Reproduction of Flowering Plants: From Flowers to Fruits

The Need Of Being Versed In Country Things

The birds that came to it through the air
At broken windows flew out and in,
Their murmur more like the sigh we sigh
From too much dwelling on what has been.

The house had gone to bring again
To the midnight sky a sunset glow.
Now the chimney was all of the house that stood,
Like a pistil after the petals go.

The barn opposed across the way,
That would have joined the house in flame
Had it been the will of the wind, was left
To bear forsaken the place’s name.

No more it opened with all one end
For teams that came by the stony road
To drum on the floor with scurrying hoofs
And brush the mow with the summer load.

Yet for them the lilac renewed its leaf,
And the aged elm, though touched with fire;
And the dry pump flung up an awkward arm;
And the fence post carried a strand of wire.

For them there was really nothing sad.
But though they rejoiced in the nest they kept,
One had to be versed in country things
Not to believe the phoebes wept.

--Robert Frost

The objectives of this lab are that you:

• learn the structures of a flower and their functions
• become familiar with the ways that flower and fruit structures vary from species to species
• learn the floral origin of the various structures of a fruit
• understand the fruit structure of a variety of familiar fruits and "vegetables"

Introduction: flowers and fruits in perspective

Flowers are the reproductive structures of flowering plants (Angiosperms). Flowers can range from being very colorful and conspicuous, such as a rose or orchid, to being very simple, reduced and inconspicuous, such as those of grasses, oaks, and elms. The function of a flower is to produce the reproductive cells of the plant (eggs and pollen) and then produce seeds, the dormant young plant of the next generation.

The seeds of flowering plants are surrounded by a tissue called the fruit, which may be fleshy or dry. The culinary designation of “vegetable” is based on the use of the plant part (eaten as part of the main course in a meal). Vegetables are actually various plant parts; some are fruits (e.g., tomatoes and peppers), leaf stalks (celery), leaf blades (spinach), lateral buds (Brussels sprouts), young shoot (asparagus), massive flowering structure in bud stage (broccoli), root (sweet potato), underground storage stem (white potato).

Functions of fruit. Although fruits come in all shapes and sizes, they all function in protecting the seeds inside and in aiding seed dispersal. Protection may be afforded by hardening of the fruit to make accessing the seeds more difficult, or by accumulation of acids or other toxins. Fleshy colored fruit attract birds and animals; seeds pass through the gut unharmed. Some types of seeds cannot germinate unless they have first passed through the digestive tract of an animal. Many fruits promote wind dispersal. Other fruits have hooks, spines, and bristles that readily cling to fur and clothing—just walk your dog in an old field in autumn and see! Fruits called pods dry out as they mature and rip open, flinging out the seeds.
From Flowers to Fruits in Pictures

Figure 1. Parts of a flower.

**Female structure**
- **Pistil**: receives pollen to fertilize the egg located in ovary.

**Male structure**
- **Stamen**: produces pollen.

**Other structures**
- **Petals**: attract pollinators.
- **Sepals**: cover immature flower bud, may later help protect seeds, or be colorful and help attract pollinators.
- **Receptacle**: top of flower stalk on which flower resides.

Figure 2. Parts of the Pistil and Stamen.

**Pistil structure**
- **Stigma** receives pollen, which grows down **style** to ovary. **Ovary** contains **ovules**, which contain an **egg**.

**Male structure**
- **Stamen** consists of a long stalk called a **filament** that supports an **anther**, which is where the **pollen** is produced.

Figure 3. Arrangement of ovary and flowers relative to the receptacle can vary.

- **Superior ovary**: ovary rests above receptacle.
- **Inferior ovary**: ovary is embedded within the receptacle.
- **Inflorescence**: many separate flowers clustered to a receptacle or a stem.

Where indicated, images used with permission of D.G. MacKean, Biology Teaching & Learning Resources.
http://www.biology-resources.com/
Figure 4. Within the ovary, the ovules may have different arrangements within chambers called “locules”.

**Ovary:** female reproductive structure of flower which usually develops into the fruit.

**Ovule:** egg-bearing structure of the flower that develops into a seed.

**Locule:** internal chamber of the ovary.

The structure of the ovary is often reflected in the structure of the fruit that develops from it.

Figure 5. A “fruit” is the tissues that surround the seed. Those layers that develop from the ovary are called “pericarp”.

**Ovary:** female reproductive structure that usually develops into the fruit.

**Pericarp:** layers of fruit derived from the ovary and surrounding the seeds.

**Seeds:** develop from the ovules within the ovary.

In some flowers, other parts of the flower may also develop into parts of a fruit.

Figure 6. The arrangement of the ovules in the chambers (locules) of the ovary determines how the seeds are arranged in the fruit.

**Ovary:** female reproductive structure of flower that usually develops into the fruit.

**Pericarp:** fruit tissues surrounding the seeds that are derived from the ovary.

**Ovule:** egg-bearing structure of the flower that develops into a seed.
Figure 7. **The fruit may be fleshy or dry.** Some fruits may be dry when mature, although we may be more familiar with an immature pericarp (such as bean pods), which we eat before ripening. The pericarp of some foods may be removed before marketing (such as for walnuts and coconuts).

![Fleshy and dry pericarp](image)

**Figure 8.** Botanists generally consider ‘fruit’ to be structures derived from pericarp, which may form fleshy or hard layers.

**Berry:** an entirely fleshy fruit containing one or more seeds. In common usage, ‘berry’ may be used inaccurately (e.g., see discussion of strawberry below).

**Pod:** a dry pericarp that splits in two; seeds usually aligned in a row.

**Hesperidium:** a berry with a thick leathery rind and many internal sections that form locules.

**Nut:** in a true nut the entire pericarp forms a single hard dry wall around a single seed.

**Drupe:** The inner layer of the pericarp (not the seed itself) forms a hard layer. The outer layers may be fleshy or dry.

**Achene:** A small dry pericarp that dries leaving empty space around a single seed. Do not confuse this with a pod, which when dry may leave space around one or more seeds.
Figure 9. The tissues of some fruits develop from flower structures other than the ovary.

**Pome**: the outer tissue arises from the receptacle and is usually discernible from the inner tissue of the pericarp.

**Pepo**: the outer tissue is not pericarp, and forms a tough, skin-like outer covering.

**Pericarp**: layers of fruit derived from the ovary and surrounding the seeds.

**Inferior Ovary**: ovary is located within the receptacle.

---

Figure 10. An “aggregate fruit” develops from many pistils that are present in a single flower.

**Fleshy receptacle**: The receptacle becomes fleshy and the seeds are in achenes.

**Cluster of berries**: Each ovary forms a fleshy drupe-like fruit.

**Hip**: Seeds and pericarps form within a fleshy receptacle. Ovary was inferior.

**Achene**: A hard pericarp that dries leaving a void around the seed

**Receptacle**: top of flower stalk on which the flower resides.
**Figure 11. A ‘multiple fruit’ develops from a flower inflorescence.** Maize produces separate inflorescences of male and female flowers. The female flowers mature into the kernels of the ear.

**Tassel:** inflorescence of male flowers.

**Ear:** forms from inflorescence of female flowers.

**Kernel:** individual maize fruit, consisting of a seed surrounded by a hard pericarp.

**Inflorescence:** a cluster of separate flowers arranged on a stem or receptacle.

**Style:** the elongated part of a pistil between the ovary and the stigma, the very long styles of maize are called the **silk**.

---

**Figure 12. Seeds that store food in cotyledons.** These types of seeds contain the immature plant (**embryo**) plus food reserves in large **cotyledons**, surrounded by a seed coat.

**Cotyledons:** main food storage tissue.

**Embryo:** immature plant.

Since these seeds usually contain two cotyledons, the plants are called **dicots**.

---

**Figure 13. Seeds that store food in endosperm.** In some plants, most of the seed food reserve is stored in a tissue called **endosperm**.

**Endosperm:** main food storage tissue of these seeds.

**Embryo:** immature plant.

Since these seeds usually contain only a single small cotyledon, the plants are called **monocots**.
Lab Activities

I. Examination of flower structure.
1. Referring to Figures 1 and 2, what are the functions of:
   
   Petals:
   
   Sepals:
   
   Stamens:
   
   Pistil:
   
   Ovary:

2. Identify the structural properties of the three types of flowers provided in the lab. Dissect each carefully with your partner. Refer to Figures 1, 2 and 3.

1. **Lily.** **Draw a stamen** and label the anther and filament.
   
   After carefully counting and removing the sepals, petals, and stamens, determine the position of the ovary relative to the receptacle. Make a **drawing** of the pistil, ovary and receptacle and label each part.
   
<table>
<thead>
<tr>
<th># sepals</th>
<th># petals</th>
<th># stamens</th>
<th>ovary position*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   *superior or inferior

2. **Alstroemeria.** After carefully counting and removing the sepals, petals and stamens, determine the position of the ovary relative to the receptacle. Make a **drawing** of the pistil, ovary and receptacle and label each part.

<table>
<thead>
<tr>
<th># sepals</th>
<th># petals</th>
<th># stamens</th>
<th>ovary position*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   *superior or inferior

3. **Daisy.** Carefully slice the receptacle in half vertically, and note the numerous small flowers clustered at the flower head.

   What type of flower is this? ________________

   There are **two types of flowers**; the outer “ray” flowers have a single fused petal facing outward, and the petals of the inner “disc” flowers are barely visible as a small tube. Look carefully at the flowers: there are also separate **male** (stamen-bearing) and **female** (pistil-bearing) flowers.

   Make a **labeled drawing** of the flower in cross-section.
II. Examination of fruit structure.

1. Referring to Figures 4 – 6, what are:

Ovules:

Pericarp:

Receptacle:

Locule:

2. Detailed examination of specific fruits

A. TOMATO – a berry type fruit (see Figure 8)
Cut a tomato in half vertically, and then draw into the diagram and label the arrangement of the sepals, pericarp and seeds.

Envision how the ovules and locule were arranged in the original tomato flower, and then draw how they would have appeared (see Figure 6):

Was the ovary superior or inferior? ________________
(Examine Figures 5 and 9):
Explain why this is classified as a berry type fruit (see Figure 8):

B. PEACH – a drupe type fruit
Cut a peach in half vertically, and compare with Figure 8.

Complete the diagram and label all of the parts of the peach that are part of the pericarp.

Use a nut cracker to open the peach “pit” – if you can.
In the second diagram, label the pericarp and the seed.

All of these parts develop from the ___________ of the flower.

There was/were _____ ovule(s) in the ovary of the peach flower.
B. ORANGE – a hesperidium
Describe the distinguishing traits of a hesperidium (Figure 8):

Slice the orange crosswise, and in the diagram draw the appearance of the fleshy tissue showing the sections and seeds.

The rind and juicy flesh both are part of the ________________, which developed from the _______________ of the flower.

There were ______ locules in the original flower.

Peel part of the rind: fold the peeling over with the orange-side outward, and pinch it to sharply kink it and notice the fine mist of fragrant oils squirting into the air. Citrus fruits contain a variety of sharp-tasting chemicals in the rind and a high concentration of citric acid in the inner fluids. Reread the section on fruit function in the introduction and then Explain how these contribute to the function of the fruit:

C. BLACKBERRY -- an “aggregate” type fruit
Examine a blackberry and explain why this is classified as an aggregate type fruit (see Figure 10):

Slice the blackberry in half vertically, and then complete the diagram to the right to show how the ovaries were originally arranged on the flower receptacle.

Explain how you would determine the number of ovaries that were originally present on the flower receptacle:

D. STRAWBERRY -- another aggregate fruit
Examine a strawberry, slice it in half and compare to Figure 10.

Does this aggregate fruit have a cluster of berries or a fleshy receptacle?

From which flower parts did the following fruit parts develop?
  the collar of green leafy parts:_________________
  the red flesh:_________________

The little hard structures on the surface are “achenes” (see Figure 8)
  Why is it incorrect to call these “seeds”?

Flowers and Fruits
C. APPLE – a pome type fruit
Slice an apple from top to bottom, and compare to Figure 9.
Draw the appearance of the two fleshy tissue layers in the diagram to the right. Label the tissues originating from the ovary and receptacle.

The position of the ovary in the apple flower was ____________.
(Examine Figures 3 and 9) (superior or inferior)
What other parts of the flower (indicated by the arrow) remains on the mature apple?

Holding together the two halves, slice the apple crosswise. In the second diagram, again draw the appearance of the of the two fleshy tissue layers, seeds and seed chambers.

There were ____ locules and _____ ovules in the original apple flower.

3. Examine the types of fruit on display in the lab.
Is each an achene, aggregate, berry, compound, drupe, hesperidium, nut, pepo, pome, or samara?

<table>
<thead>
<tr>
<th>Fruit name</th>
<th>Fruit type</th>
<th>Explanation (Review Figures 8, 9 and 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maple key</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>Coconut</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>Squash</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>Kiwi</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>Black Walnut</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>(think about the fruit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pear</td>
<td>__________</td>
<td></td>
</tr>
</tbody>
</table>
III. Examination of seed structure

1. From Figures 11 and 12, what are:

   Embryo:

   Cotyledons:

   Endosperm:

2. Examine the structures of these seeds

   A. PEANUT IN THE SHELL
      The description in Figure 8 that best describes the peanut fruit is a __________________
      Hint: It is not a nut.
      Split open a peanut shell to release the seeds;
      The thin reddish papery covering is the ________________
      Carefully split the seed in half and compare its structure to Figure 12
      Label the parts of the peanut shown in the picture.
      Is the peanut plant a monocot or dicot? ________________

   B. CORN
      Examine the corn cob, and examine Figure 11
      What type of fruit is this? ________________
      Explain why the corn cob is classified this way.
      Dissect a corn kernel, and in the diagram label the embryo, endosperm, and pericarp. Is the corn a monocot or dicot? ________________

IV. Summarize the development of flowers from fruits

   The wall of the ovary develops into the ________________ of the fruit, although sometimes the fleshy tissue may develop from other parts of the flower, such as the _________________. The structure of the fruit is determined by the position of the ovary relative to the ________________, the number of chambers called ____________, and the arrangement of _________ which later develop into the seeds.
So, what good is knowing stuff about flowers and fruits?

Predicting pumpkin production?
If you have a pumpkin patch, you cannot predict the number of potential pumpkins by counting the total number of flowers. Why? Pumpkin plants have separate male flowers and female flowers on the same plant. A pumpkin fruit develops from the pistil of a female flower. Identify a female flower by its bulging inferior ovary at the end of the flower stalk beneath the sepals and petals. Thus, to determine the number of potential pumpkins that you will be harvesting, you count only the number of FEMALE flowers present! (This is true also for the zucchini, squash, cucumber, and most other members of the gourd family.)

Q: You look at your pumpkin patch in the garden and there are 7 flowers; upon closer examination you discover that all 7 are female flowers. How many pumpkins would you expect to harvest? ______ (Be careful now… remember that “it takes two”.)

No berries on your berry tree?
Some plants such as sassafras are dioecious, meaning that an individual plant has either all male flowers or all female flowers. Holly trees are nearly dioecious, producing an occasional perfect flower (having both male and female parts). Thus if you want a holly tree that will produce lots of holly berries for the winter birds and for decoration, you need a tree that is predominantly female.

Q: If a holly tree has lots of flowers but produces only a couple of berries each year, give one possible explanation:

Few or no apples on your apple tree?
If you plant fruit trees, you must know whether your variety is a SELF-POLLINATOR or is SELF-INCOMPATIBLE. A single tree of a self-pollinator variety will allow you to get a fruit harvest. However in self-incompatible plants, pollen MUST come from another individual. Its own pollen is not capable of penetrating or growing through its pistil tissue due to a chemical incompatibility. In addition, in sweet cherries, almonds, and some apple, pear, and plum cultivated varieties, the pollen has to come not just from another tree but from a tree from a different cultivated variety of that crop; don’t expect to harvest a crop if you plant a single tree of these (Ray et al., 1983, 285)!
Why do plants flower when they do?

Day-neutral plants—such as dandelions, tomatoes, corn, and sunflowers—will flower when physiologically ready, regardless of the day length to which they are exposed. (Dandelions however, you may have observed, have a flowering peak in May.)

Short-day plants—Poinsettia, chrysanthemum, goldenrod, ragweed, and aster—grow through the summer and flower in the autumn when day lengths get shorter. Experiments have shown that it is actually the length of uninterrupted darkness that is critical to these plants. If the dark period is briefly interrupted by light, the plant resets its clock, perceiving two short nights instead on one long one. Each of these plants needs a light cycle having a period of uninterrupted darkness that is greater than a certain critical length.

Q: Poinsettias are growing in a greenhouse under correct light/dark cycle for them to initiate flower production (at least 14 hours darkness for traditional poinsettias). What if a security person turned on the lights in the middle of the night while making his rounds?

Long-day plants—such as lettuce, spinach, clover, petunia, and Black-eyed Susans—develop flowers when the day length is LONGER than some critical day length (or more precisely, the night length is shorter than some critical length). The leaves of lettuce and spinach plants are edible before they flower; when these plants sense the appropriate light/dark cycles, they “bolt”—the stem rapidly elongates and then flowers—at which time the leaves become somewhat bitter.

Q: Why do lettuce and spinach seed packets suggest planting the seeds either in the early spring or in late summer/autumn, but not late spring and early summer? Explain.

Literature Cited
