ICREA Workshop: from model systems to crops – challenges for a new era in plant biology

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The increasing world population will pose an unprecedented challenge to the agricultural system. By 2050, farmers will need to produce roughly about 70% more agricultural products than they currently do. It is also foreseen that by 2050 there will be a rise in global mean temperatures and increased weather variability. Plant growth and crop productivity are particularly vulnerable to these climate changes. Science and newly developed scientific research programs will play a key role in addressing these issues. However, to achieve this complex task, it is essential that research policymakers turn the current trend and realize that a proper balance between basic and applied research is a more efficient way to approach the upcoming agricultural needs and demands (President's Council of Advisors on Science and Technology 2012, ASPB Report: Unleashing a Decade of Innovation in Plant Science 2013, EASAC Policy Report 21 2013, UK Plant Science: Current Status and Future Challenges 2014, MIT Committee to Evaluate the Innovation Deficit 2015).

The idea behind the ICREA Workshop celebrated in Barcelona (7–8 May 2014) was precisely to highlight the significant advances in basic plant sciences mostly using the model plant *Arabidopsis thaliana*, and how these advances have led the way to relevant findings in other species such as *Arabis alpina* (a perennial relative of *A. thaliana*), *Chlamydomonas reinhardtii* (a unicellular algae used as a model for its simplicity), rice, tomato, aspen, poplar or palm trees. The workshop gathered some of the most prominent experts of each field to present the state-of-the-art knowledge in their respective areas and opened the ground for discussions on relevant research topics currently emerging. Future directions and novel avenues of research in plants were also discussed. Workshop assistants presented a total of 41 posters, covering different aspects of plant biology. The poster sessions also promoted interactions and discussions.

The workshop stressed the relevance of many different areas in plant research. For instance, the plasticity of PLANT GROWTH, DEVELOPMENT AND LIFE-SPAN and their intimate communication with the environmental conditions was a recurrent point of discussion. Interesting insights about the mechanisms controlling annual and perennial flowering was presented by Dr George Coupland (Max Planck Institute for Plant Breeding Research, Cologne, Germany), introducing also novel findings on senescence after flowering that were extended by Dr Cristina Ferrándiz (Instituto de Biología Molecular y Celular de Plantas, Valencia, Spain) with an interesting talk about how life-span might be controlled in monocarpic (non-perennial) plants [see Ballester et al. (2015) for the role of the conserved TCP-NGA interaction in leaf development]. The role of photoperiodic conditions on growth and floral induction in trees, studied using poplar, Norway spruce and *Arabidopsis*, was presented by Dr Ove Nilsson (Umeå Plant Science Centre, Sweden), who also provided a very interesting review on the crucial roles of the CLE peptide signaling for a huge variety of plant developmental processes (Kucukoglu and Nilsson 2015). Dr Philip Wigge (Sainsbury Laboratory, University of Cambridge, United Kingdom) presented his work on how temperature is sensed, focusing on the ambient temperature response, as a way to understand how plants integrate environmental information into development, while Dr Doris Wagner (University of Pennsylvania, Philadelphia, USA) described the opposing functions of the hormone gibberellin in promoting termination of vegetative development but also inhibiting flower formation in *Arabidopsis* [see Winter et al. (2015) on the common LFY and AP1 transcriptional programs].

Another beautiful example of combined research in model species and crops was presented by Dr Gerco Angenent (Wageningen University & Business Unit Bioscience, The Netherlands), who described novel findings about the genetic determinants and molecular mechanisms involved in the regulation of fruit development in both *Arabidopsis* and tomato.

Another area of increasing research interest is the EPIGENETIC REGULATION of many essential biological activities in plants. Dr Detlef Weigel (Max Planck Institute for Developmental Biology, Tübingen, Germany) opened the workshop with an excellent lecture about exploring key questions in evolution (mutation, selection, speciation) using genome-wide population studies in *Arabidopsis* and quantifying mutation and epi-mutation rates and spectra in the laboratory and in the wild, as both types of alterations can contribute to plant adaptation. Dr Huiming Zhang (Purdue Agriculture, Indiana, USA) in turn dug into interesting and novel mechanisms and regulators of epigenetic silencing and anti-silencing mechanisms, mostly in *Arabidopsis* and using forward, reverse and chemical genetic approaches, while Dr Elizabeth Dennis (CSIRO Plant Industry, Canberra, Australia) discussed the increased yield of hybrid offspring relative to the parents (known as hybrid vigor), and the role of epigenetics and DNA methylation patterns resulting in heterotic phenotypes.

The increasing advances on plant genome sequencing have opened the way for novel areas of research from FUNCTIONAL GENOMICS all the way to plant ADAPTATION AND DOMESTICATION. The interesting seminar by Dr Jordi García-Mas (Centre for Research in Agricultural Genomics, Barcelona, Spain) gave a prime example on how genomic data from the recently sequenced melon genome can be exploited to extrapolate relevant quality traits [see Argyris et al. (2015) on melon fruit quality and virus resistance]. Dr Kazuki Saito (RIKEN Center for Sustainable Resource Science, Yokohama, Japan) also explained how to use metabolomics for functional genomics in both *Arabidopsis* and other plants with medicinal interest (see Okazaki et al. (2015) on accumulation of GlcADG under phosphorus starvation). The ultimate example of functional genomics application to the field was provided by Dr Wout Boerjan (Flanders Institute for Biotechnology, Ghent, Belgium), who provided details about engineering poplar trees for biorefinery, and demonstrating the use of *Arabidopsis* as a model for systems biology studies of the lignin pathway. Dr Michael Purugganan (Center for Genomics and Systems Biology, New York University, New York, USA) gave an excellent lecture on plant genome variation and structure (from *Chlamydomonas* to date palm) from a population genomics view, as a way to understand the genetic basis of adaptation and its role on crop domestication [see Pires et al. (2015) for rice responses to salinity] while Dr Nicholas Harberd (University of Oxford, Oxford, United Kingdom) explained how short-term adaptation and long-term evolution intersect in plant responses to abiotic stresses.

It has become increasingly evident that scientific questions must be addressed from a multidisciplinary viewpoint through collaborative research of biologists, mathematicians and informaticians. Accordingly, several seminars at the workshop dealt with MATHEMATICAL MODELING, ADVANCED TOOLS AND NOVEL TECHNOLOGIES in plant research. For instance, Dr Gloria Coruzzi's (Center for Genomics and Systems Biology, New York University, New York, USA) seminar focused on network modeling and its application to obtain clues about evolutionary traits. The use of advanced computational tools for plant research was also developed in Dr David Amar's talk [The Blavatnik School of Computer Science, Tel Aviv University, Israel; see Amar et al. (2015) for the new MORPH-R tool]. The workshop was closed with an interesting seminar by Dr Oliver Ratcliffe (Mendel Biotechnology, Hayward, California, USA), who exemplified how the use of novel technologies can help crop productivity.

Overall, the workshop provided an excellent opportunity to exchange ideas, knowledge and expertise in a very inspiring atmosphere. Discussions were highly useful to improve our understanding on the molecular and physiological events and mechanisms that allow proper adjustments of plant growth and crop productivity. As put forward during the meeting by one of the speakers, it is the use of model systems that has really transformed plant biology over the past 25–30 years, and analyses of these models in new, imaginative ways will be of continued importance to address the challenges looming in the future.