

## Chapter 3

### Biology of Flowering Plants: Reproduction

#### Flowers and Pollination

##### *Objectives*

**Angiosperms.** Understand the distinguishing characteristics of angiosperms. Know the differences pertaining to floral structure between and examples of the two major groups of angiosperms, the monocots and dicots.

**Flowers.** Besides identifying parts of a flower, understand the relationship between structure and function for the parts of a flower. Know the variations and terminology that exist in flower structure (*e.g.* presence or absence of different reproductive parts in the same flower, in different flowers on the same plant, and/or on different plants; symmetry; ovary placement; inflorescences) and how these variations relate to pollination success and evolution.

**Pollination.** Understand the process of pollination and the importance of the process for completion of the plant life cycle. Be able to give examples of modes of pollination, explain how these correlate with floral structure, and explain some of the advantages and disadvantages for these strategies.

##### *Introduction to Flowering Plants<sup>1</sup>*

The angiosperms<sup>2</sup>, flowering plants, are the largest and most diverse group of vascular plants (we will study the other category of plants, the non-vascular plants, later in the course). Angiosperms constitute most of the visible vegetation on earth and most of the plants that you are familiar with are angiosperms. Organisms in the phylum Anthophyta (angiosperms), the largest phylum of photosynthetic organisms, range in size from the 300-foot *Eucalyptus* tree of Australia<sup>3</sup> to the aquatic duckweed<sup>4</sup> (family Lamnaceae) of only a few millimeters (imagine how small the flowers are of a plant that is only one millimeter). Primary distinguishing characteristics of angiosperms include the presence of flowers, fruits (seed(s) enclosed in a vessel or carpel, the basic unit of the pistil), and double fertilization<sup>5</sup> (one to produce the endosperm and the other to form the zygote).

**Monocots and Dicots.** The two largest classes of angiosperms are the Monocotyledones (monocots) with at least 90,000 species and the Eudicotyledones (eudicots or commonly dicots) with at least 200,000 species<sup>6</sup>. Some familiar monocots include grasses (*e.g.* lawn, maize, wheat), lilies, orchids, irises, cattails, and palms. A few familiar dicots, both herbaceous

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<sup>1</sup> pp. 434-435

<sup>2</sup> p. 436. This name comes from two Greek words, *angion* (vessel), and *sperma* (seed). Angiosperms are plants with seeds that are born in vessels (*e.g.* the pod, or fruit, of peas) .

<sup>3</sup> Fig. 19-1

<sup>4</sup> Fig. 19-2

<sup>5</sup> p. 446 and Fig. 19-22 and a subject of the next chapter of the lab

<sup>6</sup> p. 435-436, Fig. 19-3, and Fig. 19-4

(non-woody) and woody (flowering trees and shrubs), include peanuts and the related legumes, azaleas, blueberries, strawberries, oak, crape myrtle, rose, carrot, and dill. There are several features that can be used to differentiate monocots and dicots<sup>7</sup> and include such traits as number of cotyledons (*e.g. mono* (one) *cot* (cotyledon)), function of cotyledons, presence or absence of endosperm at seed maturity, number of flower parts, root structure, presence or absence of secondary growth in the shoot, vascular bundles arrangement, and leaf venation. Monocots and dicots will be contrasted throughout this course.

**In your lab notebook**, create a table to contrast monocots and dicots. Include at least the characteristics mentioned above. Likely, you will be adding to this table as the semester progresses. Utilize your textbook, the BOT 3015 lecture notes, and any other reliable resources available to you.

**A guided, interactive tour of a flower.** The presence of a flower is a major distinguishing characteristic of angiosperms. Taxonomists use details of floral structure to identify species; thus, one reason it is important to learn the terminology associated with floral structure. In addition, a deeper understanding of the structure leads to an understanding of the function of a flower. The parts of a flower<sup>8</sup> are, anatomically, modified leaves born on shoots that have evolved as reproductive parts of angiosperms.

### **Specimen 1: Flower<sup>9</sup> dissection**

1. When obtaining a flower, be sure to cut below the receptacle, the part of the flower stalk to which the floral parts are attached.
2. Notice how the floral parts are arranged around the vertical axis of the flower. One floral evolutionary trend is for the parts to move from a spiral arrangement to a whorled arrangement at separate levels.
3. The most recognizable parts of most flowers are the petals; however, the outermost parts of a flower are the sepals. The sepals are collectively called the calyx and are what encase the flower as a bud. Many times they are green and leaf-like, but in some cases look very much like petals, in which case they are called petaloid or are called tepals.
4. Just inside the sepals, you will find the petals, collectively called the corolla. Together the infertile calyx and the corolla are called the perianth.
5. Count and note the number of sepals and petals.
6. Carefully, to keep the other parts of the flowers intact, dissect and keep intact the sepals and a few petals from the flower.
7. In your notebook, create a dissection press with unlined paper. The first page of the flower dissection press will be blank and will serve as a cover. Keep one sepal and tape one sepal to the second page at the top of the page (see diagram step 9). Do the same with petals, taping a couple of them on the bottom half of the page. Label them.
8. Observe the sepal and petal that you saved under the dissecting microscope. Under the taped, lived specimens, describe what you see under the dissecting microscope.
9. You will be setting up a third page of your press, similar to the page with the sepals and petals, for the reproductive parts of the flower, the stamens and carpel. After dissecting away the perianth, the entire structures of the reproductive structures are revealed. First look at the pollen-bearing stamens, collectively called the androecium (*andro* (man) *ecium* (house)), that

<sup>7</sup> Table 19-1 and table in *Angiosperm Anatomy and Selected Aspects of Physiology* of Outlaw's BOT 3015 lecture notes available at <http://www.southernmatters.com>

<sup>8</sup> pp. 436-437

<sup>9</sup> As you are dissecting and observing this specimen, use Fig. 19-6 as a reference

surround the pistil that is in the middle. The stamens are also called microsporophylls (microspore-producing modified leaves). In most angiosperms, the stamen is made up of a two-lobed anther, containing microsporangia (pollen sacs), atop a filament. Count and note the number of stamens.

10. Dissect a few of the stamens from the flower, keep one and tape the others onto the top of a third page of the flower-dissection press in your notebook and label them.
11. Observe the stamen that you kept under the dissecting scope describe (including function) under the taped specimen. While you are looking, dissect into the anther to find the pollen.
12. You are left with the carpel (when fused or single, also termed pistil), collectively known as the gynoecium (*gyno* (woman) *ecium* (house)). The leaf-like megasporophyll encloses one or more ovules. The tip of the carpel (furthest from the receptacle) is the stigma that receives pollen. The pollen grows a pollen tube that travels down the style, which is usually long, of the carpel until it reaches the ovules that are inside the lower part, the ovary, of the carpel. It is within the ovule that the megagametophyte ("female" gametophyte, derived from mitotic cell division of spores (1N and produced from meiosis)), is found. We will look closer at the gametophyte in the next lab.
13. Under the dissecting scope, carefully slice the ovary open to observe the ovules inside. After fertilization, the ovules develop into seeds. When carpels fuse, the ovary is generally, but not always, partitioned into chambers called locules. The portion of the ovary from which the ovules originate and remain attached is the placenta. The arrangement of the placentae, known as placentation<sup>10</sup>, varies and is a way for taxonomists to distinguish different species. Leaving a place to tape the opened carpel to the middle of page three of your press (under the stamen section), draw the carpel, details as under the dissecting scope, label (pistil, stigma, style, ovary, and ovules), and describe (including function) the opened carpel.
14. Finally, tape the opened carpel onto the lower half of page three.

### Variations in flowers and trends in floral evolution<sup>11</sup>

1. Evolution tends to favor reductions in the number of floral parts<sup>12</sup>. For example, the *Gladiolus* flower that you just dissected has both carpels and stamens, this is a perfect flower; whereas, an imperfect flower is missing one of these reproductive parts. Imperfect flowers may be either staminate, having only stamens and no pistil, or pistillate, having no stamens. Of course, for species with imperfect flowers to reproduce, both staminate and pistillate flowers must exist for that species. For monoecious (*mono* (one) *ecious* (house)) species, such as maize and oak, staminate and pistillate flowers exist on the same plant. For dioecious (*di* (two) and *ecious* (house)), such as *Cannibis sativa* and willow, pistillate and staminate flowers do not exist on the same plant body, but on different plant bodies.
2. As mentioned before, a cyclic arrangement of parts is favored evolutionarily over a spiral arrangement.

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<sup>10</sup> p. 438 and Fig. 19-9

<sup>11</sup> p. 458

<sup>12</sup> p. 438

3. Evolution tends to favor fused floral parts over free parts. As discussed during the flower dissection, carpels are often fused. One can also find examples of fused petals, stamens, and even fusion of stamens and pistils.
4. Floral evolution has tended to favor bilateral symmetry (irregularity) over radial symmetry (regularity). Flowers have evolved ornately shaped petals to attract pollinators or as guides and landing pads for pollinators. Some intermediates in regularity exist such as radially symmetric shape, but bilaterally symmetric color.
5. There are also evolutionary trends in the insertion of floral parts along the floral axis. In some cases, the sepals, petals, and stamens arise from below the ovary, which is termed superior. When the ovary is below the insertion points of the sepals, petals, and stamens, it is termed inferior. The evolutionary trend is toward an inferior ovary. Of course, there are intermediates between these two conditions.

**In your lab notebook** answer the following questions (all answers in your lab notebook should be incomplete sentences) about the flower that you dissected.

1. Is it a monocot or dicot and what determining characteristics did you use?
2. Is the ovary superior or inferior?

### **Specimens 2 and 3: More flowers**

1. Obtain two of each of two more flowers.
2. Count the number of sepals, petals, stamens, and pistils.
3. Dissect away a couple of petals and/or sepals to reveal the ovary.
4. Draw and label the flower with the intact ovary.
5. Make a longitudinal section of one of each kind of flower, including the ovary, draw and label (sepals, petals, stamens, stigma(s), style, ovary, ovules).
6. Make a cross-section of the ovary of one of each kind of flower, draw and label (ovary, ovules).
7. To your dissection press (new page), add sepals, petals, stamens, and ovaries from these flowers.
8. List the traits of each flower that are advanced.
9. List the traits of each flower that are primitive.

### **Inflorescences<sup>13</sup>**

Many plants produce their flowers in clusters called inflorescences. Although there are many inflorescence arrangements, one of the most advanced kinds of inflorescences is produced by members of the composite family such as sunflowers, daisies, and dandelions. What appear to be petals on the edge of a sunflower or daisy are actually individual flowers called ray flowers. Ray flowers are bilaterally symmetrical, pistillate flowers with one enlarged petal that, together with the other ray flowers, attract pollinators to the inflorescence. The central part of the inflorescence usually consists of numerous, small disk flowers, each of which is radially symmetrical perfect flower with tiny petals.

### **Specimen 4: Inflorescence**

1. Observe the inflorescence with your naked eye and identify the ray and disc flowers.

<sup>13</sup> Figs. 19-7 and 19-8, pp. 458-459 and Fig. 20-9

2. Carefully tease out a ray flower and a disc flower. Observe them under the dissecting microscope. Try to find the reproductive structures in each of the flowers.
3. Tape a disc and a ray flower into your press and, beside each, describe the reproductive structures found in each.

### ***Pollination and the co-evolution of angiosperms and insects***

Pollination is the process by which pollen grains<sup>14</sup>, which contains the microgametophyte, are carried over to the megagametophyte in the carpel or pistil. This process is imperative for completion of the plant life cycle. Plants are sessile; thus, they must depend on external factors to carry out pollination. Land plants accomplish this in two different ways, by wind and by biotic vectors.

Wind facilitated pollination<sup>15</sup> is the major mechanism of pollen transfer in non-flowering seed plants, such as pine, but is also present in angiosperms, such as oak and grasses. Wind pollination can be an efficient means of uniting micro- and megagametophytes when there is a large population of one species in a small area, such as a pine forest or a field of grass. Instead of investing energy into producing showy flowers to attract biotic vectors, wind-pollinated plants invest energy into making large amounts of pollen.

Some flowering plants have evolved flowers that attract biotic vectors such as insects, birds, and some mammals<sup>16</sup>. Flowers can attract biotic vectors by site, smell, and/or rewards such as nectar or pollen (some flowers even mimic, with petal structure and color, a mate of the biotic vector); thus, flowers and their biotic vectors have co-evolved in a mutually beneficial manner. In many cases, this relationship is very specific; meaning that a particular species of plant is only fertilized by a particular animal species. Flowers have evolved specific structures, colors, smells, and rewards that make them most attractive for their vectors, resulting in a fascinating diversity and complexity of flowers. In addition, flowers have evolved specific placement of reproductive parts to maximize successful pollination. Animal vectors evolve structures that enable them to successfully obtain the reward such as the long proboscis of some moths and the long, slender beak of the hummingbird. Thus, the variations in flower morphology that you observe are not random, but are the results of millions of years of evolution during which increasingly complex and specialized reproductive strategies developed.

The earliest angiosperms were insect pollinated, probably by beetles, but they retained the primitive tendency toward having many reproductive structures. Magnolia trees, which are considered one of the most primitive angiosperms, are pollinated by beetles and have superior ovaries in radially symmetrical flowers with many floral parts. Beetles are rewarded during pollination with food, they eat the flower parts, but do not destroy all the fertilized ovules. Beetle pollination is more efficient than wind pollination for this species, but clearly, leaves much to be desired for the plant.

Bees are the main biotic vectors for pollination, but flies, wasps, butterflies, moths, birds, bats, and more are pollination vectors. Often, the association of a flower and its pollinator is quite specific. Perhaps, the most extreme example is that of the wasp-pollinated orchid *Ophrys*. Orchids are among the most advanced angiosperms; the ovary is inferior and stamens, petals, and pistils are fused. In *Ophrys*, the petals closely resemble the female of a certain species of wasp.

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<sup>14</sup> pp. 442-444 and Figs. 19-14, 19-15, and 19-16.

<sup>15</sup> p. 463

<sup>16</sup> pp. 460-462

This resemblance is so strong that male wasps attempt to copulate with the flowers and in so doing, carry pollen from flower to flower. Some plants spend large amounts of energy to attract insects. The arum lily, generates heat that causes the evaporation of volatile chemicals that attract insects to the flower.

### **Video: Pollination Biology**

In addition to the video, you will certainly see pollination taking place around you.

### ***Review Questions***

In addition to the questions and writings found in text.

1. What are the functions of a flower and how are these functions important for the survival of a species?
2. For each of perfect and imperfect flowers, give at least one advantage that each has over the other.
3. Based on the function of flowers, why do you think flower structure is diverse across plant families and sometimes species, but evolutionarily conserved within species?
4. Why do you think there is an evolutionary trend toward (*i.e.* what are the advantages to) reduced numbers of floral parts?
5. Describe at least one advantage of inflorescences for reproductive success.
6. Some angiosperms invest energy in ornate flowers (e.g. orchids and sunflowers) and others (e.g. grasses and oaks) do not. Give one possible explanation for how they are both successful despite this difference.