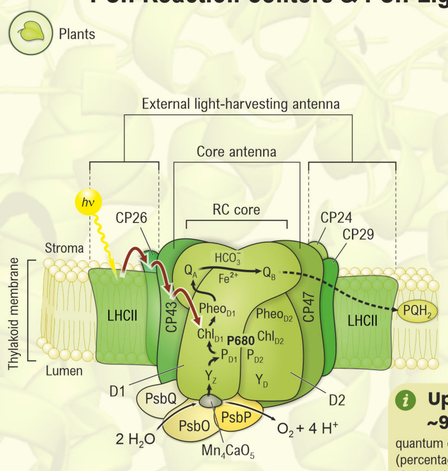
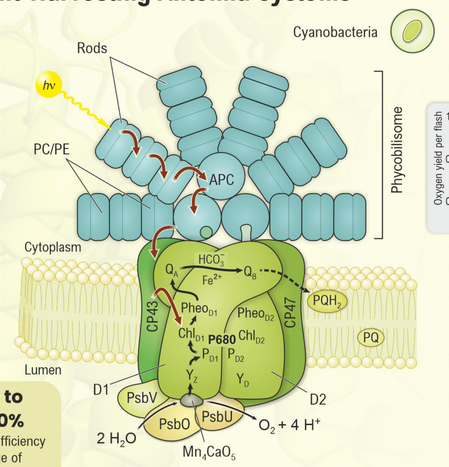
Best wishes for your research
Govindjee

Photosystem II: Enzyme That Gives Us Molecular Oxygen

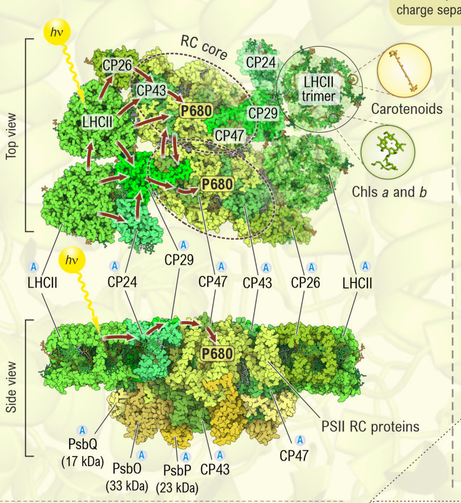
PSII Reaction Centers & PSII Light-Harvesting Antenna Systems



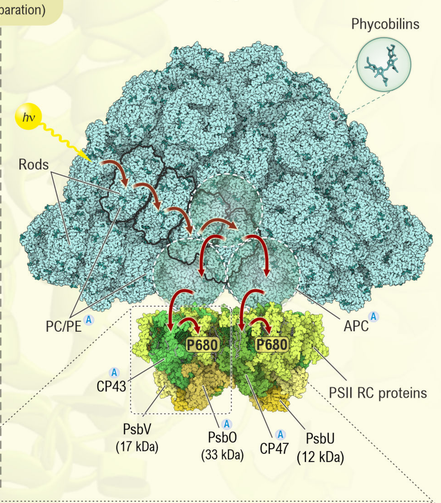


Up to ~90% quantum efficiency (percentage of absorbed photons that are trapped by PSII and promote charge separation)

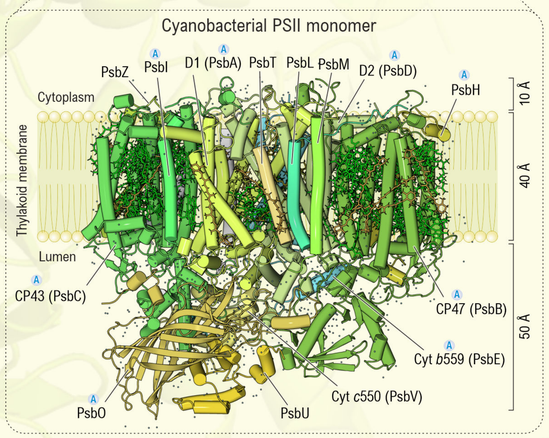
C2S2M2-type PSII-LHCII supercomplex



PSII dimer with phycobilisomes



Cyanobacterial PSII monomer

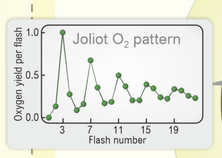


Each PSII monomer consists of >20 subunits ~100 cofactors

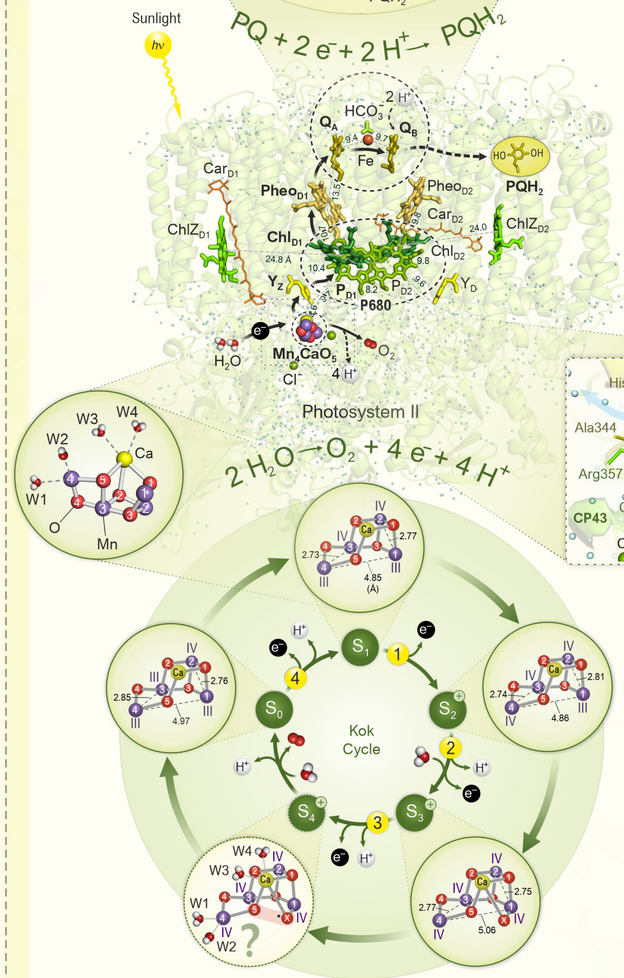
Under full sunlight PSII needs to be repaired every 30 min

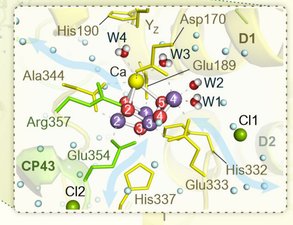
Symbols

- Antibodies provided by Agrisera
- Bridging oxygen atoms
- Molecular oxygen
- Metal bound water molecules (W1-W4)
- Other water molecules
- Light flash number
- Electron
- Proton
- Suggested water/proton channels
- Excitation energy transfer
- Electron transfer
- Molecular movement
- Oxidizing equivalent



PQ + 2 e$^-$ + 2 H$^+$ → PQH$_2$

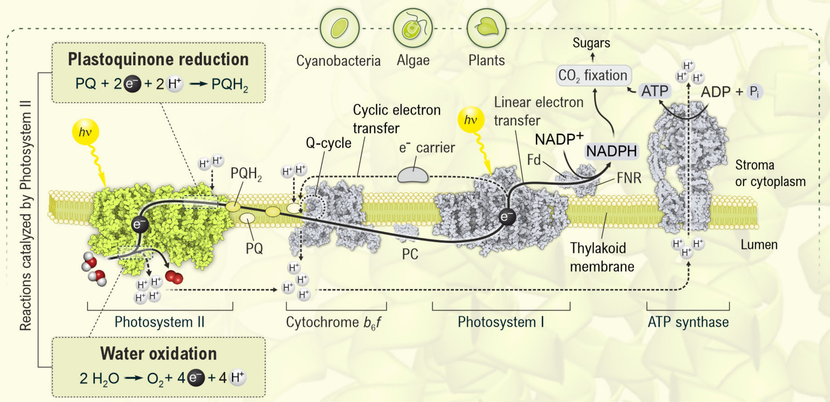




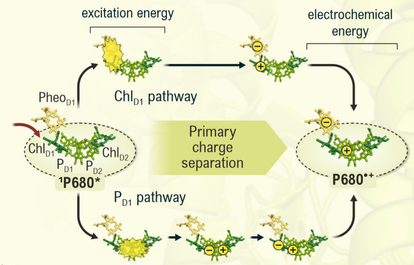
Up to ~50 O$_2$ are released per second (turnover frequency)

~100 000 O$_2$ can be produced before PSII needs to be repaired (turnover number)

Reactions catalyzed by Photosystem II

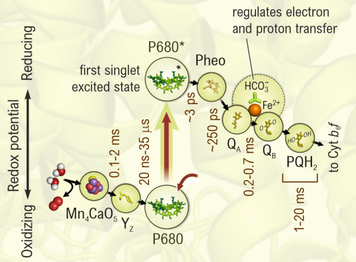


Conversion of Light Energy to Chemical Energy

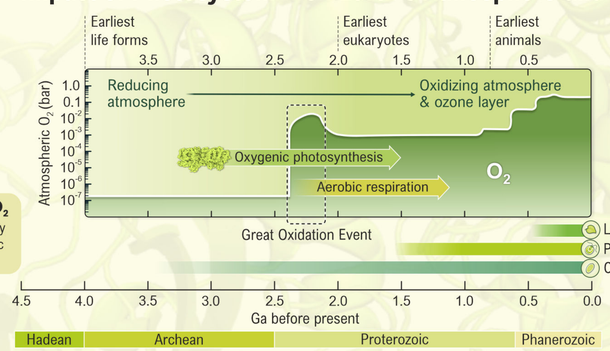


~3 ps is needed to convert excitation energy to electro-chemical energy

~+1.25 V is the mid point potential of generated P680^{+}; the highest known oxidizing potential in nature



Impact of Photosystem II on Earth's Atmosphere and Life



~21% O$_2$ in Earth's atmosphere was accumulated due to PSII

~280 Gt O$_2$ is released annually by PSII of oxygenic organisms

Photosystem II Poster: Structure and function of the enzyme Photosystem II (PSII; water:plastoquinone oxidoreductase; EC 1.10.3.9). For further information, see [1-9] and refs therein. Send questions and comments to G. Govindjee (gov@illinois.edu) and/or to D. Shevela (info@scigrafik.se). **Abbreviations:** ADP, adenosine diphosphate; APC, allophycocyanin; ATP, adenosine triphosphate; Cyt b_6f, cytochrome b_6f complex; Fd, ferredoxin; FNR, ferredoxin-NADP reductase; Mn_4CaO_5, manganese-calcium-oxygen complex; NADP$^+$/NADPH, nicotinamide adenine dinucleotide phosphate (oxidized/reduced forms); PE/PC, phycoerythrin/phycocyanin; PC, plastocyanin; Pheo, pheophytin of which $Pheo_{D1}$ is the primary electron acceptor of PSII; PQ/PQH_2, mobile plastoquinone molecules (oxidized/reduced forms); P680, primary electron donor of PSII that includes the chlorophyll (Chl) *a* molecules P_{D1}, P_{D2}, Chl_{D1}, and Chl_{D2}; Q_A and Q_B, primary and secondary plastoquinone electron acceptors; RC, reaction center; Y_D/Y_Z, redox-active tyrosines D/Z. **Notes:** Complexes and cofactors were generated with PyMOL and Protein Imager software using coordinates of the following PDB codes: 1ag6, 1vf5, 2mh7, 3arc, 3w5u, 4y28, 5xnl, 6b8h, 6kgx, 6w1o, 6w1r, and 6w1p. Phytol tails of Chls and Pheo, and the isoprenyl chains of the quinones are not shown. **Acknowledgements:** We thank Jian-Ren Shen, Holger Dau, Robert Blankenship, and Elisabet Romero for their valuable comments and corrections. We are highly grateful to Agrisera for sponsoring the poster design, printing, and free distribution at conferences around the world. **Citation:** Shevela D, Kern J, Whitmarsh J, Messinger J, Govindjee G (2021) Photosystem II: Enzyme that gives us molecular oxygen, *Agrisera Educational Poster 5*: doi:10.6084/m9.figshare.14802924.

References: [1] Shevela D, Kern JF, Govindjee G, Whitmarsh J, Messinger J (2021) Photosystem II. *eLS* 2: 1-20; [2] Blankenship R (2021) Molecular Mechanisms of Photosynthesis, 3rd edn, Oxford, Wiley; [3] Kern J, Chatterjee R, Young ID, Fuller FD, Lassalle L *et al.* (2018) Structures of the intermediates of Kok's photosynthetic water oxidation clock. *Nature* 563: 421–425; [4] Su X, Ma J, Wei X, Cao P, Zhu D *et al.* (2017) Structure and assembly mechanism of plant C2S2M2-type PSII-LHCII supercomplex. *Science* 357: 815-820; [5] Müh F, Zouni A (2020) Structural basis of light-harvesting in the photosystem II core complex. *Prot. Sci.* 29: 1090-1119; [6] Siegbahn PEM (2009) Structures and Energetics for O_2 Formation in Photosystem II. *Acc. Chem. Res.* 42: 1871-1880; [7] Dau H, Zaharieva I (2009) Principles, efficiency, and blueprint character of solar-energy conversion in photosynthetic water oxidation. *Acc. Chem. Res.* 42: 1861-1870; [8] Shen J-R (2015) The structure of Photosystem II and the mechanism of water oxidation in photosynthesis. *Annu. Rev. Plant Physiol.* 66: 24-48; [9] Romero E, Novoderezhkin VI, van Grondelle R (2017) Quantum design of photosynthesis for bio-inspired solar-energy conversion. *Nature* 543: 355-365.

Poster 5 - Photosystem II, 2021 (updated 2022)

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