PLANTS: REPRODUCTION

Flowers and Inflorescences

Flowers are short shoots (rosettes) specialized for sexual reproduction. The stem is called the **receptacle** and bears modified leaves. Although the number of parts can vary, flowers can have up to 4 whorls of "leaves". The first 2 whorls, the sepals and petals, are sterile and are often modified for protection of the developing flower and/or for attraction of pollinators (Figure 1). The term for all of the sepals is **calyx**, while the term for all of the petals is **corolla**. The last two whorls, the stamens and **carpels**, are the fertile parts. The stamens are usually differentiated into the **filament** and **anther** (Figure 1). The anthers are the site of meiosis and produce the pollen or male gametophyte. The carpels are usually differentiated into the **stigma**, which receives the pollen, the **style** that supports the stigma, and the ovary (Figure 1). The **ovules** are inside the ovary. Meiosis also occurs in the ovules, producing the female gametophyte, which, after double fertilization, makes the **embryo** and **endosperm**. The ovules mature into the **seeds**, while the ovary, sometimes with additional parts, matures into the **fruit**.

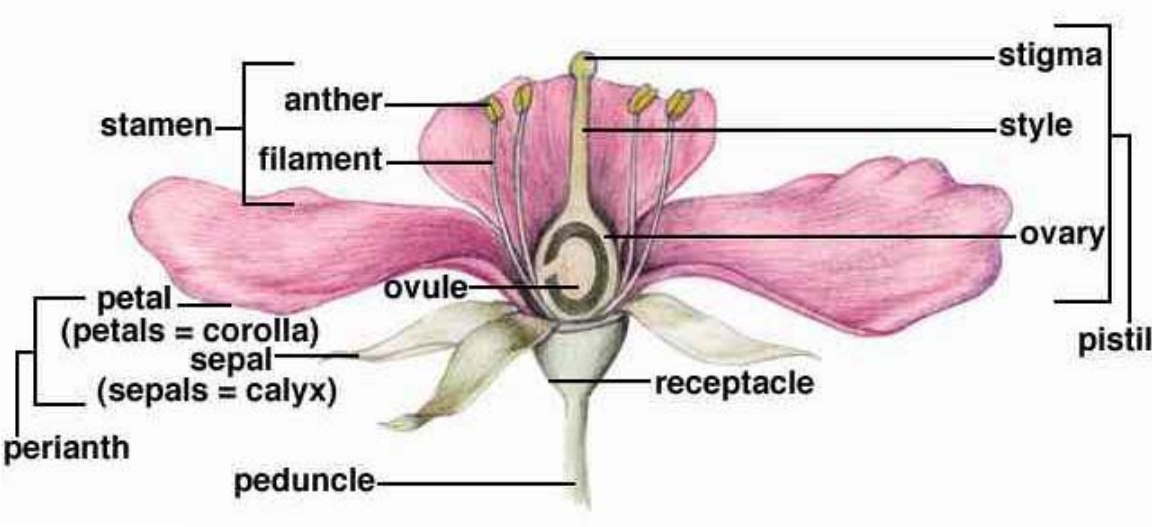

Figure 1.

Flowers thus have a number of functions. They provide plants with the opportunity to spread genes, since both the pollen and seeds can leave the parent plant. Because they enable the plant to reproduce sexually, flowers mix male and female genes and contribute to genetic diversity. Through the production of fruits, they help to disperse the next generation, and through provisioning of the seeds, they help that generation to begin to grow.

There is enormous variation in flower structure among species. They can lack sepals and/or petals, or these whorls can resemble each other, as in many monocots, such as lilies. The parts of a whorl can fuse to each other, as in the tubular corollas of sunflowers, or to adjacent whorls, as when stamens are attached to the corolla. A fundamental difference is in the position of the carpels in relation to other parts of the flower. If the sepals, petals, and sta-

mens are inserted on the top of the ovary, the ovary is said to be **inferior** and the flower is **epigynous** (Figure 2). The individual flowers of the sunflower provide an example. If the sepals, petals, and stamens are inserted below the ovary, the ovary is **superior** and the flower is **hypogynous** (Figure 2). Bean flowers are hypogenous, as are those of *Brassica*. Sometimes the other floral parts are fused halfway to the ovary, or fuse to themselves, forming a cup that comes up partway around the ovary. These flowers are **perigynous**.

The number of parts per whorl also varies. In general, **monocots** have parts in 3s or multiples of 3, while **dicots** have parts in 4s or 5s or multiples of these numbers. The overall symmetry of a flower can be radial (**actinomorphic**), with the whorls distributed evenly around the receptacle, as in strawberry flowers or the flowers of *Brassica* (Figure 3). Alternatively, the flower can have bilateral symmetry (be **zygomorphic**), in which case it has a distinct top and bottom, as in orchid flowers or bean flowers (Figure 3).

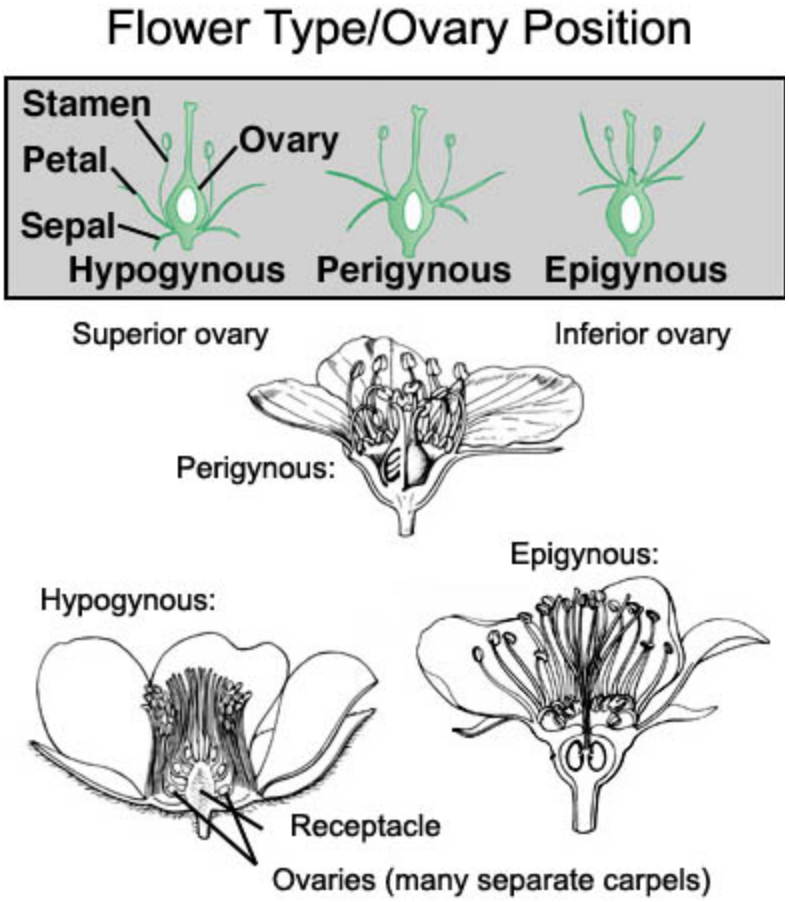

Figure 2.

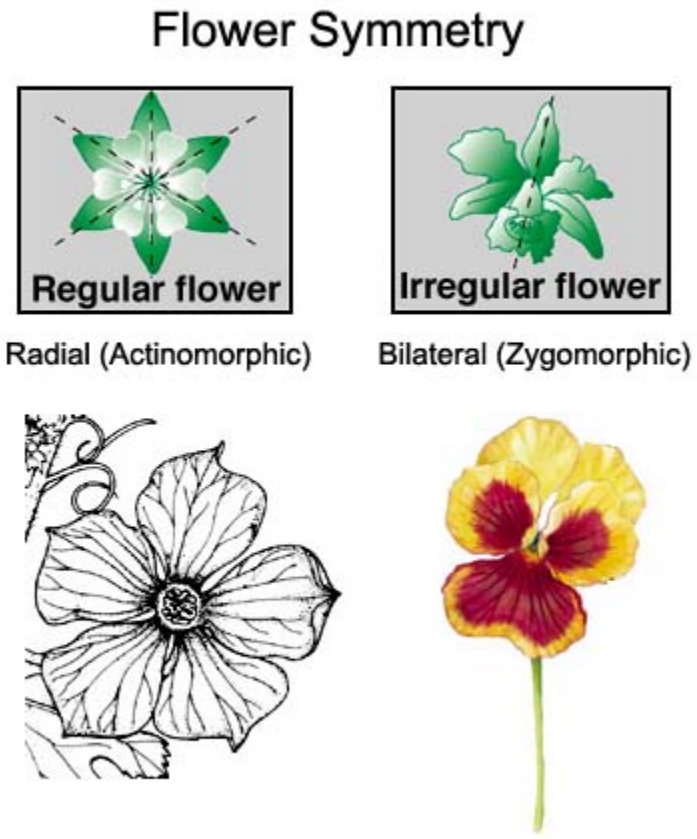

Figure 3.

Because one of the functions of flowers is to enhance pollination (the transfer of pollen from the anthers to a stigma), the structure of flowers varies with the type of pollinator. Wind pollinated flowers are generally not colorful (the wind can't see), very small, have no or reduced sepals and petals, and may separate the anthers and stigmas into different flowers. They also produce huge amounts of pollen. Animal-pollinated flowers are often more colorful, have sepals and petals, and vary in size, color, and symmetry, depending on the type of pollinator. Because hummingbirds see red, hummingbird-pollinated flowers are often red, whereas bee-pollinated flowers tend to be yellow or blue, because bees see these colors. Moth-pollinated flowers are often white, but have strong scents that are emitted at night, as moths are sensitive to odor and are active at night.

Flowers have to both attract pollinators and provide them with a reward, so that the pollinators will visit other flowers of the same species. Common rewards are pollen itself, which is often rich in proteins and lipids, and nectar secreted by glands in the flower.

Remember the difference between **pollination** and **fertilization**. In pollination pollen is transferred from anthers to the stigma. The pollen germinates on the stigma, grows down the style, and passes into the **micropyle** of the ovule. It grows through the **nucellus**, releasing two sperm into the **embryo sac**. Fertilization comes at this point: one sperm fertilizes the egg and thus forms the first cell of the daughter embryo; the other sperm fuses with the polar nuclei, producing the triploid **endosperm**.

Plants often produce flowers in groups, called **inflorescences**. The arrangement of flowers in an inflorescence, as well as the timing of flower maturation, contributes to the attractiveness of plants to pollinators. Inflorescences differ in the degree of branching within the inflorescence, the arrangement of flowers on the branches, and the timing of maturation of the flowers. Inflorescences are distinguished into two large groups that differ in whether the shoot apical meristem differentiates as a flower and matures first (**cymose inflorescence**) or whether the shoot apical meristem keeps on growing (remains indeterminate) and the axillary flowers mature from the base toward the apex (**racemose inflorescence**). Figure 4 illustrates different inflorescence types.

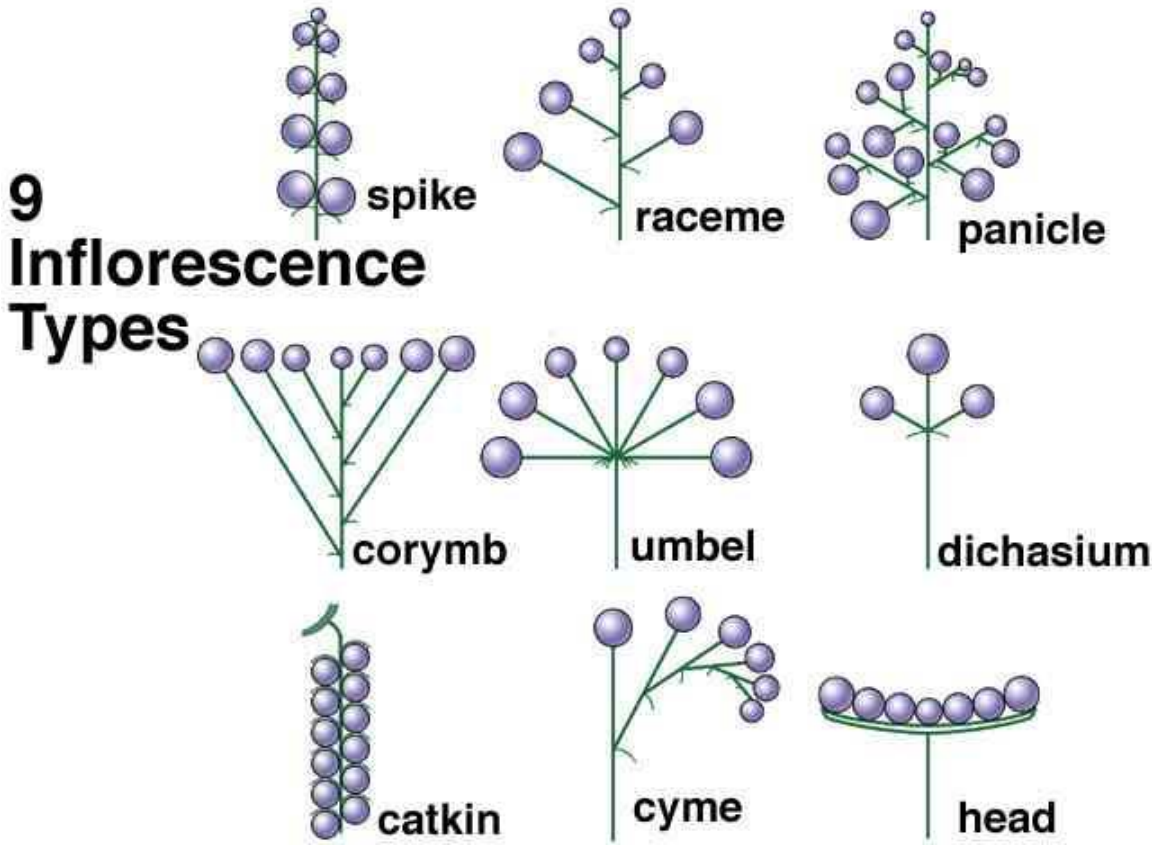

Figure 4

Fruits

Simply stated, fruits are ripened ovaries. Once fertilization occurs the ovules develop into seeds, and the ovary wall develops into the fruit wall. The wall develops from leaf-like structures, called **carpels**. A fruit may develop from one or many carpels. How the carpels fuse together determines the numbers of chambers in the fruit, from one to many, and each of these may contain one to many seeds. Under exceptional circumstances the fruit may develop in the absence of seeds (as a seedless grape or naval orange), a process called **parthenocarpy**. It is possible to examine a fruit to determine the ovary's position in the flower. If scars or parts of old petal and sepals are at the tip of the fruit, the ovary was **inferior** (as an apple). If these parts are at the base, then the ovary was **superior** (as an orange). If the ovary wall is fleshy, the fruit is a **berry**; if it is dry at maturity and breaks open, the fruit is a **capsule**. Sometimes the ovary wall develops into a fruit of different layers, including an inner one that is stony, producing a **drupe** (like a peach). Sometimes additional flower parts form part of the flesh of the fruit, making an **accessory fruit** (like an apple). Some flowers have multiple carpels that don't fuse together; if the ripening ovaries of these carpels fuse together, they form an **aggregate fruit** (like a raspberry or blackberry). Sometimes the ovaries of separate flowers fuse together to form a **compound or multiple fruit**, such as a pineapple. You can quickly find a great diversity of types of fruits by examining the produce in a supermarket, looking at the fresh fruits and nuts.

Tasks for Lab

1. Dissect the flowers on display. Can you tell which are monocots and which are dicots? Identify the different parts of the floral whorls. Note the presence or absence of each whorl, and whether the parts are fused within a whorl or between whorls, i.e., are sepals and petals separate or joined into a single tube and do the stamens arise from the base of the flower or do they come off of the petals? Where does meiosis occur in these flowers?

2. Look at the different types of inflorescences on display.

3. Examine the fruits and seeds on display. For the fruits, identify whether they are simple, aggregate or multiple fruits. Can you tell if these fruits came from superior or inferior ovaries? Look at modifications of the **pericarp** (exo, meso, endocarp) and relate these to probable dispersal agents. Examine the seeds and identify the **seed coats**, the site of nutrient storage (**Endosperm**? **Cotyledons**? Something else?), and the embryo. You will have to cut into the seeds to see the different parts.