

# LAB 14 – The Plant Kingdom

## **Objectives**

1. Examine examples of various taxa within the plant kingdom.
2. Dissect multiple flowers to identify and examine their anatomical structures and functions in angiosperm reproduction.
3. Examine a variety of fruits and seeds to identify various modes of seed dispersal.

## **Overview**

The importance of plants for life on earth cannot be overstated. Plants along with photosynthetic microbes produce all of the oxygen gas (O<sub>2</sub>) in our atmosphere. Essentially all of the food consumed by human beings and other organisms is dependent on photosynthetic organisms such as plants. This includes not only plant foods such as fruits, vegetables and grains, but meat, eggs and dairy as well, which depend on animals that are fed plant foods. Wood and paper are also derived from plants as are many medicines. Given the obvious importance of plants, we will close the laboratory portion of this course by reviewing the important features of plants and their reproduction. You will first learn about various groups in the **Kingdom Plantae**, and then focus on flowering plant structure and reproduction.

## **Part 1: A Tour of Kingdom Plantae**

Kingdom **Plantae** includes multi-cellular organisms that produce their own biological macromolecules through photosynthesis using light as an energy source. With very few exceptions, all plants are **photoautotrophic** (“light” “self” “feeding”). Plants are essential for the survival many different organisms. All animals and fungi, for example, depend on plants for their food and much of the oxygen they need for cellular respiration (photosynthetic algae in the kingdom Protista actually produce over half of the oxygen in our atmosphere). Without plants, Earth’s biosphere would consist mainly of bacteria, archaea and a few protista. An effective way to approach the more than 280,000 species of plants that have been identified is to examine the chronological history of plants which reveals milestones in the evolution of their structure.

### **Non-vascular plants**

The very first plant species to evolve about 500 million years ago were those that could transport materials throughout their body without the need for special tubes or vessels (Latin = *vascule*). These are called the non-vascular plants or **bryophytes** (“moss-like” “plant”). There are three phyla of bryophytes: Hepatophyta (liverworts), Bryophyta (moss) and Anthocerophyta (hornworts). Note that the term bryophyte is used as the general word for all non-vascular plants whereas Bryophyta refers to the non-vascular plants that include mosses.

The sexual reproductive cycle of non-vascular plants is fascinating. None of these plants use seeds for reproduction. A mature non-vascular plant has an organ called a **sporangium** to produce haploid (1n) spores. A male spore will grow into a structure with a reproductive organ called an **antheridium**. A female spore will grow into a reproductive organ called an **archegonium**. The antheridium will produce haploid (1n) sperm cells while the archegonium will produce a haploid (1n) egg. The sperm will fertilize the egg within the archegonium leading to the formation of a single cell called a **zygote**. It is the diploid (2n) zygote that will undergo mitosis to produce a new plant.

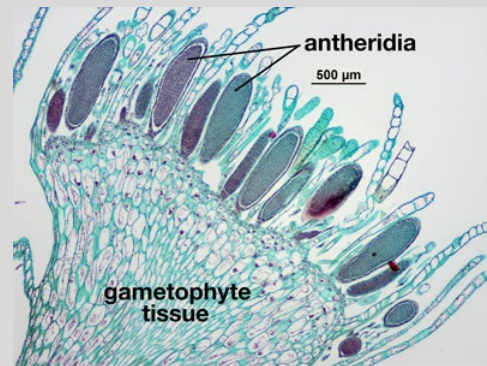


### **Exercise 1A – Observing whole non-vascular plants**

1. Go to the table that has examples of non-vascular plants on display.
2. Select one of the species and draw a picture of it in the circle provided on your worksheet.

### **Exercise 1B – Observing the general structure and antheridia of moss**

1. Get a prepared slide of *Mnium* (a common moss) with antheridia.
2. Use the compound light microscope to examine the general structure and identify the antheridia.
3. Draw an example of what you observe in the circle provided on your worksheet.



***Mnium* antheridial head, c.s.**

## **Seedless Vascular Plants**

By 425 million years ago, in order to grow larger, plants evolved special internal tube-like vessels called **xylem** (to transport water and minerals) and **phloem** (to transport sugars produced by photosynthesis). We will examine these plant vessels in the next section. There are two phyla of seedless vascular plants: **Lycophytes** and **Pterophytes**.

As detailed above, the seedless vascular plants demonstrate a similar reproductive and life cycle as the bryophytes. They have **sporangia** that produce spores that lead to the production of haploid (1n) sperm and egg. Upon fertilization, a zygote is formed from which the new plant will emerge.

In this investigation, you will observe the simplest forms of Pterophytes called ferns and horsetails. You may be able to observe the sporangia - small brown spots - on the underside surface of the leaves of the fern.

### **Exercise 1C – Observing seedless vascular plants**

1. Go to the table that has examples of seedless plants of two Pterophytes, **fern** and **horsetail**.
2. Draw an example of what you observe in the circle provided on your worksheet. If present, you will observe the sporangia on the fern mentioned above.



## **Seed-bearing Vascular Plants**

350 million years ago, the vascular plants evolved to have a new mode of reproduction that included a new structure called a **seed**. In this life cycle and reproductive pattern, plants form male gametes (sex cells) in grains of **pollen** and female gametes called **ova** (eggs). These evolutionary adaptations allowed plants to more easily survive in harsh terrestrial environments and widen the dispersal of their offspring. Another adaptive feature was the evolution of leaves with a waxy **cuticle** that prevents too much water loss.

The first seed-bearing vascular plants to appear in the fossil record were the **gymnosperms** (“naked” “seed”). There are four phyla in this group: **Ginkos**, **Cycads**, **Gnetophytes** and **Conifers**. Most people are familiar with everyday conifers (cone trees) such as pines, redwoods and cedars. The largest organisms on the planet are the giant sequoias (*Sequoiadendron giganteum*) while the oldest organisms are the bristlecone pine (genus *Pinus*) which can be up to 2,500 years old.



### **Exercise 1D – Observing gymnosperms**

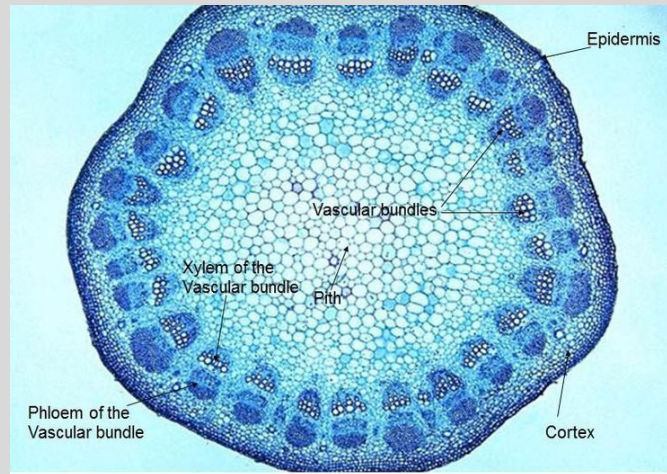
1. Examine the photographic samples and live samples of Cycads and Ginkgos. Draw the structure of a cycad and the leaf of a ginkgo on your worksheet.
2. Examine the **female cone** of a pine (the type of cone you are familiar with) and observe the seeds. Examine the **male cone** of a pine and observe the pollen. Describe the differences between female and male pine cones on your worksheet.
3. Examine photographic samples and descriptions of *Welwitschia*, *Gnetum*, and *Ephedra* in the phylum Gnetophyta, and compare their characteristics with conifers on your worksheet.

The most recently evolved group of plants are the flowering plants or **angiosperms** (“covered” “seeds”). This name is derived from the fact that in almost all species, the seeds are present in a **fruit**, which is technically the developed ovary of the plant. The angiosperms belong to a single phylum called **Anthophyta**.

### **Exercise 1E – Xylem and phloem in angiosperms**











In the next exercise, you will examine a cross-section through a stem similar to the one shown below to observe the **xylem** and **phloem** vessels (“**vascules**”) of a typical angiosperm.

1. Obtain a prepared slide of a cross-section through the stem of a typical angiosperm, an alfalfa (*Medicago*) stem.
2. Use the compound light microscope to examine the xylem and phloem.
3. Draw a picture of what you observe in the circle provided on your worksheet. Label the phloem and xylem in your picture.



### **Monocots vs Dicots**

Angiosperms can be further divided into two subgroups – **monocots** and **dicots** – based on the characteristics shown below:

<b>Monocots</b>				
				
One cotyledon	Veins usually parallel	Vascular bundles usually complexly arranged	Fibrous root system	Floral parts usually in multiples of three
Embryos	Leaf venation	Stems	Roots	Flowers
<b>Dicots</b>				
				
Two cotyledons	Veins usually netlike	Vascular bundles usually arranged in ring	Taproot usually present	Floral parts usually in multiples of four or five

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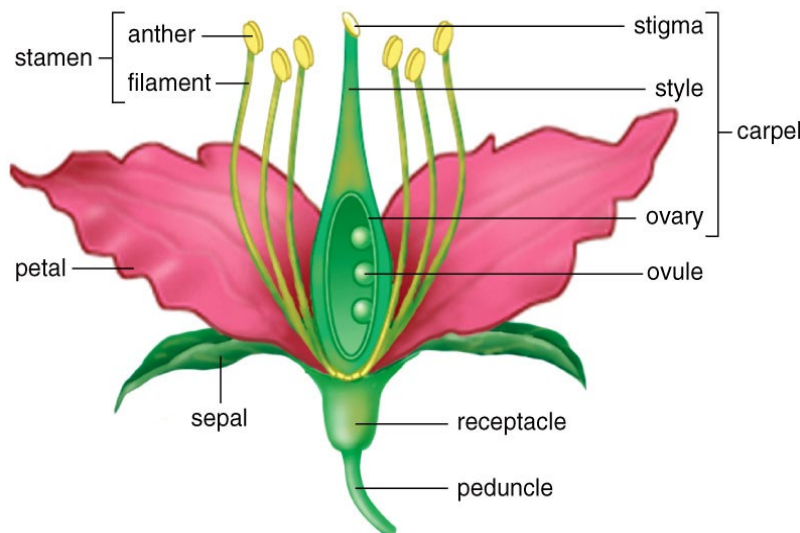
## Exercise 1F – Monocot & dicot characteristics

1. Refer to the diagram on the previous to fill out the chart on your worksheet.

## Part 2: Angiosperm Reproduction

### Flowers

The dominant group of terrestrial plants is the flowering plants or angiosperms. Angiosperms reproduce sexually by producing egg and sperm in their reproductive structures – flowers. Referring to the diagram below, let us review the various flower structures and their roles in reproduction:



**PEDUNCLE & RECEPTACLE** – These are support structures at the base of the flower.

**SEPAL** – Sepals collectively form the **calyx** which is the outermost layer that protects the developing flower when it is a bud. Sepals are usually, but not always, green.

**PETAL** – The petals collectively form the **corolla** of a flower which attracts **pollinators** (e.g., birds, bats and insects). Petals vary widely in color and shape depending on the pollinator.

**STAMEN** – Stamens are the male reproductive structures and consist of a long, slender **filament** supporting an **anther**. The anther is where **pollen grains**, the **male gametophytes**, form. Pollen grains contain sperm and tube cells which are necessary for fertilization.

**CARPEL** – The carpel is the female reproductive structure consisting of a **stigma** to which pollen adheres, a slender **style**, and a swollen **ovary** at its base. Within the ovary are one or more **ovules** containing the **female gametophyte**, the **embryo sac**, which contains an egg.

Many flowers contain all of these parts and referred to as **complete flowers**. Some flowers lack one part or another and are thus **incomplete flowers**.

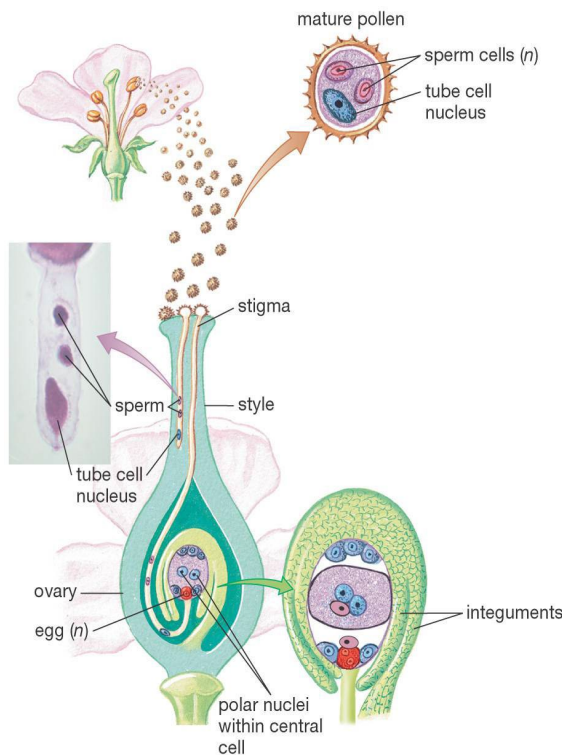
### **Exercise 2A – Flower dissection**

*NOTE: The following should be done individually, not as a group.*

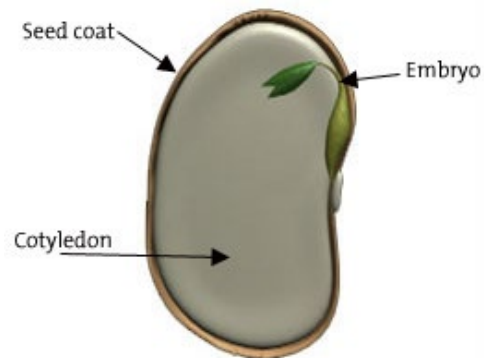
1. Obtain 3 different flowers from the front of the lab. **If available, you may also collect flowers from outside or in the garden.** If the name of a flower is indicated then write the name on your worksheet.
2. On each flower, identify and carefully remove one of each of the following parts: sepal, petal, stamen, carpel. Use tweezers, scissors and the dissection microscope as necessary.
3. Use transparent tape to fix each part to your worksheet.
4. Based on flower and leaf structure, determine whether each flower is from a monocot or dicot plant.

### **Seeds**

Pollinators such as “the birds and the bees” inadvertently transfer pollen from one flower to the stigma of another as they feed. This is called **pollination** and will result in the tube cell within a pollen grain forming a **pollen tube**. The pollen tube will pass through the style and penetrate an ovule allowing the sperm access to the embryo sac and the egg inside.



Once **fertilization** is accomplished (union of egg and sperm), a plant embryo will briefly develop and then be packaged in a **seed**. In addition to the plant embryo, a seed contains nutrient material called **endosperm**, and a seed coat that forms from the wall of the ovule. The embryo within the seed will have one or two **cotyledons** which absorb nutrients from the endosperm for the embryo.



The wall of the ovary will develop into a fruit which will help disperse the seed.

In the next exercise you will dissect two different seeds and identify each seed structure.

### **Exercise 2B – Seed dissection**

*NOTE: The following should be done in groups of 2 or 3 (i.e., two groups per table).*

1. Open the shell of your peanut (at your lab bench). The shell is derived from the **ovary** wall.
2. Remove the brown, paper-like coating of a peanut. This is the seed coat which is derived from the wall of the **ovule**.
3. Split the peanut in half. Each half is a **cotyledon** which has absorbed endosperm (nutrients) from within the seed.
4. Attached at the base of one of the cotyledons you will find the plant embryo. Each person in your group should examine the embryo with the dissecting microscope and draw the embryo on your worksheet.
5. Repeat this process with the string bean at your lab bench, keeping in mind that the pod is analogous to the peanut shell.
6. Answer the corresponding questions on your worksheet.

### **Seed Dispersal**

For a plant to successfully reproduce and spread, its seeds must be dispersed in some way. This is the function of **fruits** – to facilitate seed dispersal. Fruits develop from the ovary wall and surround the seed(s), aiding in its dispersal in a variety of ways:

- **Wind** – fruits carried on the wind as seen with dandelions
- **Water** – fruits that float such as coconuts
- **Animals** – edible fruits eaten by animals or hitchhiker fruits that stick to animals
- **Mechanical Dispersal** – fruits that “fling” seeds when dried such as peas or tamarind

In the next exercise you will examine various fruits to determine the mode of seed dispersal.

### **Exercise 2C – Fruits & seed dispersal**

1. Examine the various fruits on the side counter.
2. Identify one or more fruits with seeds dispersed by the following methods, and write the name of the fruit(s) in the corresponding space on your worksheet:

WIND  
WATER  
ANIMAL (edible)  
ANIMAL (hitchhiker)  
MECHANICAL DISPERSAL (e.g., flung from pods when they dry out)

***Before you leave, please make sure your table is clean, organized, and contains all supplies listed below so that the next lab will be ready to begin. Thank you!***

### **SUPPLY LIST**

- Model of a flower
- Lens paper
- Petri dish for flower dissection
- Dissecting kit: small green tray with scissors, forceps, dissecting needles, single edged razor or scalpel and large petri dish lid to dissect on

***Also PLEASE be sure to do the following before you leave:***

- Throw away any leftover dissection fragments and clean dissecting instruments, tray.
- Return prepared slides to their correct tray.
- Return stereoscopic microscopes to the cupboard from which they came.
- Compound microscopes should be stored as follows:
  - turn off power
  - secure the power cord to the back of the microscope
  - set to the lowest magnification (4X objective)
  - cover and place “arm out” in the cupboard at your table



## Laboratory 14 worksheet – The Plant Kingdom

Name: \_\_\_\_\_ Group: \_\_\_\_\_

Date: \_\_\_\_\_

### **Exercise 1A – Observing whole non-vascular plants**

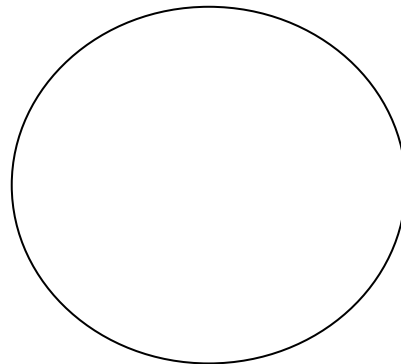
Draw an example below of a typical non-vascular plant that is on display. Write the name of the plant under your drawing.

Non-vascular plant name \_\_\_\_\_

### **Exercise 1B – Observing the general structure and antheridia of moss**

Draw a picture of a cross-section through a simple moss *Mnium* showing the antheridia.

Cross section through *Mnium* with antheridia



total magnification \_\_\_\_\_

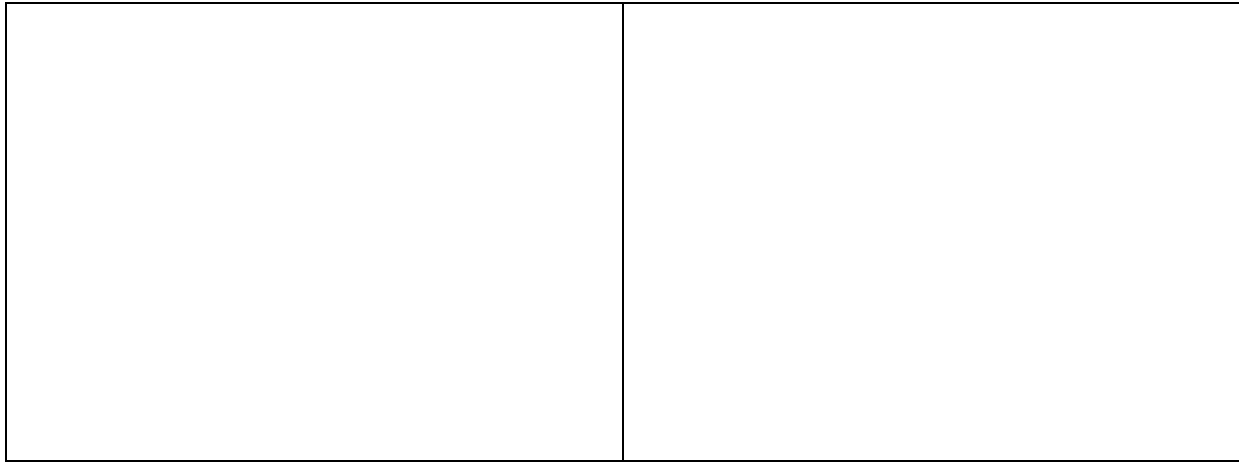
### **Exercise 1C – Observing seedless vascular plants**

In the space below, draw an example of a typical seedless vascular plant that is on display. Write the name of the plant under your drawing.

Seedless vascular plant name \_\_\_\_\_

**Exercise 1D – Observing gymnosperms**

*As directed in the laboratory manual, draw a picture of the following items:*



**Structure of a Cycad**

**Leaf of a Ginkgo**

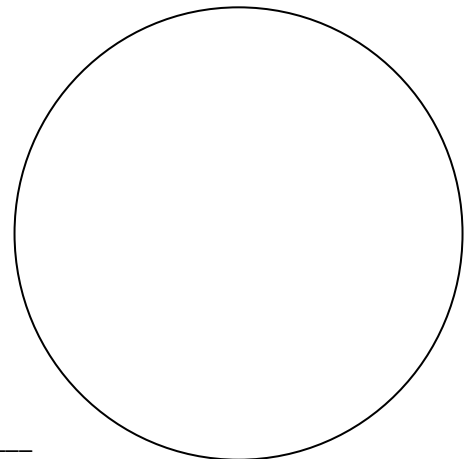
- Describe the differences between female cones and male cones of a pine tree.
  
- Observe a species of Gnetophyta on display in the lab and indicate how its overall appearance differs from a conifer such as a pine tree.

**Species of Gnetophyta observed** \_\_\_\_\_

**Exercise 1E – Xylem and phloem in angiosperms**

*Draw a cross section through an alfalfa (Medicago) stem and label the phloem and xylem on your drawing.*

**Cross section through alfalfa stem with phloem and xylem**



*total magnification* \_\_\_\_\_

**Exercise 1F – Monocot & dicot characteristics**

*Complete the chart below distinguishing each characteristic between monocots and dicots.*

Characteristic	MONOCOT	DICOT
<b>Flower structure</b>		
<b>Root structure</b>		
<b>Leaf structure</b>		
<b>Stem structure</b>		
<b>Seed structure</b>		

**Exercise 2A – Flower dissection**

*Examine 3 different flowers under a dissecting microscope. For each flower specimen, indicate the flower's name and tape (with transparent tape) each dissected part in the appropriate space.*

Flower 1 - \_\_\_\_\_

Flower 2 - \_\_\_\_\_

Flower 3 - \_\_\_\_\_

Sepal:

Sepal:

Sepal:

Petal:

Petal:

Petal:

Stamen:

Stamen:

Stamen:

Carpel:

Carpel:

Carpel:

*Monocot or Dicot?*

*Monocot or Dicot?*

*Monocot or Dicot?*

## **Exercise 2B – Seed dissection**

*Draw and label the peanut and string bean embryos from your dissected seeds below:*

### **Peanut**

### **String Bean**

- Which part of a peanut is the seed coat?
- Which part of a string bean is the seed coat?
- Which part of a peanut is the fruit?
- Which part of a string bean is the fruit?
- Are peanut and string bean plants monocots or dicots? (circle one)

## **Exercise 2C – Fruits & seed dispersal**

*Indicate one or more fruits that disperse seeds in the following ways:*

WIND

WATER

ANIMAL (edible)

ANIMAL (hitchhiker)

MECHANICAL DISPERSAL