

OEB 104 – Plants and Human Affairs

Plant Anatomy Lab 1: Stems, Leaves and Roots

Objectives of the Lab:

- 1) Master operation of the light and compound microscopes as well as basic sectioning and staining techniques.
- 2) Explore the structure and function of major plant tissues and organs, including:
 - leaves
 - roots
 - stems
 - meristems (lateral and apical)
 - epidermis
 - ground tissue
 - xylem
 - phloem
- 3) Distinguish between monocots and dicots.

Recognizing monocots and dicots:

Flowering plants are broadly divided into two categories: monocots (monocotyledonous plants) and dicots (dicotyledonous plants). Dicots are more numerous, but many of the world's most important crops are monocots. All grasses are monocots, and most of the world's grains are grasses (corn, rice, wheat, oats, rye, millet, sorghum). Most woody flowering plants are dicots. The following table elaborates some of the chief differences between monocots and dicots:

Monocots	Dicots
Veins in leaves are parallel	Veins in leaves form net-like pattern (reticulated)
No strong leaf midrib	Clear central vein or midrib present in leaves
Single cotyledon	Two cotyledons
Petals and other flower parts occur in multiples of three	Petals and other flower parts occur in multiples of four or five
Vascular bundles scattered throughout stem	Vascular bundles circularly arranged
Secondary growth (e.g. wood) rare and loosely organized	Secondary growth occurs from vascular cambium and leads to secondary increase in girth
Stomata have barbell-shaped guard cells	Guard cells more oval in shape
Primarily adventitious roots and no clear taproot	Frequently a strong taproot present

Look at the overall structural differences between the group of monocots and the group of dicots that are assembled in the lab.

Differences between Stems and Roots

Stems	Roots
Can be divided into modular units consisting of nodes and internodes	No organized nodes or modular units
Branching meristem on periphery of plant	Branching meristems located internally
Apical meristem not covered by other cells	Apical meristem covered by root cap
Vascular bundles arranged circularly (dicots) or scattered (monocots)	Vascular bundles can be arranged circularly or with xylem in an “X” or “Y” shape with phloem in between the arms (in primary roots)

You will look at differences in internal anatomy between stems and roots when you make sections of corn (a monocot) and bean (a dicot), but make sure you also look at the gross differences between stems and roots on the uprooted, washed seedlings.

Sections:

Make the following sections on each of your seedlings (corn, bean):

- cross section of stem in an internode
- cross section of stem at a node
- cross section of a leaf
- cross section of a root
- longitudinal section of a stem
- longitudinal section of a root

Also look at a leaf of each seedling under the light microscope. Make longitudinal sections of the shoot and root tip and look at the structure of the meristems. Also, try making a cross section of a root at a branching point. See if you can see where the root branch originated from.

Stains to try on your sections:

Glycerine (to make into 1:1 mix with water for untreated sections to see chloroplasts)

Toluidine blue (0.1% aqueous solution)

Iodine potassium iodide (I₂KI) (for staining starch dark)

Bleach-clears cell contents

Concentrated HCl (40% aqueous) gets rid of starch in cells

Phloroglucinol (saturated solution in 95% EtOH) [add first HCl then phl. for stain of lignin]

Look for the occurrence and distribution of the following tissues and cell types in each section:

	Name	Characteristics	Location
Dermal Tissues	Epidermis	Usually heavily fortified on exterior wall (cuticle)	Outermost cell layer of plant
	Periderm	Cork and cork cambium	Just inside epidermis, usually on woody plants
Ground Tissues	Parenchyma	Very variable; pith	In cortex, pith, vascular bundles
	Collenchyma	Elongated cells with thickened but non-lignified cell walls	Near periphery in young stems; in ribs along veins in leaves
	Fibers	Elongated cell with thick, sometimes lignified cell walls	Usually with xylem and phloem; in leaves of many monocots
	Sclereids or stone cells	Not elongated, irregularly shaped; sometimes lignified cell walls	Throughout
Vascular Tissues	Tracheids	Elongated, tapering in shape; lignified and dead	In xylem
	Vessel Elements	Elongated, very large diameter; lignified and dead	In xylem
	Sieve-tube elements	Elongated; no nucleus; lots of pores and callose in cell walls	In phloem
	Companion cells	Usually elongate; closely associated with sieve-tube elements, probably supplying these with nutrition	In phloem

Meristems:

Meristems are the plant organs responsible for continuing growth. In the shoot, there are meristems at the very tip of the plant (**shoot apical meristem**) and typically at the base of each leaf (**axillary meristems**). [In woody stems, there may be a **vascular cambium** and a **cork cambium** that contribute to increases in stem girth. These are lateral meristems, and we will see them in a later lab.] In the roots, there is a **root apical meristem** near the apex, but this is covered by a layer of protective cells called the root cap. Side shoots are initiated from well within the root, unlike the generation of above-ground side shoots, which are initiated from the periphery of the plant. [In woody plants, there may also be a vascular cambium in the roots.]

Epidermis:

Description: Outer layer of cells, plant's "skin." This layer separates a plant from its external environment. Often covered in waxes, hairs and/or glands. Gas exchange (generally plants give off carbon dioxide and water vapor and take up oxygen) takes place in specialized pores called stomata that the plant can open and close. Stomata are generally found on the epidermis on the underside of leaves, although they can be located on other parts of the plant as well. In roots, the epidermis forms long, thin root hairs.

Notable features: Tends to be a thin tissue whose protective role is minimal in most woody plants (where the role is taken over by bark).

Economic importance: Cotton comes from the hairs originating on the seed epidermis of *Gossypium hirsutum* (and a few other species in the genus). Members of the family Urticaceae (nettle family) have nasty little stinging hairs that inject poison into passersby who touch the leaves. The poison also has some medicinal uses.

Phloem: Description: A vascular tissue made up of enucleated cells stacked end to end to form sieve tubes. The phloem is used to transport sugars (plant sap) from one part of the plant to another. Phloem has a "source-sink" flow pattern. For instance, during the day the flow direction is generally away from the photosynthesizing leaves to other parts of the plant. In spring bulbs, the phloem will transport sugars from the starchy bulb to the green, growing leaves. Later in the season the flow will reverse, building up the starchy bulb for the next spring's growth. (This is why we harvest many starchy storage organs in the fall e.g. potatoes, beets, parsnips...the fall is when they are at peak capacity.)

Notable features of the phloem: The active phloem is usually very close to the surface of the plant. Phloem is very sensitive to wounding, and in most species the plant quickly plugs up breaches and flow of sap is diverted to other, non-wounded phloem conduits. The phloem may have thickened cell walls that can create rows of cells that make up "phloem fibers."

Economic importance: Fibers from the phloem form the main component of many natural fibers (especially those derived from monocots). In a few palm species (e.g. the Chilean wine palm), the phloem is slow to respond to wounding. The long-flowing, sugary sap is harvested and either boiled to form palm honey or fermented to make palm wine. Phloem harvesting is typically fatal to the plant.

Xylem: Description: A vascular tissue made up of empty, dead cells. Flowering plants have two types of xylem cell – tracheids and vessel elements. Vessel elements are very wide and are stacked end to end to form vessels. Tracheids are much longer and narrower. The xylem is used to transport water and most minerals/nutrients from the roots to the leaves. Flow in the xylem is driven by the evaporation of water from the leaves.

Notable features of the xylem: The xylem is made up of large diameter, thick-walled cells that are lignified.

Economic importance: The lignified cell walls of the xylem are what give wood much of its strength.

Compare the structure of the various underground storage organs (potatoes, sweet potatoes, yams, beets, carrots, parsnips, malanga, cassava, ginger, onion) in the lab. What part of the plant (stem, leaf, root) is used for storage in each case? Which of these could give rise to another plant if you planted it? Why? Fill out the table provided at the end of the lab handout.

A few terms that are associated with swollen storage organs are:

Corm: short swollen stem consisting of many internodes and nodes bearing either scale or foliage leaves (e.g. crocus)

Bulb: short stem surrounded by many fleshy and/or membranous scale leaves (e.g. tulip)

Rhizome: horizontal below-ground stem (e.g. turmeric)

Stem tuber: swollen stem with scale or foliage leaves; often asymmetric

Root tuber: a swollen root produced by lateral cell division and enlargement

Storage Organs

Common Name	Scientific Name	Your Description	Leaf, stem or root?
Potato	<i>Solanum tuberosum</i>		
Sweet potato	<i>Ipomea batata</i>		
Cassava, manioc, yuca	<i>Manihot esculenta</i>		
Yam (white name)	<i>Dioscorea rotundata</i> or <i>D. alata</i>		
Yam (yellow name)	<i>Dioscorea cayenensis</i>		
Malanga blanca	<i>Xanthosoma sagittifolium</i>		
Malanga lila	<i>X. violaceum</i>		
Ginger	<i>Zingiber officinalis</i>		
Carrot	<i>Daucus carota</i>		
Parsnip	<i>Pastinaca sativa</i>		
Beet	<i>Beta vulgaris</i>		
Onion	<i>Allium cepa</i>		

Caveat: Many tubers of different origin are given the same common name (e.g. pretty much everything sold as a “yam” in the U.S. is actually a sweet potato – a different plant in a different plant family from the true yam, species in the genus *Dioscorea*, esp. *Dioscorea esculenta*). The species names given in this table are correct to the best of my knowledge. I am working on the basis of the fact that these tubers are from a grocery store (in Somerville) servicing a Caribbean clientele. However, I may have the species name wrong in some cases. In particular, “malanga” is a very broad term that can refer to almost any tuber from the family Araceae (which also includes jack-in-the-pulpit, voodoo lilies, arums). The three most commonly cultivated genera are *Xanthosoma*, *Colocasia* and *Alocasia*. Taro -- technically defined as *Colocasia esculenta* and also called dasheen and sometimes malanga or malango -- is usually cultivated in wet areas, whereas *Xanthosoma* thrives in dry. In Cuba, taro is *Colocasia* and malanga is *Xanthosoma*.

Fun Plants to Observe:

Modified leaf morphology in ant plants.

Photosynthetic roots in orchid.

Leaf movements in *Mimosa pudica*, the sensitive plant.

Leaf hairs in mapighs (branched), euphorb (stellate), sage (copious), geranium (copious).

Succulent leaves of *Aloe vera*.

Food and Drink:

Teas made from stems, roots and leaves.

Chips made from different starchy tubers (including corms, root tubers, and stem tubers).

Written by Amity Wilczek, 2003.