

## *TYPES OF PHOTOSYNTHESIS*

- **Photosynthesis:** the jamming together of CO<sub>2</sub> (carbon dioxide) with H<sub>2</sub>O (water) to make CH<sub>2</sub>O (sugar) and O<sub>2</sub> (oxygen), using the sun's energy. The sugar contains the stored energy and serves as the raw material from which other compounds are made. **Respiration** is the opposite of photosynthesis -- the stored energy in the sugar is released in the presence of oxygen, and this reaction releases the CO<sub>2</sub> and H<sub>2</sub>O originally jammed together by the sun's energy.
- **Stomata:** the "pores" in leaves (and stems) through which CO<sub>2</sub> is taken in and O<sub>2</sub> is released during photosynthesis. Plants control when stomata are open or closed and the width of the opening (formed by two guard cells that expand and contract to open and close the space between them).
- **Transpiration:** the water that evaporates out of stomata when they are open. This pulls more water and nutrients up to the top of the plant, but causes the plant to lose water and potentially dehydrate.
- **Water Use Efficiency (WUE):** How good the plant is at bringing in carbon dioxide for photosynthesis without losing much water out of its stomata. More specifically, it is the ratio of carbon dioxide intake to water lost through transpiration.
- **Photorespiration:** Under high light and high heat, the enzyme (RUBISCO) that grabs carbon dioxide for photosynthesis may grab oxygen instead, causing respiration to occur instead of photosynthesis, thus causing a slowing of the production of sugars from photosynthesis..

The three types of photosynthesis are C<sub>3</sub>, C<sub>4</sub>, and CAM. C<sub>3</sub> photosynthesis is the typical photosynthesis that most plants use and that everyone learns about in school (it was all we knew about until a few decades ago). C<sub>4</sub> and CAM photosynthesis are both adaptations to arid conditions because they result in better water use efficiency. In addition, CAM plants can "idle," saving precious energy and water during harsh times, and C<sub>4</sub> plants can photosynthesize faster under the desert's high heat and light conditions than C<sub>3</sub> plants because they use an extra biochemical pathway and special anatomy to reduce photorespiration. Below are the details.

### **C<sub>3</sub> Photosynthesis : C<sub>3</sub> plants.**

- Called C<sub>3</sub> because the CO<sub>2</sub> is first incorporated into a 3-carbon compound.
- Stomata are open during the day.
- RUBISCO, the enzyme involved in photosynthesis, is also the enzyme involved in the uptake of CO<sub>2</sub>.
- Photosynthesis takes place throughout the leaf.
- **Adaptive Value:** more efficient than C<sub>4</sub> and CAM plants under cool and moist conditions and under normal light because requires less machinery (fewer enzymes and no specialized anatomy)..
- Most plants are C<sub>3</sub>.



## C4 Photosynthesis : C4 plants.

- Called C4 because the CO<sub>2</sub> is first incorporated into a 4-carbon compound.
- Stomata are open during the day.
- Uses PEP Carboxylase for the enzyme involved in the uptake of CO<sub>2</sub>. This enzyme allows CO<sub>2</sub> to be taken into the plant very quickly, and then it "delivers" the CO<sub>2</sub> directly to RUBISCO for photosynthesis.
- Photosynthesis takes place in inner cells (requires special anatomy called Kranz Anatomy)
- **Adaptive Value:**
  - Photosynthesizes faster than C3 plants under high light intensity and high temperatures because the CO<sub>2</sub> is delivered directly to RUBISCO, not allowing it to grab oxygen and undergo photorespiration.
  - Has better Water Use Efficiency because PEP Carboxylase brings in CO<sub>2</sub> faster and so does not need to keep stomata open as much (less water lost by transpiration) for the same amount of CO<sub>2</sub> gain for photosynthesis.
- C4 plants include several thousand species in at least 19 plant families. Example: fourwing saltbush pictured here, corn, and many of our summer annual plants.



## CAM Photosynthesis : CAM plants. CAM stands for Crassulacean Acid Metabolism

- Called CAM after the plant family in which it was first found (Crassulaceae) and because the CO<sub>2</sub> is stored in the form of an acid before use in photosynthesis.
- Stomata open at night (when evaporation rates are usually lower) and are usually closed during the day. The CO<sub>2</sub> is converted to an acid and stored during the night. During the day, the acid is broken down and the CO<sub>2</sub> is released to RUBISCO for photosynthesis
- **Adaptive Value:**
  - Better Water Use Efficiency than C3 plants under arid conditions due to opening stomata at night when transpiration rates are lower (no sunlight, lower temperatures, lower wind speeds, etc.).
  - May CAM-idle. When conditions are extremely arid, CAM plants can just leave their stomata closed night and day. Oxygen given off in photosynthesis is used for respiration and CO<sub>2</sub> given off in respiration is used for photosynthesis. This is a little like a perpetual energy machine, but there are costs associated with running the machinery for respiration and photosynthesis so the plant cannot CAM-idle forever. But CAM-idling does allow the plant to survive dry spells, and it allows the plant to recover very quickly when water is available again (unlike plants that drop their leaves and twigs and go dormant during dry spells).
- CAM plants include many succulents such as cactuses and agaves and also some orchids and bromeliads

