Photosynthesis:
Physiology and Metabolism

Cajumban, Alyssa A.

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Photosynthesis: Physiology and Metabolism

Photosynthesis is the process used by plants, algae and certain bacteria to harness energy from sunlight into chemical energy. It is one example of how people and plants are dependent on each other in sustaining life. Photosynthesis happens when water is absorbed by the roots of green plants and is carried to the leaves by the xylem, and carbon dioxide is obtained from air that enters the leaves through the stomata and diffuses to the cells containing chlorophyll. The green pigment chlorophyll is uniquely capable of converting the active energy of light into a latent form that can be stored (in food) and used when needed. Photosynthesis provides us with most of the oxygen we need in order to breathe. We, in turn, exhale the carbon dioxide needed by plants. Plants are also crucial to human life because we rely on them as a source of food for ourselves and for the animals that we eat. There are two types of photosynthetic processes: oxygenic photosynthesis and anoxygenic photosynthesis. Oxygenic photosynthesis is the most common and is seen in plants, algae and cyanobacteria. On the other hand, anoxygenic photosynthesis uses electron donors other than water. The process typically occurs in bacteria such as purple bacteria and green sulfur bacteria. Plants make simple sugar by photosynthesis. It all happens in a fraction of a second. Water gets split into hydrogen and oxygen. The hydrogen is combined chemically with carbon dioxide to produce simple sugar. This dissolves easily in water and hence is transported to all parts of the plant. Oxygen is given off as a by-product. Thus, plants take in CO2 and gives out oxygen during photosynthesis reaction. Sun shines each day and does not charge us any money for the light it gives us. The light falling on Earth is very clean and will be there for a very long time as long as the Sun lasts. In addition to the current applications, Photosynthesis-based technology could also include using the concept of efficient "energy capture" to our artificial systems just as plants have been doing: thousands of chlorophyll a molecules (antenna) serving one center where the process occurs efficiently; the use of compounds, produced by plants, in triggering reactions that kill cancer cells; and the use of photosynthetic organisms in cleaning of aqueous surface environments (lakes, etc). An excellent example is in the use of cyanobacteria that literally eat up the nitrates from ground water and clear it for us. The opportunities that photosynthesis-based technology provides us are enormous. This process is extremely important for life on earth as it provides the oxygen that all other life depends on.

Alyssa Cajumban graduated with a degree in Biology at the University of the Philippines - Manila. In the broad field of biological sciences, her interests focus on microbiology and plant pathology. Some of her works include researching and writing scientific papers regarding fungi, diseases of agricultural crops, and post-harvest techniques. She also works as an editorial assistant and writer for a scientific journal and textbook publication

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About the Editor

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List of Abbreviations

ADP	Adenosine Diphosphate
ATP	Adenosine Triphosphate
ALA	Aminolevulinic Acid
BASF	Badische Anilin- & Soda-Fabrik
BIRD	Blackbody Infrared Radiative Dissociation
EET	Electronic Energy Transfer
EPR	Electron Paramagnetic Resonance
ETC	Electron Transport Chain
EPGase	Enolase-Phosphglycerase
CCM	Carbon-Concentrating Mechanism
CO_2	Carbon Dioxide
CAM	Crassulacean acid metabolism
DCA	Dichloroacetic Acid
LSC	Long Single Copy Section
MODIS	Moderate Resolution Imaging Spectroradiometer
MPD	Multiple photon dissociation
OEC	Oxygen Evolving Complex
PEPC	Phosphoenolpyruvate Carboxylase
PEP	Phosphoenolpyruvate
PGAL	Phosphoglyceraldehyde
SSC	Short Single Copy Section
SWCNT	Single Wall Carbon Nanotube

Preface

Photosynthesis is the process used by plants, algae and certain bacteria to harness energy from sunlight into chemical energy. It is one example of how people and plants are dependent on each other in sustaining life. Photosynthesis happens when water is absorbed by the roots of green plants and is carried to the leaves by the xylem, and carbon dioxide is obtained from air that enters the leaves through the stomata and diffuses to the cells containing chlorophyll. The green pigment chlorophyll is uniquely capable of converting the active energy of light into a latent form that can be stored (in food) and used when needed. Photosynthesis provides us with most of the oxygen we need in order to breathe. We, in turn, exhale the carbon dioxide needed by plants. Plants are also crucial to human life because we rely on them as a source of food for ourselves and for the animals that we eat. There are two types of photosynthetic processes: oxygenic photosynthesis and anoxygenic photosynthesis. Oxygenic photosynthesis is the most common and is seen in plants, algae and cyanobacteria. On the other hand, anoxygenic photosynthesis uses electron donors other than water. The process typically occurs in bacteria such as purple bacteria and green sulfur bacteria. Plants make simple sugar by photosynthesis. It all happens in a fraction of a second. Water gets split into hydrogen and oxygen. The hydrogen is combined chemically with carbon dioxide to produce simple sugar. This dissolves easily in water and hence is transported to all parts of the plant. Oxygen is given off as a by-product. Thus, plants take in CO2 and gives out oxygen during photosynthesis reaction. Sun shines each day and does not charge us any money for the light it gives us. The light falling on Earth is very clean and will be there for a very long time as long as the Sun lasts. In addition to the current applications, Photosynthesis-based technology could also include using the concept of efficient "energy capture" to our artificial systems just as plants have been doing: thousands of chlorophyll a molecules (antenna) serving one center where the process occurs efficiently; the use of compounds, produced by plants, in triggering reactions that kill cancer cells; and the use of photosynthetic organisms in cleaning of aqueous surface environments (lakes, etc). An excellent example is in the use of cyanobacteria that literally eat up the nitrates from ground water and clear it for us. The opportunities that photosynthesis-based technology provides us are enormous. This process is extremely important for life on earth as it provides the oxygen that all other life depends on.

Content Coverage

Chapters One and *Two* introduce about photosynthesis process and chlorophyll, correspondingly. Chlorophyll is a complex organic molecule that enables plants, and some other organisms, to carry out photosynthesis — the conversion of carbon dioxide and water to glucose and oxygen using sunlight.

Chapters Three and *Four* present the role of chloroplast and light-dependent reactions, respectively. In photosynthesis, the light-dependent reactions take place on the thylakoid membranes. The inside of the thylakoid membrane is called the lumen, and outside the thylakoid membrane is the stroma, where the light-independent reactions take place.

Chapter Five gives an overview of photodissociation, photolysis, or photodecomposition. Photolysis is part of the light-dependent reactions of photosynthesis. The effectiveness of photons of different wavelengths depends on the absorption spectra of the photosynthetic pigments in the organism. Chlorophylls absorb light in the violet-blue and red parts of the spectrum, while accessory pigments capture other wavelengths as well.

Chapter Six focuses on carbon fixation or carbon assimilation, which is the conversion process of inorganic carbon (carbon dioxide) to organic compounds by living organisms. The most prominent example is photosynthesis, although chemosynthesis is another form of carbon fixation that can take place in the absence of sunlight.

Chapters Seven and *Eight* present the process of CAM photosynthesis and RuBisCO, separately. Crassulacean acid metabolism (CAM) is a photosynthetic CO2 fixation pathway that maximizes water use efficiency (WUE) many times relative to C3 species by using a temporal CO2 pump. RuBisCO, however, is an enzyme involved in the first major step of carbon fixation, a process by which atmospheric carbon dioxide is converted by plants and other photosynthetic organisms to energy-rich molecules such as glucose.

Chapters Nine and *Ten* introduces about the Emerson and Warberg Effect. The Emerson effect is the increase in the rate of photosynthesis after chloroplasts are exposed to light of wavelength 670 nm (red light) and 700 nm (far red light). However, the Warburg's effect is the decrease in the rate of photosynthesis by high oxygen concentrations.

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