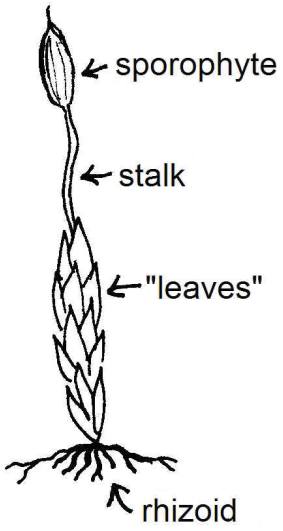
LESSON 3: NON-VASCULAR PLANTS

LEVEL ONE

Now let's tackle one of those categories on page 15: the ***non-vascular*** plants. These plants *don't* have whatever "vascular" is. The word vascular comes from the Latin word "vascularis," meaning a vessel or duct that has some kind of fluid flowing through it. So vascular plants have vessels running through them and non-vascular plants don't.

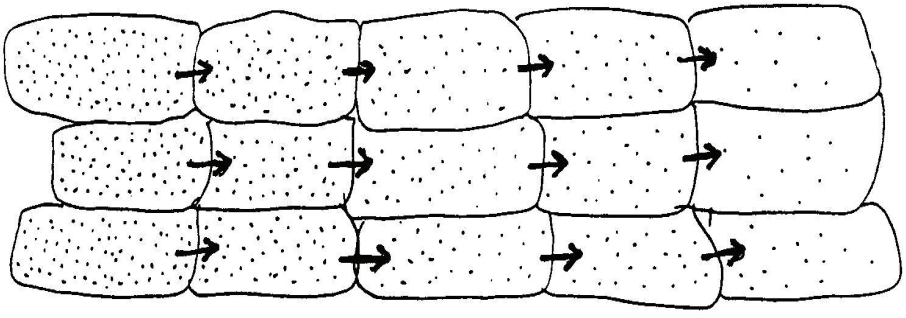
Non-vascular plants are basically ***mosses*** and make up the division called ***bryophytes*** *(bry-o-fites)*. The word bryophyte comes from two Greek words: "bryon," meaning "moss," and "phyton" meaning "plant." (A related type of plant, the **liverwort**, is usually put into this category also. If you want to know more about liverworts, read level 2.) This lesson is on moss, that soft green stuff you find growing around the roots of trees or between bricks on your shady patio. Mosses are a bit strange and deserve their own category because they don't have seeds and they don't have proper roots or stems or leaves. (But they are still plants because they use photosynthesis.) If we want to talk about the parts of a moss plant, we can't really talk about their leaves because technically they don't have leaves. But they do have green things that look like leaves and these green things do carry on photosynthesis, so we'll just use the word "leaves" but with quote marks around it, indicating that we all know that mosses don't *really* have leaves. For roots, we'll say "rhizoids." The rhizoids' job is to anchor the moss to the ground. They don't take up water like the roots of vascular plants do. (We'll talk about that sporophyte on the next page. Sorry to leave you in suspense for a few minutes...)



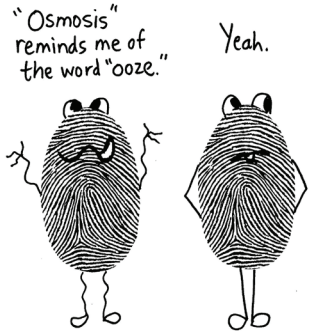
(Add some green to this boring black and white drawing!)

A vascular system is a system of "pipes" that allows plants to pump water to all parts of the plant, no matter how tall or wide the plant grows. Non-vascular plants don't have this system. The only way the parts of a non-vascular plant can get water is to absorb it right into their cells when it rains or when dew falls. For this reason, non-vascular plants must stay very small and must be in places where it stays damp. Where have you seen mosses growing? If they are in your lawn, they certainly aren't out where the sun shines a lot. They'll be in shady spots such as around the bases of large trees Some mosses can tolerate a bit of sun, but very few can survive all-day sun.

Cells that are not on the outside surface get their water by a process called ***osmosis***. This is a strange-sounding name for a simple idea. Osmosis is when a lot of something moves to a place where there is less of it. In a crowded building this might mean people moving from crowded rooms to empty rooms. Once all the rooms are equally filled, people will stop moving. In plants, osmosis means water molecules moving from cells that have lots of water to cells that have less water.



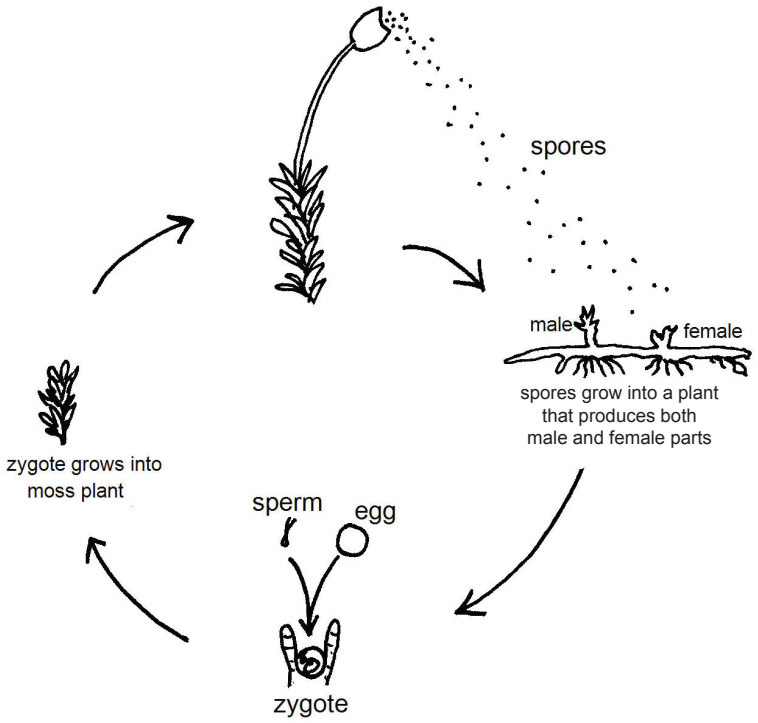
moist cells less moist cell dry cells



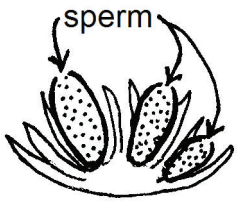
Mosses have a very strange life cycle. Like many forms of life, they produce male and female cells. However, they also produce spores like mushrooms do. They alternate back and forth between producing spores and producing male and female cells. This cycle is called ***alternation of generations***.

The moss plant (technically called the ***gametophyte*** *[gah-mee-toe-fite]* stage) grows a stalk out the top, and at the top of that stalk a ***sporophyte*** appears. The sporophyte produces... spores, of course. The sporophyte bursts open and all the spores float down and land somewhere in the nearby vicinity. It's best for the moss if they land just a little bit away, but not too much. If they land too close, the bed of moss won't grow larger, but if they land too far away, it might be out in an area that isn't suitable for moss to grow (too sunny, for example). When the spores land, they grow into a green mat-like thing that then starts to produce little male and female parts. The male parts produce sperm and the female parts produce eggs, just like in animals. Then the egg and sperm must join together to form a ***zygote***. (The word "zygote" comes from the Greek word "zygotos," meaning "joined together.")

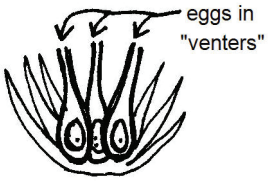
The egg can't move at all. It just sits there and waits for the sperm. The sperm can swim a very short distance, but they need water to swim in. When it rains, the sperm get picked up by the water droplets and splashed around, hopefully landing near enough to the eggs that they are only a short swim away. The sperm then swim down the venters and join with the eggs, creating a zygote that will be able to grow into a new moss plant. Then that new moss plant grows a sporophyte that produces spores. Then the spores grow into a plant that produces male and female cells, which form a zygote which grows into a moss plant, which produces a sporophyte...



Close-ups of male and female parts:



MALE



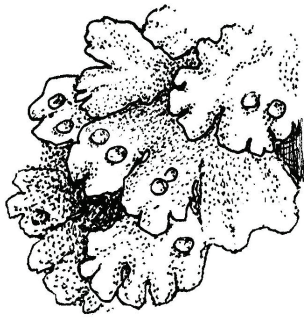
FEMALE

<u>ACTIVITY</u>: WATCH AN ANIMATION OF THE MOSS LIFE CYCLE

An animation of the information on this page is posted on the Botany playlist at www.YouTube.com/TheBasementWorkshop. There will be some new words we haven't learned here, but don't worry about it--just enjoy the show. The pictures are very helpful in understanding this cycle.

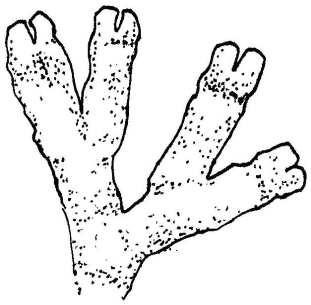
LEVEL TWO

Another main type of bryophyte is the ***liverwort***. The ending "-wort" comes from medieval times in Europe when it meant "healing herb." (You'll see the word "wort" in many plant names.) It was once thought that the liverwort was a healing herb that could help your liver. Perhaps medieval people saw some resemblance between the shape of the liverwort and the shape of a liver. Or maybe not. No one knows.

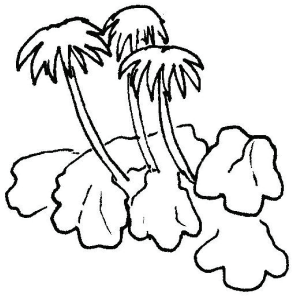


A "thallose" liverwort with gemma cups

A "leafy" liverwort



A weird-looking liverwort!



These umbrella things are male and female parts

Liverworts are found all over the world, even at the edges of deserts and arctic tundras, but they can't survive in the heart of the deserts and tundras because there isn't enough water. Like mosses, liverworts have non-vascular systems that depend on osmosis. They need to be close to the ground and be kept moist as much as possible. The liverworts that live in extreme climates must have special adaptations that allow them to be able to survive. (You'll learn about adaptations in lesson 7.) These adaptations (perhaps extra-skinny "leaves" that keep moisture in, or sporophytes that can survive drought) are not present in most mosses.

Like the mosses, the liverworts have ***alternation of generations***. (It's similar enough to mosses that it's not worth drawing another diagram.) They produce sporophytes that then produce a ***protonema*** that looks like either a mass of stringy green fibers, or they make a tiny, flat green thing called a ***thallus***. (The word thallus comes from the Greek word "thallos" meaning "young shoot or twig.") The thallus produces male and female parts that produce sperm and eggs that join together whenever there is enough rain to allow the sperm to swim. You can see in the drawing above (on the far right) that in some liverworts the male and female parts look like fancy umbrellas.

Liverworts also have a way of reproducing without the male and female cells. They can form a type of bud called a ***gemma*** (the "g" is soft, like in the word "gem"). A gemma can be a single cell or a group of cells that break off from the main plant and are then capable of growing into a whole new plant. These gemma are often found in gemma cups, little cup-like things on the tops of the liverwort "leaves." You can see some gemma cups in the first drawing above (on the left). The little gemma cells sit in the cups and wait for it to rain. Then the raindrops splash the gemma out onto other surfaces, away from the "parent" plant, where the gemma can grow into an "adult" plant. For some really nice pictures of gemmae (that's the plural) and gemmae cups, type the keyword "gemma" into an Internet image search. There are some beautiful pictures out there!

ACTIVITY 1: WATCH SOME SHORT VIDEOS OF LIVERWORTS (WOW--HOW EXCITING!)

There are some spectacular videos of liverworts and gemma cups on the Botany playlist at www.YouTube.com/TheBasementWorkshop.

ACTIVITY 2: REVIEW SOME OF THE WORDS WE JUST LEARNED

Answer these 10 questions. Then go down below to the STUPID PLANT JOKE and write the letters that correspond to each number. (Hey, it's better than having quiz or test, so don't complain!)

1) When a sperm fertilizes an egg, the result is a ___ ___ ___ ___ ___ ___
(25, 21, 8)

2) The process by which the cells in a moss plant receive water: ___ ___ ___ ___ ___ ___ ___
(3, 11)

3) The part at the top of the stalk on a moss plant: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(4, 9, 28, 31)

4) Mosses and liverworts are members of this group: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(23, 27, 30)

5) This flat, green thing produces male and female parts: ___ ___ ___ ___ ___ ___ ___
(5, 17)

6) A regular moss plant, the type we are used to seeing, is technically called this stage:

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(18, 29, 19)

7) This type of cell is NOT a reproductive cell, but nevertheless it can split off from a liverwort and grow into a new liverwort: ___ ___ ___ ___ ___
(16, 1)

8) The medieval word for "healing herb" is ___ ___ ___ ___
(10, 24)

9) Mosses and liverworts do NOT have this system: ___ ___ ___ ___ ___ ___ ___ ___
(7, 22, 15)

10) The life cycle of mosses and liverworts is called ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(13, 12, 2)

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(26, 14, 6, 20)

A STUPID PLANT JOKE

What do you call it when a ___ ___ ___ ___ and a ___ ___ ___ ___ ___ ___ ___ ___ ___ have an
(1, 2, 3, 4; 5, 6, 7, 8, 9, 10, 11, 12, 13)

___ ___ ___ ___ ___ ___ ___ ___ ? ___ ___ ___ ___ ___ - ___ ___ ___ ___ ___!
(14, 15, 16, 17, 18, 19, 20, 21; 22; 23, 24, 25, 26; 27, 28, 29, 30, 31)

ACTIVITY 3: WATCH A 30-MINUTE DOCUMENTARY ON BRYOPHYTE SCIENTISTS

Some scientists spend their whole life studying mosses and liverworts. Meet some Belgian botanists who have cataloged hundreds of species of European bryophytes and listen to them explain why it is so important both to study them and to conserve (protect) them. The video is posted on the Botany playlist.

NOTE: Half of the film is in French, but there are subtitles written in English.

LESSON 1

Level 1

Activity 5: (Crossword puzzle)

ACROSS: 1) chloroplasts 2) membrane 3) daughters 4) photosynthesis 5) elongation 6) energy 7) water 8) nucleus 9) chlorophyll 10) carbon dioxide

DOWN: 1) light 2) mitosis 3) eat 4) sugar 5) oxygen 6) DNA 7) vacuole 8) respiration 9) wall

Activity 6: Compare your drawing to the one in the chapter

Activity 7: 1)D 2)A 3)B 4)F 5)H 6)C 7)E 8)G

Level 2

Activity 1: 1)J 2)I 3)B 4)F 5)G 6)D 7)A 8)H 9)C 10)E

Activity 2: 1)B 2)F 3)C 4)G 5)A 6)D 7)H 8)E

Activity 3: 1) Answers will vary. 2) ATP 3) no 4) respiration 5) no 6) split water molecules 7) light 8) carbon dioxide and water 9) the P 10) light phase 11) RuDP 12) there would be no photosynthesis 13) no 14) magnesium

LESSON 2

Level 1

Activity 1: 1) Muehlenberg 2) Engelmann 3) Michaux 4) Kellogg

Activity 3: 1)C 2)G 3)B 4)H 5)I 6)F 7)J 8)E 9)A 10)D

Activity 4: Answers will vary.

Level 2

Activity 1: 1) H 2) A 3) I 4) D 5) C 6) F 7) J 8) B 9) G 10) E

Activity 3: 1) China, 2) Italy, 3) Virginia, 4) India, 5) Tasmania, 6) Brazil, 7) Australia

Activity 4: 1) acorn squash (same species), 2) tomato (yam is monocot), 3) chestnut (both are Fagales)

LESSON 3

Level 2

Activity 2: 1) zygote 2) osmosis 3) sporophyte 4) bryophyte 5) thallus 6) gametophyte 7) gemma 8) wort 9) vascular 10) alternation of generations

Stupid plant joke missing words: moss, liverwort, argument, a, bryo-phyte (sounds like “fight”)

LESSON 4

Level 1

Activity 3: The monocots are: corn, yucca, grass, orchid, tulip. The dicots are: oak, geranium, nasturtium, mint.

Activity 4: Vascular plants have a system of [pipes/tubes] that deliver water to their cells. They are made of two types of cells: [xylem] and [phloem]. The [xylem] tubes take water up from the roots and into the [leaves]. This process is called [transpiration]. (The reason this process works is because of the electrical attraction between [water] molecules.) The [phloem] tubes carry water that has sugars in it. This sugary water can go either up or [down] depending on where it is needed. In northern climates, sap in maple trees rises from [the roots] up into the leaves. If you put a tube into the tree you can catch some of this sap and make [maple syrup] from it.

Most vascular plants make [seeds] but a few do not, such as the fern. Most vascular plants are either monocots or [dicots]. The monocots have one [seed leaf] when they first sprout, whereas the [dicots] have two. The monocots have [parallel] veins in their leaves. The [dicots] have veins that resemble a palm shape.

The central part of a stem is called the [pith]. The outer cells are the epidermis. Just inside the epidermis is a layer of cells called the [cortex], In trees, the old, dead phloem cells become the bark.

LESSON 3

1) WATCH OSMOSIS IN ACTION

You will need:

- A strip of paper towel
- A small bowl of water

Cut a strip of paper towel that is about 1/4 inch wide (half a centimeter) and 3 inches long (8 centimeters). Hold the strip of paper towel over the water so that the end you aren't holding is just touching the surface of the water. Hold it there and wait and watch. Do you see the water gradually moving up the paper towel? What is fighting gravity and causing the water to move up? (Osmosis!)

2) WATCH A "HAIR CAP" MOSS OPEN AND CLOSE

You will need:

- A hair cap moss (They prefer sandy soil and are often found by the sides of roads.)
- Water
- Hair dryer or fan

When conditions are dry, a hair cap moss folds up and looks like this:

When conditions are moist, a hair cap moss opens its "leaves" like this:

If the hair cap moss is closed when you find it, open it up by putting water on it. If it is closed, gently dry it with a hair dryer or fan. If you use a hair dryer, be careful not to burn the moss. Once it is dry, open it again by putting water on it.

NOTE: There is a short video on the hair cap moss posted on the Botany playlist.

3) BUILD A "MOSS-A-RARIUM" (A TERRARIUM THAT FEATURES MOSS)

Back in the late 1800s, there was a gardening fad where people collected mosses and made special wooden outdoor terrariums for them. They were called "mosseries." You don't see mosseries much any more, but mosses are still considered an important part of outdoor landscaping, and mosses are almost essential for indoor terrariums.

You can easily put together a small terrarium using mosses and other natural objects you find on a walk through the woods. You will need some kind of glass or ceramic dish. You can use a glass bowl (such as a fish bowl or small aquarium) or you can use some other interesting dish you have around the house. Collect some small mounds of moss from places around your neighborhood. Take just a small amount of moss--only the amount you need. (Moss does grow back, but it takes a while.) Also collect some interesting rocks or pebbles, gnarled sticks, small plants or anything else you would like to add to your terrarium for artistic effect. Put some dirt on the bottom of the container, then arrange your moss, pressing it down firmly into the dirt. (Dirt that is the same or similar to what the moss was originally growing in might work best.) Arrange the other objects in and around the moss. You might want to use the Internet to find pictures of terrariums. You might get some great ideas from seeing what other people have done. Don't forget to keep your "mossararium" moist.

If you and your parents or friends would like to establish an outdoor moss garden, the Botany playlist has a video showing how to do this. The film was made by a professional gardener who specializes in mosses.