

### 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:

We will study a number of plant organs in this course, and we started today with leaves. I am not certain how much time we will spend with stems and roots, since I will focus next week discussing cell division and genetics. Later in the semester we will invest significant time studying flowers, fruits, and cones. Our more immediate explorations of organs will focus upon leaves, roots, and stems:

- 1) **root** (future lecture, extent TBD)
- 2) **stem** (future lecture, extent TBD)
- 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

#### Tissues from which organs are constructed:

**1° tissue**: 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.

**2° tissue**: 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.

*However...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)

### Three types of 1° tissue

*In today's lecture, the following terms were discussed and listed on the blackboard. We did not write the formal definitions as they appear here. You are required to know these definitions, in addition to where these tissues are located in/on leaves (and organs that are discussed in future lectures).*

- 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<sub>2</sub>O conservation, H<sub>2</sub>O shedding, not edible to bacteria/fungi/insects, can provide light coloration to minimize heat stress.

- 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.

Terms we might introduce in future labs/lectures (specific regions of ground tissues in stems):

**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!

### Three different cell types in plant tissue

*You should know the fundamental difference in these three categories of cells in plants (it's all about the cell wall...). I won't ask you about these in isolation on quizzes and exams (i.e., I won't ask questions that require you to define a specific cell as being either parenchyma, collenchyma, or sclerenchyma) but we will use these terms in lab and lecture, and you should understand the differences.*

Cell types from which 1° tissues are constructed. There are 3 types – defined 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!
- "Plastic": 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. Conducting sclerenchyma: "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. Non-conducting sclerenchyma: No 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...

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 avoiding heat, as well as the following:

**CAM metabolism** (stomata closed during the day!) – NOT DISCUSSED THIS SEMESTER

**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 tremuloides*)

**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.
- 6) **Carnivory!** We discussed 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 modifications of the blade and 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. rotundifolia* – trichomes have glands that exude a sweet and sticky substance that attracts then traps prey.