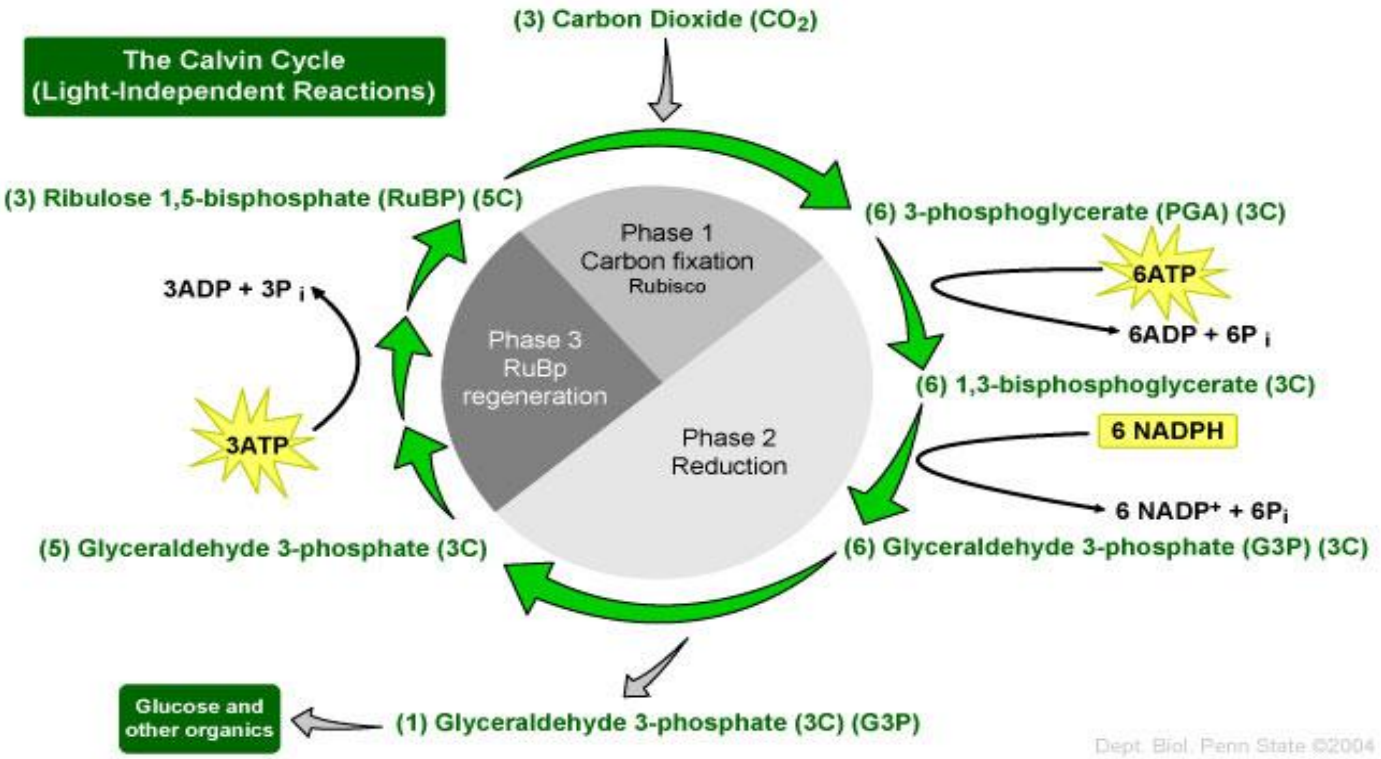
Light independent reaction (Calvin cycle)

In plants, carbon dioxide **CO_2 enters** the interior of a leaf via pores called **stomata** and **diffuses** into the stroma of the **chloroplast**—the site of the **Calvin cycle** reactions, where sugar is synthesized. These reactions are also called the **light-independent** reactions because they are **not directly driven by light**.

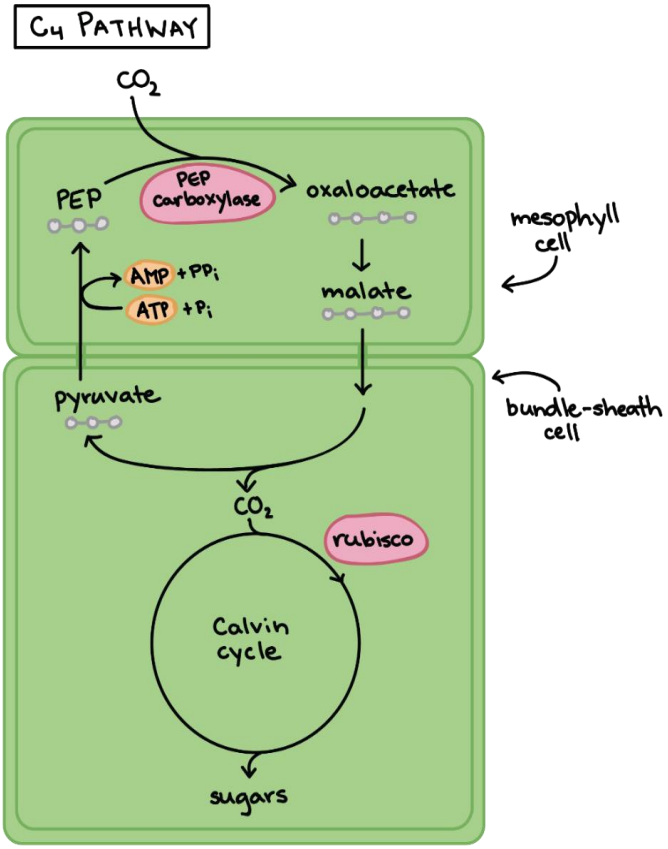
In the Calvin cycle, carbon atoms from **CO_2** are **fixed** (incorporated into organic molecules) and used to build **three-carbon sugars (3C)**. This process is **fueled by**, and dependent on, **ATP** and **NADPH** from the light reactions. Unlike the light reactions, which take place in the thylakoid membrane, the reactions of the Calvin cycle take place in the **stroma** (the inner space of chloroplasts).



C_4 Plants

In C_4 plants, the ***light-dependent reactions and the Calvin cycle are physically separated,*** with the **light-dependent reactions** occurring in the **mesophyll cells** and the **Calvin cycle** occurring in special cells around the leaf veins. These cells are called **bundle-sheath** cells.

First, **atmospheric CO_2** is **fixed** in the **mesophyll cells** to form a simple, **4-carbon organic acid (oxaloacetate)**. This step is carried out by **PEP carboxylase**, that has no tendency to bind O_2. Oxaloacetate is then converted to a similar molecule, **malate**, that can be **transported in to the bundle-sheath cells**. Inside the bundle sheath, ***malate breaks down, releasing a molecule of*** CO_2. The ***CO2 is then fixed by rubisco*** and made into sugars via the Calvin cycle, exactly **as in C3 photosynthesis**.

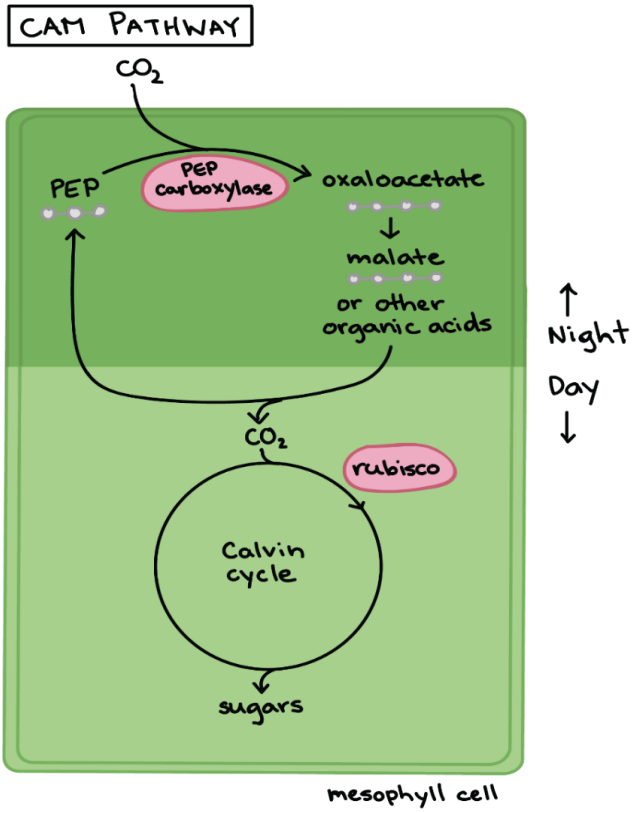


CAM plants

Some plants that are **adapted to dry environments**, such as **cacti** and **pineapples**, use the **crassulacean acid metabolism** (**CAM**) pathway to minimize photorespiration. This name comes from the family of plants, the **Crassulaceae**, in which scientists first discovered the pathway.

Instead of separating the light-dependent reactions and the use of the Calvin cycle in space, ***CAM plants separate these processes in time.*** At **night**, CAM plants **open their stomata**, allowing **CO2 to diffuse into the leaves**. This CO2 is **fixed into oxaloacetate**

by **PEP carboxylase** (the same step used by C4, then converted to **malate** or another type of organic acid. The organic acid is **stored inside vacuoles** **until the next day**. In the **daylight**, the CAM plants **do not open their stomata**, but they can still photosynthesize. That's because ***the organic acids are transported out of the vacuole and broken down to release CO2*** which enters the Calvin cycle. This controlled release maintains a high concentration of CO2 around rubisco.



TRANSPORTATION OF PHOTOSYNTHATES IN THE PHLOEM

Plants **need an energy source to grow**. In seeds and bulbs, **food is stored** in polymers (such as **starch**) that are **converted** by metabolic processes into **sucrose** for newly developing plants. Once **green shoots** and leaves are growing, plants are able to produce their own food by **photosynthesizing**. The **products of photosynthesis** are called **Photosynthates**, which are usually in the form of **simple sugars** such as **sucrose**.

Structures that **produce** Photosynthates for the growing plant are referred to as **sources**. Sugars produced in sources, such as **leaves**, need to be delivered to growing parts of the plant **via the phloem** in a process called **translocation**. The points of sugar **delivery**, such as **roots**, young **shoots**, and developing

seeds, are called **sinks**. Seeds, tubers, and bulbs can be either a source or a sink, depending on the plant's stage of development and the season.

The products from the source are usually **translocated to the nearest sink** through the **phloem**. For example, the highest leaves will send Photosynthates upward to the growing shoot tip, whereas lower leaves will direct Photosynthates downward to the roots. Intermediate leaves will send products in both directions, unlike the flow in the **xylem**, which is always **unidirectional** (soil to leaf to atmosphere). The pattern of Photosynthates flow changes as the plant grows and develops. Photosynthates are directed primarily to the roots early on, to shoots and leaves during vegetative growth, and to seeds and fruits during reproductive development. They are also directed to tubers for storage.

RESPIRATION IN PLANTS

Living cells require a continuous **supply of energy for** maintaining various life activities. This energy is obtained by **oxidizing the organic** compounds (**carbohydrates**, **proteins**, and lipids) in the cells. This process of harvesting chemical energy for metabolic activities in the form of **ATP** by oxidizing the food molecules is called 'respiration'. The most **common** substrate used in respiration for **oxidation is glucose**.

Types of respiration

There are two types of respirations:

1. **Aerobic respiration** is one in which molecular **oxygen is used** for the complete oxidation of glucose to yield **CO2**, **H2O** and **38 ATP** molecules.
2. **Anaerobic respiration** is one in which glucose is partially oxidized **without using oxygen** to yield **lactic acid** or **ethyl alcohol** and **2 ATP** molecules.

Trees need **energy** to **grow**. This energy is released from the food made by photosynthesis in a process called **respiration**. In respiration, trees convert the sugars (Photosynthates) back into energy for growth and other life and metabolic processes. The released energy drives a variety of metabolic actions. It is the same process that animals use when they respire.