
    - Plastic wrap
    - Matches
    - Wood barbecue skewer
    - Rubber gloves
    - Safety glasses
    - 1 teaspoon calcium hydroxide, $Ca(OH)_2$ (the book recommends barium carbonate, but you will use lime water in the HS Chemistry Study Guide, so using it now will save on supplies.)
    - 2-quart glass jar with lid
    - 4 cups distilled water
    - Limewater
    - Germinating seeds prepared in part 1
    - 3 small jars or beakers
    - Drinking straw
- Lesson 28
    - Masking tape
    - Marker
    - 8 small flower pots or yogurt cups with holes in the bottom
    - Saucers to put under the pots or a baking dish to set them all in
    - Seed-starting mix
    - 4 seeds of each: bean, pumpkin, sunflower, and buckwheat
    - 4 boxes which a pot of growing seedling can fit into, or 1 large box that 4 pots of growing seedling can fit into
- Lesson 31
    - Buttercups or other flowers, specimens at various stages, or watch over time

    - Pumpkin or squash flowers, both a specimen that has a round enlargement on the flower stalk and one that does not. (It's possible that pumpkin flowers will not be available yet. If that is the case, try to remember to take a close look at them this summer.)
    - Sunflower, purchased from a florist
    - Teasel flowers, if you find some growing near you
- Lesson 32
    - Seedlings started in lesson 28
    - 1 box which a pot of growing seedling can fit into
    - Scissors

Lesson 1

What is botany? Simply stated, botany is the scientific study of plants. That might include the study of the smallest bacteria or the giant redwood trees, the Venus flycatcher or seaweed. Through the text *First Studies of Plant Life* and this study guide, you will learn the structure of plants in general and how they function, but don't think this is a simple matter. In the introduction to the text, Anna Botsford Comstock, author of the *Handbook of Nature Study,* writes, "*The life processes of the plant have seemed too complex to be brought within the comprehension of the child. There is much of chemistry in operations of plant growth, and we find very few things in chemistry that are simple enough to be properly a part of nature study."* However, she assures us that we have found the right book to tackle this endeavor: "'First Studies of Plant Life' *has been written with the sole view of bringing the life processes of the plant within the reach of the child…"* Studying botany can be a bit challenging, but it can also be a lot of fun.

Read: *First Studies of Plant Life*, Chapter 1: How Seedlings Come Up From the Ground; pages 1-6, complete this chapter.

Notebook: Write what you have learned in your science notebook. Please note that it is likely to take you as long, or nearly as long, to write your narration on each chapter as it takes you to read it. This chapter was rather short, but subsequent chapters will be longer. If you find you are not able to remember many of the ideas presented, then read smaller chunks before narrating. Take your time reading, understanding each paragraph before moving on.

Activity: Plant seeds for observation.

Please Note—If necessary, you can move this activity to the next lesson.

Supplies Needed—

- Masking tape
- Marker
- 6 small flower pots or yogurt cups with holes in the bottom
- Saucers to put under the pots or a baking dish to set them all in
- Seed-starting mix
- 4 seeds of each: bean, pea, corn, pumpkin, sunflower, and buckwheat
- Plastic wrap

Procedure—

1. Use masking tape and a marker to label each pot or yogurt container with the name of the seed you will plant in it.
2. Fill the pots with a seed-starting mix to about one inch from the top.
3. Set the pots on saucers and moisten the mix with water.
4. Place three or four seeds in each pot and cover the seeds with about half an inch of soil.
5. Sprinkle with water.
6. Cover with plastic wrap. (Plastic wrap over the containers creates the warmth needed for germination and holds in the moisture.)
7. Place in a south-facing window. (Seedlings need bright light after germination. If you don't have a bright south-facing window, you can buy a grow light or make your own using a grow light bulb in a clip-on fixture, placed two to four inches above the plants. They should be exposed to this light 14 hours a day.)
8. Once the plants have germinated (emerged from the soil) remove the plastic covering.
9. Keep the soil moist but not soggy.
10. Observe daily and draw pictures in your science notebook of each plant's progress similar to those shown on pages 4-6 of the text.

Additional Resource: You might enjoy watching the video Sunflower Seeds Germination and Growth Time Lapse (2:15 min.)

For Discussion: Do you think you know a lot about plant life already? After all, you may have been doing nature study for several years. Do you believe there is more for you to learn?

Lesson 2

Do you remember the word "cotyledon" from the last lesson? What is it? Cotyledons are the first plant part you saw when your seedlings poked their heads out of the soil. They are the first leaves produced by plants, but they are not "true leaves." Sometimes they are called "seed leaves" because they are part of the seed or embryo of the plant. Cotyledons help keep the new seedling fed until it can make its own food.

Read: *First Studies of Plant Life*, Chapter 2: How the Seeds Behave When Germinating; pages 7-17, complete this chapter.

Notebook: Write what you have learned in your science notebook. This section likely took you about ten minutes to read. Therefore it should take you approximately that same amount of time to write a narration. Please remember that your narration is the work of your education.

Please Note: You will have the opportunity to soak seeds and set them to grow behind glass during the next lesson. You may wish to prepare for the next lesson a day in advance, by completing step #1 of the activity 12 - 24 hours before the lesson time.

Lesson 1 Seedlings: Make sure you are remembering to water the seeds you planted in Lesson 1. Not too much though. Just keep the soil moist. Have your seeds germinated yet? You should expect your buckwheat to break through the soil first, but the other seeds may take 14 days. As soon as your seeds germinate, take a few minutes each day or every other day to observe their progress and draw pictures in your science notebook. You may like to set aside a single page for each type of plant.

Lesson 3

Recall what you read in the last lesson. Today you will have an opportunity to try the activities mentioned in the text.

Read: No reading today.

Activity: Plant seeds behind glass for observation.

If you are doing this activity with a group, soak the seeds, as noted in step #1, before your lesson time. You might also want to set some of the bean seeds to soak at intervals (such as 1, 3, and 5 hours before class,) so students can observe the changes a seed undergoes as water is absorbed.

Supplies Needed—

- Quart size wide mouth Mason jar
- Cardstock
- Peat moss or sawdust (option 1)
- Paper Towels (option 2)
- 6 small bowls
- Water
- several of each seed: bean, pea, corn, pumpkin, sunflower, and buckwheat
- Scissors
- Knife (optional)
- Blunt wire, such as a straightened coat hanger
- Plastic wrap

Procedure—

1. Soak seeds in water for 12 hours (or up to 24 hours if needed.)
    a. Look at them at “short intervals after they have been placed in water.” Draw what you observe.
2. Separate the soaked seeds:
    a. Cut one of the soaked seeds using a pair of scissors and then one of the dry seeds. Compare the hardness.
    b. With finger or knife, split a bean seed along the line of the convex side and pull the halves apart. Look for the young embryo plant that is attached to one of these halves. Draw what you observe and label the embryo and the two cotyledons.
    c. Split another bean seed and set aside the two halves that contain the embryo to place in your germinator.
    d. Rub one of the peas between your fingers to remove the thin outer coat. Carefully break away one of the halves. Look for the young embryo plant that is attached to one of these halves.
    e. Split another pea seed and set aside the two halves that contain the embryo to place in your germinator.
3. Prepare a germinator:
    a. Cut a piece of cardstock 5 ½” wide.
    b. Roll it and place it into the Mason jar.
    c. Option 1 — Fill the center of the jar with peat moss or sawdust.
    d. Option 2 — Fill the center of the jar with paper towels by wadding them up and packing them into the jar.
4. Pour enough water into the jar to thoroughly moisten the contents of the jar.
5. Place two of each kind of soaked seed in germinator. Also, place two of your split beans and two of your split peas with the embryo side showing through the glass. Use a blunt wire to position your seeds.
6. Loosely cover with plastic wrap to maintain moisture in the jar, and add water as needed. Do not let your seeds dry out.
7. Observe the progress of each of the seeds.
8. When the roots have grown an inch or more in length, sketch some of the different positions.
9. When the plant has germinated, (it starts to sprout) sketch each type of plant.
10. Attempt to observe the root hairs.

Please Note: You may wish to prepare for the next lesson a day in advance, by completing step #1 of the activity 12 - 24 hours before the lesson time.

Lesson 1 Seedlings: Take some time to observe the plants started in Lesson 1. Most of them should have germinated by now, as it has been 14 days. Continue drawing pictures in your science notebook to record their progress.

Lesson 4

> "*It always amazes me to look at the little, wrinkled brown seeds and think of the rainbows in 'em," said Captain Jim. "When I ponder on them seeds I don't find it nowise hard to believe that we've got souls that'll live in other worlds. You couldn't hardly believe there was life in them tiny things, some no bigger than grains of dust, let alone colour and scent, if you hadn't seen the miracle, could you?*"
>
> -L.M. Montgomery, *Anne's House of Dreams*

Read: *First Studies of Plant Life*, Chapter 3: The Parts of a Seed; pages 18-23, complete this chapter.

You can follow the instructions noted in the text as you read through today's assignment, or you can observe the seeds after the reading, by completing the activity below.

Activity: Examine soaked seeds and identify their parts.

Supplies Needed—

- 6 small bowls
- Water
- several of each seed: bean, pea, corn, pumpkin, sunflower, and buckwheat
- Knife (optional)

Procedure—

1. Soak seeds in water for 12 hours (or up to 24 hours if needed.)
2. Observe a bean and pea seed:
    a. With finger or knife, split a bean seed along the line of the convex side and pull the halves apart. Look for the young embryo plant that is attached to one of these halves.
    b. Rub one of the peas between your fingers to remove the thin outer coat. Carefully break away one of the halves. Look for the young embryo plant that is attached to one of these halves.
    c. Compare the seeds.
    d. Sketch each of these split seeds and label their parts: cotyledons, seed coat, embryo, caulicle, and hypocotyl.
3. Observe a pumpkin seed and sunflower seed:
    a. Find the scar on the smaller end of the pumpkin seed.
    b. Cut carefully part way around the edge of the flattened seed and then pry it open and then apart.
    c. Cut a pumpkin seed lengthwise through the cotyledon.
    d. Complete the same steps with a sunflower seed.
    e. Compare the seeds.

    f. Make a sketch showing the seed coat, the position of the papery lining, the cotyledons as well as the short root and stem.
4. Observe a corn seed:
    a. Split the corn seed the same way you split the pumpkin and sunflower seeds.
    b. If the tiny plant is present in the seed, then it should be found in the groove.
    c. Split the soft kernel lengthwise through this groove.
    d. Make a sketch showing the cotyledons, seed coat, caulicle, and endosperm.

Notebook—

You should have several labeled seed diagrams in your science notebook from today's lesson. Add any other notes or questions that you have.

Lesson 1 Seedlings: Take some time to care for the plants you started in Lesson 1. Observe the progress of the plants and draw pictures in your science notebook.

Lesson 3 Seedlings: Also, observe the seeds you started in Lesson 3, drawing pictures of their progress. Note how old they are.

Lesson 5

When a child grows, does each part of him grow in proportion? As an infant, you likely had a relatively large head and short legs and arms, but now the dimensions of your body have balanced out. Have you ever seen a puppy with huge feet and big ears? As an adult dog, his feet and ears will fit the rest of his body better. Today as you study plants, you will learn whether a plant grows proportionally, or if they are similar to humans and animals in this respect.

Read: *First Studies of Plant Life*, Chapter 4: Growth of the Root and Stem; pages 24-26, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Examine the way the root lengthens.

Supplies Needed—

- Seeds in the Mason jar from Lesson 3
- Seedlings planted in Lesson 1
- Fine tipped permanent marker
- Ruler

Procedure—

1. Remove one of the pumpkin seedlings from your Mason jar.
2. Beginning at the tip of the root, mark off on one side very short spaces, as close together as possible. (Approximately 1 mm apart.)
3. Place the seedling back in the germinator in position, root pointing downward.
4. Repeat with a corn seedling.
5. After 24-hours, observe the results.
6. Sketch the seedlings showing their progress.
7. Use a ruler to make similar marks on the stems of some of your seedlings planted in Lesson 1. (Approximately 3 mm apart.)

Lesson 1 Seedlings: Take some time to care for the plants you started in Lesson 1. Observe the progress of the plants and draw pictures in your science notebook.

Lesson 3 Seedlings: Observe the seeds you started in Lesson 3, drawing pictures of their progress. Make sure they remain moist.

Lesson 6

Today's activity will take only a few minutes to complete. Use the extra time you will have to catch up on the records you have been keeping of the seeds you started in Lessons 1 and 3.

Read: No reading today.

Activity: Observe the downward growth of the root.

Supplies Needed—

- Seeds in the Mason jar from Lesson 3
- Seedlings planted in Lesson 1
- Fine tipped permanent marker

Procedure—

1. Remove two of the seedlings from your Mason jar.
2. Beginning at the tip of the roots, mark off on one side very short spaces, as close together as possible. (Approximately 1 mm apart.) Just as you did in the last lesson.
3. With a sharp knife, cut off the very tip of the root on one of the seedlings.
4. Place both seedlings back in the germinator, but this time, the roots should be pointed in a horizontal position.
5. Take one pot of seedlings from Lesson 1 and gently set it on its side.
6. After 24-hours, observe the results.
7. Sketch the seedlings showing their progress.

Lesson 1 Seedlings: Take some time to care for the plants you started in Lesson 1. Observe the progress of the plants and draw pictures in your science notebook.

Lesson 3 Seedlings: Observe the seeds you started in Lesson 3, drawing pictures of their progress. It is up to you how long you continue to care for these seeds. You will not need them in future lessons.

Lesson 7

In the last lesson, you set one of your seedlings with the roots pointed horizontally, instead of downward. Take a minute to observe that seedling and then read today's assignment to learn more.

Read: *First Studies of Plant Life*, Chapter 5: Direction and Growth of Root and Stem; pages 27-32, complete this chapter.

Notebook: Write what you have learned in your science notebook. Include a description of the *motor zone* and the *perceptive zone*.

Additional Resource: Watch the video Plant Control (7:53 min.) to learn how the hormones auxin, cytokinins, gibberellins, abscisic acid and ethylene help plants respond to their environment.

For Discussion: Take a few minutes to tell someone what you learned about plant hormones by watching that video.

Preparation for Lesson 19: You need a fully grown balsam plant in Lesson 19. The balsam has a thick, but soft stem, that grows 20–75 cm tall. If you would rather not grow this plant from seed, you can look for a plant with a similar long, thick stem in your local nursery when you get to Lesson 19, as balsam is rare to find in nurseries these days. To grow a balsam plant, follow the instructions on Gardening Know How or The Spruce. (The flowers of this plant will be referenced in Lesson 33, so if you do grow your own, consider planting two, as you may destroy the plant in the experiment in Lesson 19.)

Lesson 1 Seedlings: Take some time to care for the plants you started in Lesson 1. Observe the progress of the plants and draw pictures in your science notebook.

Lesson 8 (Winter Lesson)

If you come upon this lesson when it is not yet winter, please skip to lesson 11, and come back to Lessons 8-10 sometime between December and February. I will remind you.

Read: *First Studies of Plant Life*, Chapter 6: Buds and Winter Shoots; pages 33-39, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Lesson 9 (Winter Lesson) — Activity

In the last lesson you read about buds and winter shoots. Today you will have an opportunity to look at them for yourself.

Read: No reading today.

Source: Mary Holland, [by permission], via [Naturally Curious at https://naturallycuriouswithmaryholland.wordpress.com](https://naturallycuriouswithmaryholland.wordpress.com)

Activity: Observe winter buds.

Supplies Needed—

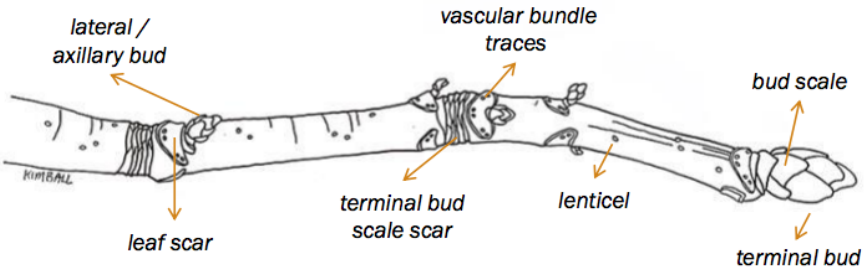
- Pin
- Sharp knife
- A tree shoot (branch) two or three feet long

Procedure—

1. Cut or break a twig and observe its pith.
2. Observe the tip of the twig. Do you see a bud?
3. Using a pin, remove the scales of the bud one by one. Observe how the scales are seated in the bud. Do you notice a sticky substance?
4. Once you have removed the bud scales, do you see the more delicate parts of the bud?
5. With a sharp knife, split the bud down through the end of the stem. Observe how closely all the scales fit together.
6. Look for a lateral bud on the side of the shoot.
7. Which buds will form branches next spring?
8. What will the terminal bud do?
9. Why is the terminal bud larger than the lateral bud?
10. Do you see a leaf scar just below the lateral bud? Can you find the leaf scar's pair?
11. Can you see the pinholes in the scar? What do you think causes them?
12. Do you see a girdle of scale scars?
13. Can you tell how old the branch you have is?
14. Cut through your branch and count the number of rings there are. What does that tell you?
15. Look for other shoots and study the buds, leaf scars, and their arrangement.
16. Bring a shoot inside, set the cut end in water, and see if it will open.

Notebook—

Write what you have learned in your science notebook. Include a description of the *terminal bud* and the *lateral bud*. Make drawings of at least one shoot, with buds and leaf scars. The following is an example of a buckeye twig.



For Discussion: Knowing the placement of buds, the texture of the bark, and the shape and size of the twigs are the best ways to identify trees in winter. You can also look on the ground for evidence of acorns and decaying leaves. And lest you think it will be easier to identify trees in the spring, consider the following statement in the Missouri FFA Forestry CDE Training Guide:

> "*Tree identification can be particularly challenging during the spring, because twigs have lost their winter characteristics (especially color characteristics), buds are swelling, and leaves are not yet out! About the only trait a student might have is bark; which can be extremely variable.*"

Lesson 10 (Winter Lesson) — Activity

One of the most amazing things about plants is that each cell can duplicate all of the parts and functions of the plant. From some plants, you can take a leaf cutting, a stem cutting, or a root cutting, and by creating the right conditions, you can grow a new plant.

This lesson is slated as a winter activity because the best time to take hardwood cuttings is when the plant is dormant, from late in the fall after a killing frost until early spring before the buds burst.

Read: No reading today.

Activity: Propagate hardwood cuttings.

Supplies Needed—

- Locate a mature hardwood shrub or tree in your neighborhood that you have permission to take cuttings from. (See suggestions below)
- Pruning shears
- Sharp knife
- Rooting compound (liquid or powder)
- Flowerpot or a sandy garden plot
- Sand
- Peat moss

Choosing your hardwood plant—

- Most deciduous shrubs including Abelia, butterfly bush, dogwood, hydrangea, pussy willow, sand cherry, rose of Sharon, forsythia, mock orange, rose, snowberry, and viburnums.
- Vines, including honeysuckle, jasmine, grapes, kiwifruit, and the currant family.
- Fruit, including gooseberries, black, red and white currants, fig, mulberry, pomegranates, and quince.
- Trees, including poplars and willow.

Procedure—

1. Identify twigs that are close to pencil-thickness from the current season's growth. Look for mature and woody twigs, not soft and green.
2. Using sharp pruning shears take cuttings that are several inches long (approximately 6-10") and include at least two buds. The top cut of each twig should be taken a few inches below the terminal bud and be cut at an angle. Discard the tip of the shoot. Make a straight cut at the bottom end, just below a bud. Always take more cuttings than you think you'll need as they may not all take root.

3. Dip the bottom end (the straight cut) in rooting compound.
4. Stir together one part sand and one part peat and fill a flowerpot with this mixture. Alternatively, set the cuttings in sandy soil in a garden plot.
5. Stick the bottom half of the cutting (the straight cut) into the soil mixture and press firmly around the cutting, so it stands upright on its own. Be sure at least one bud is still showing above the soil mixture.
6. If you are preparing more than one cutting, set them 2 inches apart.
7. Keep them slightly moist through the winter and then begin watering them daily in the spring.
8. If you keep them indoors, you can place a ziplock bag over the pot to keep it moist. But it is important to keep the bag from touching the cutting.
9. They will start leafing out in the spring but wait until late spring or mid summer to transplant.

Additional Resource: It may help to watch the watch the video Winter Time Plant Propagation (Hardwood Cuttings) (11:24 min) to see the complete process and what the cuttings should look like next winter. You can skip to 2:15 minutes when the instruction begins, but you will miss meeting the farm's two mini-donkeys, Finnegan and Fergus.

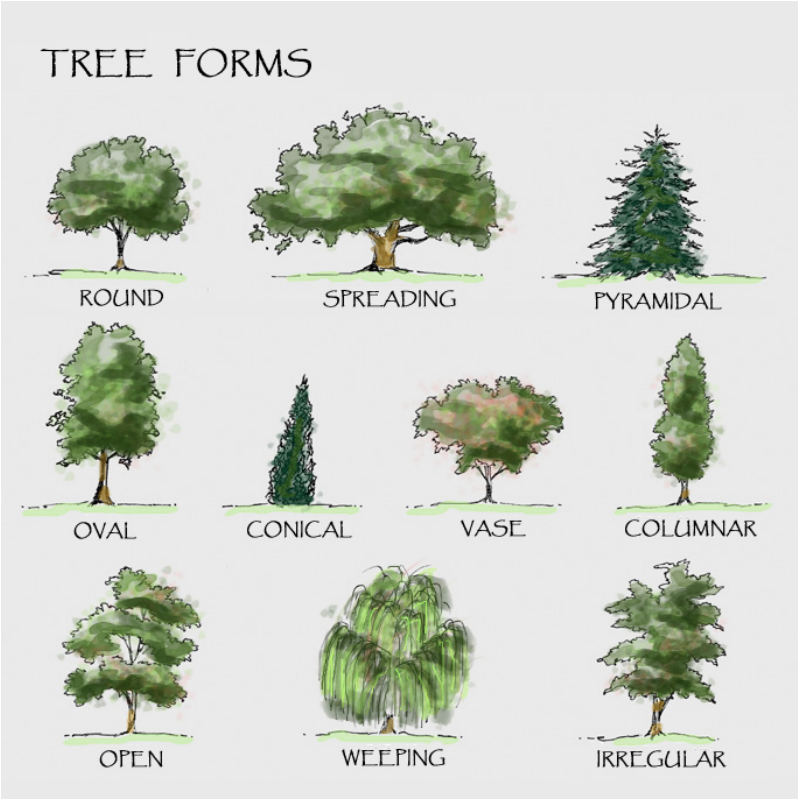
Lesson 11

Are the trees in the picture above the same shape? If not, then how many different shapes do you see? Each plant species' form is known as their habit, and a plant's habit is one of the things you will learn about today.

Read: *First Studies of Plant Life*, Chapter 7: The Full-Grown Plant and its Parts: I. The Plant; pages 40-44, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Nature Walk: When you take a nature walk this week, look for as many plant habits as you can. Sketch some of their shapes in your nature study notebook or your science notebook.



Lesson 12

Growing a potato in a jar of water allows you to observe its root and stem formation. The plant will only survive for a few weeks in water before it begins to rot, but you can enjoy it longer if you transplant it to a soil-filled pot.

Read: No reading today.

Activity 1: Grow potatoes indoors

Supplies Needed—

- A medium size organic potato that has begun sprouting (76% of conventional potatoes have been treated with chlorpropham, a herbicide that inhibits sprouting. You want a potato that will sprout.)
- Toothpicks
- Jar, a bit larger than the diameter of the potato.
- Water
- Ziplock bags (optional)

Procedures—

1. Fill the jar with tap water.
2. Insert four toothpicks into the potato, spacing them around the middle of the potato about two-thirds up from the end with the densest sprouts.
3. Set the potato in the jar, so the toothpicks support it on the rim, and the bottom one-third of the potato is in the water.
4. Place the jar in the window of a warm room. If you need to set a ziplock bag over the potato to create warmth, you can do that, but don't allow the bag to touch the potato or any of its sprouts.
5. Replenish the water in the jar, as needed, to maintain its depth, and change the water if it becomes brown or cloudy.
6. Small white rootlets should grow into the water within one to two weeks, and stems should follow soon after.
7. Optional next step #1 (if you started with a white potato): Transplant the potato to an 8-inch pot filled with a moist potting soil if you want to continue growing the plant. Take care not to break the roots or stems when transplanting. Plant the potato deep enough, so the bottom 2 inches of the stems are beneath the soil's surface. Water the potted potato when the top 1 inch of soil feels dry. Provide the plant with at least six hours of direct sun daily.
8. Optional next step #2 (if you started with a sweet potato): Carefully remove stems that are 5-inches long or more by carefully twisting them off of the sweet potato, and set them in a jar of water the way you would a cut flower. After a week or two, these "slips" will grow roots. When the roots are about an inch long the new slips are ready to be planted in loose, well-drained soil in your garden. Learn more about planting sweet potato slips at TheSpuce.com.

Notebook—

In your science notebook, record the steps you took and what you learned from each experiment. Include drawings, if you would like.

Activity 2: Prepare new seedlings for Lessons 14, 15, and 16.

Supplies Needed—

- Masking tape
- Marker
- 8 small flower pots or yogurt cups with holes in the bottom
- Saucers to put under the pots or a baking dish to set them all in
- Seed-starting mix
- 4 seeds of each: bean, pumpkin, sunflower, and buckwheat
- 4 boxes which a pot of growing seedling can fit into, or 1 large box that 4 pots of growing seedling can fit into

Procedure—

1. Use masking tape and a marker to label each pot or yogurt container with the name of the seed you will plant in it.
2. Fill the pots with a seed-starting mix to about one inch from the top.
3. Set the pots on saucers and moisten the mix with water.
4. Place three or four seeds in each pot and cover the seeds with about half an inch of soil.
5. Sprinkle with water.
6. Place one pot of each type of plant under a box to exclude all light.
7. Place the other pots in a south-facing window. (If you don't have a bright south-facing window, then use a grow light. They should be exposed to this light 14 hours a day.)
8. Keep the soil of all eight pots moist but not soggy.
9. Twice a week for three weeks, observe the plants. Measure their growth and make drawings in your science notebook of each plant's progress.
10. You will experiment with these seedlings in Lessons 14, 15, and 16.

Lesson 13

When you planted seeds, the first thing to appear above ground was simple, undeveloped shoots. As the plants grew, however, these tender shoots developed into an arrangement of stems and leaves, called the shoot system. Today your study will focus on the stems of the plant.

Read: *First Studies of Plant Life*, Chapter 8: The Full-Grown Plant and its Parts: II. The Stem; pages 45-53, complete this chapter.

Notebook: Draw an example of each of the stems mentioned in this chapter. You can reproduce the diagrams in the book, or draw from memory, or find examples in a field guide. Label each image with the name of the plant, and the type of stem.

1. Excurrent stems: which continues to the top, such as sunflower or pine trees.
2. Deliquescent stems: which seem to dissolve or become lost, such as oaks or elms.
3. Creeping or trailing stems: which creep on the ground, such as strawberries.
4. Climbing stems: which cling to other plants or places, such as the pea or Boston ivy.
5. Ascending stems: which are between erect and prostrate.
6. Burrowing stems: in which rhizomes creep under the ground, such as Solomon's seal and bracken fern.
7. Bulbs: which are short stems that are covered with numerous overlapping thick scale leaves, such as onions, lilies, and tulips.
8. Tubers: which are a thickened stem, such as potatoes.
9. Corm: which sends up a leafy flower stem, such as Jack-in-the-pulpit, crocus, and gladiolus.
10. Crown tuber: which is partly stem and partly root, such as beets and radishes.

Activity: Compare corms to bulbs.

Supplies Needed—

- Corms, such as crocuses, gladioli, or cyclamens
- Bulbs, such as daffodils, tulips, or irises

Procedures—

1. To see how corms differ from bulbs, cut them open.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Lesson 12 Seedlings: Take some time to care for the seedlings you started in Lesson 12.

Nature Walk: When you take a nature walk this week, take notice of as many different plants stems as you can.

Lesson 14

Recall what you learned about stems in the last lesson. Today you will continue looking at the parts of the plant.

"*A tree stands strong not by its fruits or branches, but by the depth of its roots.*"
~Anthony Liccione

Read: *First Studies of Plant Life*, Chapter 9: The Full-Grown Plant and its Parts: III. The Root; pages 54-59, complete this chapter.

Notebook: Write what you have learned in your science notebook. Draw a diagram of the different root types and tell the different ways roots work for the plant.

In this chapter, you learned that there are three types of root systems:

1. Taproot: with a taproot that is larger and grows faster than the branch roots;
2. Fibrous: with all roots about the same size; and
3. Adventitious: roots that form on any plant part other than the roots, including air roots, buttresses or prop roots, and aerial roots, such as Spanish moss.

Note that you did not learn the word *adventitious* in your reading today. In botany, adventitious refers to structures that develop in an unusual place. You might think of these roots as adventurous because they are not developed from the primary root system, but rather form on the stems and leaves of a plant.

Please Note: There were several suggested activities included in this chapter. You will have an opportunity to try them during lesson 15.

Activity: Examine roots

Supplies Needed—

- The seedlings you planted in Lesson 12
- Carefully dig up various plants retaining their root system for observation
- Poison ivy (optional), Please don't touch poison ivy. If you would like to bring it indoors for observation, wear rubber gloves and set it on a surface that can be thrown away, such as a sheet of tin foil.

Procedures—

1. Observe the roots of several plants to see if they are fibrous or fleshy.
2. Gently pull up some of your seedlings or a plant from outdoors and rinse the roots in water. Notice some of the soil clinging to the roots despite your effort to rinse it away.
3. If you have poison ivy or another climbing plant in your area, examine its air roots. Again, please don't touch poison ivy. If you would like to bring it indoors for observation, wear rubber gloves and set it on a surface that can be thrown away, such as a sheet of tin foil.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Additional Resource: Learn about a new robot that was inspired by plants by watching the video A Robot That Grows Like Plant Roots (4:14 min.) The robots in this video mimic the way plants move, sense the world, and grow. Someday they may be put to work in fields as diverse as agriculture, medicine, and space exploration.

For Discussion: Roots are the invisible part of the plant. Buried in soil many people never see them, yet their presence and functions are critical to the plant. A deep taproot is helpful to keep a plant in place when great winds come up. But how well does it help the plant when a cow pulls straight up on it? What might be a better root system for plants exposed to grazing animals?

Lesson 12 Seedlings: Take some time to care for the seedlings you started in Lesson 12.

Lesson 15

Today you will continue looking at the parts of the plant. You have learned about stems and roots. Now you will learn about another component of the shoot system, the leaves.

One plant species you will read about in this section is the dodder. A dodder can be identified by its thin stems that appear leafless because they are so tiny. Dodders do not possess roots, however. They are parasitic plants, surviving by penetrating the host's tissue and drawing nutrients from it.

Cuscuta (dodder) pacifica

Source: Gordon Leppig & Andrea J. Pickart, [Public Domain], via Wikimedia Commons

Read: *First Studies of Plant Life*, Chapter 10: The Full-Grown Plant and its Parts: IV. Leaves; pages 60-73, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Observe leaves.

Please Note—Today's reading was rather long. If you need to complete the following activity during an afternoon nature walk, please do so.

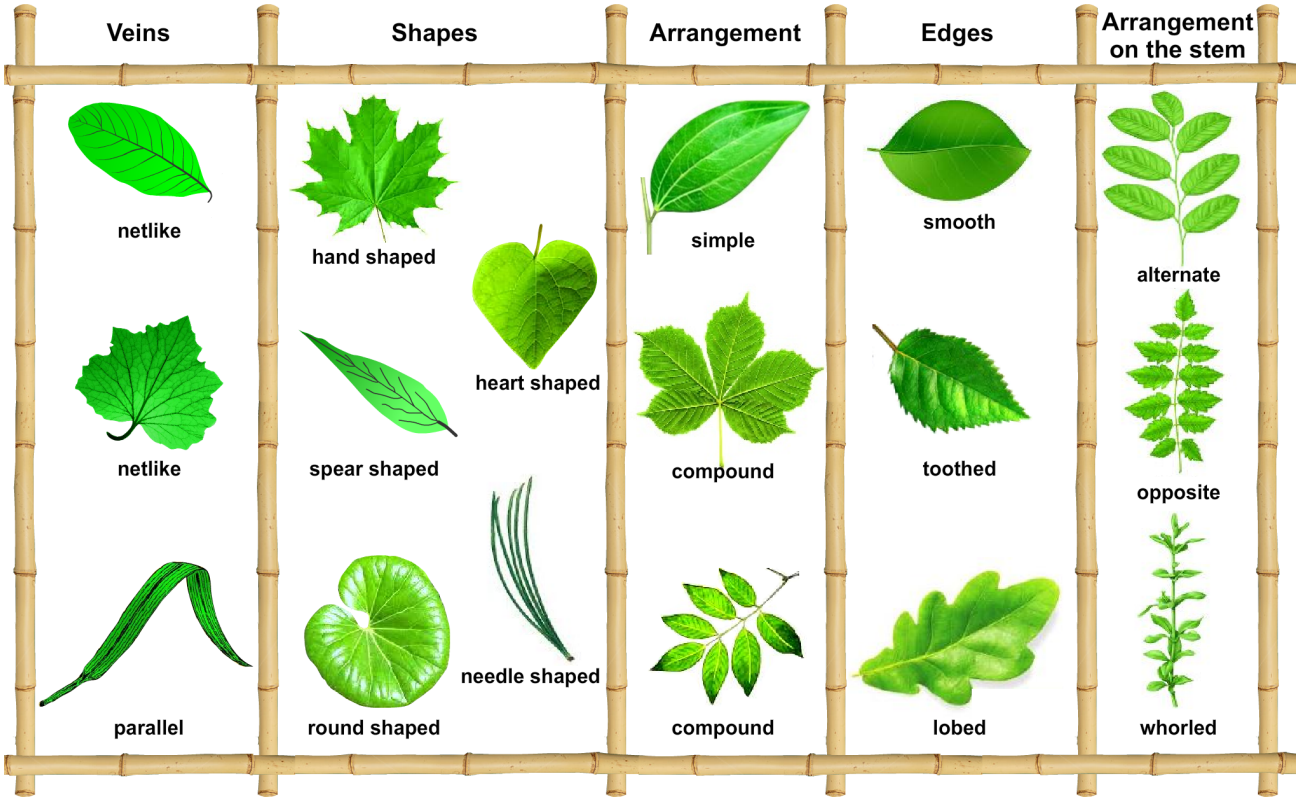
Supplies Needed—

- Gather several varieties of leaves. It is possible that you are doing this lesson at a time of the year when gathering leaves are difficult or impossible. If that is the case, gather what you can, and then you will have to rely on the observation of house plants.
- The seedlings you planted in Lesson 12

Procedure—

1. Compare the color, the thickness and shape of each leaf.
2. Are any of the leaves you gathered sessile?
3. Which is a simple leaf and which is a compound leaf?
4. Note which leaves are net-veined and which are parallel-veined.
5. Note how the veins run in the seedlings you planted.

Notebook: Draw at least one of the leaves and label the petiole and blade. Note some of its characteristics.



Nature Walk: When you take a nature walk this week, notice the placement of the leaves on the trees you see.

Lesson 12 Seedlings: Take some time to care for the seedlings you started in Lesson 12.

Lesson 16

You can stand and sit upright because of the combination of bones and muscle in your body. A plant has neither of those things, yet it can keep its particular habit as you learned about in Lesson 11. Today you will begin to learn how plants keep their shape without any muscle or bone.

Chapter 11 of the text includes several activities for you to try on your own. The reading is divided over three lessons so you will have enough time to complete these activities.

Read: *First Studies of Plant Life*, Chapter 11: How the Living Plant Uses Water to Remain Firm; pages 74-76, place your bookmark on page 76 just before the line, "*A make-believe plant cell.*"

You can follow the instructions noted in the text as you read through today's assignment, or you can complete them after the reading, by following the instructions below.

Activity: Return rigidity to a wilted plant.

Please Note—Today's activities will take longer than the suggested lesson time of 30-40 minutes because each experiment ends with the beets sitting in fresh water for 30-60 minutes. However, after they have been allowed to sit, you only need to run a quick test on them, before completing the lesson. Also, it would be fine to allow them to sit in the fresh water longer than the recommended 30-60 minutes, which would enable you to finish the experiment in the afternoon.

Supplies Needed—

- The seedlings you planted in Lesson 1
- 5 small bowls
- Water, room temperature
- Water, boiling
- Rubbing alcohol
- Beets
- Salt
- Knife

Procedure—

1. (p. 74-75) Cut off three of your seedlings and let them lie on the table for several minutes until they droop. Put the stem of one in a bowl of water with a ziplock bag over it, another in a bowl of water without a bag over it, and leave the last seedling on the table. Observe which revives fastest.
2. Cut slices from the beet 4-5 cm long, 4-5 cm wide, 2-3 cm thick. Hold them between the thumb and finger and try to bend them.

3. In a small bowl, dissolve one teaspoon of salt in 3.2 fluid ounces of water to make a 5% salt solution. Place one slice of beet in the salt solution and one slice in a bowl of fresh water. After 30-minutes test each of them by holding them between the thumb and finger and trying to bend them. Place them in a bowl of fresh cold water for about an hour and then test them again.
4. (p. 80-83) Place fresh slices of beet in water that is boiling or near boiling for a few moments. Remove the slices from the hot water and allow them to cool until you can comfortably touch them. Hold them between the thumb and finger and try to bend them. Place them in a bowl of fresh cold water for about 60-minutes and then test them again.
5. Pull up one of your seedlings. Observe its rigidity. Immerse the leaves and most of the stem in the 5% salt solution for 15-minutes. Now observe how rigid it is. Immerse the seedling in fresh water for 30-minutes and test again.
6. Now immerse the seedling in a bowl of rubbing alcohol for 15 minutes. What effect did the alcohol have on its rigidity? Immerse a red beet slice in alcohol. Note the results.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Lesson 12 Seedlings: Take some time to care for the seedlings you started in Lesson 12. If needed, you may wish to plant new seedlings for use in Lesson 22.

Lesson 17

One major difference between plant and animal cells is the presence of a cell wall surrounding the plasma membrane of each plant cell. The cell wall provides the cell with structural support and protection, and it acts as a filtering mechanism. Today you will have an opportunity to observe one of the cell wall's most important duties which is to serve as a pressure valve that prevents over expansion as water enters the cell.

Read: *First Studies of Plant Life*, Chapter 11: How the Living Plant Uses Water to Remain Firm; pages 76-80, place your bookmark on page 80 just before the line, "*A dead beet slice cannot work.*"

Activity 1: Observe diffusion and osmosis.

Please Note—Today's activity must be continued over the course of nearly two days.

Diffusion is the movement of molecules from a place where there are many molecules (high concentration) to an area where there are not so many molecules (low concentration).

Osmosis is the diffusion of water across a selectively permeable membrane. That means that water can go through membranes from areas where there are a lot of water molecules to areas where there are not so many water molecules.

Supplies Needed—

- Dialysis tubing (HomeScienceTools.com, Item# BE-MEMBRLG; you can use this rather than sheep bladder as it is a semi-permeable membrane tubing that can be used to demonstrate diffusion and osmosis.)
- String, dental floss, or the rubber bands that come with your dialysis tubing
- Pipette (HomeScienceTools.com, Item# CE-PIPET)
- Small jar or beaker
- Large jar or beaker
- Sugar
- Water
- Scale
- Needle

Procedure—

1. Cut a piece of dialysis tubing 4-6 inches long.
2. Place the dialysis tubing in a jar of fresh water to soak.
3. Combine a heaping teaspoon of sugar with a ½ cup of water in a small jar or beaker.
4. Cut 2 pieces of string about 4 inches long.

If you would like to watch a video demonstrating steps 5-9, watch [Lab Protocol - Dialysis Tubing Experiments] (first 3:34 min.)

5. Use a piece of string to tie off one end of the tubing.
6. Rub the tubing gently between your fingers to open it.
7. Use a pipette to fill the tubing with the sugar water solution. (approximately 10 ml)
8. Work out bubbles and then use another piece of string to tie off the top end of the bag so that it is limp, rather than stuffed full of fluid.
9. Use scissors to cut off the excess string and the ends of the tubing.
10. Weigh the filled dialysis tube and record this information.
11. Sink the filled tube in a large jar or beaker of fresh water (approximately 200 ml) and keep it there for 24 hours.
12. Remove the dialysis tubing bag and gently pat it dry. Observe the tube. How has it changed? Weigh the tube and record the weight.
13. Prepare a sugar solution that is so strong that not all of the sugar will dissolve.

14. Sink the tube in this sugar solution for several hours.
15. Remove the dialysis tubing bag, gently pat it dry and record the weight. Record this data. Notice its appearance.
16. Sink the tube in fresh water again. When the inside pressure returns, which may take 24 hours, pierce the membrane with a sharp needle. Did the liquid spurt out? Why? What causes the inside pressure

Notebook—

In your science notebook, record your observations. How do you know which way the particles moved? How does the dialysis tubing simulate a cell membrane? Include drawings, if you would like.

Activity 2 (Optional): Observe beet cells through a microscope. (optional, p. 80)

Supplies Needed—

- Compound microscope
- Fresh leaf specimen (use one without many holes or blemishes)
- Plain glass microscope slide
- Slide coverslip
- Sharp knife or razor blade
- Water

Procedure—

1. Before you begin, make sure the leaf is clean and dry.
2. Lay it out flat on your working surface and slice about a 1" section crosswise out of the center using the knife. The cells surrounding the central vein of the leaf are what you will want to look at; so make sure you slice across a section of the vein.
3. Then, starting at one of the short ends of the strip (the edges that you did not cut), tightly roll the leaf section. Carefully make several very thin slices off one end of the roll with a razor blade or knife. This is a 'cross section' of the leaf.
4. Make a wet mount on a plain slide with the inner part of the leaf section facing up (so the inner cells are visible). You can do this by adding a drop or two of water over the leaf section and then covering it with the coverslip.
5. Look at the slide with your microscope's 10x objective to see the general structure, and higher power to see cell detail.

Notebook—

Draw what you have observed in your science notebook.

This activity was adapted from Home Science Tools' Leaf Experiment.

Seedlings: Take some time to care for your seedlings.

Lesson 18

Recall what you have learned about plant cells so far. What do you know about how a plant maintains its rigidity? Today you will learn how a plant uses that rigidity to “muscle” itself into position.

Read: *First Studies of Plant Life*, Chapter 11: How the Living Plant Uses Water to Remain Firm; pages 80-86, complete this chapter.

Activity: Cut pieces from a leafstalk.

Supplies Needed—
PART 1

- Rhubarb, called pie plant in this section, or a piece of celery
- Knife or scissors
- 2 small bowls
- Water
- Salt

PART 2 (see note below)

- Dandelion stalks
- Soft wood, such as a popsicle stick
- Stapler

Procedure—
PART 1

1. (p. 84) Using a knife or scissors, cut a piece of rhubarb stock that is six to eight inches long. Cut the ends squarely.
2. With a knife, peel a strip from one side, the entire length of the piece.
3. Try to put it in place again. Notice that it is shorter than it was before.
4. Remove another strip and another, until the entire outer surface has been removed.
5. Now try to put one of the outside strips in place again. It is now shorter than before as compared with the center piece.
6. Notice that when the stalk is covered with the outside strips, as it is when undisturbed, the outside part is pulling to shorten the stalk, and the center is pushing to lengthen it. This lengthwise pull between the inside and outside parts makes the stalk firm.

PART 2

This section of this activity requires a dandelion stems. If dandelions are not growing at this time of year, come back to this activity in the spring. I will remind you.

7. (p. 85) Split the stem of a dandelion using your fingernails and drop it into a bowl of fresh water. Why does it curl?
8. Put the strips in a bowl of salt water. What happens? Why?
9. Now remove them from the salt water and place them back in the fresh water. What happens?
10. (p. 86) Carefully cut a narrow strip from a long dandelion stem.
11. Fasten to a piece of softwood, (possibly by stapling it,) with the ends close together, as shown in figure 122 on page 86.
12. Now place it in fresh water and watch it coil. Part of it coils one way and part another way, just as a tendril does after the free end has caught hold of some place for support.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Additional Resource: Did you watch the video Plant Control (7:53 min.) during Lesson 7? If not, try to watch it now to learn how the hormones auxin, cytokinins, gibberellins, abscisic acid and ethylene help plants respond to their environment.

Seedlings: Take some time to care for your seedlings.

Lesson 19

Recall what you have learned about how a plant maintains its rigidity. In the next two lessons, you will learn how a plant gets the water it needs from its roots to the upper portions of the plant.

Read: *First Studies of Plant Life*, Chapter 12: How the Root Lifts Water in the Plant; pages 87-90, place your bookmark on page 90 just before the line, "*A simple experiment to illustrate how root pressure works.*"

Notebook: Write what you have learned in your science notebook.

Activity: Learn about root pressure in plants.

Supplies Needed—
PART 1
- Plants begun in lesson 1

PART 2 (optional)
- Fully grown balsam plant started in Lesson 7 or a similar plant with a long thick stem
- Glass or vinyl tubing, several feet long and about the same diameter as that of the stem of the plant to be used (HomeScienceTools.com, Item# CE-TUBEPLS)
- A short piece of rubber tubing that can slip over the end of the glass tube (You might search for this in a local hardware store or automotive store.)
- Wrapping cord (HomeScienceTools.com, Item# MC-STRING)
- Water
- Tall stake, such as a 3' bamboo stake
- Sharp knife

Procedure—
PART 1
1. (p. 87) Using the plant started in Lesson 1, use a sharp knife to cut off the stem near the upper end of the plant.
2. In a few minutes watch for a drop of water forming on the cut end of the stem.

PART 2 (optional)
3. (p.89) With a sharp knife, cut off the stem squarely near the ground, as shown in figure 124 on page 89.
4. Slip one end of the rubber tubing over the end of the stem and tie it tightly with the wrapping cord.
5. Then pour in a small quantity of water to keep the end of the stem moist at the start.
6. Insert one end of the glass tubing in the other end of the rubber tube, tie it tightly, and then bind the glass tubing to the stake to hold it upright.
7. Let this contraption sit for a few days in a room that is suitable for plant growth.
8. Water the soil as if the plant were growing.
9. Make observations and record the height of the water several times a day for 2-3 days.

Notebook—
In your science notebook, record your observations. Include drawings, if you would like.

Seedlings: Take some time to care for your seedlings.

This is your first reminder to complete Lessons 8-10, the Winter Lessons. If you skipped them earlier, consider going back to them now. If winter has not set in yet, then wait a few more weeks. I will remind you again.

Lesson 20

In the last lesson, you learned how powerful the root pressure is in a plant. Today you will observe how that pressure works.

Read: *First Studies of Plant Life*, Chapter 12: How the Root Lifts Water in the Plant; pages 90-93, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Learn how root pressure in plants works.

Supplies Needed—
PART 1

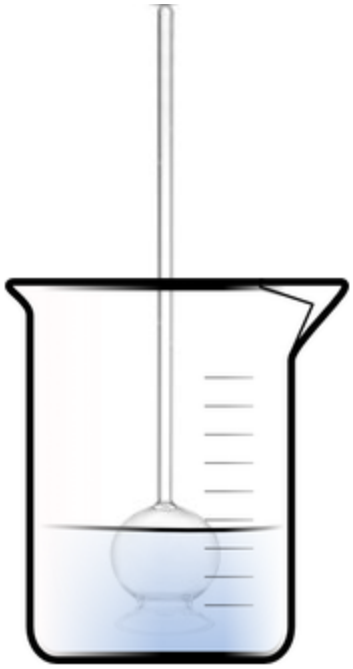
- Thistle tube (HomeScienceTools.com, Item# BE-THISGLS)
- Large jar or beaker
- Dialysis tubing (HomeScienceTools.com, Item# BE-MEMBRLG)
- String, dental floss, or the rubber bands that come with your dialysis tubing
- Water
- Molasses or sugar solution.

Part 2 (optional)

- Cork Borer (HomeScienceTools.com, Item# CE-CORBO15)
- Potato
- Sugar

Procedure—
PART 1

1. Cut a piece of dialysis tubing to fit over the large open end of a thistle tube. (approximately 8 cm)
2. Place the piece of dialysis tubing in a jar of fresh water to soak.
3. If you intend to use a sugar solution, rather than molasses, prepare it by adding sugar to a ½ cup of water until no more sugar will dissolve.
4. Fill in the interior of the tube with molasses or a concentrated sugar solution. You want the round bulb filled, but not the tube.



5. Alternatively, you could fill the thistle tube with molasses and then tie the dialysis tubing over it, while a helper holds their finger over the narrow end. Pour any extra molasses out of the short end once the dialysis tubing is in place.
6. Place the apparatus, with the bulb pointed down, in a large jar or beaker containing water.
7. To keep the thistle tube upright, you can make a small hole in a piece of plastic wrap, place the stem of the thistle tube through the hole, and then attach the plastic wrap to the jar.

PART 2 (optional)

8. Use a cork borer to cut a cylindrical piece from a potato. Bore the hole nearly through it, but not all the way.
9. Place a teaspoon of sugar in the hole.
10. Set the potato in a shallow bowl of water.
11. Observe how the sugar becomes wet as water is drawn through the potato.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Seedlings: Take some time to care for your seedlings.

Lesson 21

Recall what you have learned about the uptake of water through the roots of a plant. Today you will begin to learn what becomes of that water.

Read: *First Studies of Plant Life*, Chapter 13: How Plants Give Off Water; pages 94-98, place your bookmark on page 98 just before the line, "*The loss of water from plants.*"

Notebook: Write what you have learned in your science notebook.

Activity: Observe the loss of water by living plants.

Supplies Needed—

PART 1

- 2 large glass bowls
- Handful of fresh leaves or several leafy shoots from fresh plants
- Paper towel

PART 2 (optional — you can skip this section if you are short on time.)

- Potted plant
- Bell jar or Mason jar that will fit over the potted plant
- Plastic wrap

PART 3

- Rubber gloves
- Safety glasses
- Cobalt Chloride Test Paper (Amazon)
- If you intend to make your test paper, you will need the following items:
    - Cobalt chloride (HomeScienceTools.com, Item# CH-COCL2)
      Please note—This chemical is moderately toxic and therefore should not be inhaled, ingested, or come in contact with eyes or skin. Store it in a cool, dry, well-ventilated area, and keep it out of reach of children.
    - Water
    - Filter paper (HomeScienceTools.com, Item# CE-FILTPAP)
    - Oven set at 200°F or a hair dryer
- Potted plant
- Bell jar or Mason jar that will fit over the potted plant
- Plastic wrap
- Popsicle stick

Procedure—

PART 1

1. If the leaves are damp, then carefully dry them with a paper towel.
2. Place the leaves on a table and cover them with a glass bowl.
3. Place the other bowl next to the first bowl, in the same position, but put no leaves under it.
4. After 15-20 minutes, observe a thin film on the inner surface of the bowl.

PART 2 (optional — you can skip this section if you are short on time.)

5. Cover the pot and base of the stem with plastic wrap so no water vapor can escape.
6. Set the jar over the plant.
7. After several hours, observe a thin film on the inner surface of the jar.
8. Hold an ice cube near the outside of the jar to hasten the accumulation of the moisture into a drop of water inside the jar.

PART 3

9. Put on your safety glasses and gloves.
10. To prepare your own cobalt chloride indicator paper:
    a. Dissolve 5 g of hydrated cobalt(II) chloride in 100 cm^3 (approximately 3.5 ounces) of water
    b. Soak filter paper in this solution.
    c. Remove filter paper from the solution, drain, and dry in an oven set at 200°F, until it is blue in color. Alternatively, dry with a hair dryer.
11. Cover the pot and base of the stem with plastic wrap so no water vapor can escape.

12. Staple a piece of cobalt chloride indicator paper to a popsicle stick and place it with the plant under one of the jars.
13. Staple another piece of cobalt chloride indicator paper to a popsicle stick and place it under the other jar by itself.
14. After 15-20 minutes, observe the color of the indicator paper.
15. Save your cobalt chloride paper for the next lesson.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

For Discussion: How is the process you observed in plants similar to what humans do?

Seedlings: Take some time to care for your seedlings.

Lesson 22

In the last lesson, you learned that after absorbing water from the ground, plants release water through their leaves. This process helps plants stay cool, in the same way that perspiration keeps humans and animals cool. Today you will learn the name of this process and the structures within a plant's leaves that make it possible.

Read: *First Studies of Plant Life*, Chapter 13: How Plants Give Off Water; pages 98-104, complete this chapter.

Notebook: Write what you have learned about transpiration in your science notebook.

Activity: Observe transpiration by living plants.

Supplies Needed—
PART 1

- Seedlings from Lesson 12
- Fresh leaves from other plants

PART 2

- Cobalt chloride paper from the last lesson
- 2 panes of glass (I purchased two 4x6 glass clip picture frames from a craft store for $2.50 each, and removed the glass for this activity.)
- A dry but fresh leaf

PART 3 and 4

You are welcome to try the experiments described on pages 102 and 103 if you would like, but I have not included their instructions here.

Procedure—

PART 1

1. Pull up several of your seedlings.
2. Divide the seedlings and other leaves into two groups.
3. Immerse one group in boiling water for a few moments to kill the plants.
4. Immerse the other group in cool water, so they will also be wet at the beginning of the experiment.
5. Spread both groups on the table to dry.
6. After 24 hours, observe the two groups.

PART 2

7. Place one piece of cobalt chloride paper on a piece of glass.
8. Place a leaf on the paper.
9. Place another piece of cobalt chloride paper on the leaf.
10. Place the second piece of glass on the paper.
11. Place a light weight on top of the pile.
12. After 15-20 minutes, separate the items and observe the two pieces of cobalt chloride paper. Which side of the leaf had a greater loss of water?

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Seedlings: You can continue taking care of your seedlings if you would like. You will be prompted to plant new seeds during Lesson 28.

Lesson 23

You have learned that water enters a plant through the roots and exits through the bottom of the leaves, but what path does it take in between those two points? That is what you will learn about today.

Read: *First Studies of Plant Life*, Chapter 14: The Water Path in Plants; pages 105-108, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Observe vascular bundles in plants.

Supplies Needed—

- Celery stalks
- White carnation
- Cut a shoot from any other plants you have on hand
- Red food coloring
- Water
- Vase

Procedure—

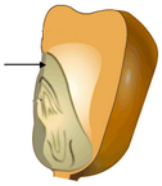
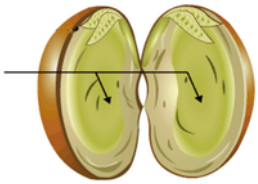
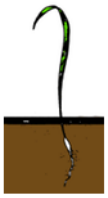
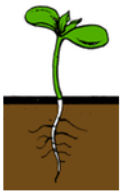
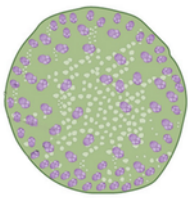
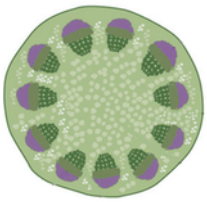
1. Combine the red food coloring and water in a vase.
2. Set the stalk of celery, the carnation, and any other plant shoots you have collected in the vase.
3. After 24 hours, the observe the shoots.
4. Cut the stalk of celery in two. Observe the pattern the vascular bundles make.
5. Cut any of the other plant stalks in half to observe the patterns of the vascular bundles.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

For Discussion: At the end of this chapter you were asked: "*What kind of venation in the leaves, and what arrangement of the vascular bundles are usually found in plants with two cotyledons? In plants with a single cotyledon? What are these two large groups of plants called?*"

Were you able to answer that question? Study the diagram on the next page to compare plants with one or two cotyledons.

Monocot	Dicot
Single Cotyledon 	Two Cotyledon 
Seedling has a Single Leaf 	Seedling has 2 Leaves 
Long Narrow Leaf Parallel Veins 	Broad Leaf Network of Veins 
Vascular Bundles Scattered 	Vascular Bundles in a Ring 
Floral Parts in Multiples of 3 	Floral Parts in Multiples of 4 or 5 

Lesson 24

When plants have been hard at work, they store up starch in their cells. Today you will have an opportunity to test various plants to see if they have been hard at work.

Read: *First Studies of Plant Life*, Chapter 15: The Living Plant Forms Starch; pages 108-114, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Test for starch.

Supplies Needed—
PART 1

- Iodine solution (HomeScienceTools.com, Item# CH-IODINE)
- Cornstarch
- 2 test tubes (HomeScienceTools.com, Item# CE-TTUBELG)
- Test tube clamp (HomeScienceTools.com, Item# CE-TUBHOLD)
- Cup of water
- Pipette (HomeScienceTools.com, Item# CE-PIPET)
- Lighter

PART 2

- Potato
- Knife
- White plate
- Lighter

PART 3

- Two plants, one must be placed in the dark and one placed on a windowsill for 24 hours before this experiment.
- Jar or beaker
- Saucepan on the stove
- Ethyl alcohol (HomeScienceTools.com, Item# UN-ETHYALC)
- Iodine solution (HomeScienceTools.com, Item# CH-IODINE)
- Tweezers (HomeScienceTools.com, Item# DE-FORPLAS)
- Wax paper or a shallow dish
- Lighter

Procedure—
PART 1

1. Add ¼ teaspoon of cornstarch to a clean, dry test tube.
2. Pour water into the test tube to a height of two inches.
3. Using a test tube clamp, hold the test tube over a flame for a few minutes to warm the water.
4. Now cool it by moving the end of the tube into a cup of water.
5. Using a pipette, add 2-3 drops of the iodine solution to the test tube.
6. Observe the color of the cornstarch solution.
7. Now hold the end of the tube over the flame again for a few minutes, but do not let it get hot.
8. The blue color disappears because the warm water extracts the iodine from the starch.
9. Cool the tube again, and the blue reappears.

PART 2

10. Cut a potato in two. On the cut surface, scrape some of the potato into a pulp with a knife.
11. Put the potato pulp on a white plate.
12. Add 2-3 drops of the iodine solution to the potato pulp.
13. Observe the color of the potato.
14. Place some of the pulp in a clean, dry test tube.
15. Pour water into the test tube to a height of two inches.
16. Using a pipette, add 2-3 drops of the iodine solution to the test tube.
17. Using a test tube clamp, hold the test tube over a flame for a few minutes to warm the water.
18. Did it behave like the cornstarch?
19. (optional) You can repeat this test with other plant materials, such as Indian corn, sweet corn, and beets.

PART 3—Only licensed laboratories can purchase the chemical solution chloral hydrate, which is needed for the experiments described on pages 112-114, so the following experiment is suggested to replace those experiments.

20. Put one of the plants in the dark and leave the other one on a windowsill.
21. After 24 hours, put some ethyl alcohol in a beaker and place that in a saucepan full of water.
22. Heat the pan until the ethyl alcohol begins to boil. Remove from the heat.
23. Remove one leaf from the plant that was kept on the windowsill. Use tweezers to dip it in the pan of hot water for 60 seconds to kill the leaf.
24. Then dip the same leaf in the ethyl alcohol until it turns almost white.
25. Set the leaf on a piece of wax paper.
26. Repeat steps 23 - 25 with the leaf that was kept in the dark for 24 hours.
27. Cover the leaves with some of the iodine solution and observe the color change.

The last activity was adapted from Home Science Tools' Photosynthesis: Testing for Starch.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Lesson 25

In the last lesson you tested leaves for the existence of starch, and you observed that starch is not present unless the leaf has been exposed to the sun. This is because the presence of starch indicates that the leaf has been hard at work and a leaf can only do its work when it is exposed to the sun. Today you will begin learning about the work that a leaf does.

Read: *First Studies of Plant Life*, Chapter 16: The Work Done By Plants in Making Starch; pages 115-120, **AND** Chapter 17: The Kind of Gas Which Plants Give Off While Making Starch; pages 121-125, complete these chapters.

Notebook: Write what you have learned in your science notebook.

Please Note: The plant needed for the experiments in the next two chapters can be difficult to sustain. The culture will come with care instructions, but because it is wise to use them within 1-2 days of arrival, you should read both chapters during this lesson, and complete the experiments from both chapters in the next lesson.

This is your second, and last, reminder to complete Lessons 8-10, the Winter Lessons. If you skipped them earlier, consider going back to them now.

Lesson 26

Recall what you learned in the last lesson. Today you will have an opportunity to try the experiments mentioned in the reading.

Read: No reading today.

Activity: Observe photosynthesis.

Please Note—This activity is not exactly the same as the one suggested in the book.

Supplies Needed—

- 8-10 sprigs of an aquatic plant, such as E. densa, E. canadensis, or Chara (Elodea, live culture, pack of 12, HomeScienceTools.com, Item# LD-ELODEA)
  Please Note—Live cultures can be difficult to sustain. The culture will come with care instructions but plan to use it within 1-2 days of arrival for best results.
- Large clear jar or beaker
- Clear container, large enough to fit the funnel inside
- 1 g Sodium Bicarbonate (HomeScienceTools.com, Item# CH-NAHC100)

- Stirring rod (HomeScienceTools.com, Item# CE-STIRROD)
- Large funnel (HomeScienceTools.com, Item# CE-FUN120G, 12 cm wide x 22 cm long) The outside diameter of the funnel stem is about 14 mm.
- Test tube (HomeScienceTools.com, Item# CE-TTUBELG)
- 20-W fluorescent light source
- Dechlorinated tap water
- Test tube stopper (HomeScienceTools.com, Item# CE-STOP0XC)
- Matches
- Wood barbecue skewer
- Safety glasses

Procedure—

PART 1

1. Place the aquatic plants in a jar of room-temperature, dechlorinated water.
2. Place one shoot with the cut end pointing up.
3. Set the jar in a window, so that they will get the brightest possible light.
4. Watch for gas bubbles to collect on the leaves and rise to the surface of the water.
5. Move the jar away from the light source and possibly even cover it with a dark cloth to shut out all light.
6. After 10-15 minutes, uncover it and observe whether the escape of the gas has ceased.
7. Move to a brightly lit window again and observe whether the bubbling starts up again.

PART 2

8. Fill the large, clear container 3/4 of the way full with the room-temperature, dechlorinated water.
9. Add 1 g of sodium bicarbonate to the water and stir until dissolved. (This is the CO2 source for the plant that is being used.)
10. Place 8-10 sprigs of the aquatic plant into the mouth of the funnel.
11. Invert the funnel and place it into the container of water, trapping the aquatic plant inside the funnel.
12. Make sure the stem of the funnel is completely submerged in the water. If it's not, add more room temperature, dechlorinated water to the container until the funnel stem is covered.
13. If your test tube is too small to fit over the end of the funnel and will instead fit inside the end of the funnel, then wrap a rubber band several times around the tube, about 1/4 of the way down the test tube. This allows the test tube to sit inside the stem of the funnel without falling all the way into it.
14. Submerge the test tube into the water in the container, filling it completely.
15. Invert the test tube in the water and place it over the stem of the funnel while it is still submerged. Make sure no air bubbles are trapped in the test tube.
16. Place a fluorescent light source near the container and turn it on.
17. Leave this setup undisturbed for 24 hours.

PART 3

18. After 24 hours, lift the test tube off the end of the funnel but do not lift the end out of the water. Reach under the water to place a stopper in the test tube that is half or fully filled with oxygen.
19. Remove it from the water and turn it right side up. It doesn't matter if there is still water in the jar.
20. Have a helper hold it for you, keeping it right side up.
21. Light the end of a wooden skewer so that it burns with a small flame. Let it burn for a moment and then blow it out so that the tip of the skewer is glowing, but there is no flame. Hold it in one hand.
22. Remove the test tube stopper and put the glowing end of the skewer into the jar.
23. The skewer should reignite, which is a positive sign for the presence of oxygen.

You have just observed photosynthesis firsthand. During this chemical reaction, light energy is required to convert carbon dioxide and water into oxygen and glucose (and later starch.)

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

This activity was adapted from Carolina: Using Aquatic Plants to Demonstrate Photosynthesis

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Lesson 27

Plants are known for their ability to convert carbon dioxide into oxygen through photosynthesis. You've studied this process in the last few lessons. But they also do another kind of work—all living things get the energy they need to live from a chemical reaction called respiration. Respiration is the reverse of photosynthesis.

The word equation for photosynthesis is:

carbon dioxide + water (+ light energy) → **glucose + oxygen**

The word equation for respiration is:

glucose + oxygen → **carbon dioxide + water (+ energy)**

All organisms, plant or animal, take in oxygen and give off carbon dioxide as long as they are alive. Today you will have an opportunity to observe respiration in germinating seeds.

Read: *First Studies of Plant Life*, Chapter 18: How Plants Breath; pages 126-133, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Observe respiration.

Supplies Needed—
PART 1
- 1 cup of pea seeds
- Water
- 3 large jars or beakers
- Plastic wrap
- Matches
- Wood barbecue skewer

PART 2
- Rubber gloves
- Safety glasses
- 1 teaspoon calcium hydroxide, $Ca(OH)_2$ (the book recommends barium carbonate, but you will use lime water in the HS Chemistry Study Guide, so using it now will save on supplies.)
- 2-quart glass jar with lid
- 4 cups distilled water

PART 3
- Limewater
- Germinating seeds prepared in part 1
- 3 small jars or beakers
- Drinking straw

Procedure—
PART 1
1. Soak a cup of pea seeds for 24-hours in water.
2. Remove them from the water and put them in a large jar or beaker.
3. Cover the jar tightly with a piece of plastic wrap.
4. Prepare a second jar of germinating peas that you can use in Part 3 of this lesson.
5. Cover an empty jar with plastic wrap in the same way.
6. Keep the jars in a moderately warm room for 24-hours.
7. Light the end of a wooden skewer so that it is burning with a small flame, and then carefully hold it in one hand away from anything flammable, such as yourself or someone else, as you follow through with the next step.

8. With your other hand, pull back the plastic wrap from one jar of peas and thrust the lighted end of the skewer into the jar. The flame should be extinguished due to the prevalence of carbon dioxide in the jar.
9. Light the wooden skewer again.
10. Pull back the plastic wrap from your empty jar and thrust the lighted end of the skewer into the jar. The flame should not be extinguished this time.

PART 2—Prepare limewater

11. Put on your safety glasses and gloves.
12. Put 1 teaspoon of calcium hydroxide in a clean 2-quart jar. (You may use a larger jar if you would like, up to 1 gallon in size, but still only use 1 teaspoon of calcium hydroxide.
13. Fill the jar with distilled water.
14. Cover tightly with a lid.
15. Shake the jar vigorously for 1-2 minutes.
16. Let the jar stand undisturbed.
17. After 24-hours, gently pour only the clear solution of calcium hydroxide ($Ca(OH)_2$, (also known as limewater) through a clean coffee filter. Be careful not to stir up the sediment at the bottom of the jar. You only want to use the clear solution from the top.
18. Your limewater should be colorless. If it is not, then you will need to delay this experiment in order to let your limewater stand undisturbed again. Later today or tomorrow, when the liquid is clear, repeat step 17 above.

PART 3

19. Pour 1 cup of the limewater into a small jar.
20. Pull back the plastic wrap from the second jar of peas and pour only the invisible gas out of the jar into the jar of lime water. Not the peas.
21. Observe the color change of the liquid.
22. Pour some fresh lime water down the inside of the jar of peas and onto the peas.
23. Notice the white substance that forms.
24. Pour 1 cup of the limewater into a separate small jar.
25. Place a straw into the liquid, and then exhale into the straw.
26. Note the same color change of the liquid.

PART 4

You are welcome to try the experiment described on pages 128-130 if you would like, but I have not included their instructions here.

The two most vital processes that occur in all green plants are photosynthesis and respiration. Plants respire all the time, whether it is dark or light, but they only photosynthesise when they are in the light.

Conditions	Photosynthesis vs. Respiration	Overall result
Dark	Respiration No photosynthesis	Oxygen is taken in Carbon dioxide is given out
Dim light	Photosynthesis rate equals respiration rate	Neither gas is taken in or given out, as each cancels the other out
Bright light	Photosynthesis rate greater than respiration rate	Carbon dioxide is taken in Oxygen is given out

In this experiment, you were able to observe respiration because the start of germination places substantial energy demands on the seed. Cellular respiration rates increase to accommodate the cell-building activities required to break open the seed and produce the initial root and stem structures.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Lesson 28

When it comes to playing with plants, there's no greater pleasure than touching the leaves of the touch-me-not plant, also known as the sensitive plant or Mimosa pudica, and watching them recoil, shrink, and "go to sleep."

Read: *First Studies of Plant Life*, Chapter 19: The Sensitive Plant; pages 132-135, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: Prepare new seedlings for Lesson 31.

Supplies Needed—

- Masking tape
- Marker
- 8 small flower pots or yogurt cups with holes in the bottom
- Saucers to put under the pots or a baking dish to set them all in
- Seed-starting mix
- 4 seeds of each: bean, pumpkin, sunflower, and buckwheat
- 4 boxes which a pot of growing seedling can fit into, or 1 large box that 4 pots of growing seedling can fit into

Procedure—

1. Use masking tape and a marker to label each pot or yogurt container with the name of the seed you will plant in it.
2. Fill the pots with a seed-starting mix to about one inch from the top.
3. Set the pots on saucers and moisten the mix with water.
4. Place three or four seeds in each pot and cover the seeds with about half an inch of soil.
5. Sprinkle with water.
6. Place one pot of each type of plant under a box to exclude all light.
7. Place the other pots in a south-facing window. (If you don't have a bright south-facing window, then use a grow light. They should be exposed to this light 14 hours a day.)
8. Keep the soil of all eight pots moist but not soggy.
9. Twice a week for three weeks, observe the plants. Measure their growth and make drawings in your science notebook of each plant's progress.
10. You will experiment with these seedlings in Lesson 31.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Optional Activities:

- Purchase a small plant. (Logee's Plants for Home and Garden)
- Purchase seeds to grow your own plants. This annual might make a nice gift. (Amazon)
- Watch a video and learn more about the plant. (ABC Science)

Lesson 29

In the last lesson, you read about the sensitive plant and its reaction to touch. Today you will learn about the reaction of all plants to light.

Read: *First Studies of Plant Life*, Chapter 20: The Behaviour of Plants Toward Light; pages 136-149, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Please Note: There were several experiments suggested in this chapter. You will have an opportunity to try them during lesson 31 when your seedlings have grown a bit more.

Nature Walk: When you take a nature walk this week, notice the position of the leaves on several different plants.

- Is each leaf in a position that allows it to receive an abundance of light?
- Are the leaves you observe standing so that the upper surface receives the light directly from above? Or do the leaves, and even the growing end of the stem, turn toward the sun.
- If the leaves are in a cluster or a "mosaic," does each leaf take a definite place, so it will be in a good position to get the light? Is there any difference in the size of any part of the leaf which enables it to take a better position in the "mosaic"?
- Notice the trees on the edge of a forest. Are there more and longer branches on the side away from the other trees?

Lesson 28 Seedlings: Take some time to care for the seedlings you started in Lesson 28.

Lesson 30

Do you recall what you learned about tendrils in Lesson 18? Today you will learn more about climbing plants.

Read: *First Studies of Plant Life*, Chapter 21: The Behavior of Climbing Plants; pages 150-155, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Activity: This is your reminder to complete Lessons 18, PART 2, the dandelion experiment. If you skipped that activity earlier, consider going back to it now.

Additional Resource: You might enjoy watching a video showing a time lapse of a climbing plant: Twining motion of vines (0:42 min.) or Growing cardinal vine (2:28 min.)

Nature Walk: When you take a nature walk this week, look for a climbing plant. Over the course of several days or weeks, watch the stems and see how they coil. You may cut several shoots and place them in a jar of water to observe. If you look at it several times over the course of a day, you will see that the stem swings slowly around in circles.

Lesson 28 Seedlings: Take some time to care for the seedlings you started in Lesson 28.

Lesson 31

The parts of a plant can be divided into two groups: sexual reproductive parts and vegetative parts. You have learned about the vegetative parts already, which includes leaves, roots, leaves, and stems. Now you will begin to learn about the sexual reproductive parts, involved in the production of seed. They include flowers, fruit, and seeds.

Read: *First Studies of Plant Life*, Chapter 22: The Behavior of Flowers; pages 156-167, complete this chapter.

Notebook: Draw a buttercup and label its parts: petal and corolla, sepal and calyx, stamen, pistil, and stigma.

Activity: Observe various flowers.

Supplies Needed—

- Buttercups or other flowers, specimens at various stages, or watch over time
- Pumpkin or squash flowers, both a specimen that has a round enlargement on the flower stalk and one that does not. (It's possible that pumpkin flowers will not be available yet. If that is the case, try to remember to take a close look at them this summer.)
- Sunflower, purchased from a florist
- Teasel flowers, if you find some growing near you

Procedure—

1. Look at a buttercup or another flower:
    a. Are the parts all wrapped up snugly and covered over by the sepals? Recall the work of the sepals at this stage.
    b. What is the work of the petals?
    c. Look for bees visiting flowers. What is the work of the bees?
    d. Watch some flowers day after day until the seed is formed. Alternatively, look at several flowers from the same plant, from young to old. Notice the changes that take place in the flowers. The sepals fall away, petals wither and fall, stamens wither, pistils grow larger, and seeds ripen.
2. Look at a pumpkin or squash flower:
    a. Can you see a difference between the buttercup and the pumpkin flower? Where are the petals?
    b. How many points are there on the rim of the urn-shaped corolla?
    c. Below the corolla, you see five green pointed leaf-like parts arranged in the form of a crown. What does each one of these parts represent?
    d. Look for the stamens.

    e. Are all the flowers alike on the outside? Do you see some with three blunt projections on the end of the column and a round enlargement on the flower stalk? (The enlargement is the lower part of the joined pistils.) Do you see some with no enlargement on the flower stalk, but having columns bearing pollen grains? (Stamens joined.)
    f. If you can get a pumpkin, cut one in half crosswise, and observe the great number of seeds. Can you tell how many parts are joined in this compound pistil which finally makes a pumpkin?
3. Look at a sunflower:
    a. Notice that the showy head is not a single flower, but rather, made up of many flowers. Can you distinguish the two kinds of florets? (Ray flowers on the edge and tubular flowers, also called disk flowers, in the center.)
    b. Cut off the head of one sunflower and put the stem in a vase of water to observe the disk flowers for several days.
    c. If you find a daisy, goldenrod, aster, or black-eyed Susan, compare it with the sunflower.
4. Look at the teasel flower.
    a. Watch for teasel flowers growing near you. If you find some, observe them as they progress through various stages.

Notebook—

In your science notebook, record your observations. Include drawings, if you would like.

Lesson 28 Seedlings: Take some time to care for the seedlings you started in Lesson 28.

Lesson 32

You planted seeds in Lesson 28 and read about several experiments to try with those seedlings in Lesson 29. They should be big enough now, so after today's reading from the text, you will have an opportunity to try those experiments for yourself.

Read: *First Studies of Plant Life*, Chapter 23: How Fruits Are Formed; pages 168-175, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Additional Resource: You might enjoy watching the video Pear flower to fruit swelling time lapse filmed over 8 weeks (1:10 min.) or a digital representation of Fruit Development (0:41 min.)

Nature Walk: If possible, visit a berry patch to observe blackberries and raspberries. See if you can tell what part of the flower makes the fruit. Sketch their shapes in your nature study notebook or your science notebook. Also, the next time you eat an apple, cut it in half crosswise and examine its chambers.

Activity: Compare seedlings grown in the light or in the dark. (Planted in Lesson 28.)

Supplies Needed—

- Seedlings started in lesson 28
- 1 box, large enough to fit a seedling pot inside
- Scissors

Procedure—

1. Look at the seedlings and consider the following questions:
    a. Do the stems grow more rapidly in the light or in the dark?
    b. Compare the leaves of the plants grown in the dark to those grown in the light.
    c. How does the buckwheat differ from the pumpkin and sunflower?
    d. Can the seedlings grown in the dark support their own weight?
    e. With your fingers, crush the stem of a seedling grown in the dark and one grown in the light. Do you detect a difference in their firmness?
2. Have the cotyledons just expanded? If so, try the following experiment:
    a. Cover a pot of sunflower seeds that have been grown in the light.
    b. Uncover it near midday after a day or two.
    c. Observe the cotyledons as they reopen.
    d. Examine the cotyledons at night, when it is dark, and again in the morning light.
    e. Observe the cotyledons of the plants grown in the dark. Notice the way the stems pushed their way out from between the cotyledons.
    f. When the plant was first uncovered, was it in a drooping position? Did it draw up after it had been in the light for a while?
3. Test the seedlings sensitivity to light:
    a. Place some seedlings in a window, or if they have already been in a window, turn them, so they are bent away from the window.
    b. Cut off the cotyledon from some of the stems.
    c. After an hour, notice whether they have turned so the cotyledons, or where the cotyledon used to be, face the light coming through the window.

Notebook—

Record your observations in your science notebook. Include drawings, if you would like.

Lesson 33

What's the difference between a flower and a weed? There is no biological difference between the two. It is just a matter of judgment. Any plant that a gardener feels is unwelcome and annoying, is labeled a weed. But what your parents think is a weed, you might think is a flower. So when you are asked to weed the "flower" beds, you might want to ask for clarification on what to pull up!

Read: *First Studies of Plant Life*, Chapter 24: How Plants Scatter Their Seeds; pages 176-184, complete this chapter.

Notebook: Write what you have learned in your science notebook.

Nature Walk: As school ends, and a long break ensues, keep plant seeds and how they travel, in mind. Watch for plants that burst and scatter their seeds, seeds with a soft tuft of hairs on the end that easily blow in the wind, seeds with wing-like expansions on the side, and seeds with bristles all around to catch on pants and animal fur. Sketch some of the seeds you find in your nature study notebook or your science notebook.
