

Botany: Plant Dissection

Teacher Version

In this lab, we will learn about the structure and function of plants, and how plants are useful in our everyday lives.

Preparation and Lab Notes:

- Soak the lima beans in water at room temperature overnight (I plan on at least two beans per student, to ensure that at least one turns out well!)
- Boil the artichoke, if you have one (just for 10 or 15 minutes – it doesn't need to be soft enough to eat, just to pull apart)
- If you have access to a color printer, it is recommended to print out at least one color copy of the plant/product matching problem on pages 7 and 8.

Prerequisites:

- This is a pretty basic lab. No previous experience is necessary.

California Science Content Standards:

- Note: There are no specific California State Science Content Standards that address plant anatomy, physiology, and the other concepts presented in this lab activity. General standards that can be aligned to this lab are as follows:
- **1. Cell Biology: The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells.**
- 1c. Students know how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.
- 1f. Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.
- **6. Ecology: Stability in an ecosystem is a balance between competing effects.**
- 6a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

Complete List of Materials:

- A computer with internet access
- Flowers (at least 3 kinds)
- Dried lima beans
- Soaked lima beans (16-24 hours in water)
- Hand lens / magnifying glass
- Paper plates or paper towels (one per student)
- Fruits / vegetables (artichoke, broccoli, etc – number / variety is flexible)
- Plastic knives (one per student)
- Optional: Venus flytrap, seed burrs, maple seed “helicopters” (see what you can find)

Key Concepts:

- Plants have been on Earth for hundreds of millions of years!
- Most plants are made up of **roots, stems, leaves**, which are important for plant growth, and **flowers and fruits**, which are part of the plant reproductive system
- We use plants in almost every aspect of our lives, including **food, clothing, medicine**, and more
- Plants have different **adaptations** to help them to survive in different environments

Introductory Mini-Lecture:

How long ago did dinosaurs first appear on the Earth? Was it 1,000 years ago? 100,000? A million? *[Have the students raise their hands to indicate their agreement as you go back in time]*

The earliest dinosaurs emerged about 225 million years ago.¹ That's a long time ago! However, the first recognizable plant fossils appear on land 415-440 million years ago.¹ That means that plants had already been around for 200 *million* years before the dinosaurs. That's a really long time! After all, the dinosaurs only went extinct about 65 million years ago, which is only a fraction of that time!

Now, why do you think it's important that plants came before the dinosaurs? *[First, some dinosaurs relied on them for food. More importantly, however, the plants made all the oxygen for the dinosaurs (and later, humans!) to breathe.]*

Humans (of the genus *Homo*) finally showed up about 1.8-2 million years ago.¹ That means that plants have been around 220x longer than even our most ancient human ancestors! Indeed, humans (and almost all other life on Earth) never would have existed without them – before plants, there was no oxygen in the atmosphere to support animal life. All of the oxygen that we breathe, even today, is thanks to plants!

Today we're going to learn about plants – how they work, what the different parts are called, how they adapt to different environments, and how we humans use them every day!

Part 1: Growth

Generally speaking, a plant has two goals – to grow and to make more plants (reproduce). In order to grow, most plants need water, sunlight, and carbon dioxide (CO₂). There are several plant structures which help to gather these ingredients – the roots (which collect water), the stems (which transport water), and the leaves (which collect sunlight and CO₂).

Q1. Plants use water, sunlight, and CO₂ in a process called photosynthesis. What does the plant make during this process? Hint: What do you think that the plant uses for energy to grow?

It makes sugars.

QSA1. The plant tissue in the stem which carries water from the roots to the leaves is called “xylem.” Running right next to the xylem is a second tissue, called phloem, which carries things in the opposite direction. What do you think it carries? Why?

Phloem carries sugars from the leaves (where they are made) to the rest of the plant, which the cells use as energy for growing and dividing.

Plants can sense the direction of the light and turn towards it, in order to maximize the amount of sunlight they absorb with their leaves. This process is called **phototropism**. “Photo” means “light” and “trop” means “to turn.”

Watch the videos “Cool corn phototropism” and “Sunflower solar tracking” located in the left-hand navigation bar at

<http://plantsinmotion.bio.indiana.edu/plantmotion/movements/tropism/tropisms.html>

Q2. Compare the seedlings at the beginning of the “cool corn phototropism” movie to the end. What has changed? Why?

They are taller and have turned green. This is because the light gave them energy to make food (and grow). The green color indicates the production of chlorophyll, a compound which absorbs light for use in photosynthesis. Therefore, these seedlings have likely started making their own food via photosynthesis by the end of the movie.

Q3. Describe the leaves in the sunflower video. What characteristics do they have that allow them to capture the maximum amount of sunlight?

They are large and flat, which provides a lot of surface area for light absorption (like a solar panel on the roof of a house).

QSA4. What kind of environment do you think sunflowers live in, based on the characteristics of these leaves?

They probably live in a cooler climate with lots of rainfall, as the large leaves maximize light absorption (suggesting that it may be scarce) while disregarding water loss from the large surface area (suggesting that there is plenty of rain).

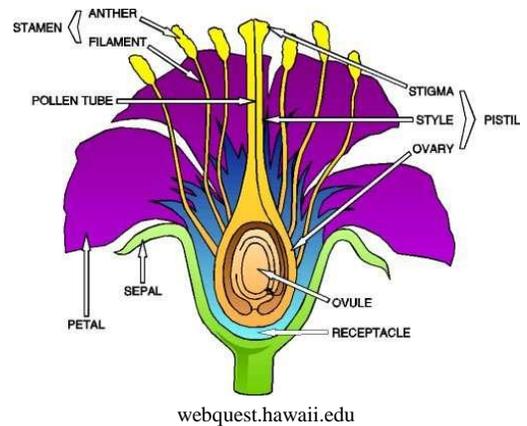
*** Teacher's note: Be sure to point out to the students that the plant turns its leaves toward the sun even before the sun rises. It anticipates where the sun will be.*

Part 2: Reproduction

Just like a bird lays an egg to make a baby bird, most plants create seeds to make new plants.

Section 1: Flowers

Many plants use flowers as “seed factories.” Each flower has male and female parts - the female part in the middle (the **pistil**) grows and shelters the ovule, or egg, while the male parts along the outside (the **stamens**) produce pollen. When pollen and the ovule come together, a seed is formed! However, even though a single flower has both male and female parts, the seed is usually made with pollen from a *different* flower, not the one in which it's grown.



QS4, QSA5. How does pollen move from flower to flower?

Insects, small birds, and even bats are known to move pollen from one flower to another.

QSA6. Why do you think that seeds are usually made from two different plants (ovule from one, but pollen from another)?

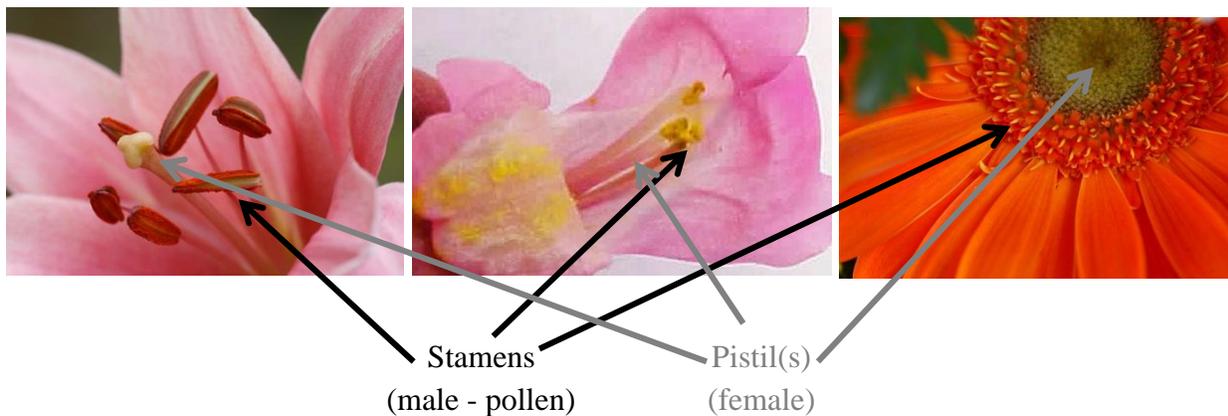
With the current system, the seed ends up with DNA from two different plants, which likely have slight differences between them. If flowers always “self-pollinated,” then there would never be any new information to incorporate. This would slow down the spread of beneficial traits. In addition, if a plant has a mutation that causes a disease, it might normally be masked by a “good copy” from another plant. If it never gets DNA from another plant, though, then that bad trait is more likely to show up and cause disease in the plant. This is the same reason why humans are discouraged from marrying and reproducing with close relatives. More genetic diversity is generally better!

Over time, plants have evolved flowers that look very different from each other!

Using a hand lens, identify the following structures in three different flowers.

Three examples from a store-bought mixed bouquet are given below – these have very easily identifiable structures. However, most flowers will do. Note that non-Gerber daisies are tricky, since they have a “compound” flower structure, with both male and female parts hidden in the bumpy center. Also, red Gerber daisies are best, as orange/yellow blend in with the stamens!

Type of Flower:	1. Lily	2. Snap dragon	3. Gerber daisy
Petals? (yes / no)	Yes	Yes	Yes
Stamen? (yes / no)	Yes	Yes	Yes
Pistil? (yes / no)	Yes	Yes	Yes
Identify a Unique Feature	Large petals, reproductive parts	Unique petals	Many, many reproductive parts



QS5, QSA7. Do all the flowers have the same basic parts?

Yes, for the most part.

QS6, QSA8. Why do you think these flowers look so different from each other? What is the function of having unique traits?

Flowers co-evolve with their pollinators. They use bright colors, differently shaped flowers, and appealing smells and tastes to lure in the “right” types of insects and keep out the “wrong” ones – it’s all designed to help move around pollen.

Once a seed is created, it needs to be dispersed and planted. Just as plants need insects and animals in order to be pollinated, they also rely on them to disperse their seeds! Otherwise a plant would only ever grow in one, limited area. One way to make seeds more attractive to animals is to develop them into a “fruit.” This structure forms at the base of the flower, and expands as it fills with sugars and other nutrients to protect the developing seeds and appeal to passing animals.

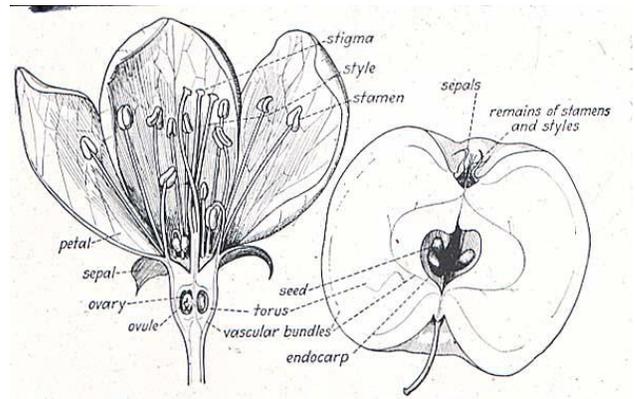


FIG. 381. Flower and fruit of apple (*Malus pumila*), cut lengthwise to show the relation of the parts of the flower to the torus.

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This is not the only way to disperse seeds, though. Plants can also envelope them in sticky or spiny coats (often called **burrs**), which will grab on to an animal’s fur (or your socks!) as it walks through a wooded or grassy area. Seeds can also be dispersed on the wind or by water.



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QS7, QSA9. Can you think of an example of seeds that are dispersed by wind? Think about a popular weed...

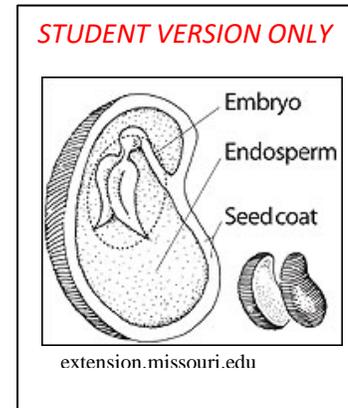
Dandelions! Another popular example is the “helicopter” seeds that are produced by maple trees.



Section 2: Seeds²

After the seed is dispersed and planted, it's ready to sprout! Everything that the baby plant needs to grow is already there, packaged neatly into the seed.

Since the seed is completely in the dark underground, the plant inside (called the **embryo**) cannot use photosynthesis to make its own food. Instead, the seed contains an energy-rich, sugary substance called “**endosperm**” that the embryo uses in order to grow.



QS8, QSA10. Chances are you've eaten the endosperm of a corn kernel (a seed) before. What is this called?

Popcorn!

1. Your teacher will give you a dried bean and a bean that has been soaked in water.

QS9, QSA11. Look at the two beans under a hand lens. Describe what differences you see (and feel!).

The soaked bean will be larger, and have a firmer coat. It will also be softer to the touch.

QS10, QSA12. If you planted these two seeds, which do you think is more likely to sprout faster? Why?

The soaked one. The seed coat is softer, which will allow the embryonic plant to emerge more easily. In addition, the plant needs water to grow, so the soaked bean has an advantage by already having a supply of water.

2. Carefully remove the seed coat from the soaked bean with your fingers.
3. Gently pry apart the two halves of the bean.

QS11, QSA13. Draw what you see inside the bean. Label the embryo and the endosperm.

Should look similar to the picture above (note that there is no picture in the advanced version).

*** Teacher note – you may need to do a few beans in order to find one where the embryo is intact. It's very easy to pull the embryo off with the seed coat, so be very careful when removing it, especially from the inner portion of the bean (where the “scar” is).*

Part 3: What parts of plants do we use?

We interact with plants and plant products every day, from food to clothing to the very oxygen that we breathe! But what parts of plants do we use?

1. Based on what we've learned about the different parts of plants, identify whether you think each item is a root, stem, leaf, flower, or fruit.

Use a plastic knife in order to see what's inside each specimen, if necessary. Be sure to cut neatly so that others can look at your work and make their own conclusions! Be sure to identify specific characteristics which support your answer.³

STUDENT VERSION ONLY

Here are some sample questions to think about and help your decision-making:

- *Does it have seeds?*
- *Does it have leaves or stems growing out of it?*
- *Does it have roots (or a place where roots used to be)?*

Given Name	Plant Part	Evidence
<i>Artichoke</i>	<i>Flower</i>	<i>Has flower parts near the "heart" (anthers and pistils); shaped like a flower NOTE – it's best if the artichoke was cooked the day before, as it can be hard to get to the center otherwise</i>
<i>Broccoli</i>	<i>Flower</i>	<i>Stem-like base with leaves on the stem; flower parts inside the closed buds</i>
<i>Avocado</i>	<i>Fruit</i>	<i>(Giant) seed in the center</i>
<i>Corn</i>	<i>Fruit</i>	<i>Seeds (each kernel is a seed) attached to a stem (cob)</i>
<i>Peas</i>	<i>Fruit</i>	<i>Seeds (each pea is a seed) with the remnants of flower parts on the top</i>
<i>Squash</i>	<i>Fruit</i>	<i>Seeds</i>
<i>Tomato</i>	<i>Fruit</i>	<i>Seeds, flower part remnants</i>
<i>Brussels Sprouts</i>	<i>Leaf</i>	<i>Attached to a stem; composed of leaves</i>
<i>Carrot</i>	<i>Root</i>	<i>Has leaves / stems growing from the top; root hairs</i>
<i>Radish</i>	<i>Root</i>	<i>Has leaves / stems growing from the top; root hairs</i>
<i>Sweet potato</i>	<i>Root</i>	<i>Root hairs</i>
<i>Asparagus</i>	<i>Stem</i>	<i>Small leaves and buds</i>
<i>Potato</i>	<i>Stem</i>	<i>Tricky! Grows roots and leaves if planted</i>

These items are all relatively easy to identify, since they go almost directly from the plant to the plate! However, many other plant products that we use have been processed so much, it's hard to tell what the plant originally looked like!

QSI2, QSA14. Can you identify the item in each picture below? Then draw a line connecting each plant with its corresponding finished product.

Plants



Cotton



Wood chips / pulp



Tree sap

Products



Paper towels



Maple syrup



Cotton t-shirt



Poppy flower



Cinnamon



Indigo plant



Indigo dye



Bark (cinnamon)



Codeine

***Teacher note: If printed in black-and-white, the indigo is difficult to identify. However, the students can use process of elimination in order to figure it out.*

Part 4: Unique Adaptations

We've talked a little bit about how root systems, leaves, flowers, and seeds can all look different depending on the environment where they grow. These differences are referred to as “**adaptations**.” Some plants, however, have developed extremely specialized adaptations in order to survive in specific environments!

1. Either demonstrate the closure of a Venus flytrap in real-time (if you have a live plant) or watch the “Venus flytrap” video from the left-hand navigation bar at <http://plantsinmotion.bio.indiana.edu/plantmotion/movements/nastic/nastic.html>
2. Watch the “Sensitive plant” video at the same site (including the “stronger stimulus” version found by scrolling down to the bottom of the description)

QS13, QSA15. Why do you think these plants have these responses? Why are they beneficial?

Venus flytrap – This response helps the plant capture flies to eat. This means that the plant can grow in soil with poor nutrients, as it can get nutrients from insects.

Sensitive plant (Mimosa) – This response helps to protect the plant if attacked (like being eaten).

QS13, QSA16. Look at the time scales for each of these reactions. Are they faster or slower than the phototropism response that we saw earlier? Why do you think this is?

Much faster. The phototropism response is a time-lapse, taken every 4 minutes over 24 hours. The Venus flytrap and Mimosa plant videos are taken in real time. These responses need to be faster because plant is reacting to something which happens quickly, and doesn't last very long.

3. As we saw earlier, plants often adapt to the day/night cycle by orienting their leaves. However, they can also adapt in other ways – watch the “Pulsing pumpkins” video at <http://plantsinmotion.bio.indiana.edu/plantmotion/movements/leafmovements/clocks.html>

QS15, QSA17. Why is this growth cycle considered an adaptation? How does it benefit the plant?

By separating photosynthesis and growth, the plant uses its time and energy efficiently. If the plant devotes its entire daylight cycle to capturing sunlight and producing sugar, then it can use these energy stores at night to promote growth of the fruit.

Many years from now, you're a brilliant Plant Biologist who studies adaptations. One day you get a call - astronauts have been working hard to make Mars livable for humans, and they need your help to get plants to grow there! They've created an environment that is sunny, dry, windy, and full of insects that only come out at night. It's quite a challenge! Can you help them out and design a plant that will survive there?

Draw your plant (think about roots, stems, leaves, flowers (and pollinators), and seeds!) and describe how each part is adapted for this specific Martian environment. What unique features does it have to help it survive?

Answers will vary. Some key things to look for might include:

- *wide-spread, shallow roots (sunny, dry)*
- *short stems (windy)*
- *narrow leaves (sunny, dry)*
- *seeds which are carried by wind (windy)*
- *flowers that open at night (insect pollinators)*
- *other specialized adaptations*

¹Smithsonian Department of Paleobiology <http://paleobiology.si.edu/geotime/main/htmlversion/>

²Adapted from "Seeds, Inside and Out" - <http://www.cas.muohio.edu/scienceforohio/Teacher/index.html>

³Adapted from "What Parts of a Plant Do We Eat?" - http://serendip.brynmawr.edu/sci_edu/waldron/