Fall 11-11-2014

Grocery Store Botany

Laura K. Thompson Dr
Furman University

http://www.econbot.org/themes/econbot/pdfs/2014/FinalProgram.pdf

Recommended Citation
http://scholarexchange.furman.edu/bio-publications/7

This Article (Journal or Newsletter) is made available online by Biology, part of the Furman University Scholar Exchange (FUSE). It has been accepted for inclusion in Biology Publications by an authorized FUSE administrator. For terms of use, please refer to the FUSE Institutional Repository Guidelines. For more information, please contact scholarexchange@furman.edu.
The vast majority of the plants we consume in our diets are Angiosperms. Today, Angiosperms make up the vast majority of on Earth. We encounter Angiosperms not only in the landscape around us, but also in the local grocery store. During this laboratory session, we will build on last week’s laboratory by using vegetables from our local grocery store to explore Angiosperm morphology. The term “morphology” means the “study of body”, a term coined by the German poet and scientist Johann Wolfgang von Goethe (1749 – 1832). Although we use a relatively few number of domesticated plants for food, we find a wide range of forms in the roots, stems, and leaves. As we will see in this laboratory, Angiosperm food sources have diverse morphology much of which came about through selective breeding over hundreds of years. Some of the specialized plant organs that we will observe have come about through the domestication process that emphasizes selected plants structures that have been selected for over many generations to produce the features sought after in crops. It is these highly modified plant structure that compose many wonderful components of our diet.

Flowers
FLOWER PARTS: The flower consists of a series of whorls of modified leaves. The whorls consist of the (1) male reproductive parts, (2) female reproductive parts, (3) corolla, and (4) calix. Below are descriptions of the parts of a flower.

Male Reproductive Structures
Stamen: The stamen is the male reproductive structure of an Angiosperm flower and is anther. Typically the number of stamen will equal the number of petals in the flower. The assembly of all the stamens in a flower is called the **Androecium**.

Anther: The anther is where the pollen is produced. Anthers are usually at the end of the long stalks called **Filaments** which look like a fine hair.

Female Reproductive Structures:
**Pistil/Carpel**: The pistil contains the ovules in the flower. Pistils can be made up of one or more units called carpels. For our class we will use these terms synonymously. The Pistil/Carpel is made up of the stigma, style, and ovary. Carpels are actually constructed out of one or more rolled leaf like structures. The collection of all the carpels is the **Gynoecium**.

Stigma: This is the sticky top of the Pistil/Carpel in the center of the flower. It is where the pollen grain is received and where the pollen grain germinates.

Style: This is a long stalk between the stigma and ovary through which the pollen tube grows when the pollen grain germinates. It is important in the transfer of the sperm nuclei to the ovary and ovule.

Ovary: Located at the bottom of the Pistil/Carpel the ovary contains the ovules which after maturation become the seeds. The ovary matures into the fruit that we eat.

Ovule: After fertilization by the pollen sperm nuclei these structures become the seeds.

Other Important Flower Parts
**Petal**: These modified leaves can be colorful and are important in the attraction of pollinators. The petals are usually the reason why we buy and enjoy flowers. The collection of all the petals is called the **corolla**.

**Sepal**: These are the small green leaves at the base of the flower that cover the flower bud to protect it before opening. The collection of all the sepals is called the **calyx**.
Flower Types

**Perfect Flower:** These are bisexual flowers that contain both the male and female reproductive structures. Examples: gladiolus, onions, and roses

** Imperfect Flower:** These are unisex flowers – they contain either male parts or female parts, but not both. Examples: melons, squash, cucumbers, and pumpkins

**ACTIVITY #1:** Obtain a flower and dissect it!

**Study Question 1:** Draw the flower parts and add the following labels to your drawing: sepal, petal, carpel (ovary, ovule, stigma, style), stamen (filament and anther). Is the flower you are dissecting Perfect or Imperfect?

---

**Seeds**

We obtain new plants when we plant seeds. The seed encloses the embryonic plant. In the life cycle of an Angiosperm, seeds are produced after pollination and fertilization. Seeds are important in aiding the dispersal from the parental plant and to that end seeds have developed many specializations that aid in the protection of the embryo during the dispersal process.

As an example of seeds in our diets we will look at beans and peanuts. Many beans like the pinto and kidney beans, have a hard outer covering called a seed coat. This structure is specialized to protect the embryo during dispersal. If you want to prepare dried beans, you would soak them overnight to soften the seed coat and allow the cotyledons to hydrate.

Soaking the seed aids in the removal of the seed coat, and once the coat is removed the embryo is visible. The embryo is a small plant body which may already have most of the basic plant parts. The embryonic root is called the radicle. The radicle is the first part of the embryo to emerge during germination. Then comes the hypocotyl which means “below the attachment of the cotyledon. At the top of the embryo is the epicotyl (above the cotyledon) which is sometimes called the plumule. The plumule is composed of small immature leaves. You can think of the hypocotyl as the embryonic root and the epicotyl as the embryonic stem.

Some of these embryonic body parts are specialized. For example, one of the most prominent features of the Angiosperm embryo is the cotyledons. The cotyledons or “seed leaves” are the first leaves that are formed by the embryonic plant as it developments. The embryo can also have other leaves in addition to the cotyledons, but the cotyledons are the most prominent leaves that are present on the embryo. Among some plants the cotyledons are specialized for nutrient storage. In the life cycle of a plant, after the embryo has formed and the seed is developing, the parent plant moves nutrients into the seed. These nutrients will
be critical for the further development of the embryo once the seed has separated from the parent plant. In some Angiosperms, such as bean plants, these nutrients that enter the seed are stored in enlarged cotyledons. Because of their function in nutrient storage in the seed phase of the life cycle, cotyledons do not look like the normal foliage leaves that we typically associate with plants.

If we remove one cotyledon from a bean embryo, we can see the other basic parts of the plant body that are already present. These include the hypocotyl and the epicotyl that bears additional young foliage leaves.

Observe the beans and peanuts under the dissection microscope. In the space below, diagram the seed and label its parts

---

**Seedlings: Established Root and Shoot Systems**

Alfalfa and Mung sprouts commonly used in salads are seedlings or immature plants. Seedlings are rapidly growing young plants that develop after seed germination. Germination involves the emergence of the embryonic root (radicle) from inside of the seed. During the germination process the seedlings use stored nutrients from the cotyledons or endosperm. Once the seedling establishes itself on a substrate, such as soil, it will begin to photosynthesize and produce its own nutritive sugars.

During the seedling stage, two primary regions that compose the plant body can be observed: (1) the root system and (2) the shoot system. Also present are the cotyledons, which have a very different structure from those of the mature plant.

- Observe the Alfalfa or Mung bean sprouts under the dissection microscope. Can you delineate the point at which the root and shoot separate? Also see if you can see other leaves between the cotyledons.
Carrots: Specialized Root Systems

Carrots are edible tap roots. Tap root systems consist of a single large root off of which may come smaller side roots. This contrasts with fibrous root systems that have many small roots. Many agricultural plants, like carrots, have been bred to form a single large tap root in which nutrients stored.

Despite the conspicuous tap root, the carrot has a very short, modest stem. When you cut a carrot root in half length-wise you can see the shoot system and where the leaves attach at the top.

Look at the large tap root and small stem of the grocery store carrot. When growing carrots from seed a shoot and root system develop as expected. The leaves grow quickly and utilize solar energy in photosynthesis to make sugars and other storage products. The sugars are stored in the root which causes the root to expand, forming the tap root. If carrots are not harvested at the end of the first year of the growing season, they will over winter and finish their life cycle in the second year. This means that carrots are biennials – they have a two year life cycle. At the end of the first year of growth, the leaves die and the plant becomes dormant. In the spring of the second year, the stored sugars in the tap root move upward into the re-growing stem. The stem lengthens upward in a process called bolting to form the flowers and fruits. Flowering and fruiting requires great energy, which is obtained from the stored sugars in the root during the first year of growth.

Like many of our agriculturally important root crops, carrots are harvested in the first year of growth to obtain the storage roots that are filled with nutrients. Carrots show how humans have artificially selected particular plant characteristics. Carrot have a large tap root that functions as a storage structure and a highly reduced stem system that holds the photosynthetic leaves.

Did you know that carrots were originally purple and have been artificially selected by people for the orange color?
- Obtain a carrot and slice through it longitudinally. In the space below draw the carrot root and label the following structures: (1) the stem, (2) phloem, (3) xylem, (4) place where a lateral root would develop.

**Shoot Systems: Asparagus and Kohlrabi**

Plant usually have very different looking root and shoot systems. As we saw with the root systems in the section above, roots can branch in two main ways (tap root or fibrous roots) to form the root system that penetrates throughout the soil in the area around the plant. Shoot systems in contrast tend to be much more morphologically diverse. The shoot system is composed of two main parts, the shoots (stems) and leaves. Stems support the leaves by holding them up to the sun and supplying them with water and nutrients from the xylem and phloem respectively. **Nodes** are the location on a stem where the leaves are attached. The portion of the stem between nodes is called the **internode**.

Stems can be found in a myriad number of forms. Just look outside the classroom and notice that there are large trees with woody trunks, small intricate stems on bushes, and tiny stems in grasses. Artificial selection in agriculture has produced a number of economically important food sources that display unusual stems. Two examples we will use today are the asparagus and the kohlrabi.

Asparagus is harvested in early spring when the young tender shoots emerge from the soil. In the grocery store we are seeing only the very early spring stem growth along with the immature inflorescence (flower stalk). Along the stem small triangular scales can be seen at the nodes. This is where the side branches would develop if the Asparagus were allowed to develop.

Kohlrabi has a stem that is almost spherical. In some way the Kohlrabi stem is like the storage root of a carrot, both are specialized for nutrient storage. Kohlrabi stems swell as they store photosynthate (sugars). The result is a short fat stem with short internodes causing the leaf nodes to be spaced close together.
Obtain an asparagus stalk and a kohlrabi. Draw each of the plants in the space below. Label the (1) nodes and (2) internodes on these stems.

Party fact! What does the name Kohlrabi mean? _______________________________

Party fact! What amino acid is abundant in Asparagus? __________________________

Shoot Systems: Potato

Another example of a storage stem is found in the white potato. Unlike the Kohlrabi that formed a spherical above ground storage stem with leaves emerging from the nodes, potatoes are horizontal underground storage stems with tiny scale like leaves. In botanical terms, a horizontal underground storage stem is called a tuber. The potato is made up of a great number of parenchyma cells that are full of starch grains. Sugars produced in the leave through photosynthesis are transported to these underground stems where the sugar is converted to starch for storage. The potato swells as more and more starch is accumulated.

Tubers have nodes and internodes like other stems. Potatoes purchased at the grocery store are cleaned and washed, which removes the small scale like leaves at the nodes. But close examination reveals the “eyes” at each node. The semicircular scares are where the leaf was attached. Just above this scare is a small protuberance which is the axillary bud. The axillary bud would produce a new shoot in the axis of the leaf, hence the name.

Potato growers obtain new potato plants by cutting potato tubers into pieces with at least one “eye” per piece. A new shoot system will develop from the axillary bud producing. Eventually new underground tubers will form.

Another plant that has an underground stem is taro. Because of taro’s underground stem it is often mislabeled as a root on some grocery labels.
Obtain a potato and look for the eyes, or lateral buds. Observe the eyes with a magnifying glass. Notice that each eye is associated with a semicircular leaf scare. Place the potato on the table and make a sketch of one side in the potato in the space below. Show the location of the nodes. Label the following: (1) node, (2) internode, (3) leaf scare, and (4) axillary bud.

Party Fact! Where are white potatoes originally from? _____________________________

---

Edible Leaves: Spinach and Celery

Leaves are solar receptors for the plant. They are the location where solar energy is converted to chemical energy. Because leaves need to collect light, they are typically broad and flat. Grocery store produce sections are full of plants from which we gain nutrition by eating leaves. Leaves can be quite variable, so we will start by examining a typical leaf.

A typical leaf consists of three structure: (1) base, (2) petiole, and (3) lamina. The broad region where the leaf joins to the main stem is called the leaf base. The long stalk like region between the leaf base and the flatten area (lamina) is the petiole. The petiole functions to hold the leaf away from the stem of the plant to help position the lamina so that it can gain better access to light. The broad, flat region of the leaf is called the lamina. This flattened structure is important for increasing surface area for light collection and for aiding in gas exchange during photosynthesis. Usually all three of these leaf structures can be seen in spinach.

Sometimes grocery stores will carry entire spinach plants. The short stem will carry a number of leaves attached at the base and long petioles from with the lamina is formed. In spinach, the lamina is what we usually eat.
In celery, however, it is the petiole that we typically eat. Grocery stores usually sale the entire celery shoot system. The celery stem is very small with tightly spaced nodes from with the overlapping leaves develop. Removing the celery leaves reveals the stem with its shortened internodes. Each celery stalk contains the broad base and the edible petiole. At the end of the petiole, we find the upper portion of the leaf is divided into a numerous separate pieces of the lamina. Leaves in which the lamina is separated into parts are called compound leaves.

- Obtain a stalk of celery with the lamina attached (you may have to eat some of the outer stalks to find the inner stalks with the lamina). Compare the Petiole of the Celery leaf to that of the Spinach or Lettuce leaf. In the space below draw a stalk of celery and label (1) base, (2) petiole, and (3) lamina.

### Onions and Garlic: Specialized Storage Leaves

Onions and garlic, like carrot roots and potato stems, have specialized underground storage structures. In this case, the specialized storage structures are leaves.

The vertical underground storage stems of onions and garlic are called bulbs. Bulbs have a short, compact stem with broad, fleshy leaves. Over the course of a growing season onions produce three forms of leaves: (1) cylindrical above ground photosynthetic leaves, (2) broad, thick leaves that store sugar and nutrients, and (3) thin, scale like leaves that surround the bulb.

The cylindrical photosynthetic leaves occur early in the growing season. These are purchased in the grocery store as "green onions". Sugars produced in the photosynthetic leaves are transported to the broad, thick underground storage leaves. The storage leaves thicken toward the end of the growing season and are harvest as onion bulbs.

Garlic is a close relative of onion that also has short fleshy underground storage leaves. There is a difference in the structure of the garlic bulb. Under the thin scale leaves that surround a garlic are the "coves." A clove is a branch on the garlic stem. Each clove is in the form of a bulb with a short, compact stem that bears a cluster of broad, fleshy leaves. This means a garlic has a shoot system that consists of a set of tightly aggregated bulbs.

- Take an onion and cut it so that the stem becomes evident. Also, take about a garlic to expose the stem at the center. In the space below, draw an onion and a garlic in cross section. Label the stem and leaf.
Cabbage: An Enlarged Shoot Apical Meristem

Stems and roots typically grow from apical meristems located at their tips. The term meristem comes from the Greek word meristos, which means “to divide.” Meristems are active regions of mitotic cell division. Just behind the dividing cells of the apical meristem is a region of cell elongation. As cells elongate they mature and become specialize such as the production of leaves. Cabbage can be thought of as a highly enlarged shoot apical meristem. Shoot apical meristems produce new cells that develop into new leaves. Since the internodes near the apical meristem do not elongate the leave arch over the apical meristem forming the tightly packed array in the cabbage head. If a cabbage is cut in half lengthwise, the apex of the stem at its core has a small dome on which there are no leaves can be seen. This is the actual shoot apical meristem in which cell division of the stem is located.

- Slice a cabbage through the center longitudinally to expose the stem with its apical meristem. Observe how the leaves are spaced very close together at the nodes with very little internode space. Make a diagram in the space below that illustrates the tightly packed leaves around the shoot apex.

Broccoli: Shoots at the Time of Flowering

Many of the vegetables that we find in the grocery store are Angiosperms. Angiosperms are distinctive in that their reproductive structure is the flower. Flowers are where pollination, fertilization, and seed production occur. Flowers are produced on specialized shoot systems called inflorescences. Broccoli is an inflorescence. It consists of a cluster of stem branches each bearing an arrow flowers. Broccoli is eaten at a stage when the flowers are still young and not fully developed. You can tell when broccoli is getting old, the yellow flowers common in the Brassica family will become evident.
Obtain a Broccoli Inflorescence and examine the flowers with a microscope. Good quality Broccoli will have flowers that are tightly covered by the sepals. As the Broccoli gets old (i.e. it has been on the grocery shelf a long time) that flowers will open and the yellow petals will be visible. In the space below, draw a flower from the broccoli.

Artichokes: Modified Flower Petals:

Artichokes also have flowers that we eat. Actually the leaf like structures that cover the Artichoke flower are called bracts. These are modified leaves that protect the flowers. These are the same type structures that are found in Poinsettias (the red bracts) and Dogwood (the 4 white or pink bracts). The artichokes we purchase for cooking are the ends of the stems where the inflorescence develops. In this region of the artichoke shoot, the internodes are short and the bracts overlap one-another. Underneath the bracts you will find the actual flower.

• Obtain an Artichoke and slice it longitudinally though the center to expose the flower inside. In the space below draw the cross section of the Artichoke. Label the bracts and the portion of the flower that is called the “Artichoke Heart”.

Bracts found in Poinsettia and Dogwood. The Flowers are in the center of the bracts.

All pictures from commons.wikimedia.org
**Whole Plant:**

<table>
<thead>
<tr>
<th>Dicots:</th>
<th>Monocots:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Herbaceous or woody plants.</td>
<td>(1) Tend to be herbs, but can occasionally be woody</td>
</tr>
<tr>
<td>(2) Stem vascular bundles arranged in a ring around a small pith.</td>
<td>(2) Stem vascular bundles are scattered</td>
</tr>
<tr>
<td>(3) Vascular cambium (the lateral tissue involved in cell division) produces secondary xylem toward the interior of the stem, and secondary phloem toward the outside of the stem.</td>
<td>(3) Leaves have major veins that run in parallel</td>
</tr>
<tr>
<td>(4) Leaf venation is netted that can be either palmate (like the palm of your hand or a Palmetto leaf) or pinnate (like a feather)</td>
<td>(4) Almost always have smooth leaf margins</td>
</tr>
<tr>
<td>(5) Flower parts in multiples of four or five</td>
<td>(5) Flower parts are in multiples of three</td>
</tr>
<tr>
<td>(6) Embryo has two cotyledons (seed leaves)</td>
<td>(6) Embryo has one cotyledon</td>
</tr>
<tr>
<td>(7) Examples: magnolias, oaks, beeches, willows, maples, asters, zinnias, marigolds, cacti, jade plant, tomatoes and potatoes, poison ivy, cotton, blueberries, and rhododendrons</td>
<td>(7) Examples: grasses (wheat, oats, corn, and rice), sedges, lilies, irises, palms, orchids, and bananas</td>
</tr>
</tbody>
</table>

Observe the plants on the front table.

**Study Question 2:** Using the samples of plants on the front table, decide if they are monocots or dicots.
Key to Common Fruits

1a Fruits Fleshy at Maturity
   2a Fruits Simple (derived from a flower with a single pistil/carpel)
      3a Fruits with a single seed enclosed in a hard pit.......................... DRUPE
      3b Fruits with more than one seed, the seeds not enclosed in a hard pit (one or more seeds do not develop in avocados and the common banana)
         4a Fruits derived from the ovary only (fruit below the flower – look for the old sepals)……. BERRY
            (berries with a thin skin are referred to as TRUE BERRIES; berries with leathery skin containing oils are referred to as HESPERIDIUMS)
         4b Fruits derived from the ovary plus other parts of the flower (accessory fruits). (Fruit above the flower – the flower is on the end of the fruit where the peduncle – fruit stalk - is attached.)
            5a Fruits with a relatively hard rind .................................................. PEPO
            5b Fruits without a hard rind
               6a. Endocarp leathery or papery .................................................... POME
               6b Endocarp not leathery or papery.................................................. FALSE BERRY
   2b Fruits derived from more than one pistil/carpel
      7a Fruits derived from a single flower having several to many pistils/carpel……. AGGREGATE FRUITS
      7b Fruits derived from several to many separate flowers in an inflorescence, the fruits coalescing to varying degrees to form a single “fruit” at maturity... MULTIPLE FRUIT

1b Fruits Dry at Maturity
   8a Fruits not splitting at maturity.
      9a Fruits with a wing .......................................................... SAMARA
      9b Fruits without a wing
         10a Fruits with a hard shell surrounding the seed .................................. NUT
         10b Fruits without a hard shell
            11a Fruit wall fused to the seed coat............................................ GRAIN
            11b Fruit with seed loosely attached ............................................. ACHENE
   8b Fruits splitting in various ways at maturity
      12a Fruits splitting along or between carpel lines or forming a cap that comes off or a row of pores near the top .................................... CAPSULE
      12b Fruits splitting lengthwise along the edges
         13a Fruits leaving a central partition to which the seeds are attached ................................ SILIQUE OR SILICLE
         13b Fruits not leaving a central partition
            14a Fruits splitting along one edge only...................................... FOLLICLE
            14b Fruits splitting along both edges.......................................... LEGUME
<table>
<thead>
<tr>
<th>Fruit</th>
<th>Numbers and Letters from Key</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>