Experimental Plant Biology: Why Not?!

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Recent achievements and trends in experimental plant biology

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Abstract

Between 21 and 25 September 2009, Krakow hosted the 4th Conference of the Polish Society of Experimental Plant Biology, co-organized with the Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University, Krakow, and supported by the Biochemical Society. The aim of the conference was to present and discuss the most important topics in different disciplines of plant experimental science as well as to facilitate the interaction and co-operation between scientists. To achieve this goal, about 30 top specialists in various areas of plant biology were invited to give plenary lectures in the following sessions: Plant structure and development; Plant–microbial interactions; Mitochondria and chloroplasts in cell metabolism; Stress tolerance in plants; Structural and functional organization of plant genomes; Mutants in developmental and metabolic studies; Secondary metabolites as pharmaceutics and nutraceutics; Plant membranes; and Integrating plant functions via signalling molecules: molecular mechanisms. Some of the main problems highlighted in the plenary lectures are briefly summarized in the present paper. Two poster sessions enabled a discussion of over 200 posters presented. The conference had an international character, its official language was English, and among the more than 350 participants, about 60 were from abroad. Several plenary lectures were prepared as short review papers and they are published in this issue of *Biochemical Society Transactions*.

Introduction

The 4th biennial conference of the Polish Society of Experimental Plant Biology: 'Experimental Plant Biology: Why Not?!', co-organized with the Faculty of Biochemistry Biophysics and Biotechnology, Jagiellonian University, was held on 21–25 September 2009 on the premises of the 3rd Campus of the Jagiellonian University in Krakow. The conference was supported by the Biochemical Society and was held under the honorary patronage of the Mayor of the City of Krakow, the Rectors of the Jagiellonian University and the Pedagogical University of Krakow and the media patronage of http://www.magiczny.Krakow.pl. Numerous sponsors supported the conference, with the most generous being the Ministry of Science and Higher Education.

The aim of the conference was to review recent achievements and discuss future trends in selected areas of plant experimental biology. The programme consisted of nine sessions devoted to the following areas of plant science: Plant structure and development; Plant–microbial interactions; Mitochondria and chloroplasts in cell metabolism; Stress tolerance in plants; Structural and functional organization of plant genome; Mutants in developmental and metabolic studies; Secondary metabolites as pharmaceutics and nutraceutics; Plant membranes; and Integrating plant functions via signalling molecules: molecular mechanisms.

The conference attracted more than 350 participants from 20 countries, among whom there were about 60 participants from abroad. About 30 companies and firms related to bioscience also exhibited their products and promoted new research techniques and instruments. The official language

Key words: chloroplast, experimental plant biology, membrane, pharmaceutic, plant–microbial interaction, signalling.
Abbreviations used: LHCII, light-harvesting complex II; snoRNA, small nucleolar RNA.
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of the conference was English. For each session, top-class specialists in their area were invited to give plenary lectures. Altogether, more than 50 plenary lectures and oral presentations selected from posters were given. Also, over 200 posters related to respective sessions were presented. The conference was a good platform for exchanging ideas, establishing new contacts and fostering co-operation. The most relevant problems and findings presented in the plenary lectures are summarized below. Several of these lectures, covering selected problems from the respective sessions, are published in this issue of *Biochemical Society Transactions* as short review papers.

Plant structure and development

New data and perspectives on the development of the shape of plants were presented by E. Coen [1]. The emphasis was on understanding how genes control the growth of multicellular tissues in three-dimensional space. The problem was addressed using a multiple approach: genetic, morphological, computational and imaging, and the results of such research show the advantage of integrating biological and computational studies in this area of research. Quantitative approaches in studying plant development were presented by E. Bayer et al. [2]. They point out that during midvein initiation, two different PIN1 mechanisms of polarization work in tandem. They also suggest that some cells in the epidermis as well as in the internal meristem may change their polarization strategy. The role of chemical dynamics in plant morphogenesis was described by D. Holloway [3]. After a brief background history of chemical patterning, morphogenetic modelling was discussed. In particular, the importance of chemical kinetics for an understanding of the formation of localized concentration patterns of growth factors was emphasized.

Plant–microbial interactions

In this session, plant–microbe interactions in the rhizosphere, using a metabolomic approach, was reported by D. Scheel et al. [4]. Analysing the complex pattern of the compounds which are possibly involved in interorganismic signalling, they found a difference in metabolite composition in the culture media, roots and mycelia between *Arabidopsis* plants grown individually and the plants co-cultivated with different microbial species. The problem of grass–endophyte symbiosis was extensively reviewed by K. Saikkonen [5]. Using meta-analysis, he indicates that grass–endophyte interaction is much more complex than described previously in the literature, and that it may involve such interactions as selfishness, cheating and power struggles between the species involved. An important aspect of plant–microbe interaction is the mechanism of infection of a plant by pathogenic organisms. J. Jones et al. [6] provided interesting data on the effectors of *Albugo candida*. Their analysis may give a new insight into host defence mechanisms. In addition, using T3SS delivery of oomycete effectors, they obtained interesting results concerning the molecular basis of pathogen/host specificity and non-host resistance.

Mitochondria and chloroplasts in cell metabolism

Plant mitochondria play a fundamental role in maintaining the redox homoeostasis of the cell. A. Rasmusson characterized several enzymes involved in this homoeostasis: alternative oxidases and external NAD(P)H dehydrogenases [7]. An important factor in redox homoeostasis, NADPH level, is the result of the interplay between mitochondrial oxidation and the oxidative pentose phosphate pathway. Stress-related processes also substantially affect the NADPH reduction levels [8]. An important problem linked to the redox homoeostasis of plant cells is the regulation of excess energy dissipation in the photosynthetic apparatus. R. Bassi described the mechanisms involved in protection against reactive oxygen species born during photosynthesis [9]. Furthermore, the transient formation of cation radicals, followed by charge recombination was proposed as the mechanism underlying the dissipation of excess energy absorbed by photosynthetic pigments.

Stress tolerance in plants

This session, which covered a very broad area, attracted the biggest number of contributions. The plenary lecture by P. Mullineaux et al. [10] gave an overview of the genetic background of the regulation of the response to different types of stresses, as well as presenting new data showing that single regulatory genes may control the response to various types of stress [10]. In other words, a plant subjected to a certain abiotic stress may become resistant not only to another kind of abiotic, but also to biotic stresses. New findings on the regulation of plant resistance to host-adapted pathogens were presented by J. Parker et al. [11]. They identified a number of components of the resistance machinery in *Arabidopsis* and they tried to explain the modes of action of intracellular immune receptors and defence regulatory complexes.

Structural and functional organization of plant genomes

The important problem of the role of alternative splicing in the regulation of plant gene expression was highlighted by W. Brown [12]. Current applications and developments of the high-resolution RT (reverse transcription)–PCR system in studies of alternative splicing were described, with a special focus on the roles of splicing factors, cap-binding proteins and nonsense-mediated decay proteins. The involvement of snoRNAs (small nucleolar RNAs) in RNA modifications, and the identification and functional characterization of a novel gene AtNUFIP, controlling biogenesis of snoRNAs, was reported by M. Echeverria et al. [13]. New data on the involvement of this gene in RNA methylation and its impact on plant development were presented. Whereas studies on

the biogenesis of snoRNAs in animals and yeast reveal the involvement of several auxiliary proteins, not much is known about the situation in plants. M. Echeverria et al. [14] describe recent data from genomics and functional analysis and characterize the factors controlling the biogenesis of plant snoRNAs. The interphase chromosome arrangement and its dynamics is important for such events as replication, transcription, repair and recombination occurring in the nucleus. Present knowledge about the organization of interphase chromosomes in Brassicae, including the positioning of chromosome territories, the somatic pairing of homologues and sister chromatid alignment in meristematic and differentiated tissues was reviewed by I. Schubert [15].

Mutants in developmental and metabolic studies

The importance of mutants in developmental and metabolic studies were highlighted in three plenary lectures. In his talk, H. Bauwe reviewed the present-day knowledge on photorespiration, its significance for plant metabolism, photosynthetic efficiency and agriculture. The advantage of using mutants, functional analyses by reverse genetics and other advanced technologies for understanding the functioning and regulation of this important process were highlighted, whereas studies with cyanobacteria shed light on the evolutionary origin of photorespiration [16,17]. Any direct identification of the genes involved in quantitative traits by means of classical genetic analysis is troublesome and time consuming. A. Druka et al. [18] employed induced mutations as a tool to dissect quantitative traits in barley. They identified isogenic lines with introgression mapping to the same chromosomal regions as grain yield quantitative trait loci [18]. S. Rasmussen used a reverse genetic tool to identify phytic acid mutants in plants [19]. Such mutants are very important for understanding the mechanism of biosynthesis and the accumulation of this phosphate storage compound, as well as for the identification of genes engaged in these processes.

Secondary metabolites as pharmaceutics and nutraceutics

F. Bourgaud reported on the functional characterization of new cytochromes P450 which are involved in plant furanocoumarin biosynthesis [20]. Four enzymes of the furanocoumarin pathway, acting as psoralen synthase and angelicin synthase were isolated and characterized. The authors also genetically transformed the medicinal plant *Ruta graveolens*, obtaining a 4-fold increase in the content of furanocoumarins (psoralen, 5-methoxypsoralen and 8-methoxypsoralen). The possible medical application of another secondary metabolite, genistein, was reviewed by G. Węgrzyn et al. [21]. Genistein exhibits various biological activities, and it is considered as a potential drug for untreatable genetic diseases, such as cystic fibrosis and mucopolysaccharidosis. The effects on animals and pilot clinical trials suggest their potential applicability as effective drugs in these inherited disorders.

Plant membranes

Invited lectures in this session dealt with the regulatory mechanisms present in photosynthetic membranes as well as in the plasma membranes of plant cells. W. Gruszecki [22] reviewed recent data on the regulatory mechanisms functioning in the antenna complex, LHCII (light-harvesting complex II), protecting the photosynthetic apparatus against light stress [22]. It appears that the main factors involved in photoprotection are light-induced conformational changes in violaxanthin and neoxanthin molecules, the xanthophylls associated with LHCII. New data on the regulation of channels in the plasma membrane by phosphoinositides were presented by N. Moran and co-workers [23]. They studied tobacco cultured cells in suspension having a genetically modified level of phosphoinositides, and, on the basis of their results, they postulate that both ion and water channels are subject to phosphoinositide signalling in intact plant cells. Interesting findings connected with the stomatal control of plant water status were presented by R. Hedrich [24], with data on the identification of kinases and phosphatases being the regulators of the putative guard cell anion transporter, SLAC1. Furthermore, it was demonstrated that SLAC1 is the slow inactivating weak voltage-dependent anion channel of guard cells and is controlled by reversible phosphorylation.

Integrating plant functions via signalling molecules: molecular mechanisms

In this session, four plenary talks were given. O. Leyser and colleagues presented the results of studies on the network of interacting hormonal signals involved in systemically transmitted information, controlling shoot branching [25]. Special attention was paid to the action of auxin and strigolactones. The role of small GTPase effectors in plant cell morphogenesis was presented by V. Žárský and M. Potocký [26]. They demonstrated that phospholipases D and phosphatidic acid are engaged in the regulation of the secretory pathway in plants. On the other hand, specific NADPH oxidases which produce reactive oxygen species are involved in cell growth. The authors also described a putative GTPase–effector complex exocyst involved in exocytic tethering in plants. Signalling by nitric oxide and hydrogen peroxide, including their involvement in cross-talk between different stimuli and their role in integrating various functions in plants, was reviewed by S. Neill et al. [27]. Current models of their turnover and the molecular mechanisms of their perception were also discussed. The newest data on phytochrome three-dimensional structures and functions were presented by J. Hughes [28]. The complete module structures of the Pr ground state of *Synechocystis* phytochrome Cph1 and the Pfr ground state of bacteriophytochrome PaBph1 were described.

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