VASCULAR PLANT MORPHOLOGY
LABORATORY 12

Flowering Plants, the Angiosperms

Floral Morphology and Reproduction

This laboratory will serve to introduce you to the subject of the morphology of the flowers of angiosperms. The range of flora structure present among the flowering plants is staggering. In general, each family has a distinct floral type, and most genera are also fairly distinct in their floral structure. Numerous modifications of the basic parts of the flower are present in various plants, and this occurring in combination with fusion of parts, various forms of parts, and reduction of parts, allows for almost limitless variation in floral morphology.

In the first portion of the laboratory you will study typical dicot and monocot flowers to familiarize yourself with the basic floral parts and associated terminology. The second portion of the laboratory will deal with the range of floral structure. This latter part is designed to let you attempt to interpret the flora structures, and to appreciate some of the major types of floral types. You should view this latter part of the laboratory as an introduction to the diversity of floral types. You will not be held responsible for the specific names of the examples.

Flower of a Typical Dicot and Monocot

Obtain flowers and note the nature, number, and arrangements of the parts. In the dicot: sepals, petals, stamens, pistil(s). Note the anther and narrow filament of the stamens, and the stigma(s), style(s) and ovary of the pistil. What do the terms corolla and calyx refer to? What is the perianth?

Carefully cut a median longitudinal section of the flowers. Note the level at which the parts are borne upon the receptacle. Sketch the dicot flower as it appears in longitudinal section.

Carefully cut a transverse section of the ovary and locate the ovary wall, vascular supplies, locule(s), and ovule(s). Does the ovary appear to be simple (a simple pistil or one carpel) or compound? The term placenta is used to denote the region(s) where the ovules are attached to the ovary wall. Diagram the transverse section of the Dicot ovary.

Repeat the process of examination and dissection for the Monocot flower. Note the differences in numbers of parts and the general petal-like appearance of the entire perianth. Sketch the monocot flower longitudinal section and diagram the ovary transverse section.

Position of Ovary

The position of the ovary with respect to the other floral parts varies greatly in flowers. The superior or hypogenous condition is one in which the ovary lies above the level of insertion of the accessory and stamen parts of the flower on the receptacle. The opposite extreme is the inferior or epigynous ovary which lies below the level of insertion of the other floral parts. An intermediate condition is the half-inferior, or perigynous condition. In this case, the ovary is partly above and partly beneath the base of the perianth and stamens.

Which of these conditions were present in the typical flowers you have just finished studying?

Examples of these three conditions are present in the laboratory. Examine the flowers you are directed to, to note the differences.

Morphological Variability, Floral Evolution

Examine the selection of flowers in the laboratory. These illustrate numerous features of floral structure.

Pollination Modes

Pollination modes (e.g., wind, insect, humming bird) greatly influence the type of floral features one finds. As you examine the various flowers note the following sets of correlated characters:

wind pollinated **-** reduced size, lack of brilliant color, lack of odor, reduced accessory organs, prominent anthers and stigma

insect pollinated **-** large size, odoriferous, bright colors, form reflecting role of insect in pollination, special placement of parts, especially the essential ones to insure pollen transfer.

The following trends are believed to have occurred numerous times during the course of evolution of the flowering plants. If you wish you may use an arbitrary scoring system to gain some idea of the relative degree of advancement shown by the various flowers in the laboratory.

Summary of Floral Evolutionary Trends

Primitive	Advanced
1. Numerous parts, indefinite number	1. Few parts, definite number
2. Several free simple pistils	2. Compound pistil
3. Spiral arrangement of parts on floral axis	3. Whorled arrangement of parts on floral axis
4. Leaf-like perianth parts	4. Modified perianth parts
5. Radial symmetry	5. Bilateral symmetry
6. Superior ovary	6. Inferior ovary
7. Features of insect pollination	7. Features of wind pollination
8. Bisexual flowers	8. Unisexual flowers
9. Flowers complete	9. Flowers lacking calyx and corolla

10. Individual flowers clearly recognizable	10. Groupings of several flowers, organized into tight clusters which themselves resemble flowers

Internal Structure of the Flower - Hypogynous Type

Examine a prepared slide of *Capsella* (Family: Crucifera, Mustard Fam.). This slide is cut through an entire inflorescence, and flowers may be found in varying stages of development. The mature flower has six stamens and a compound pistil. The ovary is superior (the flower hypogynous), with two locules and numerous ovules. The perianth is composed of four sepals and four petals.

Look for a flower that is cut in cross-section and locate the parts, noting the appearance of the flower in this plane of section. Now try to interpret the various oblique and longitudinal sections. The latter type will allow you to note the position of the ovary with respect to the other flower parts.

Examine the structure of the anther. Note the **connective**, with a single vascular strand, the four pollen sacs (microsporangia), and their lining of tapetal cells. You will find various stages in the production of microspores and the maturation of pollen grains in the different ages within the inflorescence.

Examine now the structure of the pistil. Note the wall, the single septum dividing the interior into two locules, the numerous ovules, and the placental tissue to which the ovules are attached. Prepare composite diagrams of a transverse section and a longitudinal section through the flower *Capsella*.

Draw a single anther and include the cellular detail of a portion of it. When you do this, note the special cells within the walls of the pollen sacs (located in two areas) where the anther dehisces for pollen release.

Examine a prepared slide of transverse sections through the flower of *Nicotiana*, a member of the Solanaceae. This flower provides a good example of fused perianth parts. The outer whorl of fused parts is the calyx. Can you determine how many sepals compose the calyx? The next whorl of fused parts is the corolla. Can you determine how many petals are fused into this tube? What type of structural evidence can be used to determine the number of originally free parts that fused?

Internal Structure of the Flower - Epigynous Type

Examine a prepared slide of a flower with an inferior ovary (e.g., an epigynous flower) such as *Erigeron* (Compositae) or *Epilobium* (Onagraceae). Note the differences between this type and the hypogynous flower you examined.

Examine a prepared slide of the flower of *Prunus* (Rosaceae) on demonstration. This is a **perigynous** flower with a superior ovary. Note the single pistil and the **hypanthium**. Note the position where the free parts of the perianth and stamens arise in the flower.

Reproduction of the Flowering Plant

In this portion of the laboratory, we will deal with cytological aspects of the reproduction of a typical flowering plant. Emphasis will be placed on the events occurring within the anthers and ovules, including the development of the micro- and megagametophytes.

Traditionally, the genus *Lilium* has been used to represent the typical flowering plant reproductive cycle. The structures are large, and the material is easily obtained. It was discovered, however, that Lilium differs from the vast majority of flowering plants. This atypical nature of the genus lies primarily in the mode of development of its megagametophyte, which is not of the usual or *Polygonum* type. *Lilium* has the *Fritilliaria* type of embryo sac development. Refer to your text to note how this differs from the Polygonum type.

Megaspore Mother Cell and Megagametophyte Development

Obtain a series of slides of four *Lilium* slides labeled, megaspore m.c., 2-nucleate stage, 4-nucleate stage, and 8-nucleate stage. Examine the mother cell slide and note the general organization of the ovary as it appears in transverse section. Locate the ovary wall, locules, ovules, and the nucellus and integument of the ovules. In the nucellar region will be found the relatively massive megaspore mother cell.

Examine now the 2-nucleate, and 4-nucleate stages of embryo sac development. What type of changes are occurring during the development?

Examine now the 8-nucleate stage. This is the mature embryo sac or megagametophyte. You should be able to locate: 3 **antipodal** cells near the end of the embryo sac farthest from the micropyle; 3 cells near the micropylar end of the embryo sac, which are the single egg cell and two **synergids**; and 2 free nuclei near the center of the embryo sac, which are the **polar nuclei**. Examine several sections in sequence if necessary to see all of these features.

After examining the series of *Lilium* slides, make a series of drawings of the sac development. Draw the entire ovule in addition to the sac in the case of the mature 8 nucleate stage.

Microspore Mother Cell and Microgametophyte Development

Obtain a prepared slide of *Lilium* anthers having microspore mother cells. Note the appearance of the mother cells and the surrounding tapetal tissue.

Obtain a slide of a later stage of development of the microspores, and a slide showing the tetrads of microspores within the pollen sac. *Lilium* has very obvious areas on either side of the anther where the sacs open. Prior to the release of the pollen, the wall lying between each pair of pollen sacs on either side of the connective breaks down so that two cavities result. Each of these then opens, releasing the pollen grains.

Attempt to find mature pollen grains. Thee will be binucleate. The elongate nucleus is the generative nucleus; the more spherical one is the tube nucleus.

Draw several stages in the production of microspore and the development of mature pollen grains.

Fertilization

Examine a demonstration slide illustrating double fertilization. The male gamete nuclei are recognizable by their elongate and curved shape. What results from this double fusion of nuclei? How does the endosperm of flowering plants differ from the tissue that nourishes the embryo in gymnosperms?

Embryogeny and Seeds

Having now covered the reproductive cycle of the flowering plant up to the point of fertilization, we will examine the subsequent events in the life cycle. In addition, some variety of mature seed structure will be touched upon, and the early development of the young sporophyte as the process of germination occurs. You will recall that while the maturation of the ovule(s) into seed(s) is occurring, the ovary portion of the pistil is also undergoing numerous structural, and physiological changes which result in the thing we call the fruit.

Monocotyledonous Forms

1. Early Embryology

Examine a prepared slide of a transverse section of the ovary of *Lilium*. You will see the three locules, six rows of ovules, and within the nucellar region of these will be seen early stages in the development of the embryo and endosperm. The embryo will appear as a small cluster of relatively few cells near the micropylar end of the old embryo sac, while the endosperm will consist of scattered, relatively large nuclei lying in a common cytoplasm in the embryo sac. Note that most of the endosperm nuclei are near the margin of the sac.

Draw the early stage of embryo and endosperm development.

2. Mature Seed

Examine a mature kernel of *Zea* (corn) that has been soaked in water for one day. As in all grasses, the **grain** or **kernel** is actually a fruit whose outer portion is dry, hard ovary wall. This is fused with the outer part of the seed proper. You can locate the embryo as a light area (elliptical in outline) on one side of the kernel. Note the fused fruit-seed tissue, the massive endosperm (which is white), and the embryo. Examine the embryo and note the two growing points and the somewhat slipper shaped single cotyledon.

Examine a prepared slide of a median longitudinal section of the kernel of *Zea*. Locate the fruit-seed coat area, the endosperm, the embryo with two growing points, and the single massive cotyledon. You will find that the growing points are surrounded by sheaths of tissue: the **coleoptile**, covering the **epicotyl** or shoot apex; and the **coleorhiza**, covering the young primary root. Columnar digestive gland cells may be found lining the cotyledon. What is their function?

Draw the median longitudinal section of the kernel.

3. Early Development of Young Seedling

Examine germinating corn kernels. Note the appearance of the early seedling stages. What function does the cotyledon appear to serve? Does it appear above ground? You will find numerous adventitious roots on the young seedling, as well as the primary root. The mature root system is of the diffuse type. You will also see the first foliage leaves breaking through the tip of the coleoptile.

Sketch the seedling.

Dicotyledonous Forms

1. Embryology

Examine a prepared slide of the genus *Capsella*. Note that the slide bears the developing fruits of several flowers, each of which contains several developing seeds Within the latter you will find various stages in embryo and endosperm development. You should find stages in which the embryo is pear-shaped and borne on a single row of cells. This row is the **suspensor**. Free nuclei of the endosperm will also be present. As the embryo develops the size increases, the cotyledons become much more prominent, and a shoot apex develops between the bases of the two cotyledons. Also, the lower portion of the embryo becomes an elongate hypocotyl, at whose lower tip the primary root will develop from a growing point (the radicle). Slides of older fruits are also available, in which the mature seeds are present. Note that the integument tissue has developed into a seed coat; the walls of its cells are variously thickened and sclerotic. You may be able to locate a thin layer of darkly staining material near one of the cotyledons, appressed to the inner surface of the nucellus. This represents horny tissue developed from the antipodals. Endosperm is absent in the mature seed, having been broken down and reabsorbed by the embryo during the course of development.

Diagram one or more of the stages in seed development in *Capsella*.

2. Seed Structure

Examine a soaked seed of a typical dicot lacking endosperm such as *Pisum* (pea) or *Phaseolus* (bean). Remove the seed coat, which will come away with the nucellus adhering to its inner surface. Note the two large cotyledons making up the major portion of the embryo. Note also the hypocotyl and epicotyl, which are small and may be exposed by pulling apart the cotyledons The primary root will develop from the lower tip of the hypocotyl region, the radicle. Note that the first foliage leaves are already present in the epicotyl region.

Examine germinating seeds of bean and pea. Note the difference in mode of germination, especially with respect to the cotyledons (location, color etc.). What functions do the cotyledons appear to be carrying out in these two forms?

Draw the external features of one of the above seed types, noting the small micropyle in the seed coats, and the point or attachment to the ovary wall, which may be found by locating a scar on the seed coat, the **hilum**.

Draw the embryo, indicating its parts, for one of the above seeds.

Examine a soaked seed of a typical dicot with abundant endosperm in the mature seed, such as Ricinus (castor bean). Note the projecting **caruncle**, a porous structure for water absorption. The scar of the micropyle will appear just above and to the side of the caruncle. Carefully remove the seed coat, and note the light-colored, somewhat papery nucellus. The remaining portion of the seed consists of a massive endosperm surrounding the embryo. Carefully split the endosperm along one side, and remove this tissue. You will expose the embryo with two large, leaf-like cotyledons and a small cylindrical structure composed of the epicotyl and hypocotyl, to which the cotyledons are attached.

Examine a prepared slide of a cross section of a Ricinus seed. Locate the seed coats, nucellus, endosperm, and cotyledons of the embryo.

Draw a seed showing external features, and a view showing the embryo and endosperm.

Examine seedlings of Ricinus, noting the mode of germination as regards the cotyledons and the fate of the remaining part of the seed. How doe this differ from the other plants you have studied in this laboratory? Considering the examples we have used, review the various functions that the parts of the seed can have in angiosperms.