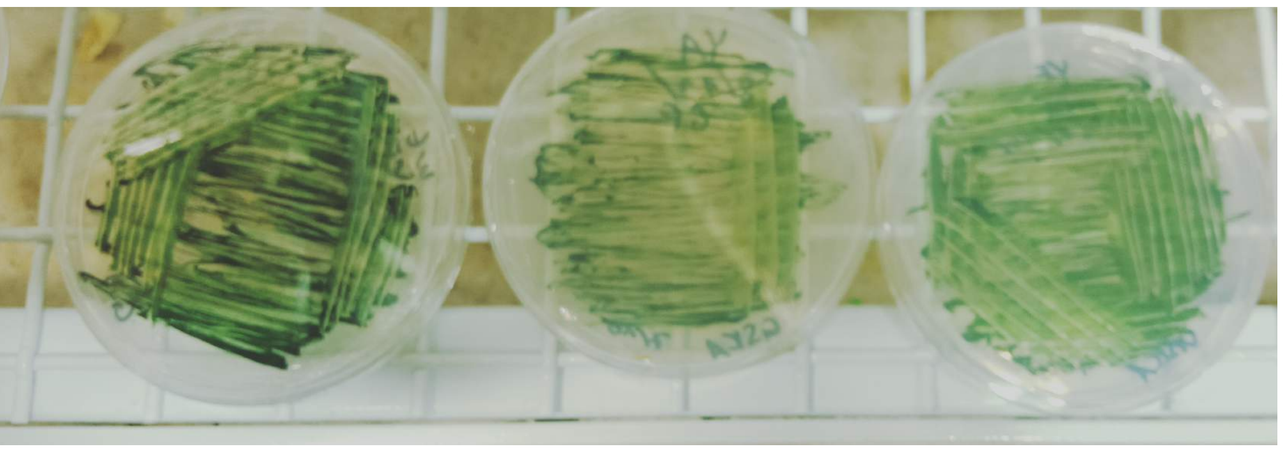
Dynamics of water splitting kinetics by cyanobacteria: potential source of fuel

Faiza Arshad[1], Julian Eaton-Rye[1]

[1]Department of Biochemistry, University of Otago

Introduction

- Plants and cyanobacteria are natural rescuers to assimilate CO_2 and H_2O (greenhouse gases) and they produce O_2 and carbohydrates in a process called photosynthesis, a term coined by Charles Barnes in 1893.
- A profusely available form of renewable energy is solar energy, and the chlorophyll-containing organisms have the ability to convert that energy into other forms of energy.
- These organisms make food for their own existence, split water and release O_2 in the environment.



Benefits of Blue green algae as model organism

- Cyanobacteria have a number of advantages to study photosynthesis as a model system because of the availability of the complete genetic makeup in the literature.
- Cloning, inactivation of specific genes or introducing point mutations in the genetic makeup of cyanobacteria is well established and cyanobacteria compare favorably with plants because of their compact genome and short generation time.

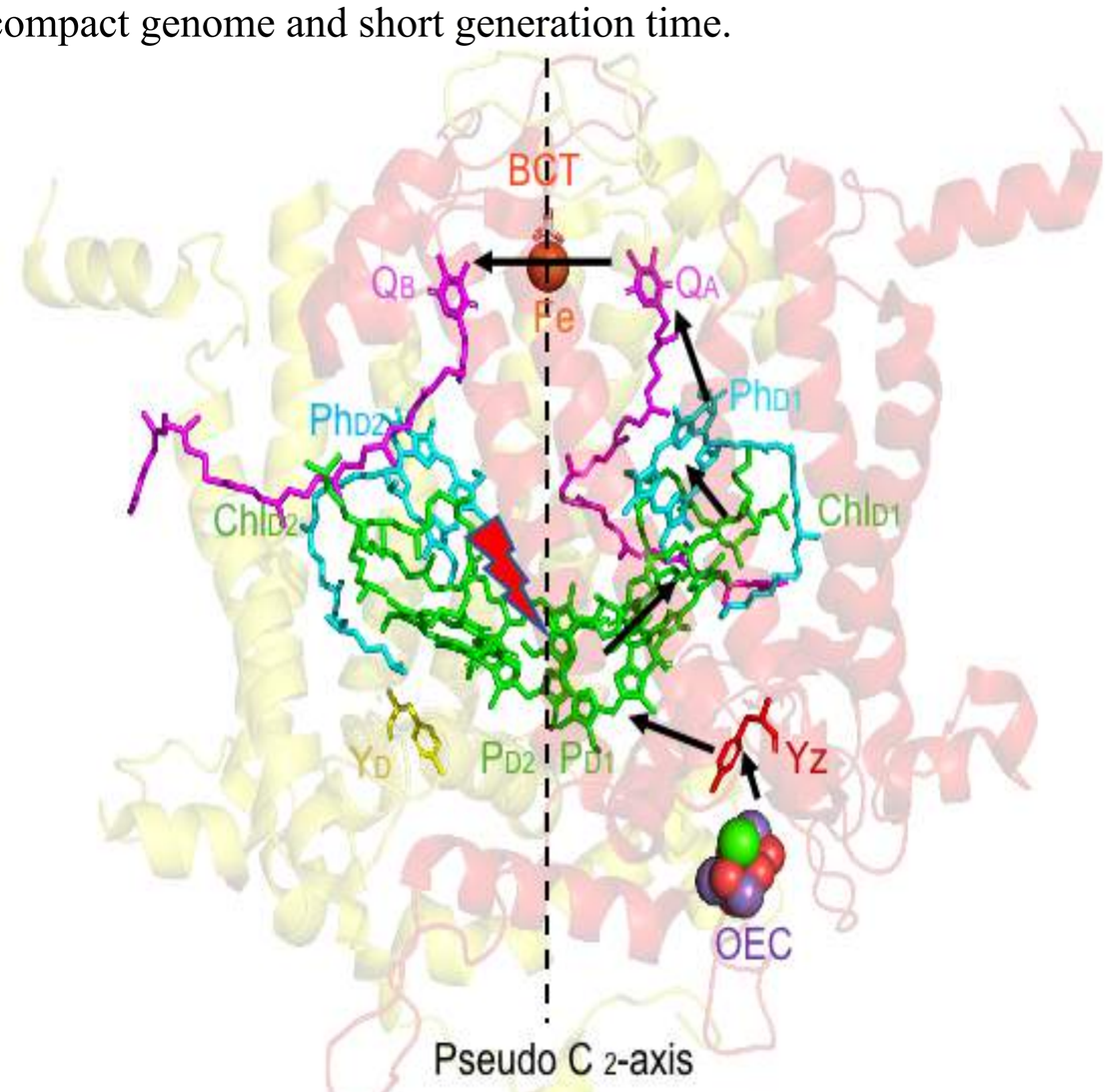


Figure 1 D1 and D2 proteins and cofactors involved in PETC

Prospective results

- The goal of this research is to investigate changes that may increase the rate of O_2 evolution.
- The OEC consist of specific catalytic Mn-containing cluster.
- The potential outcomes of this study can be exploited for the biological production of H_2 for fuels or increased biomass can be harnessed for the production of biofuels[3].
- Just like Covid-19, the greenhouse gas emission is a global problem.
- In particular, finding alternative ways to generate fuel and to reduce the emission of greenhouse gases will have a substantial impact on the areas located in proximity to the oceans by reducing the impact of rising water levels that result in erosion and flooding.

Background

- Zero-carbon emission is possible by reduced emission of greenhouse gases and developing alternative cost effective, environment friendly, and sustainable sources of fuel for industry. O_2 and H^+ are the by-products of photosynthesis.
- O_2 is the fuel for environment whereas, H_2 is a fuel for industry. Most of the H_2 consumed by industry comes from oxidation of the non-renewable fossil fuel.
- The problems associated with fossil fuels is production of greenhouse gases and obviously their non-renewable nature.
- Nature has taught us to split H_2O in an eco-friendly, sustainable and economical fashion in the form of photosynthesis.

Method

- Targeted changes in amino acid residues around the photosynthetic oxygen-evolving complex (OEC) to increase the electrophilic character of the OEC is the area of study of my research.
- The amino acids targeted in the study are part of the CP43 protein and are present in 2nd ligand sphere of the OEC.
- CP43 forms two hydrogen bonds with the OEC via E341 and R344[1].
- Due to the accumulation of the positive charge around the cluster in the dark-adapted S-state transitions (Kok cycle) i.e. in S_2 and S_3, the rate of reaction slows.
- Y160 reduction is even slower around 1 ms, this is the rate-limiting step of water oxidation[2].
- To establish the role of CP43 residues in the photosynthetic electron transport chain in the rate-limiting step, two sets of residues are selected to be changed to more basic ones to increase the rate of the overall water catalytic cycle.

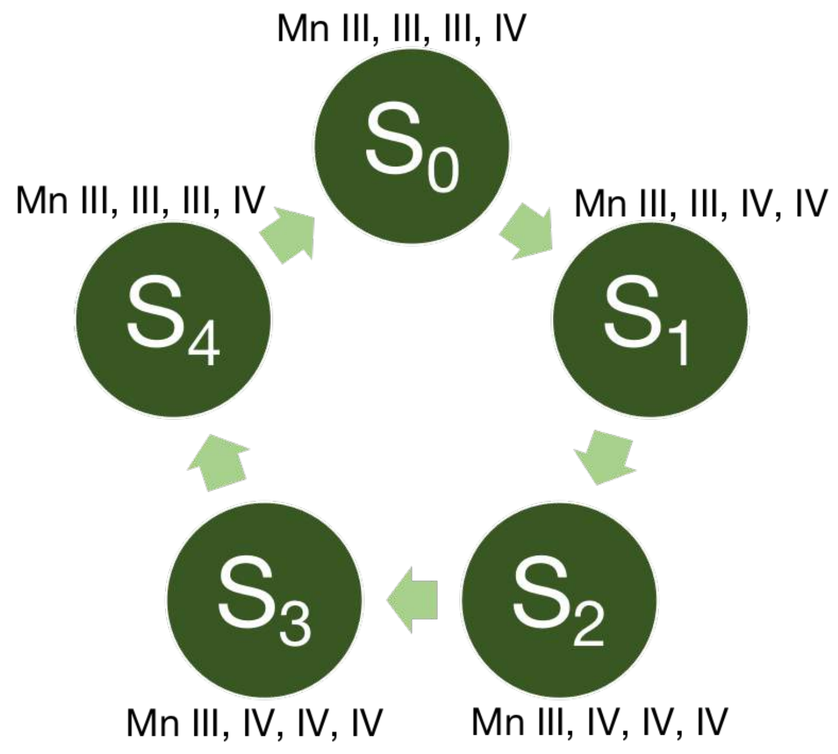


Figure 2 Oxidation states of Mn in Kok's cycle

Faiza Arshad
arsfa057@student.otago.ac.nz

References
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