Intro to Synthetic Biology
Summer HSSP 2020
Week 1 Notes - 7/11/2020
Introduction; How do Plants Grow?

Though plants and animals are both eukaryotic, they share many differences. Among the more notable are that plants can make their own food and have cell walls, while animals do not have these characteristics. Other traits that directly influence specific parts of plant biology include the fact that plant germ lines are not sequestered and that organogenesis is continual.

Plant cells are cemented in place by their cell walls. Because of this three, control of **timing, orientation, and symmetry** of plant cell division are important.

- Timing is important because asynchronous plant growth results in warped or even non-functional plant organs.
- Orientation is important because the beginning layer of cells sets the direction for the rest of the cells that comes after it. **Anticlinal divisions** are perpendicular to surface of plant occur near the tip of a growing plant shoot. These divisions increase the plant's height. **Periclinal divisions** are parallel to the surface of the plant and occur away from the plant's tip. These divisions increase the plant's width.
- Symmetry is important because, for the most part, plant cells have to be roughly the same size.

Plants separate cell division and expansion by first dividing and then expanding. Most cell expansion occurs by **diffuse growth** in which the vacuole uses osmotic pressure to expand and stretch the cell wall isotropically (in all directions). **Tip growth** occurs when cell expansion occurs specifically at one end of the cell.

Pressure-driven growth turns most objects into spheres, but not all plant cells are spherical. Walled cells using pressure to drive growth must also control when and where the wall can expand. The final cell shape is controlled by the cytoskeleton and cell wall. The cytoskeleton orientation and cell wall microfibrils act like a cage through which plant cells can create complex shapes. For example, cellulose strands run around the long surface of a plant cell act like hoops on a barrel. They constrain expansion in one orientation but allow it in another.

Meristems are populations of perpetually dividing, undifferentiated cells that create all tissue in a plant. Plants grow by a continual process of organogenesis which is generated by the activity of meristems. Meristems occur in:

- **apical regions** (shoot and root meristems)
    - **Shoot meristems** produce phytomers.
    - **Root meristems** are different from shoot meristems because they do not produce lateral organs or branches in specific patterns.
- **lateral regions** (axillary meristems, vascular cambium, cork cambium)
- **intercalary regions**

Meristems (such as apical meristems) can be single-cellular. Multicellular meristems can also be divided into **zones** which show different rates of cell division.

- In the **central zone**, cells divide slowly and remain undifferentiated.
- In the **peripheral zone**, cells divide rapidly and are quickly made into new organs.
- In the **rib meristem**, cells underlie the central zone and create plant vasculature.

Different **layers** show different orientations of cell division.

- The **L1 layer** is a single-cell layer, but the **L2 layer** may be composed of multiple cell layers. L1 and L2 comprise the **tunica**, in which cells only divide anticlinally.
- The **L3 layer** is the **corpus**, in which cells divides in all planes.
- All layers are continuous throughout the plant

Note that since meristems are at the top and bottom of a plant, all of the cells in those places will continually undergo cell division and be undifferentiated and identical to each other. Cells towards the middle of a plant will be mature with a specialized structure and function and no new cell division.

A **phytomer** is a repeating morphological unit produced by the shoot apical meristem. It consists of a node (point where the leaf is attached), an internode (elongated stem between nodes), and an axillary meristem produced in the "axil" between the junction of the leaf base and the stem. By varying many different aspects of these subunits, plants create diversity both within their body and between species.