Photosystem is the form of pigments on the thylakoid membrane. It collects energy over the wavelengths and concentrates it to one molecule which uses the energy to pass one of its electrons on to a series of enzymes. Photosystem II occurs with two series of enzymes followed by Photosystem I in order to create energy for a plant. In Photosystem II which also called water- plastoquinone oxidoreductase, the generated hydrogen ions help to create a proton gradient that is used by ATP synthase to generate ATP, and the transferred energized electrons are used to reduce 2NADP+ to 2NADPH.

Photosystem II is the first membrane protein complex in oxygenic photosynthetic organisms in nature. It produces atmospheric oxygen to catalyze the photo-oxidation of water by using light energy. It oxidizes two molecules of water into one molecule of molecular oxygen. The four electrons removed from the water molecules are transferred by an electron transport chain which is formed hydrogen ions and molecular oxygen to plastoquinone. By obtaining these electrons from water, photosystem II provides the electrons for all of photosynthesis to occur.

Photosystem II is composed of 20 subunits such as D1, D2, CP43, CP47, and PsbO. Subunit D1 (beta-carotene, quinin and manganese center) reacts in the center of protein and binds Chlorophyll P680 and pheophytin, and Subunit D2 reacts in the center Protein. D1 and D2 form the core of this membrane protein. D1 (colored in red) is homologous to the L subunit of the bacterial photosystem where as D2 (colored in blue) is homologous to the M subunit of the bacterial photosystem. Chlorophylls is bounded by D1 and D2 and colored in green in the Figure A shown below. CP43 binds with manganese center and CP47 appears in Photosystem I. Last, PsbO (colored in purple) occurs in Manganese center to stabilize Protein.

These subunits contains 99 cofactors and coenzymes; “35 chlorophyll a, 12 beta – carotene, two pheophytin, three plastoquinone, two heme, bicarbonate, 25 lipid and seven n-dodecyl – beta – D – maltoside detergent molecules, the six components of the Mn4Ca cluster, and one Fe2+ and two putative Ca2+ ion per monomer”1. Chlorophyll absorbs light, Beta – carotene absorbs photoexcitation energy, and heme contains iron. Pheophytin is transferred an electron from P680 which is formed of 2 chlorophylls that absorb light at the wavelength of 680nm. It is a primary electron acceptor and contains chlorophyll with the Magnesium replaced by two protons. Then the electron is transferred to Plastoquinone (PQ) at QA site then QB site. Plastoquinone can be one or two electron acceptor or donor from Photosystem II to the cytochrome bf complex in mobile intra-thylakoid membrane. The arrival of a second electron at QB site with the uptake of two protons produces PQH2. When Plastoquinone is fully reduced to PQH2, it is called Plastoquinol. Therefore, the overall reaction for Photosystem II is shown below;

$$2PQ + 2H2O -> O2 + 2PQH2 \ (3)$$

When the electron is transferred from P680 to Phephytin, a positive charge is formed on P680+ which is a strong oxidant that extracts electrons from water at manganese center. Manganese center is the oxygen evolving center (OEC) and the site of water oxidation. It includes 4 manganese ions, a calcium ion, a chloride ion, and a tyrosine radical. It is the core of this redox center because it has four stable oxidation states such as Mn2+, Mn3+, Mn4+, and Mn5+. Each time the P680 is excited and an electron is kicked out, the positively charged pair extracts an electron from the manganese center.

The manganese center is oxidized one electron at a time so it requires four steps to complete the oxidation. A tyrosine residue is not shown participates in the proton electron transfers, therefore; the structures are designated S0 through S4.
to indicate the number of electrons removed. We know there are five different oxidation states because of $S_0$ through $S_4$. When $S_4$ is attained, an oxygen molecule is released and two new molecules of water bind.

The site of plastoquinone reduction is on the stroma side of the membrane. The manganese complex is on the thylakoid lumen side of the membrane. For every four electrons harvested from water, two molecules of PQH2 are formed extracting four protons from the stroma. The four protons formed during the oxidation of water are released into the thylakoid lumen. This distribution of protons across the thylakoid membrane generates a pH gradient with a low pH in the lumen and a high pH in the stroma.

The oxygen evolving complex of photosystem II contains Mn4, a redox-active tyrosine, and Ca2+/Cl- ions, but its molecular structure has not yet determined. However, by looking at Figure B above, the point group for Photosystem II can be determined as C2 with a metal, Mn7. The Figure B describes an oblique surface-rendered view of the 3D structure of the C. reinhardtii supercomplex. The supercomplex is dimeric, therefore; it is found to be C2 point group symmetric containing two sets of subunits.

The primary emphasis of the Raman study in Photosystem II is on the low frequency range from 220 to 620 (cm-1). The low frequency region is examined for both S1 and S2. The Raman spectra of Photosystem II in the S1 state represents a few unique low-frequency bands that do not represent in S2 state. This indicates that it is coordinated by two H2O or OH-. The Raman Mn-depleted Photosystem II and Photosystem II in the S2 are almost the same. This indicates that the S1 state of the Manganese has a near infrared electronic transition from the resonance enhanced Raman scattering can be induced.

Photosystem II which is a part of Photosynthesis is one of the protein complexes. It has been the focus on many studies as a major biological energy source for life on the earth. This process requires water to obtain the electrons in order to provide the electrons for all of photosynthesis.

References

5. Bryant M. Photosystems I and II. 2003