SCHOOL OF LIFE & ENVIRONMENTAL SCIENCES

Academic Researcher:	Professor Min Chen
Project Title:	**Iron-stressed conditions and the impact of iron nutrient-limitation on photosynthetic activities in Chl-f cyanobacterium**
Project Summary:	Iron is an essential nutrient for the most living organisms and engages in different metabolic activities. Many studies showed that a number of cyanobacteria species have modified their morphological and physiological characters to respond to the iron deficiency condition. Chlorophyll f is the most red-shifted chlorophyll found in oxygenic photosynthetic organisms. Chlorophyll f provides a potential selective advantage and it enables to use infrared light (>700nm). However, chlorophyll f-producing cyanobacterium responses to the iron-stress conditions are still unknown. This project aims to characterize photo-physiological modifications of chlorophyll f-producing cyanobacterium in response to the iron nutrient limitations, especially the chlorophyll f-photosynthesis under iron-stress conditions.
Project Synopsis:	Cyanobacteria mainly depend on iron for photosynthetic reactions including alternative light-harvesting system and electron transport pathways. Iron deficiency triggers a variety of responses that range from up-regulation of the iron acquisition system to reduction of molecules or structural changes, such as new photosynthetic apparatus assembled in response to low iron concentration. Iron-stress induced protein A (IsiA) is a membrane-bound Chl a-binding protein produced in photosynthetic organisms under iron deficiency. Halomicronema hongdechloris is chlorophyll f-producing cyanobacterium isolated from Western Australia. There are two IsiA homologous reported in H. hongdechloris genome. Current project will be part of ARC DP (DP210102187) and will start with understanding the morphological and physiological changes under iron-stressed and chnaged light conditions. H. hongdechloris is a cyanobacterium that successfully grows in far-red light conditions with capability to quickly remodel the photosynthetic apparatus including chlorophyll f production. IsiA proteins in H,. hongdechloris not only play important roles in nutrient changed conditions, but also play vital roles in chlorophyll replacement in photosynthetic system. The project will characterize the isolated chlorophyll-binding IsiA proteins and define the changes of photosynthetic systems containing replaced chlorophyll compositions in order to understand the remodeled photosynthetic apparatus driven by long wavelength light and iron-stress conditions. Cyanobacteria played an important role in the evolution of biosphere and responsible for the oxygenation of the atmosphere and ocean. They are also major primary producers in oceans (significantly responsible for half of the global net primary productivity), and the ancestors of the chloroplast. They are well adapted to the diverse environments including harsh conditions by evolving range of fascinating repertoires of unique biomolecules and secondary metabolites to support their survival and growth. These phototrophs are provided as excellent models for unraveling the mysteries of basic biochemical and physiological processes taking place in higher plant.

	Due to their potential biotechnological and commercial applications, there is an imperative need to engineer robust cyanobacteria in such a way that they can tolerate and acclimatize to ever-changing environmental condition.

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Project Title:	**Structural basis of red-shifted phycobiliprotein complexes - broad-spectral light-harvesting proteins**
Project Summary:	This project will provide structural details on the assembly factors and co-factors that support the assembling and regulation of the phycobilisome (PBS) - light-harvesting antennae complex located on the surface of thylakoid membrane that transfers light energy to the photosynthetic reaction center in various photosynthetic organisms (including cyanobacteria and algae). Phycobilisomes (PBSs) is composed of mainly two structural components: chromophore-bearing phycobiliproteins (PBPs) and linker proteins (mostly colorless). Canonical PBS use light in the range of 550 nm - 670 nm. Chen's team discovered new PBS that has the maximal absorption peak at 710 nm, even longer wavelength than that of chlorophyll a and its photosystems can capture. According to the genomic sequence and whole proteomic analysis in Halomicronema hongdechloris (chlorophyll f-producing cyanobacterium), a group of genes encoding for red-shifted PBPs are reported . The project will set-up the targeting candidate protein by comparing the changes and modifications of red-shifted PBS. Using in vitro reconstitution systems and site-mutant technology we will understand the details of structural interaction between peptides and chromophore in order to define the molecular basis of formation of red-shifted PBS. This switchable (quickly assembling under far-red light and de-assembling under white light) PBS structural changes in respond to the changed light conditions open a new research area of understanding relationship between protein structure and function, a new strategy for photo-acclimation in photosynthetic organisms. This project will reveal the molecular mechanism of switchable PBS under different light conditions.
Project Synopsis:	The absorption of light is the gateway for all photosynthetic organisms and different organisms use various light-harvesting complexes thriving in changed light environments. The supermolecular protein complex-PBS is approximately 5-30 MDa in size and this multimolecular structure is made up of several conserved polypeptide species ligating with different bilins. Light energy captured by red-shifted PBS can be efficiently transferred to the chlorophyll f-photosystems within the membrane. Previous study from Chen's laboratory had depicted the existing of red-shifted PBP under far red-light conditions and commonly distributed in Chl f-producing cyanobacteria (Li et al 2016).Previous study (Chen et al 2019) also reported that red-shifted PBS has the similar protein subunits and chromophores as the typical PBS. This project will investigate the shifted spectral properties of various

	assembly/disassembly of the phycobiliprotein complexes. What kind of structural changes undergo and regulated by changed light conditions (light quantity and quality)? The new questions relating to the assembly/disassembly patterns of new PBS will lead to the answers for the gene expression pattern and their evolutionary and ecological significance in cyanobacteria. The various PBS mutant pool will be designed and generated to study the functional changes of individual PBP's including their photo-biological properties. Later we will develop mutant varieties that contribute to understand the conserved and functional motif regions that are responsible for the formation of red-shifted PBS using cyanobacterium, Halomicronema hongdechloris, as a model system for the project. Halomicronema hongdechloris is chlorophyll f-producing cyanobacterium isolated from Western Australia. There are two IsiA homologous reported in H. hongdechloris genome. Current project will be part of ARC DP (DP210102187) and will start with understanding the morphological and physiological changes under iron-stressed and chnaged light conditions. H. hongdechloris is a cyanobacterium that successfully grows in far-red light conditions with capability to quickly remodel the photosynthetic apparatus including chlorophyll f production. IsiA proteins in H,. hongdechloris not only play important roles in nutrient changed conditions, but also play vital roles in chlorophyll replacement in photosynthetic system. The project will characterize the isolated chlorophyll-binding IsiA proteins and define the changes of photosynthetic systems containing replaced chlorophyll compositions in order to understand the remodeled photosynthetic apparatus driven by long wavelength light and iron-stress conditions. Cyanobacteria played an important role in the evolution of biosphere and responsible for the oxygenation of the atmosphere and ocean. They are also major primary producers in oceans (significantly responsible for half of the global net primary productivity), and the ancestors of the chloroplast. They are well adapted to the diverse environments including harsh conditions by evolving range of fascinating repertoires of unique biomolecules and secondary metabolites to support their survival and growth. These phototrophs are provided as excellent models for unraveling the mysteries of basic biochemical and physiological processes taking place in higher plant. Due to their potential biotechnological and commercial applications, there is an imperative need to engineer robust cyanobacteria in such a way that they can tolerate and acclimatize to ever-changing environmental condition.