Special Features of Plant Cells

Lecture 11

-Know that all plant cells have **plastids** (organelle in cells of certain groups of eukaryotes that is the site of such activities as food manufacture and storage; plastids are bounded by two membranes), that the plastid can be modified for several specialized functions – **chloroplasts** for photosynthesis, **amyloplasts** for storage of starch and also senses gravity, and **chromoplasts** for storage of carotenoid pigments.

-The **cell wall** provides structural support, there are two types of cell walls: **primary cell wall** are found in plant cells that are growing (enlarging), when cell growth has ceased some plant cells lay down a **secondary cell wall**.

-Know the model of the structure of the primary cell wall (rods of **cellulose mibrofibrils** embedded in a **matrix** of other shorter chain polysaccharides), that the primary cell wall can be stretched and enlarged to accommodate cell growth.

-Know that secondary walls are composed of approximately equal parts Cellulose, microfibrils, and **lignin**. The lignin is composed of **phenolic compounds** that are polymerized into a matrix that is a stiff, rigid glue. Once the secondary wall has been formed the cell can no longer grow. Secondary walls are found in collenchyma cells, tracheids, vessel elements, and fibers (sclerids).

-Plant cells have a large **central vacuole** containing a concentrated solution of potassium salts. The primary function of the central vacuole is to generate turgor pressure (a positive internal hydrostatic pressure) which keeps plant cells rigid and provides the driving force for plant cell enlargement.

-**Plasmodesmata** are cytoplasmic connections between neighboring plant cells. Plasmodesmata permit the movement of small molecules between plant cells. Proteins and RNAs can also be actively transported through plasmodesmata.

Lecture 12 - photosynthesis

-You should be able to write a chemical equation that describes photosynthesis, know that it occurs in two separate reactions, the light rxn and the Calvin cycle. The light rxn takes place on the thylakoid membranes and light captured by chlorophyll leads to electron transport and finally to the formation of ATP (from ADP) and the reduction of NADP to NADPH. The Calvin cycle takes place in the stroma of the chloroplast and fixes CO2 into carbohydrates using ATP and NADPH produced by the light reactions.

-Know the difference between and action spectrum and an absorption spectrum and what the roles of chlorophyll b and carotenoids are in photosynthesis.

-Know that the enzyme that carries out CO2 fixation is Rubisco and this enzyme converts a 5 carbon sugar RuBP into two 3 carbon sugars (PGA). Six turns of the Calvin cycle are needed to make one glucose. Excess glucose can be stored as starch.

-Know what photorespiration is, why it is a problem and under what conditions it occurs.

-photorespiration is the process by which RuBP (sugar) has oxygen added to it by enzyme Rubisco instead of CO2 during normal photosynthesis. This occurs when CO_2 to O_2 levels are low and photorespiration works to produce more CO_2 due to this deficiency. Photosynthesis occurs when the CO_2 to O_2 levels are high, limiting photorespiration.

-Be able to explain the differences between the photosynthetic schemes of C3 plants C4 plants and CAM plants and the advantages of each.

-**C3 plants**- Fix CO_2 into 2 molecules of PGA, a 3 carbon compound. When the temperature is high, C3 plants suffer from photorespiration

-**C4 plants**- Nature's solution to photorespiration problem.

-Fixes CO_2 into a 4 carbon compound-malate. CO_2 to O_2 levels are high, promoting photosynthesis and limiting photorespiration.

-C4 plants make malate in mesophyll cells (site of CO_2 fixation) which are transported to the bundle sheath cells (site of Calvin cycle), where CO_2 released enters the Calvin cycle, ultimately yielding sugars and starch.

-spatial separation (mesophyll and bundle sheath cells)
-more efficient than C3 plants at high temps and moderately dry conditions

-CAM plants-A C4 modification

-temporal separation (time: night and day)of CO_2 fixation and calvin cycle
-use malate to fix CO_2
-stored in the vacuole as malic acid (aka Crassulacean Acid)
- opening/closing of stomates in CAM plants opposite compared to C4 plants
CAM plants:
-at night stomates are open : CO_2 is fixed into malate.
-at day stomates are closed : CO_2 released from malate and Calvin cycle operates
-Save H_2O
-grow in dry and hot areas (pactus and pineapples)

Objectives for Lecture 13 – Plant nutrition

-Know what nutrients are and the difference between macronutrients and micronutrients. Know that carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, and calcium are macronutrients.
-Know that the amount of nitrogen, phosphorus and potassium are often limiting for plant growth, that nitrogen in the soil is mostly in the form of nitrate which quickly leaches from the soil.
-Know that mineral ion uptake requires active transport and that most ion and water uptake occurs through the youngest parts of roots, including the root hairs, which greatly increase the surface area of the root.
-Know what the terms apoplast and symplast refer to. Understand the role of the endodermis in allowing plants to maintain mineral ion concentrations in the xylem that are higher than in the surrounding soil.
-Know what the casperian strip is, where it is located, and its role in mineral ion uptake.
-Casparian strip located on cell wall of endodermis.
-Know what the terms apoplast and symplast refer to. Understand the role of the endodermis in allowing plants to maintain mineral ion concentrations in the xylem that are higher than in the surrounding soil.
-Apoplastic route- diffusion through cell walls
-symplastic route- uptake in the cytoplasm of a cell and movement from cell to cell via plasmodesmata
-Transcellular route- uptake in the cytoplasm of a cell and movement from cell to cell across plasma membrane
-For the apoplastic pathways, before entering the vascular cylinder nutrients must enter the cytoplasm of a cell to pass through the endodermis
-The cell walls of the endodermis have a water-tight waxy layer -- Casparian strips – that forces minerals and water to enter the cytoplasm. This allows the mineral content of the xylem to be regulated and maintained at a higher concentration than in the soil.
-Be able to outline the nitrogen cycle, understand the terms nitrogen fixation, nitrification, ammonification, denitrification, and know what the precursor and product is in each of these reactions, know that each of these reactions is carried out only by bacteria.
-nitrogen fixation- incorporation of atmospheric nitrogen into nitrogen(N_2) compounds such as ammonium and nitrate
-nitrification- Oxidation of ammonium ions or ammonia to nitrate
-ammonification-decomposition of amino acids and other nitrogen containing organic compounds, resulting in the production of ammonia (NH_3) and ammonium ions (NH_4^{+})
-denitrification-conversion of nitrate to gaseous nitrogen
- 1. **Nitrogen fixation** is the process by which atmospheric N_2 is reduced to NH_4^+. and is now

available for organisms to use. N-fixation can be carried out only by certain symbiotic and free-living bacteria. N-fixation is energetically expensive

2. During **nitrification**, bacteria oxidize ammonium ions (NH_4+), first converting them to nitrite (NO_2^-), then to nitrate (NO_3^-).
This is an energy yielding reaction (chemoautotrophic organisms).

3. **Ammonification** occurs as saprophytic bacteria and fungi release excess nitrogen as ammonium ions (NH_4+) in the course of incorporating nitrogen from complex organic compounds like amino acids and nucleic acids.

4. The major loss of nitrogen from the soil-plant system is by **denitrification**, an anaerobic process in which nitrate (NO_3^-) is reduced to volatile forms of nitrogen, such as nitrogen gas (N_2).

-Know that nitrogen fixation is an energy requiring reaction, bacteria that do it are chemoheterotrophs or photoautotrophs, whereas ammonification, nitrification, and denitrification are energy yielding reactions carried out by chemoautotropic bacteria.

-Know that plants in the legume (bean) family form symbiotic associations with the nitrogen fixing bacterium Rhizobium. The bacteria enter plant roots through the root hairs and proliferate in cells of the cortex of the root forming nodules. In the nodules the bacterium obtains sugars from the plant and provides the plant with reduced nitrogen.

-Know what mycorrhizae are and how they benefit plants.

-myocorrhizae – mutualistic fungi infecting the roots of plants. They are critical for phosphate uptake. Plants grown with myocorrhizae greatly increase the root surface area. They obtain sugar from the plant in exchange for minerals, primarily phosphate.

Objectives for Lecture 14 – water and nutrient transport

-Know what transpiration is and why it is an inevitable aspect of photosynthesis in land plants.

-transpiration- water loss in plants

-inevitable because when water is exposed to dry air (such as when the stomata opens) evaporation occurs

-Know what the cuticle is, where it is located, its composition and function and understand that transpiration occurs through pores, stomates, whose opening is regulated.

- Composed of cutin (waxy substance) located on the outer wall of epidermal cells. Functions to limit water loss.

-Know that stomatal opening and closing is the result of osmotic swelling/shrinking of the guard cells, which is driven by the active uptake of potassium ions during opening and the passive efflux of potassium during closing.

-Understand how the structure of the guard cell wall results in bending of the cells and opening of the stomatal pore when the guard cells undergo osmotic swelling.

- the inner (ventral) wall of the guard cell is thick and rigid. Increases in turgor pressure causes the outer walls of the guard cells to move outward relative to their inner walls, and as this happens the pore opens.

-Understand the Cohesion-Tension Theory for the movement of fluid in the xylem, know that the driving force is the difference in relative humidity between the inside of the leaf and the air, the important role of hydrogen bonding between water molecules, and the existence of negative pressures inside the xylem.

- Transpiration in leaves creates tension (negative pressure) in the mesophyll cells. Because of this tension, water is literally being pulled up from the roots into the leaves, helped by cohesion (the pull between individual water molecules, due to hydrogen bonds) and adhesion (the stickiness between water molecules and the hydrophilic cell walls of plants). This mechanism of water flow works because of water potential (water flows from high to low potential), and the rules of simple diffusion.

-Be able to cite two pieces of evidence which support the Cohesion-Tension Theory.

-negative pressures in the trunk and leaves can be measured

-stem diameters shrink during the day and increase at night