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Editorial

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Introduction

Plant lipids have been studied for centuries for their practical use in industrial applications ranging from food, feed and biofuel, and for their important roles in plant physiology and development. The International Symposium on Plant Lipids (ISPL), initiated in 1974 by Professor Terry Galliard, provides an important platform for communication, knowledge sharing and networking amongst the growing, international plant lipid community. Since its debut in 1974, ISPL runs once every two years and the ISPL-2018 was the 23rd symposium, which was chaired by Professor Ikuo Nishida and took place in the impressive Osanbashi Hall, a replica of a gigantic wooden ship overlooking Yokohama Bay, Japan. ISPL-2018 welcomed over 240 delegates from over 22 countries including Ph.D. students, early career scientists, professors, government scientists and company R & D representatives. This Special Focus Issue on “Lipid metabolism in plants and algae” in *Plant and Cell Physiology* showcases recent developments in the area as discussed during the ISPL-2018.

Progress in methodology and research focus

In the past 50 years, plant lipid research has undergone dramatic modernization with the focus shifting and building on from structure and biochemistry to metabolism and function. Thus, the major approaches that are now used to study lipids have shifted from biochemistry to genetics, genomics, and lipidomics. Notably, with the advent of *in situ* imaging of lipid metabolites and genome editing tools, studies of lipids have

promised to reveal another level of complexity and importance in plant and algal physiology and development. The accessibility of Ultra Performance Liquid Chromatography-tandem Mass Spectrometry (UPLC-MS/MS), for example, has allowed the identification and quantification of not only major structural lipids but also of minor and transitory lipid-based signaling molecules. Matrix Assisted Laser Desorption Ionization Mass Spectrometry (MALDI-MS) has enabled visualization of lipid metabolites *in situ* revealing unexpected heterogeneity in lipid organization and highlights complex subcellular organization and differential gene expression of proteins involved in lipid metabolism. Genome editing tools have enabled researchers to go beyond hypotheses and provide functional evidence for predicted genes or hypothetical pathways, and will continue to do so. As a result, lipids are increasingly found at the frontiers of several research areas including cell cycle, circadian rhythms, chloroplast metabolism, cellular signal transduction processes, autophagy and development, to name just a few.

Model organisms

Research into lipids that is geared towards either industrial applications or uncovering structural diversity and physiological or evolutionary roles, has been facilitated by the ever-expanding choice of model species. The group of Prof. Chris Somerville at Michigan State University (MSU) pioneered the use of *Arabidopsis thaliana* in lipid research in the 80s'. Since then, a myriad of knowledge and discoveries in the area of plant lipids has been attained and subsequently expanded to crop species – notably rapeseed and soybean, with Camelina as an emerging oil crop species – with the goal of increasing oil content in seeds, which has societal and economic value. Microalgae have long been subjected to research on lipids due to them being a rich source of genes for the synthesis/ modification/ metabolism of very long chain (VLC)-polyunsaturated fatty acids (PUFA), and for their superior biomass productivity, and therefore great potential as a feedstock for biofuel and bio-products. The current trend in microalgae lipid research is apparent by the application of state-of-the-art genome editing and synthetic biology tools. The three flagship algal species being intensively studied at many levels include *Chlamydomonas reinhardtii*, *Nannochloropsis spp.* and *Pheaodactylum tricornutum*. In addition, lipid research has also been investigated in the liverwort *Physcomitrella patens*, which occupies a unique position in the evolutionary tree and possessing features of both water-living

algal species and that of land plants. Taken together, lessons learnt through the use of multiple photosynthetic organisms will continue to give rise to unprecedented insights into the structural divergence and evolutionary significance of lipid function in plant and algal development.

In this issue

Here we feature four invited reviews and six research papers aimed at providing both a glimpse of what was discussed during the last ISPL meeting and highlighting the current trends in plant lipid research.

The invited reviews in this Spotlight issue include: i) a description of distinct lipid profiles present within the model moss *Physcomitrella patens,* which show unique features similar to algae or land plants (Resemann *et al.* 2019), consistent with its special evolutionary position between the two clades; ii) Lavell and Benning's (2019) latest view on several aspects of plant lipid metabolism, highlighting its complexity and the importance of lipid transport especially in the context of subcellular organization and regulation of glycerolipid metabolism; iii) a review by Kong *et al.* (2019) on the versatile range of molecular genetic tools that have been developed for the model green microalga *Chlamydomonas reinhardtii*, including examples of their use in manipulating algal oil accumulation. And finally, iv), Zhou *et al.* (2019) summarize current efforts in engineering new lipid traits into oilseed crop *Brassica* species via biotechnological means.

The research papers featured here highlight the many ways in which plant and algae lipids affect growth and development at the cellular and whole-organism level. They include a report on the role of VLC-PUFAs in conferring stress tolerance in the green alga *Lobospheaera incisa* (Kugler *et al.* 2019). Fujii *et al.* (2019) describe a role for galactolipids during etioplast-to-chloroplast differentiation. June *et al.* (2019) report the function of malonyl CoA-acyl-carrier protein malonyltransferase in cell division and oil storage. Warakanont *et al*. (2019) identified an algal lipase LIP4, orthologous to *Arabidopsis* Sugar-dependent 1 (SDP1), and report its involvement in triacylglycerol degradation in the green microalga *Chlamydomonas reinhardtii*. Finally, Chevalier *et al.* (2019) describe the importance of interplay between jasmonic acid and phosphate signaling on the regulation of glycerolipid metabolism in

Arabidopsis. From a biotechnological angle, Li *et al.* (2019) report the development of the industrial oil crop *Crambe abyssinica* for wax ester production through metabolic engineering and genetic crosses.

With this Special Focus Issue, we intend to provide a primer to spark interest on plant and algal lipids. To this end, the review articles covering some of the major areas of plant and algal lipids that feature in this issue should provide a starting point from which to explore the latest trends in the study of plant and algal lipids. This is by no means a comprehensive overview, as other exciting research areas discussed at the ISPL2018 meeting (lipid catabolism, lipid droplet biology, membrane topology and micro-domains, surface lipids, sphingolipids, *etc*) are not covered here due to space limitations. We therefore encourage students and early career researchers to go beyond what is presented here.

Finally, as demonstrated by the collection of papers included in this Special Focus Issue, it is clear that lipids are at the heart of many fundamental biological processes, and many more probably remain to be evidenced. We hope you enjoy reading the featured articles in this issue, and come away with a stronger interest in lipids, and knowledge of what lies at the frontier of plant and algal lipid research and what is yet to come.

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