Photoinhibition, photo-ecophysiology, and biophysics, a special issue in honor of Wah Soon Chow

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In December 2018, during the Algal Phenomics colloquium organized by the Climate Change Cluster (University of Technology Sydney), the editors of this issue made a new year's resolution: to edit a special issue in *Photosynthesis Research* to honor the career and achievements of Prof. Wah Soon (Fred) Chow in the occasion of his 70th birthday. Due to the catastrophic fires that Australia suffered in 2019 and the current COVID19 pandemic, the project was delayed nearly two years. While many of our readers know well who Fred is and what he has achieved, we would like to briefly introduce this illustrious Australian scientist.

Fred was originally born in China and then emigrated to North Borneo in the mid 1960's. He moved to Tasmania in 1966 where he was admitted to University of Tasmania. He did his PhD at Flinders University under the supervision of Alex Hope. After completing his PhD, he had postdoctoral positions in London at Jim Barber's lab and then in Littlehampton. He then returned to Canberra and joined the groups of Jan Anderson (at CSIRO) and Barry Osmond (at the Australian National University), where he had been working until his promotion to Emeritus Professorship. As detailed in his autobiography in the current issue (Chow 2021), Fred has achieved several breakthroughs: (1) describing lateral heterogeneity of thylakoid membranes and spillover; (2) the description of the electrostatic forces that regulate the thylakoid structure in plants (Chow et al. 2005); (3) determination of the quantum yield of PSII (Chow

et al. 1989, 1991); (4) development of methods to probe P700 (Fan et al. 2007) and cyclic electron flow in vivo in a non-invasive manner in plants (Osmond et al. 2017) and corals (Szabó et al. 2017); (5) describing the dual mechanism of Photosystem II inactivation (Oguchi et al. 2011). His kindness, wisdom, selfless, and humble personality have inspired generations of students, postdocs, and other scientists. Undoubtedly, Fred has been one of the most illustrious Australian photosynthesis researchers and his contributions to the field of light reactions place him among the giants in our field. Therefore, there is no surprise he has influenced scientists of associated fields, such as ecophysiology, marine sciences, agriculture, and food production.

We hope this text, in conjunction with this special issue in *Photosynthesis Research*, will serve as a testimony of his contributions for future generations and will let them know the importance of Fred Chow for photosynthesis during the twentieth and twenty-first centuries. At his 72 years, Fred has over 178 publications (according to Scopus) between articles, reviews, and book chapters and his work has been cited 8325 times in all his career. From those publications, Fred has contributed to *Photosynthesis Research* with 37 articles, which makes him the fifth main contributor in this journal.

In fact, three of the articles where he has been a co-author are in the top-50 most cited articles in this journal: #28 (Anderson et al. 1995) (348 citations), #33 (Strid et al. 1994) (324 citations), and #39 (Hendrickson et al. 2004) (290 citations). Therefore, it is worth summarizing these three most cited works.

First, Anderson et al. 1995 is a mini-review on how the photosynthetic apparatus responds to the spectral light quality and photon flux density, and how these responses contribute to the tolerance of light stress. The authors proposed that regulation by signal transduction was affected by the phytochromes, the blue light receptors, and the two photosystems. Also, they hypothesized that the redox state of the two photosystems, the pool of cytochrome b_6f ,

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FeS, plastoquinone pool, the pH change, and the balance of reducing power for CO₂ fixation (ATP/NADPH) act as transducers. This review would have become one of the most influential texts in regulation of the photosynthetic apparatus at the time.

Strid et al. 1994 is another mini-review on the effect of UV-B light to the photosynthetic apparatus. The review focused on the early effects and low doses of UV-B on plants, and it was published in a time where the ozone layer depletion was gaining mainstream relevance. In fact, two years later Paul J Crutzen, Frank Sherwood Rowland, and Mario Molina (who just passed away in 2020) won the Nobel prize for the discovery of the effect of chlorofluorocarbons on the ozone layer (Rowland and Molina 1975). Strid, Chow, and Anderson highlighted that the integrity of the thylakoid membrane was much more sensitive than the photoinactivation of the photosystems.

The last of the three highlighted articles, Hendrickson, Furbank, and Chow 2006, proposed a new method to determine the total amount of excessive excitation, E^* , that did not require the use of F_0 and F_0' yielded similar results to the highly cited famous paper by Kramer et al. 2004 (fourth most cited work in *Photosynthesis Research*), which is a simplified measurement of this excess excitation quantity.

To celebrate Fred, 62 authors have contributed 15 original research articles, one review, and one tribute written by friends and former students. These contributions could be arranged within three themes: photoinhibition and photoprotection, photo-ecophysiology, and pure biophysics. In the front of photoinhibition, Zheng et al. (2020) report a study of *Arabidopsis* lines lacking anthocyanin synthesis, but possessing high antioxidant capacity. These lines exhibited diminished tolerance to high irradiances as compared to the lines that performed anthocyanin synthesis but impaired antioxidant capacity, illustrating the prominent role of anthocyanins as light attenuators. Then, Yu et al. (2020) investigated the relationship between anthocyanin accumulation and photoprotective capacity in dominant subtropical tree species. Qiao et al. (2020) explored how the fine-tuning of photosynthetic reactions prevents photoinhibition under fluctuating light in maize. On that note, Terashima et al. (2021) report the effect of oscillating light and photoinhibition of Photosystem I in *Alocasia odora*. Also on PSI, Oguchi et al. (2021) investigated the rate of the photoinhibition in Photosystem I under different wavelengths of visible light and revealed that by varying the wavelengths, the rates of photoinhibition of PSI and PSII are different, and that PSI and PSII are independently photoinhibited with different mechanisms. Bashir et al. (2021) show how extrinsic photosensitization of ¹O₂ can contribute during PSII photodamage in thylakoid membranes and green algae. Finally, Zavafer 2021 presents a synthesis of all the literature of the last decade supporting the dual hypothesis of PSII photoinhibition.

In the theme of photo-ecophysiology a study of *Sphagneticola* species of South China, Cai et al. (2020) demonstrated that the invasive species *Sphagneticola trilobata* L. exhibited elevated low temperature tolerance and therefore possibly enhanced adaptive potential as compared to the native species *Sphagneticola calendulacea* L., indicating the importance of photosynthetic performance in studying the ecophysiological aspects of invasive species. Perera-Castro et al. (2020) studied several different bryophyte species in Antarctica, and demonstrated that energy partitioning, photoprotection, and desiccation/freezing tolerance are important drivers of fitness under extreme environments, which also show species-specific features. Li et al. (2020) studied the biomass allocation and carbohydrate content under long-term submergence in tolerant and sensitive perennial plants. They showed that the tolerant and sensitive species followed different strategies in carbohydrate allocation and biomass change under long-term submergence conditions, indicating the importance of the characterization of physiological mechanisms of key species for restoration projects. Ver Sagun et al. (2021) explored the role of the Mehler reaction in C3 and C4 photosynthesis and its importance for low light and low CO₂. He et al. (2021) explored the spectral quantity and quality on Cos lettuce and how the supplement of artificial light enhances photosynthetic capacity and production. Finally, Saucedo-García et al. (2021) investigated the role of MAP kinases in cold acclimation in *Arabidopsis thaliana*. They found that cold acclimation induced alterations in chloroplast ultrastructure, which lead to the preservation of optimal performance of PSII.

This special issue finishes with two biophysical studies. First, Schreiber and Klughammer (2021) analyzed the contribution of Photosystem I to the variable fluorescence during the polyphasic rise of the Chl fluorescence in green algae, cyanobacteria, and plants. The authors used selective enhancement of the I₂-P phase of the O-I₁-I₂-P fluorescence induction curves using different detection wavelength ranges ($F > 700$ vs. $F < 710$ nm). Then, Karlický et al. 2021 investigated the effect of geranylgeranyl chlorophylls on the assembly of pigment-protein complexes and the structural flexibility of chiral macrodomains, and its impact on photosynthetic performance.

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bleaching project in Canberra that yielded exciting results and expanded our knowledge on biophysical methods.

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