Light

$$6CO_2 + 12H_2O \xrightarrow[\text{Energy}]{\text{Light}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

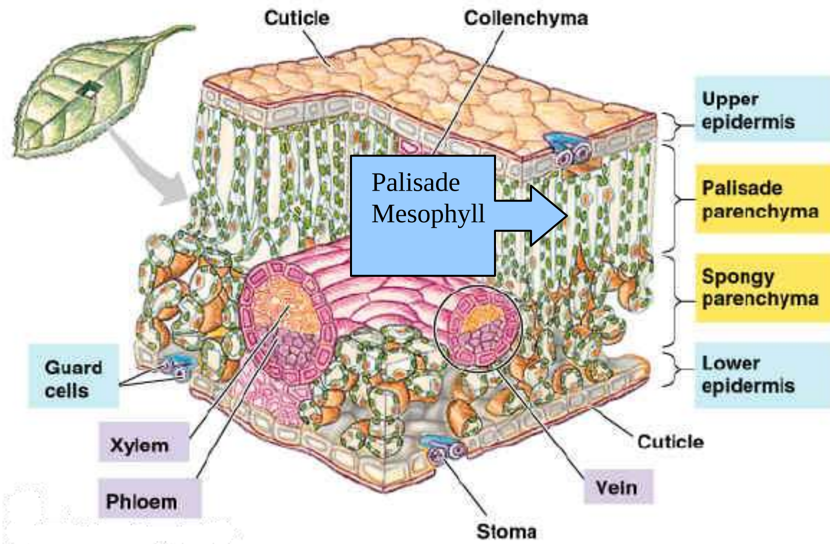
Energy

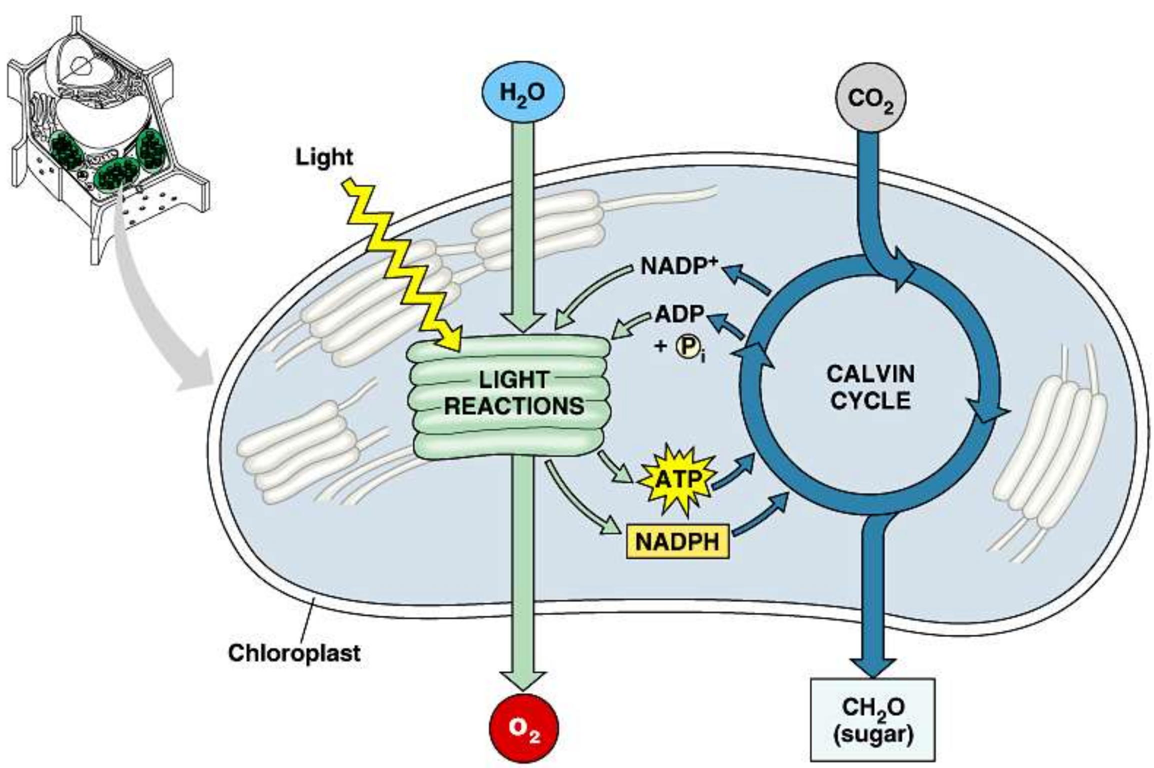
Autotroph -

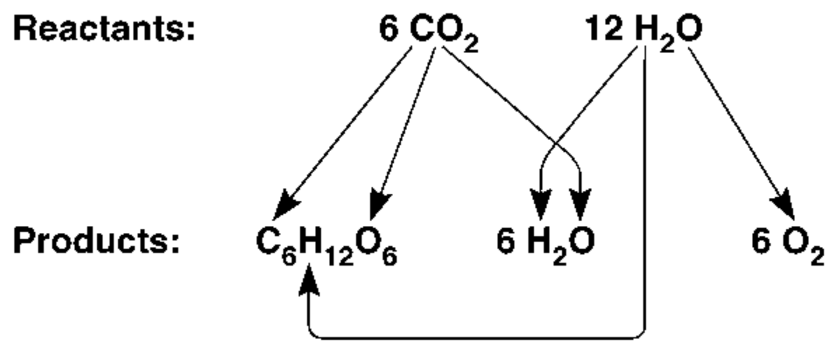
Photoautotroph -

Chemoautotroph -

Heterotroph -



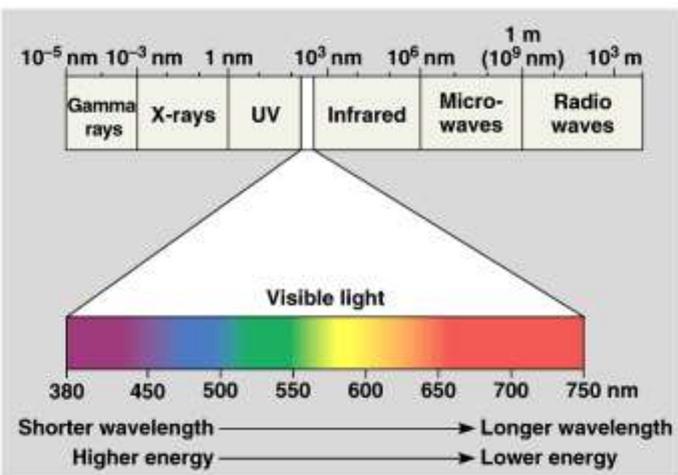


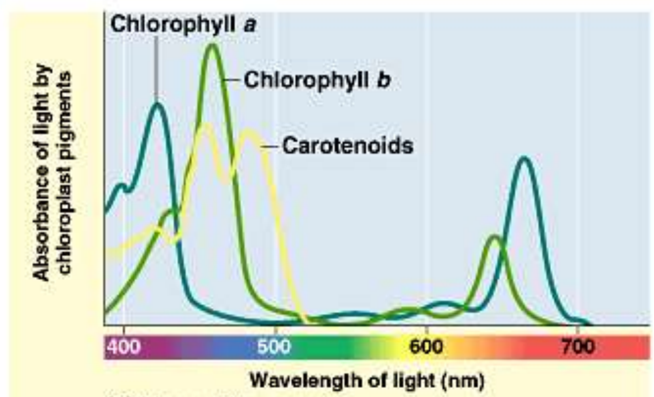


Reduction

$$6CO_2 + 12H_2O \text{ ------------> } C_6H_{12}O_6 + 6H_2O + 6O_2$$

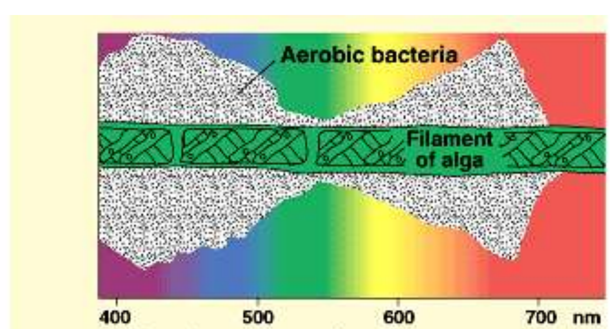
Oxidation



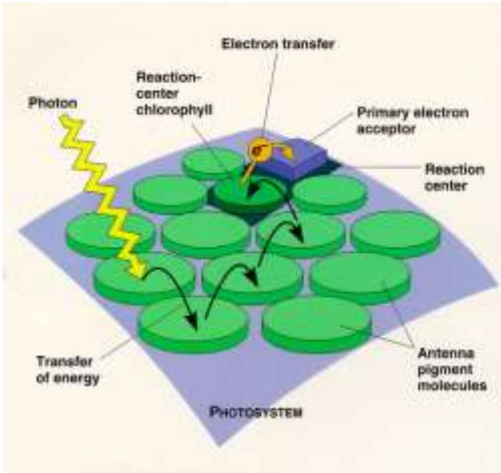


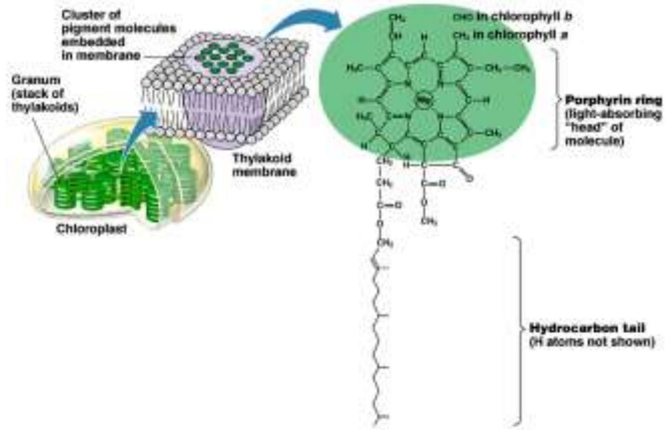
(a) Absorption spectra

(b) Action spectrum



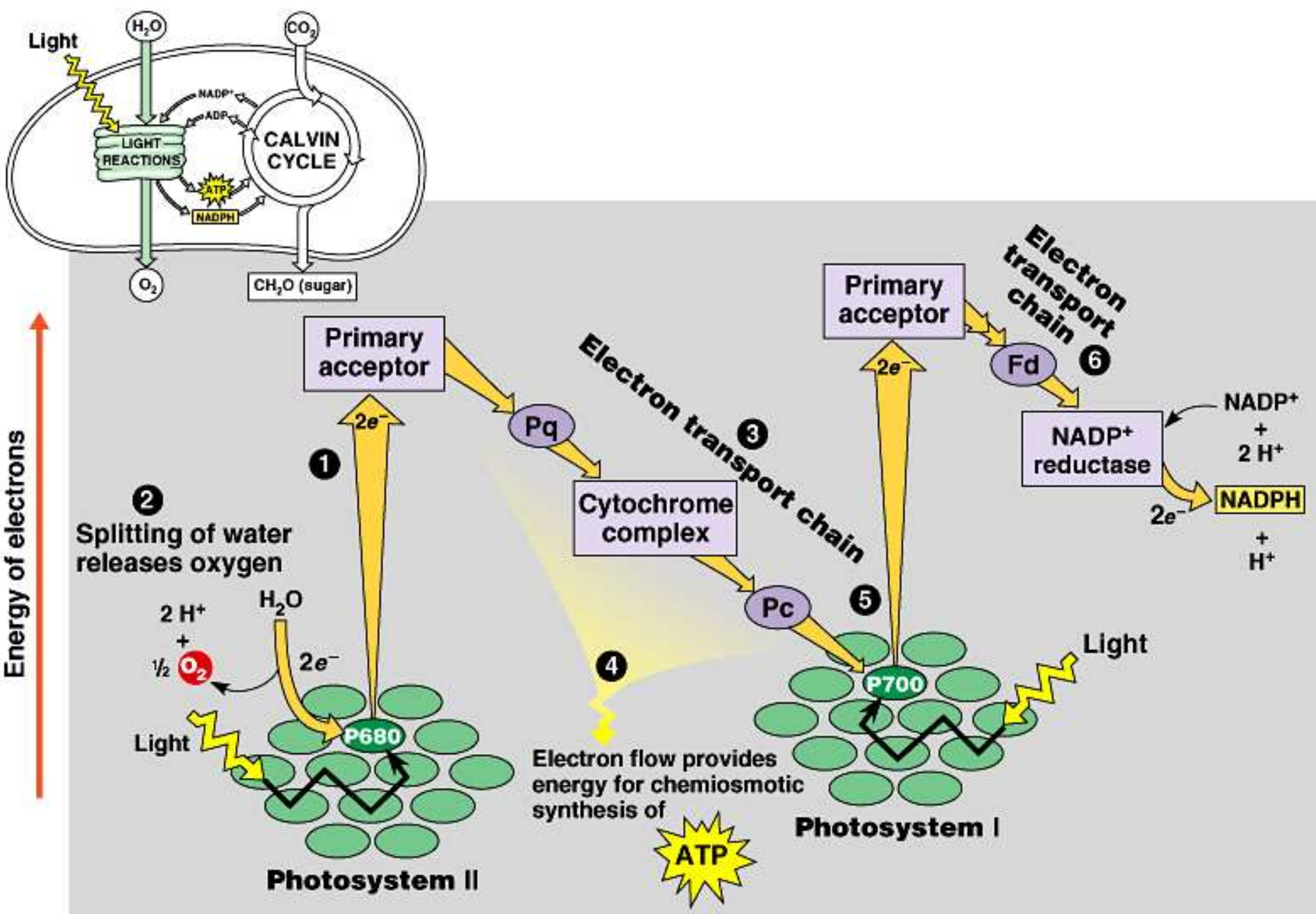
(c) Engelmann's experiment

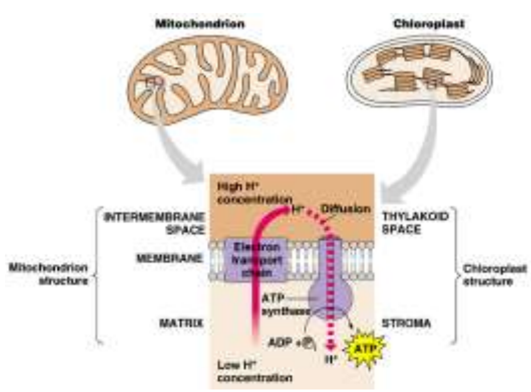


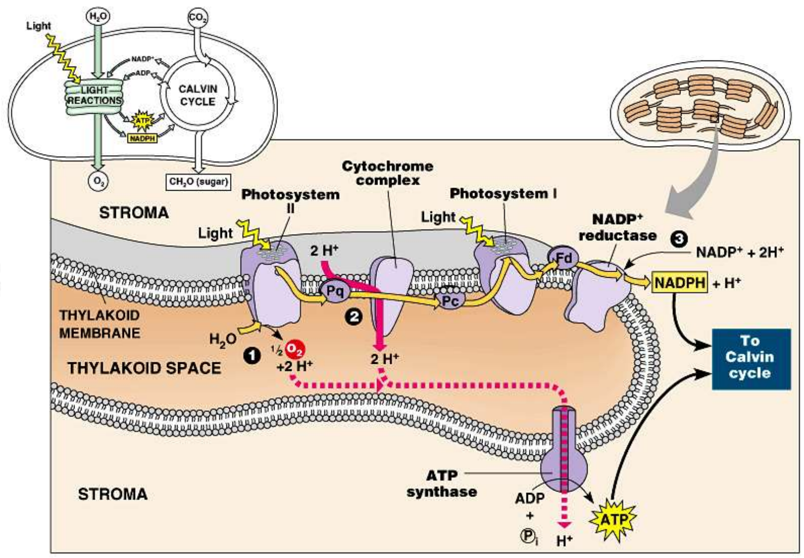


PHOTOSYSTEM Chlorophyll a

- Chlorophyll a – (blue-green) reaction center molecule
- Chlorophyll b – (yellow green) accessory pigment
- Carotenoids – (yellows and oranges) accessory pigments; also absorb light that may damage chlorophylls







Nobel Prizes related to photosynthesis research

•Richard Martin Willstätter, Chemistry, 1915, Research on plant pigments, especially chlorophyll
•Hans Fischer, Chemistry, 1930, Research on the constitution of haemin and chlorophyll and the synthesis of haemin
•Melvin Calvin, Chemistry, 1961, Research on the carbon dioxide assimilation in plants
•Robert Burns Woodward, Chemistry, 1965, Outstanding achievements in the art of organic synthesis (Chlorophyll synthesis)
•Peter D. Mitchell, Chemistry, 1978, Contribution to the understanding of biological energy transfer through the formulation of the chemiosmotic theory
•Johann Deisenhofer, Robert Huber, Hartmut Michel, Chemistry, 1988, Determination of the three-dimensional structure of a photosynthetic reaction center.

ALL HAIL RUBISCO !

THE ALL MIGHTY DUD ! Huh? Yeah, it has some evolutionary baggage.

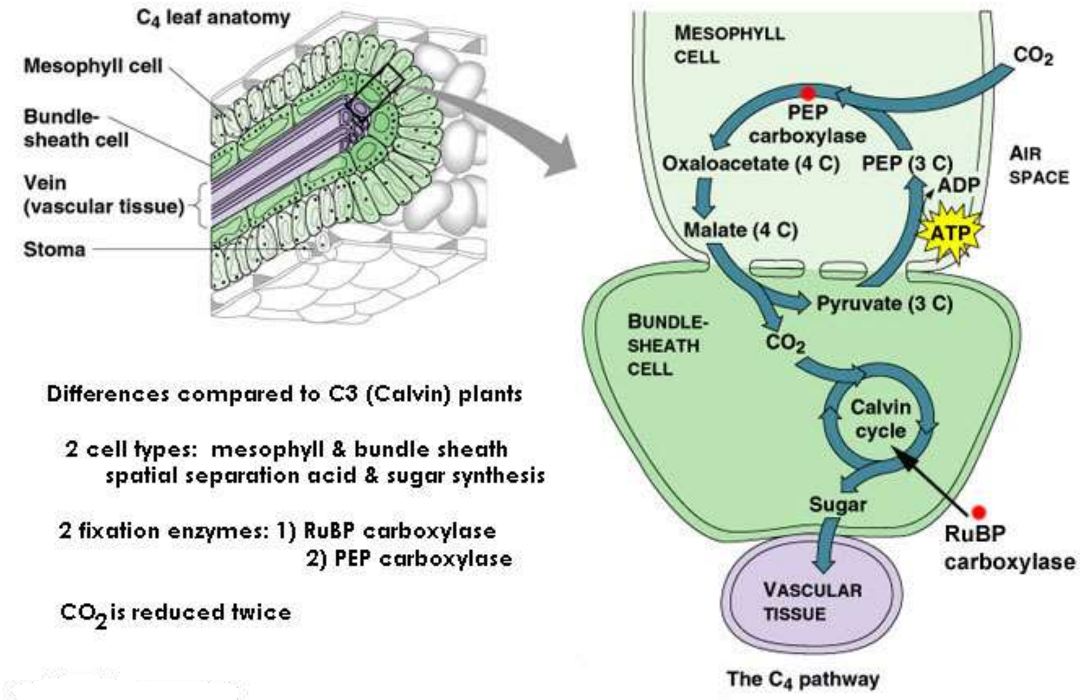
● Most plants incorporate CO_2 directly into the Calvin cycle. Thus the first stable organic compound formed is glyceraldehyde 3-phosphate (G3P). Since G3P contains three carbon atoms, these plants are called **C3 plants**. For all plants, hot summer weather increases the amount of water that evaporates from the plant. *Plants lessen the amount of water that evaporates* by keeping their stomates closed during hot, dry weather. Unfortunately, this means that once the CO_2 in their leaves reaches a low level, they must stop photosynthesizing. Meanwhile, O_2 from the light reactions begins to build up. Because of the abundance of O_2 and the lack of CO_2, Rubisco incorporates O_2 into the Calvin Cycle and produces a 2-C compound instead of 3-C G3P. The plant cell then breaks down this 2-C compound into CO_2 and H_2O. This process is called **photorespiration**. Unlike photosynthesis , photorespiration yields *no sugar molecules*. Unlike respiration, it yields *no ATP*. No sugar, no ATP…it accomplishes nothing☹ and the plant either turns dormant or dies.

● Some species (soybeans and others) lose 50% of productivity due to photorespiration. Think of the crop yields and food supplies increase if we could reduce photorespiration.

C4 PLANTS

This is potentially a BIG PROBLEM, but some plants (called `C4 plants`) have come up with an evolutionary solution to this problem.

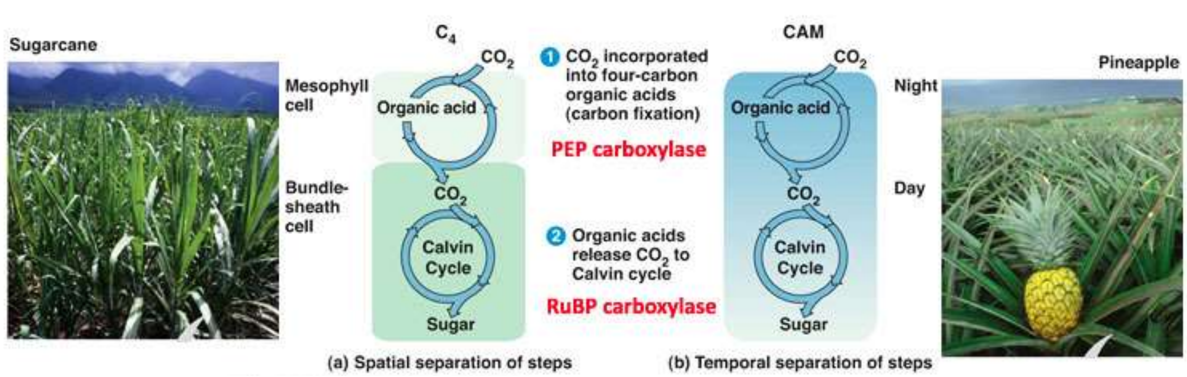
Please note: C4 photosynthesis requires more ATP (this is the big tradeoff) BUT more ATP is generated because these plants usually grow under high sunlight conditions!

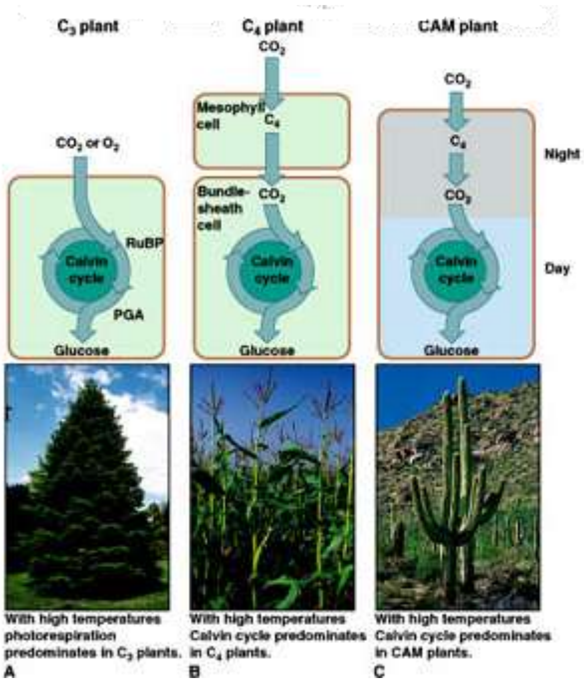


CAM PLANTS

There is another strategy to cope with very hot, dry, desert weather and conserve water. Some plants (for example, cacti and pineapple) that live in extremely hot, dry areas like deserts can only safely open their stomates at night when the weather is cool. Thus, there is no chance for them to get the CO_2 needed for the dark reaction during the daytime. At night when they can open their stomates and take in CO_2, these plants incorporate the CO_2 into a 4-C compound (Malic Acid) to store it. In the daytime, when the light reaction is occurring and ATP is available (but the stomates must remain closed), they take the CO_2 from Malic Acid and transfer it to the Calvin Cycle.

These plants are called **CAM plants**, which stands for `crassulacean acid metabolism` after the plant family, Crassulaceae (which includes the garden plants *Sedum and Jade*) where this process was first discovered.





CAM photosynthesis occurs in a single mesophyll cell, fixing carbon dioxide by night and releasing it by day (temporal separation). C4 Photosynthesis differs because CO_2 is fixed in one cell (a mesophyll cell) and then released to the Calvin Cycle in a different cell (bundle sheathe cell) (this is spatial separation) – C4 photosynthesis occurs during the day only.