vate/desolvate) that leads to drug degradation and loss of API (active pharmaceutical ingredient) during process development. The session devoted to reactivity in the solid state was quite illuminating. Jarugu N. Moorthy (India) addressed the effect of light in inducing, controlling and crystallizing new phases in the solid state by choosing appropriate organic solids; Gerd Kaupp (Germany) showed the significance of mechanochemistry and how reactions could be monitored with state-of-art-techniques. Two-dimensional crystal engineering is not only topical but assumes significant relevance to shaping industrial materials. Steven De Feyter (Belgium) and Paolo Samori (France) showed the significance of surface in influencing interfacial growth. Krzysztof Wozniak (Poland) and Katharina Fromm (Germany) contributed short presentations on electron density studies and silver coordination polymers respectively. The concluding session provided some thought-provoking projections about the future of crystal engineering by Marcus Neumann, Janet Scott, Mike J. Zaworotko and Peter Erk in their own inimitable styles. They touched upon some important issues related to the challenging task of blind tests, applicability and limitations of crystal structure prediction towards realizing a virtual diffractometer and recognizing the signature of supramolecular building blocks in designing materials.

According to the GRC tradition and to allow all attendees to present their recent results, two poster sessions were organized. Senior researchers as well as graduate students participated in these sessions enthusiastically and presented a total of 110 posters on various topics of crystal engineering. These sessions facilitated a more detailed discussion of the results from various research laboratories. In addition to these formal interactions, the conference also provided a setting and ample time to allow informal discussions fostering new collaborations and joint efforts in the field. By all measures, the first GRC on crystal engineering was a big success and is poised to continue in the same trajectory into the future. On the scientific level, the conference highlighted the shortcomings of our capabilities to predict structure and function of solids based on the current understanding of inter- and intramolecular interactions, and the need for better understanding of thermodynamics and kinetics of crystallization process. On the other hand, there were several successes that showcased design of desirable structures of metal organic frameworks with potential applications in storage and delivery of hydrogen and other materials, the potential benefits of co-crystals in formulating APIs, and durable implants coated with anti-infective drugs, etc. The current high level interest of Indian scientists in the field of crystal engineering and the significant impact they have already made in advancing this field are well positioned to contribute towards discoveries of solid materials useful in harnessing newer sources of energy, tackling problems of environmental degradation, and development of new implants and novel pharmaceuticals for better health of the growing world population.

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MEETING REPORT

Plant biotechnology: from basic research to crop improvement*

In the coming decades, there is an urgent need to dramatically increase the world's food output whilst at the same time protect our environment. This will require a concerted effort among plant biotechnologists to improve plant traits, which will eventually result in higher productivity under resource-limiting or stressful conditions. An annual scientific meeting highlighted recent research activities within plant biotechnology. The conference was attended by more than 200 academic and industrial delegates and included scientific presentations from three keynote speakers and 22 talks from plant scientists around the globe. The meeting was organized into seven sessions: (1) Products and productivity, (2) Nutrition and diseases, (3) Breeding and systems biology, (4) Technologies, (5) Public–private partnership, (6) Systems biology – a developer's tool and (7) Green growth. The meeting covered a wide range of plant biotechnology related topics such as medicinal importance of plant products, molecular adaptive strategies of plants, novel technologies to create, identify and utilize DNA sequence polymorphisms in crop improvement, next generation sequencing techniques and the role of biotechnology in eco-farming/organic farming and biofuel production. The meeting started with a welcome address by the head of the steering committee for PBD, Preben Bach Holm (Aarhus University, Denmark). He stated the importance of basic and applied plant research in the current era given the fact that plants form an integral part of our food, feed and fuel supply. The first keynote speaker in the scientific session, Rainer Hedrich (Institute for Molecular Plant Physiology and Biophysics, University of Würzburg, Germany) discussed the molecular aspects of stomatal closure in plants in response to drought and the phytohormone abscisic acid (ABA). He presented experimental evidence that under drought conditions, ABA triggers stomatal closure by the release of anions from guard cells. His group has identified one of the novel guard cell anion channels in plants, SLAC1. In his talk, he presented evidence that SLAC1 is a key member of the signalling pathway leading to stomatal closure under drought conditions, and SLAC1 invariably requires a protein kinase OST1 and a phosphatase ABI1 to exert its function. SLAC1 seems to be a potential candidate gene involved in drought tolerance in plants. In an oral presentation during the same session, Michael D. Mikkelsen (University of Copenhagen, Denmark) highlighted the importance and effect of plant derived, cancer-preventing compound glucoraphanin on human health. Glucoraphanin is a cancer preventing compound derived from methionine in cruciferous plants. Essentially, its production involves 14 intermediates and 13 enzymes. By ex-

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pressing genes involved in (1) chain elongation (methionine to dihomo-methionine) and (2) conversion of dihomo-methionine to glucoraphanin, he was successful in producing glucoraphanin in tobacco, signifying a major breakthrough in engineering medicinally important plant products. The next session focused on crop improvement and the keynote speaker Leon Kochian (Cornell University, USA) gave a talk on plant adaptive strategies to deal with toxic metals in the soil. He highlighted the genetic variability and the identification of a number of genes conferring aluminum toxicity in plants. In particular, he emphasized the role of specialized transporter proteins, which release organic acids into the rhizosphere, to chelate and prevent solubilized aluminum from entering the roots. Daniel P. Persson (University of Copenhagen, Denmark) talked about genetically engineered plants producing more nicotianamine, to combat iron deficiencies, especially in developing countries. Nicotianamine, a chelator of metals like iron and zinc, is present ubiquitously in higher plants. Persson showed that rice plants over-expressing nicotianamine synthase genes produce more nicotianamine and as a result 7-fold and 16-fold more iron and zinc respectively, than wild type rice plants. This research promises to be a major step in enhancing the nutritional value of traditional food crops like rice. Majse Nafisi (University of Copenhagen, Denmark) highlighted the role of the plant cell wall as a physical barrier and also as a sensor of pathogen infection. The afternoon session focused on breeding and associated technologies for crop improvement. The first talk by keynote speaker Harro Bouwmeester (Wageningen University, The Netherlands) was interesting for both basic and applied plant researchers. Current technologies in the field of plant biology (microarrays, proteomics and metabolomics) generate abundant data. Integrating data from different 'omics', and translating them into a biologically meaningful context was the highlight of his talk. He presented examples of biological systems where they have successfully used 'omics' to understand the complexity of the underlying genetic factors associated with a quantitative trait. He also mentioned the chemistry and genetic manipulation of low molecular weight and predator-attracting volatile organic compounds (VOCs) in plants. He said that VOCs released from plants help predatory mites to find the feeding insect on the plant and VOCs production, which is mediated by terpenoid synthase genes could be genetically engineered with obvious effects on plant–insect–predator interactions. Three oral presentations in the session were technology-oriented with implications on crop breeding programmes. Anna Maria Torp (University of Copenhagen, Denmark) discussed TILLING (Targeting Induced Local Lesions IN Genomics), a non-transgenic gene modifications technique, that is attractive not only for functional genomics but also for agricultural applications. TILLING combines chemical or physical mutagenesis and PCR-based screening to identify mutations in one or more target genes. In her talk, she presented the challenges associated with TILLING in polyploid wheat as compared to diploids and the need to use high throughput technologies like next generation sequencing or high resolution melting (HRM) analysis. Bruno Studer (Aarhus University, Denmark) talked in detail about the HRM techniques which was conceptually called 'blind mapping' to identify DNA markers for genome analysis and breeding applications. HRM measures the dissociation of double stranded DNA of a PCR product amplified in the presence of a saturating dye. He presented a case study from ryegrass to detect single nucleotide polymorphisms (SNP) in LpVRN3 (involved in vernalization response) gene in F2 mapping population of perennial ryegrass. Single nucleotide polymorphisms in LpVRN3 resulted in differences in melting curve patterns which helped in identifying heterozygous and homozygous genotypes. Compared to conventional methods, HRM analysis is a cheap and fast procedure to map DNA polymorphisms. Using HRM analysis in TILLING can be a relatively cheap method to identify gain of function point mutation in plants. Stig Uggerhøj Andersen (Aarhus University, Denmark) discussed the software package called SHOREmap (http://1001genomes.org/downloads/shore). This software supports genome-wide genotyping and candidate gene sequencing in a single step through analysis of deep sequencing data from a large pool of recombinants.

Jocelyn K. C. Rose (Cornell University, Ithaca, USA) talked about a tomato mutant named 'Delayed Fruit Deterioration' (DFD), which exhibits a surprisingly longer shelf life (up to 9 months). A detailed phenotypic and molecular analysis revealed that ripening-related processes in the DFD mutant, such as changes in colour, aroma and sugars appear to be typical, when compared with wild type fruit. Furthermore, he showed evidence that a thicker fruit cuticle in DFD mutant contributed mainly to the fruit firmness, in addition to primary cell wall polysaccharide metabolism. This research truly holds a great deal of importance for post-harvest technologies. Etienne Paux (INRA, Clermont Ferrand, France) delivered the importance of wheat breeding and improvement in the 'post-green revolution era'. He highlighted some of the problems associated with the wheat genome compared to other cereal and molecular tools that for marker development, map-based cloning and quantitative trait loci (QTL) analysis. He ended his talk by updating the status of wheat genome sequencing by the International Wheat Genome Sequencing Consortium (IWGSC). The final session of the meeting was about green growth. Uffe Jørgensen (Aarhus University, Denmark) presented the ideal traits of a sustainable bioenergy crop. Using perennial crops (e.g., willow (*Salix*)) with a long growing season could result in increasing the biomass yield and also sustainable bioenergy production. Perennial crops are much more sustainable, in terms of high carbon soil storage, high nutrient use and low demand for pesticides as compared to annuals. Two notable posters: (1) Inge B. Holme and co-workers (Aarhus University, Denmark) introduced a novel genetic transformation concept called Cisgenesis and (2) C. Lunde and D. P. Drew (University of Copenhagen, Denmark) characterized novel candidate genes from *Physcomitrella patens* (moss) to design salt-tolerant crops. In general, the meeting highlighted various molecular biology and biotechnology methodologies that could be employed to understand (1) how plants cope with various stress-related factors, (2) plant products to improve human health and (3) breeding and non-transgenic crop improvement techniques. To a great extent, the meeting connected basic research with applied agriculture research effectively.

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