

Guided Research

Variation in Photosynthesis

Explain How are the three pathways of photosynthesis similar in terms of carbon and the formation of carbon-based molecules?

Not all plants carry out photosynthesis in exactly the same way. There are three different pathways of photosynthesis that depend on the carbon-based compound first produced when CO_2 enters the light-independent reactions. Recall the light-independent reactions, or Calvin cycle, use energy from ATP and NADPH to build sugars from smaller molecules. Carbon enters the Calvin cycle as CO_2 molecules, which are rearranged during chemical reactions to form sugar. Early in the process, 3-carbon molecules are formed and exit the cycle to form 6-carbon sugars. The formation of 3-carbon molecules occurs in most plants, resulting in the name C₃ plants. This is one pathway in which carbon is rearranged in plants. A second pathway results in 4-carbon molecules being formed early in the Calvin cycle. These plants are called C₄ plants. Finally, a third pathway takes in CO_2 and incorporates the carbon in organic acids called crassulacean acids, named after the plant types in which this process occurs. Crassulacean plants include the succulent, or water-storing plants, such as cacti.

Nearly all land plants exchange gases through openings called stomata. Carbon dioxide enters and oxygen exits through these openings. At the same time, water that has been absorbed through the plant roots transpires, or is given off as water vapor through the open stomata. So the stomata play an important role in regulating the input of CO_2 and the output of oxygen as part of photosynthesis, as well as overall water loss.

FIGURE 12: Stomata are found on above-ground parts of plants, including the petals of flowers, stems, and leaves.



The stomata do not stay open all the time. Instead, the stomata open and close in response to homeostatic mechanisms in the plant. This helps the plant conserve water when water availability is limited. In general, plants lose water fastest during intense sunlight, especially when the temperature is warm, or when the air is dry, or in windy conditions. The variations among C₃, C₄, and CAM plants are mainly based on plant adaptations to different climates.

Plants can be classified by the way their photosynthetic pathways are adapted to environmental conditions. Most plants are C3 and C4 plants, which open their stomata during the day, losing most of the water taken up by their roots. But CAM plants are adapted for life in extremely hot and arid climates. These plants generally keep their stomata closed during the day to reduce the amount of water that is lost in transpiration. The stomata often are open through the night, when it is cooler and more humid. CAM plants fix CO₂ at night, avoiding water loss by not opening their stomata during the day. The CO₂ is released during the day to be used in photosynthetic reactions.



Predict How would you expect the abundance of C3 plants to change as regions around the world become warmer and drier?

FIGURE 13: Three Pathways of Photosynthesis

C3 Plants	C4 Plants	CAM Plants
rice, wheat, oat, soybean, cotton, most trees and lawn grasses	corn, nutgrass, and tumbleweed	succulents, cacti, bromeliads, and orchids
stomata open in daytime	stomata open in daytime	stomata open at night



Language Arts Connection Carry out further research to learn more about these variations in photosynthesis. Prepare a presentation to explain the differences between C3, C4, and CAM plants. In your presentation, include information about how each type of plant carries out photosynthesis, and how the differences help plants survive in different environments. Use text, visuals, and interactive components to make the concepts in your presentation engaging and easy to understand.

A multimedia presentation combines text, sounds, and images. A successful multimedia presentation includes:

- a clear and consistent focus
- ideas that are presented clearly and logically
- graphics, text, music, video, and sounds that support key points
- an organization that is appropriate to its purpose and audience



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