Name: _____ Date/Lab time: _____

Lab 8: VASCULAR PLANTS: Flowering, Seed-Bearing Vascular Plants (Angiosperms)

Supplies:

Flowers (Monocot and Dicot)	Germinating pollen culture (Lily pollen tubes)
Slides of anther cross section.	Imbibed bean and corn
Slides of female gametophytes (embryo sacs) within ovules of a flower	Assorted fruits, pea pods, green beans, apple, orange etc.
Lily embryo slide	Iodine stain

Vocabulary to know:
Anther, Bracts, Locule, Class, Cotyledons, Double fertilization, Endosperm, Filament, Fruit, Microgametophyte , Microspores, Monocotyledonae, Ovary , Ovules, Petals, Pistil , Pollen grains, Sepals, Stamens, Stigma, Style

LAB SYNOPSIS:

We will examine the morphology and anatomy of the reproductive organ of the flowering plants.
Compare dicot vs. monocot flower morphology.
Anatomy of the male part of a flower vs. the female part of the flower.
Seed- the mature ovule within the flower ovary.
Fruit- the mature ovary of a flower.

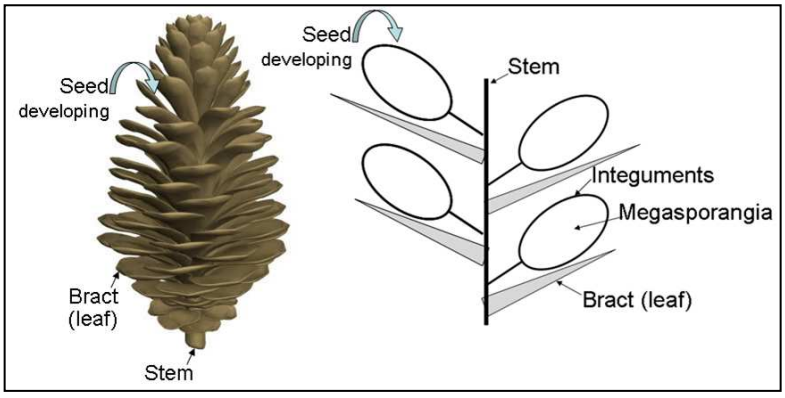
Introduction:

Kingdom Plantae
Phylum Magnoliophyta- Commonly known as Angiosperms

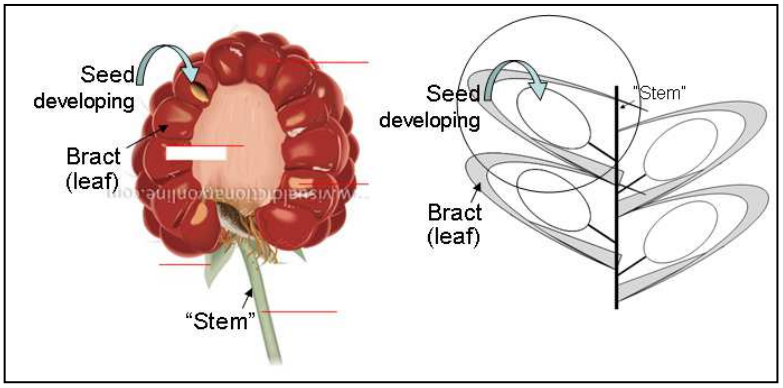
What is a fruit?

The term angiosperm literally means "enclosed" "seed". The "enclosure" refers to the fact that the seeds of angiosperms are surrounded by the fruit. Gymnosperm seeds, like pine, are not surrounded by fruit tissue.

Imagine a pine seed cone (see figure to right). The hard scales are modified leaves (bracts). The axis of the bracts is where seeds develop. Note that the bract does not enclose the seed. The seeds are naked. The term gymnosperm literally means "naked" "seed".



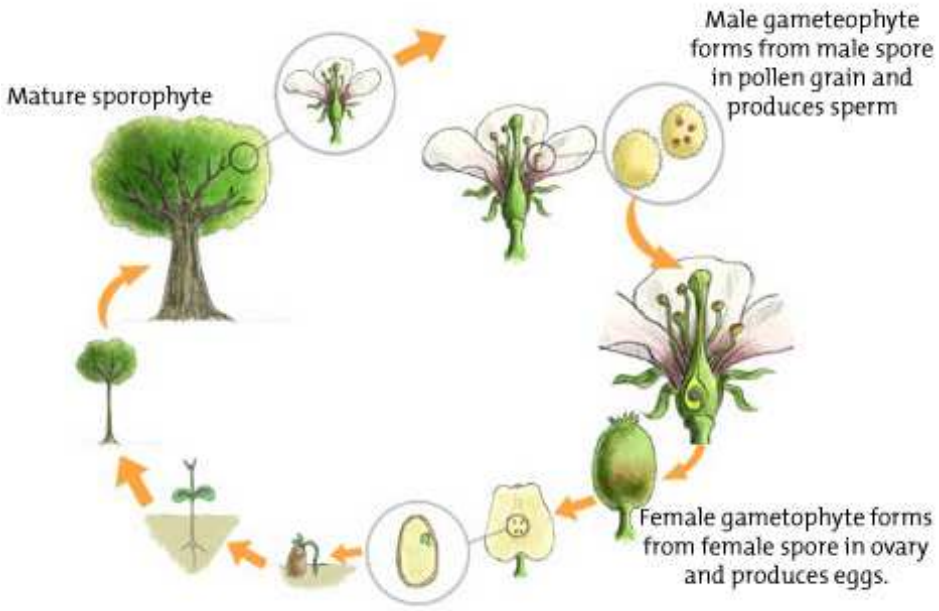
Now imagine a raspberry (see figure to right). A raspberry is a compound fruit. Each little fruitlet forms from a separate ovary and contains one seed. Each of these fruitlets is formed from a modified leaf completely surrounding and enclosing the developing seed. The seeds are not naked.



We will examine fruits in more details below.

Alternation of generations- life cycle that alternates between a multicellular diploid and multicellular haploid phase.

The details of alternation of generation will be covered in lecture. Circle parts identified as you proceed through the lab.



Sporophyte- "spore-bearing-plant". The multicellular diploid (2n) generation of the plant. In angiosperms, within the sporophyte's flowers, meiosis will give rise to 2 types of haploid spores (male spores and a female spore).

Gametophyte- "gamete- bearing-plant". The multicellular haploid (1n) generation of the plant. In angiosperms, within the sporophyte's flowers, the 2 types of haploid spores will undergo cell division, each giving rise to multicellular haploid gametophytes (male spores → male gametophytes & female spore → female gametophyte).

Gametes- sperm and egg.
Male Gametophyte- AKA pollen. In angiosperms the mature pollen contains 3 cells. 1 is a tube cell, 2 are sperm. Both sperm take part in "double fertilization" see below.
Female Gametophyte- In angiosperms the mature pollen contains 8 cells. 1 will develop into an egg.

In angiosperms, the sporophyte is the large plant you see (whole trees, bushes, grasses, etc.). The gametophytes are found within the flowers and are microscopic.

PROCEDURE- Monocot Vs. Dicots Flower Morphology

Kingdom Plantae
Phylum Magnoliophyta- Commonly known as Angiosperms
Class- Magnoliopsida (dicots)
Class- Liliopsida (monocots)

There are 2 major Classes of flowering plants, Magnoliopsida and Liliopsida, commonly called dicots and monocots. These 2 classes differ in the morphology and anatomy of their stems, roots and leaves (review your plant forms table). Dicots also differ from monocots in the morphology of their reproductive structure (flowers). Dicot flower parts usually occur in multiples of 4s or 5s, while those of monocots usually occur in multiples of 3s.

1. **Flower classification**. Examine the flowers available in lab. Identify those that are in the Class Magnoliopsida and those in the Class Liliopsida.

PROCEDURE- The Reproductive Structure of Angiosperms. <u>The Flower</u>. (Observation and Drawing)

1. Choose one of the simple complete flowers available. Using the dissection microscope (if necessary), locate and examine each of the following structures: (note, not all flowers have all these structures).

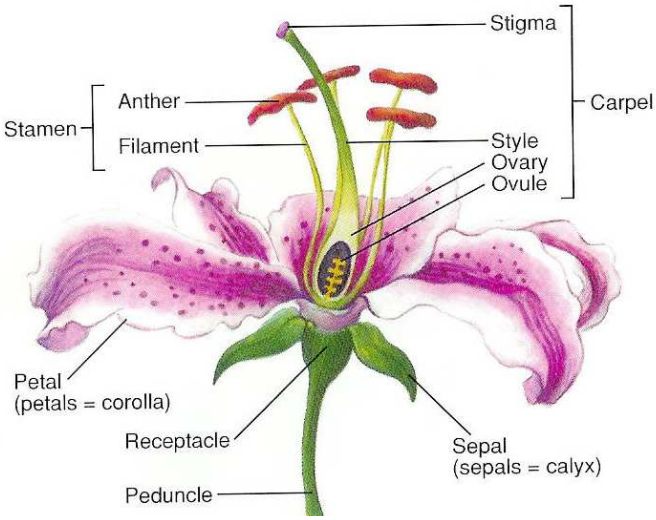


Fig. Reproductive structures of the lily

BRACTS- some flowers (not all) have specialized leaves associated with the flower. These floral leaves are called bracts. Some bracts are showy (the red "petals" of *Poinsettia* and the white "petals" of dogwood are actually bracts- the true flower parts of these species are actually quite small). (see examples in lab or in your atlas).

SEPALS (plural- calyx). The sepals surround the flower base and are the outermost structures of the flower; they are typically green, although they may be large, showy and colorful. In some cases sepals may be absent.

PETALS (plural- corolla). The petals are internal to the sepals, and may be green, white or highly colored. In addition to color, petals may also have structures producing fragrance or otherwise associated with enticing pollinators. Sugar producing cells called <u>nectaries</u> are often associated with petals.

STAMENS (male reproductive structure) (plural- androecium). The stamens are structures internal to the petals. Each stamen typically consists of a stalk (the **filament**) and a terminal sporangium (the **anther**), which when mature contains the pollen grains. The **pollen grains** are the **microgametophyte** (multicellular haploid portion of the angiosperm life cycle) and contain 3 cells (discussed below).

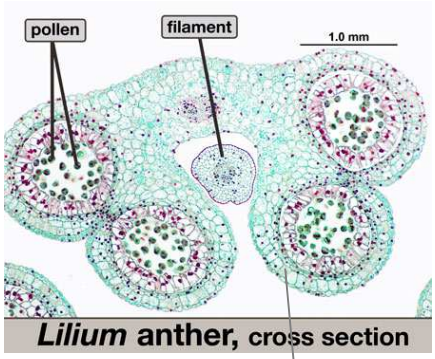
PISTIL (the whole female reproductive structure) (plural- gymnasium). The pistil is found in the center of the flower. The pistil is divided into the **stigma** (the tip where pollen lands), the **style** (pistil stalk) and the **ovary** (where **ovules** are located). Within the ovules is found the megagametophyte. The ovary is the structure that typically develops into the fruit. The pistil may be longitudinally divided into fused locule**s** (e.g. each orange wedge is a locule).

Some Additional Flower Terms: <u>can you recognize these in the flowers available</u>?
Inflorescence- multiple flowers grouped together
Complete flower- a flower that has <u>all</u> flower parts
Incomplete flower- lack one or more flower part
Perfect flower- hermaphroditic (has both androecium and gynoecium) not necessarily complete
Imperfect flower- has either androecium **<u>or</u>** gynoecium, not both
Dioecious - ("2 houses") a plant that has separate male and female flowers on different plants. Humans are dioecious. (English holly is dioecious)
Monoecious - ("1 house") a plant that has separate male and female flowers on the same plant. (pumpkin is monoecious)
Hermaphroditic- a plant that has perfect flowers.

2. Draw a complete flower labeling flower parts.

PROCEDURE- The Male Part of the Flower. Anthers (Male Spores and the Male Gametophyte). (Observation and Drawing)

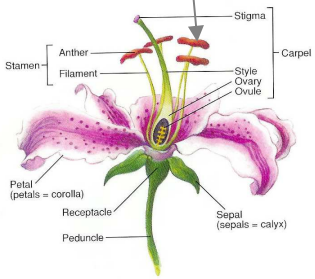
We will be making microscopic examinations of the reproductive parts of lily flowers. Review the structures of a lily flowers available in lab.



1. **Young lily anther**. Examine prepared slides of a young lily anther. Locate the cells that will divide to form the **male spores**. The **male** spores will divide mitotically forming the small multicellular male gametophyte (only 3 cells) termed pollen grains.

2. **Older lily anther.** For a more detailed examination of the pollen grain, obtain prepared slides showing a section through an older lily anther. Locate the numerous maturing pollen grains. Examine at 400x.

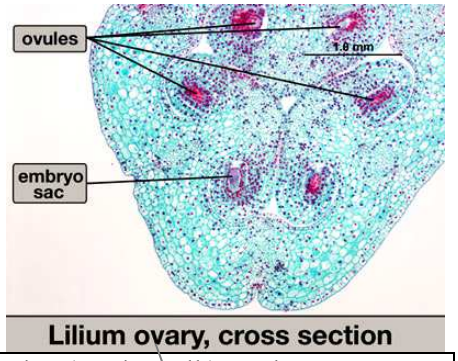
Draw a cross sectional view of a prepared slide of older lily anther at 400x magnification (do we have this slide?). Label male gametophyte (pollen grains). Or look at pollen tube slide.



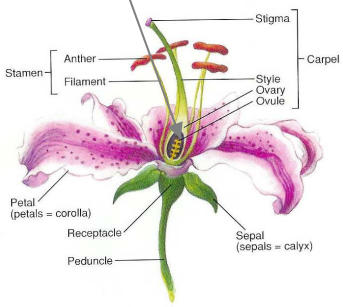
3. **Fresh pollen**. Remove an anther from one of the available flowers, crush it into a drop of water on a microscope slide, add a cover slip and examine it under the microscope. Pollen structure differs between groups of plants and has been used for forensic, anthropology, ecology and evolutionary studies.

PROCEDURE- The Female Part of the Flower. Ovaries, Ovules, and the Female Gametophyte. (Observation and Drawing)

1. **Lily embryo sac.** Examine a series of demonstration slides that show stages in the development of female lily gametophytes (embryo sacs) within ovules of a flower. Your instructor will go through this slide series with you, explaining in detail various aspects of development of the female gametophyte:)



Draw a 400x view of prepared slide of ovule. Label the following: Funiculus (ovule stalk), embryo sac, integuments- (the layer of tissue surrounding the embryo sac) and the micropyle (the opening in the integument through which pollen tube grows). Note any cells associated with the female gametophyte.



Double fertilization- both sperm within pollen (the male gametophyte) are involved in fertilization.

Embryo- the result of one sperm fertilizing one egg. This will result in the new seed diploid embryo and the new sporophyte generation.

Endosperm- the result of one sperm fertilizing 2 female gametophyte nuclei. This will result in triploid nutritive tissue for the developing embryo.

PROCEDURE- Double Fertilization: The Embryo and Endosperm. (Observation and Drawing)

1. If available, examine under the dissecting scope the cultures of germinating pollen and observe the pollen tubes (or look at prepared slide of lily pollen tubes). If possible, locate the two male gametes (sperm nuclei) and the tube nuclei. Sketch below.

2. **Lily older embryo sac.** Look at a slide showing the embryo (fertilized egg and early embryogenesis) of lily. Notice the storage tissue surrounding the developing embryo. This food storage (the endosperm) is the result of fertilization of a second sperm cell with two nuclei from the female gametophyte of lily two nuclei.

What is a seed?

The seeds of both gymnosperms and angiosperms are made up of 3 things:

Embryo- the result of sperm fertilizing an egg. Will develop into the new plant.

Nutritive tissue- either starchy endosperm, or stored nutrients in embryo's cotyledons.

Seed coat- the outer most layer of seed. Forms from the ovule's integument.

Fruits and Seeds

Seeds develop from ovules inside the flower ovary. The mature ovary forms the fruit. The fruit can provide several functions. It encloses and protects the developing seed. Fruits are often green undergoing photosynthesis to help feed itself and the seeds. Fruits can also functions in seed dispersal. Fruits can aid in seed dispersal by 1. Being edible (seeds often pass through your digestive systems easily), 2. By being barbed (such that they catch in animal fur and your shoe laces), 3. Being "winged" (thus the wind carries them) 4. etc. etc. etc.

Fruits can get quite large. Sometimes 1000's of times the size of the original ovary. Pumpkin flower ovaries are only about 1 inch long.

PROCEDURE- Examine fruits.

1. Look at the garden pea pod (fruit), of *Pisum* or of green bean, *Phaseolus vulgaris*. Notice that it is formed from a single fused modified leaf. In this case, the pistil is made up of just <u>one</u> locule. Recall a locule is a pistil chamber (each wedge of an orange is a locule). Open up the pod and look at the seed inside.

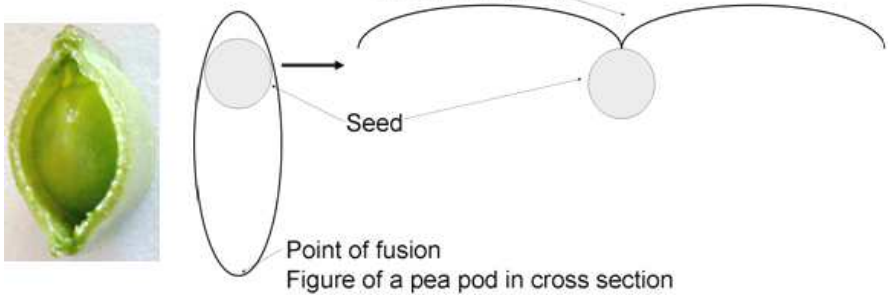


Figure of a pea pod in cross section

2. Examine cross sections of an apple, banana, orange, squash etc. <u>How many locules make up each of these fruits</u>? <u>How many seeds per locule</u>? If there are too many seeds to count say "many"

Fruit	Number of locules	Number of seeds per locule (one, few, many)

There are a multitude of fruit types and categories. How many can you identify? You may need your textbook or the internet to help.

<u>Types of fruits:</u>

Achene, Berry, Capsule, Caryopsis, Drupe, Follicle, Hesperidium, Legume, Loment, Nut, Pome, Samara, Schizocarp, Silique, Syconium

<u>Categories of fruits"</u>

Accessory fruit, Simple fruit, Aggregate fruit, Multiple fruit, Dehiscent fruit

3. Examine some of fruits and their seeds available. Seeds contain an outer seed coat, nutritive tissue and an embryo. Angiosperms have double fertilization. One of these fertilization events results in the

embryo, the other in nutritive endosperm. Some mature seeds lack endosperm having used it up during embryogenesis. These types of seeds typically store their energy reserves in their cotyledons (embryonic leaves).

PROCEDURE- Seed germination and the sporophyte generation of angiosperms (observations and drawings)

The phylum Magnoliophyta is divided into two major Classes: **Liliopsida,** the monocots ("one" "cotyledon") and **Magnoliosida,** the dicots ("two" "cotyledon"). A cotyledon is an embryonic leaf.

We will compare the seeds of corn (a monocot) vs. bean (a dicot) to observe these differences in the seed structure of these two classes

Examine the imbibed corn and bean seeds available.

1. **Starch in a dicot seed.** The mature seed of bean does not contain endosperm. During early embryo development (embryogenesis), the bean embryo uses up the endosperm and stores oils and proteins in its 2 large cotyledons. Pull apart the 2 cotyledons (Dicotyledons) and locate the bean embryo. Under the dissection scope, note that the embryo contains a young root and shoot. Note the appearance of leaves on the shoot. Make a longitudinal cut of the bean cotyledon and stain with iodine. You will need to cut the cotyledon to get the stain into the tissue.

Does bean show any presence of starch? If so, where?

2. **Starch in a monocot seed.** Cut a corn (a Monocot) seed (actually a caryopsis fruit) longitudinally and stain it with iodine (iodine stains starch black). Observe the stained corn seed under the dissection scope. Starch is contained in the endosperm of corn and some other specie's seeds. Note: The single cotyledon of corn and other monocots is challenging to observe within a seed.

Draw below the results of the staining. Label the endosperm, seed coat and embryo.

Plant forms table

We have been examining many parts of the reproductive organs of flowering plants. We will compare these and other structures to those in found in other groups of plants including the gymnosperms, pterophytes and the bryophytes. To aid in understanding these differences, record your observation into your plants form table

Questions

1. What flower parts are considered to be modified leaves?

2. What is a seed? What are the 3 components of seed?

3. It takes only one pollen grain for fertilization and development of an embryo and food reserves in an angiosperm, yet a single flower produces often thousands of times as many pollen grains as ovules. Why are such large numbers of pollen grains necessary?