Oct 2 lecture notes – Organs and 1° tissues part II: stems

Stem: Organ (typically aboveground) that provides vertical structure and bears leaves. Divided into nodes and internodes:

Node: site from which stems give rise to leaf buds, other stems, flowers or cones, or roots.
Internode: region of a stem between two successive nodes
Axil: angle between top of a leaf and a stem
Axillary bud: bud located in the axil, where leaf and stem connect

<u>Stems</u>
In lab, we will examine the tissue & cellular structure of stems. (We did this in lecture for leaves last week). On future exams, you should be able to recognize/diagram a cross section of a dicot and/or monocot stem (stay tuned for lab!).

We examined the tip of a stem, and labeled the apical meristem, leaf primordia, and apical buds (often called "bumps" at this stage of development). We established that the function of an apical meristem was impossible to understand without an introduction to plant hormones:

Meristem: Plant tissue where new cells (and cell types) are formed. (Meristems are areas of active growth, and they contain undifferentiated cells that can develop into other cell types. Thus, these cells are conceptually similar to "stem cells" in animals).
(We'll discuss three meristem types/locations this semester: apical meristems of stems and roots (give rise to 1° tissues) and lateral meristems (give rise to 2° tissues – wood and bark…)

Plant hormones: Molecules produced by plants that regulate growth and development. (Hormones are typically produced in one region of a plant and stimulate a cellular response in another region.)

There are five classes of hormones (today we discuss only auxin. You do not need to memorize the other four classes – I include them here for completeness and clarity. We might discuss others later in Botany 100).

Five classes of plant hormones
1) Gibberellins / gibberellic acids
2) Ethylene
3) Cytokinins
4) Abscisic acid
5) Auxins

Auxin – Has many roles, but we discussed <u>stem elongation</u>, <u>apical dominance</u>, and <u>phototropism</u>.

Stem elongation and apical dominance

- Auxin is produced in the apex of the stem near the apical meristem.
- High [auxin] surrounding the internode cells near the apex causes cell elongation and subsequent stem elongation.
- As auxin diffuses down the stem, its concentration decreases. Low [auxin] is therefore found at the sites of axillary buds. Low [auxin] at axillary buds inhibits their development into axillary stems. This is the basis for <u>apical dominance</u>.
- Axillary buds develop into stems (or other structures) when [auxin] at the axillary bud is <u>extremely low</u> (or <u>zero</u>). Zero or extremely low [auxin] at axillary buds can develop for two reasons:
  (1) the apical meristem is very far from the axillary buds (i.e., the stem has grown to be very long and therefore the stem apex is far enough away from some axillary buds that no auxin diffuses

to them). In this manner, the plant controls the density of branches and leaves near the stem apex, and ensures that there aren't "too many" leaves there that will compete against each other for light – brilliant! …(no pun intended…), and
(2) the stem apex is removed due to grazing or pruning.

2,4 D – an auxin mimic

- 2,4 D is an herbicide that is an auxin mimic. As an herbicide, 2,4 D causes unsustainable stem elongation in dicots, but does not affect most monocots (see explanation below). If doses are high enough, dicot stems become extremely long and cannot be physically supported, their leaves atrophy (a condition called leaf-curl) and plants die.
- Many monocots (such as grasses, agricultural examples of which are corn and sugarcane) do not suffer under aerial application of 2,4 D in the same manner as dicots because their meristems are at the base of the plant (intercalary meristem). Think about how grass – a typical monocot – grows after it has been cut. It can do this because the intercalary meristem remains in place. It is thought that such growth is an adaptation to grazing of grasses by bison, dear, elk, etc. Many monocots (such as corn) also have an ability to process 2,4 D, and the biochemistry of this is not completely understood.
- Because auxin affects dicots but not (so much…) monocots, it is said to be a **selective herbicide**. It is often applied aerially over crops of monocots (corn, cane, etc) to control/kill dicot weeds.
- 2,4 D was discovered quite by accident, but almost simultaneously by USA and UK scientists, during chemical weapon research during WWII. Ironically, it was discovered during chemical weapons research, and was not the result of intentional agricultural R&D. Because of international prohibitions on chemical weapons at the time, US and British scientist conducted their work under the guise of agricultural research. Only after WWII did 2,4 D find application as an herbicide!
  In another ironic twist, 2,4 D did find its way onto the battlefield decades after its discovery, and after it was a well-established herbicide. 2,4 D was the active defoliating ingredient in agent orange. We discussed agent orange use during the Vietnam war, and the effects upon human health due mostly to dioxin in agent orange. We watched a video that can be viewed at: http://www.nytimes.com/video/us/100000002872288/agent-orange.html (0:00-3:17)

Phototropism

Phototropism: Directional growth of a plant in response to light.
Heliotropism: phototropism in which the sun is the light source
Positive phototropism: growth of a plant towards a light source
Negative phototropism: growth of a plant away from a light source

Examples of phototropism: 1) general drawing, with high [auxin] on the "shaded" side of a stem; 2) photo of a palm tree growing "sideways" then emerging from forest canopy and growing vertically, and; 3) sunflowers, which are phototropic until they mature, at which point their flowers remain facing east (presumably to warm faster in the early morning and attract more pollinators.

Video: {Sunflowers tracking the sun: https://www.youtube.com/watch?v=1gaWrMCiZR8}
Video: here is another sunflower video. Can you tell me what's wrong (i.e., botanically inaccurate) about this otherwise beautiful video? https://www.youtube.com/watch?v=g8mr0R3ibPU&t=24s

Specialized stems:

I. Asexual propagation / spreading of plants

1) **Stolons**: Stems with long internodes that establish plantlets. Plantlets form adventitious roots and become new plant. (e.g., strawberry)
2) **Rhizome**: Fleshy, horizontal, underground stem that allows plant to spread laterally. (e.g. crabgrass, ginger, bamboo)

II. Storage

1) **Succulent stems**: thickened stems for storage of water (e.g., cacti). *{video: Planet Earth "Deserts" 18:00-19:45}*
2) **Stem tuber**: Enlarged stolon or rhizome for storing nutrients (e.g., starch). (e.g., potato)
3) **Bulb**: A vertical, subterranean, short stem with THICK fleshy leaves. Used by plants (typically biennials) as an overwintering structure. (e.g., onion, garlic, lily, tulip, iris, amaryllis)
4) **Corm**: A short, subterranean, THICK stem with thin papery leaves. Used by plants as an overwintering structure (or during other periods of dormancy). (e.g., crocus, gladiolus, taro)

III. Protection

1) **Thorn**: A sharp projection derived from development of a stem (ultimately, an axillary bud).

Given the position of a thorn/spine/prickle relative to the node, leaf, and/or axillary bud on a stem, and know how to define the difference between a **thorn**, **spine**, and a **prickle**.