Plant 1° tissues I: overview and leaves

The structure of a 'typical' plant (we'll address this generalization later…) is organized at three levels:

ORGANS —built from→ TISSUES —built from→ CELLS

<u>Organs</u>:

Over the next three lectures, and two labs, we consider three types of organs:

1) **root** (future lecture)
2) **stem** (future lecture)
3) **leaf:** lateral appendage of the stem. Many functions – but the foliage leaf is typical and adapted for photosynthesis.
    - **Blade** (aka lamina) – flat part of foliage leaf
    - **Petiole** – thin tissue that attaches blade to the stem

<u>Tissues</u> from which organs are constructed:

<u>1° tissue</u>: tissues that arise from an apical meristem. In general, non-woody (**herbaceous**) plants are constructed entirely from 1° tissue. Today we deal only with 1° tissues, and we will explore meristems in our next lecture.

<u>2° tissue</u>: tissues that arise from lateral meristems that develop after initial activity of the apical meristem has constructed 1° tissues. 2° tissues are wood or bark – but we'll get deeper into this in a future lecture! Woody plants (e.g., oak trees, pine trees, roses) are constructed from 1° tissue and 2° tissue.

Hovever…in case you just CAN'T wait to learn about meristems…

Meristem: region of a plant where new tissues are formed

Apical meristems: Meristems at the tip of root or stem, cell division causes tissue elongation (1° growth, 1° tissue)

Lateral meristems: Meristems not at tips of stems/roots – cell division causes thickening of tissue (2° growth, 2° tissue). Two lateral meristems: cork cambium (makes bark) and vascular cambium (makes wood)

<u>Three types of 1° tissue</u>

1) **epidermis:** outermost layer of tissue, separates plant organ from outside environment. The epidermis on stems and roots of herbaceous (non-woody) stems is replaced by bark in woody plants. Depending upon the organ, one or more of the following may be present:
    - **trichomes:** fine hairs that are outgrowths of epidermal cells – many purposes…stay tuned!
    - **stomata**: pore through which gas exchange occurs – see previous lectures;
    - **cuticle:** waxy layer formed on outer surface of epidermal cells – H_2O conservation, H_2Oshedding, not edible to bacteria/fungi/insets, can provide light coloration.
2) **vascular tissue:** tissue through which water, nutrients, and sugars are transported. Two types: xylem and phloem:
    - **Xylem**: vascular tissue through which water and nutrients are transported (from roots to stems and leaves). Xylem cells dead at maturity. (mostly parenchyma, some sclerenchyma)
    - **Phloem**: vascular tissue through which food (sugars) are transported (from photosynthetic tissues to other tissues that require sugars). Phloem cells are alive at maturity. (Paren., some scler.)

****We will discuss the structure of xylem and phloem in great detail in a future lecture****

3) **ground tissue**: all tissue other than the epidermis and vascular tissues. Includes the <u>cortex</u> and, if present, the <u>pith</u> (the term "ground tissue" is not used in your book – which is odd…)

Cortex: outer layer of a stem or root, bounded by the epidermis and the endodermis of the cortex.

Pith: ground tissue at the center of a stem or root, inside the xylem/phloem of the vascular tissues.

* note that we did introduce the terms "cortex" and "pith" in today's lecture – but we will soon!)

<u>Cell types</u> from which 1° tissues are constructed. There are 3 types – defines by CELL WALL thickness:

1) Parenchyma – cells with thin primary cell walls only (no 2° cell wall)

- Ubiquitous, and by far, the most common cell type in plant 1° tissues
- Highly diverse in form and function (we'll study many in labs throughout the semester)
- Examples in leaves: palisade parenchyma, spongy parenchyma, epidermis, phloem, xylem (as we will learn, xylem can also exist as sclerenchyma cells when it develops a 2° cell wall (in wood) – we'll get to that next week when we explore 2° tissues!)
- FYI - (chlorenchyma cells are panerchyma cells that contain chloroplasts, don't need to know this for exams)

2) Collenchyma – cells with thickened primary cell walls.

- Relatively rare - a low percentage of plant calls are collenchyma.
- Used to provide structural support in leaves and herbaceous stems – mostly absent in roots!
- "<u>Plastic</u>": Can be deformed and maintain a new shape. Critical for leaves and the tips of herbaceous stems that must change shape as they grow
- Examples in leaves: small bundles that provide support in herbaceous leaves/stems.

3) **Sclerenchyma cells**: Cells with thickened and lignified secondary cell walls.

- Provide structural support.
- May or may not be living at maturity.
- Two main types:
  A. <u>Conducting sclerenchyma</u>: "Hollow tubes" through which water travels, also provide structural support. Example = **2° xylem** in wood (such xylem, and wood itself, is a 2° tissue that we will discuss in great detail in future labs and lectures!! **2° xylem** in wood are not 1° tissues!!!)
  B. <u>Non-conducting sclerenchyma</u>: <u>No</u> water travels through (solid or hollow):
     Fibers: elongated, tapering sclerenchyma cell used primarily for structural support
     Sclereids: Short "cuboidal"/ "box-shaped" cells. Provide protection, Ex: walnut and almond "shells" (we'll develop more sophisticated vocabulary later), also responsible for the "gritty" texture of the fruit in pears…

OK, now that we understand the basic structure of plant organs, tissues, and cells, let's link and *form and function* by having a look at how the cells and tissues of "typical" leaves, stems, and roots are arranged, and how they enable function. We will also examine atypical adaptations of the leaf, stem, and root organs. This lecture, let's examine leaves.

Leaves

Foliage leaves:

By far the most common leaf function is photosynthesis, and the leaves that are designed to maximize this process are **foliage leaves**. The form of foliage leaves reflects their function: they are flat and have large surface area to maximize sunlight absorption, and they are thin and covered with stomata to maximize gas exchange.

This form presents an inherent trade-off: thin tissues with large surface areas are more efficient for performing photosynthesis, but they are inherently delicate and vulnerable to physical damage, herbivory (being eaten), overheating, or freezing. Plants have many adaptations for avoiding these stresses (*a partial list is presented here – we will explore more this semester!*):

Adaptations for avoiding heat stress (recall which proteins are damaged by heat stress…?)

Light color (often provided by trichomes)
Orientation (vertical vs. horizontal)
Thick epidermis
Small size

Adaptations for avoiding excessive water loss

Those listed above for avaoiding heat, as well as the following:
CAM metabolism (stomata closed during the day!)
Stomata in pits (often with trichomes to slow evaporation – we'll see this in our leaf lab next week)
Trichomes (slow evaporation)

Adaptations for avoiding predation or infection (bacteria & fungi):

Chemical defenses – will be discussed in a future lecture devote to secondary metabolites!
Physical defenses (a partial list here):
trichomes that interfere with insect mouthparts, may be chemically "armed" as well - as in stinging nettle! (PLOP video "growing" 23:10-24:20).
Quaking petiole (*Populus tremuliodes*)
Waxy cuticle surface – helps prevent insect attack – waxes are indigestible.
Thick epidermis
Spines not listed as an adaptation that serves to protect leaves – why not?!

Adaptations for avoiding physical damage (i.e., tattering, tearing):

Flexibility of blade
Born off of a **petiole** so that leaf can rotate and not tear
Size is limited to avoid tearing

Adaptations for avoiding freezing:

Thick epidermis
Thicker leaves
Deciduous…
Antifreezes (we'll discuss later when we explore the conifers in detail…)

Other specialized leaves:

1) **Sclerophyllous foliage leaves (sclerophylls)**: foliage leaves with sclerenchyma cells (typically fibers). In a real sense, sclerophylls are just heavily reinforced foliage leaves.
2) **Bud scales**: protect young leaves that have not yet emerged from buds
3) **Tendrils**: provide support. We discussed mechanism by which they form coils – did you write that down (including a diagram)?!
4) **Spines**: are modified leaves with lots of sclerenchyma (typically fiber cells with lignified secondary cell walls) – so, here leaves are adapted are protecting the stem (or other) tissue! More next lecture! http://www.youtube.com/watch?v=z1Y4RHscdjE
5) **Cotyledons** – "seed leaves". Leaf-like structures that are part of the embryo, emerge at germination, and that store nutrients (in dicots and gymnosperms) or transfer nutrients (monocots) for the embryo. Flowering plants are divided into two groups: dicots (two cotyledons emerge at germination) and monocots (a single leaf emerges at germination). Monocots and dicots have other important differences that we will explore throughout the semester.

THIS MATERIAL WILL BE COVERED IN A FUTURE LECTURE. I WILL INCLUDE THE FOLLOWING NOTES IN THE LECTURE NOTES FROM THAT DAY, BUT HERE THEY ARE FOR TODAY AS WELL… JUST TO BE THOROUGH!

6) **Carnivory**! In a future lecture, we will discuss three strategies by which plants modify their leaves for carnivory, then watched a video on the subject *{PLOP "Growing" 30:55-38:30}*
All strategies involved trichomes – recall the difference in how trichomes were used in these instances?!!
   1) Venus' Flytrap (e.g., *Dionaea muscipula*): trichomes act as triggers that causes two modified leaves to close upon each other. The mechanism by which the leaves close upon each other is not completely understood, but it involves rapid flowing of water into/out of cells due to osmosis, and a corresponding change in pressure within the leaves that causes them to deform, and thus close.
   2) Pitcher plants (e.g., *Darlingtonia californica*) trichomes point downwards and make the interior of the plant "slippery" and difficult to escape.
   3) Sundews (e.g., *Drosera capensis, D. rotunidfolia* – trichomes have glands that exude a sweet and sticky substance that attracts then traps prey.