Chlorophyll (also **chlorophyl**) is any of several related green pigments found in the mesosomes of cyanobacteria and in the chloroplasts of algae and plants.[1] Its name is derived from the Greek words χλωρός, *khloros* ("pale green") and φύλλον, *phyllon* ("leaf").[2] Chlorophyll is essential in photosynthesis, allowing plants to absorb energy from light.

Chlorophylls absorb light most strongly in the blue portion of the electromagnetic spectrum as well as the red portion.[3] Conversely, it is a poor absorber of green and near-green portions of the spectrum, which it reflects, producing the green color of chlorophyll-containing tissues. Two types of chlorophyll exist in the photosystems of green plants: chlorophyll a and b.[4]

History

Chlorophyll was first isolated and named by Joseph Bienaimé Caventou and Pierre Joseph Pelletier in 1817.[5] The presence of magnesium in chlorophyll was discovered in 1906,[6] and was that element's first detection in living tissue.[7]

After initial work done by German chemist Richard Willstätter spanning from 1905 to 1915, the general structure of chlorophyll *a* was elucidated by Hans Fischer in 1940. By 1960, when most of the stereochemistry of chlorophyll *a* was known, Robert Burns Woodward published a total synthesis of the molecule.[7][8] In 1967, the last remaining stereochemical elucidation was completed by Ian Fleming,[9] and in 1990 Woodward and co-authors published an updated synthesis.[10] Chlorophyll f was announced to be present in cyanobacteria and other oxygenic microorganisms that form stromatolites in 2010;[11][12] a molecular formula of $C_{55}H_{70}O_6N_4Mg$ and a structure of (2-formyl)-chlorophyll *a* were deduced based on NMR, optical and mass spectra.[13]

Photosynthesis

Chlorophyll is vital for photosynthesis, which allows plants to absorb energy from light.[14]

Chlorophyll molecules are arranged in and around photosystems that are embedded in the thylakoid membranes of chloroplasts.[15] In these complexes, chlorophyll serves three functions. The function of the vast majority of chlorophyll (up to several hundred molecules per photosystem) is to absorb light. Having done so, these same centers execute their second function: the transfer of that light energy by resonance energy transfer to a specific chlorophyll pair in the reaction center of the photosystems. This pair effects the final function of chlorophylls, charge separation, leading to biosynthesis. The two currently accepted photosystem units are photosystem II and photosystem I, which have their own distinct reaction centres, named P680 and P700, respectively. These centres are named after the wavelength (in nanometers) of their red-peak absorption maximum. The identity, function and spectral properties of the types of chlorophyll in each photosystem are distinct and determined by each other and the protein structure surrounding them. Once extracted from the protein into a solvent (such as acetone or methanol),[16][17][18] these chlorophyll pigments can be separated into chlorophyll a and chlorophyll b.

The function of the reaction center of chlorophyll is to absorb light energy and transfer it to other parts of the photosystem. The absorbed energy of the photon is transferred to an electron in a process called charge separation. The removal of the electron from the chlorophyll is an oxidation reaction. The chlorophyll donates the high energy electron to a series of molecular intermediates called an electron transport chain. The charged reaction center of chlorophyll ($P680^+$) is then reduced back to its ground state by accepting an electron stripped from water. The electron that reduces $P680^+$ ultimately comes from the oxidation of water into O_2 and H^+ through several intermediates. This reaction is how photosynthetic organisms such as plants produce O_2 gas, and is the source for practically all the O_2 in Earth's atmosphere. Photosystem I typically works in series with Photosystem II; thus the $P700^+$ of Photosystem I is usually reduced as it accepts the electron, via many intermediates in the thylakoid membrane, by electrons coming, ultimately, from Photosystem II. Electron transfer reactions in the thylakoid membranes are complex, however, and the source of electrons used to reduce $P700^+$ can vary.

The electron flow produced by the reaction center chlorophyll pigments is used to pump H^+ ions across the thylakoid membrane, setting up a chemiosmotic potential used mainly in the production of ATP (stored chemical energy) or to reduce $NADP^+$ to NADPH. NADPH is a universal agent used to reduce CO_2 into sugars as well as other biosynthetic reactions.

Reaction center chlorophyll–protein complexes are capable of directly absorbing light and performing charge separation events without the assistance of other chlorophyll pigments, but the probability of that happening under a given light intensity is small. Thus, the other chlorophylls in the photosystem and antenna pigment proteins all cooperatively absorb and funnel light energy to the reaction center. Besides chlorophyll *a*, there are other pigments, called accessory pigments, which occur in these pigment–protein antenna complexes.

Chemical structure

Chlorophylls are numerous in types, but all are defined by the presence of a fifth ring beyond the four pyrrole-like rings. Most chlorophylls are classified as chlorins, which are reduced relatives of porphyrins (found in hemoglobin). They share a common biosynthetic pathway with porphyrins, including the precursor **uroporphyrinogen III**. Unlike hemes, which feature iron at the center of the tetrapyrrole ring, chlorophylls bind magnesium. For the structures depicted in this article, some of the ligands attached to the Mg^{2+} center are omitted for clarity. The chlorin ring can have various side chains, usually including a long phytol chain. The most widely distributed form in terrestrial plants is chlorophyll *a*.

The structures of chlorophylls are summarized below:[19][13]