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# Foreword

## Legumes: vital for life

Legumes have a significant input into the quality of life on this planet. Their biochemical and developmental repertoire results in their being a major crop for human food, animal feed and forage, synthesis of biofuels and medicinal and nutriceutical compounds, such as phytoestrogens and anti-oxidants, bio-remediation, timber and biomass, and soil improvement. Legumes are diverse, existing from the polar circle to the tropics; they can be small annual plants or large timber trees.

Legumes have been part of agricultural production in several continents for thousands of years. Their seeds are easily harvested from the family-defining pod. Most legumes possess seeds rich in protein, oils and starches, although the composition may vary. Legumes have also been fundamental to many discoveries in plant science, including the classical recognition of the laws of genetic inheritance by Gregor Mendel.

Many legume species possess the ability to form a nitrogen-fixing symbiosis in specialised root structures called 'nodules'. This process, involving complex interaction and communication between the causative microbe (broadly called rhizobia) and the vascular plant, leads to the reduction of nitrogen gas from the near-limitless supply in the atmosphere to ammonia, which is assimilated by plant mechanisms to yield amino acids, the building blocks of proteins and other bioactive molecules. Proteins in turn function as catalysts, regulators and scaffolds to facilitate the construction of the complex machinery needed to run essential plant processes such as photosynthesis, mineral absorption, biomass production and seed development. Legumes also form effective symbioses with mycorrhizal fungi leading to increased phosphorus and water uptake. Interestingly, many of the genetic requirements of the rhizobial and fungal symbioses are shared, although the developmental and morphological outcomes are distinct. Through the combination of these processes, legume plants are able to convert seemingly limitless solar energy effectively into nitrogen-containing chemical energy available as food, feed and biofuels.

The global environment is facing population growth, predicted climate change, dietary shifts brought about by social and economic changes, and increased demand on arable land and water. Additionally, we are faced with insecurities for future fuel and protein supplies. For example, fossil fuel reserves, particularly crude oil, are finite and geo-politically sensitive, thus their present use is not sustainable. Similarly, emerging infectious diseases, such as BSE and avian flu, threaten future protein production.

Legumes have the potential to play an increasing role in alleviating these threats owing to their ability to produce, with minimal environmental damage and external energy input in the form of nitrogenous and phosphorous fertilisers, large amounts of protein (40% in soybean seeds) and biofuels (from 20% in soybean to 28% oil content in seeds of the legume tree *Pongamia pinnata*).

There is a need in legume species to optimise plant and organ architecture as well as responses to both biotic and abiotic stresses to facilitate increased production and adaptation. This requires detailed knowledge of the heritable components, in other words the genetics and genomics, of legumes as distinct from those of non-legume species such as rice, poplar and *Arabidopsis*.

The subject area of legume genomics and genetics received a boost through the international focus on model legumes *Lotus japonicus* and *Medicago truncatula*. The elucidation of the genomes of both of these species (at least the predicted gene space) is nearing completion, with the soybean genome initiative also advancing rapidly. Through whole-genome approaches to DNA, RNA and protein sequences, functional genomics, and the application of comparative genomics and bioinformatics, technology transfer from the models to crop legumes has been achieved, and will lead in the future to substantial benefits to the planet.

Conceptual advances in legume biology are impressive. Over 20 genes controlling the development of nodules have been cloned (and functionally defined by mutations); somewhat similar advances have now been reported for the control of shoot architecture including flowering, flower structure, leaf architecture and lateral branching. Gene interactions, pathways and networks are being discovered and computational models exist for advanced hypothesis testing. Coupling genetics and genomics has created the essential nexus between function and structure — a persistent goal of all biological research.

This Special Issue of *Functional Plant Biology* provides a set of cutting-edge articles written by participants of the International Conference of Legume Genomics and Genetics III, held in Brisbane in April 2006. To varying extents, these articles show how the overall study of plant biology benefits from an evolutionary perspective, enabled by the analysis of a spread of plant species, legume and non-legume. As for all crop species, disease pathology is given attention. Although nodulation is clearly an important topic in legumes, leaf and flower development is providing broader insights on plant development. A holy grail in plant development is to determine how to transfer the capacity to fix nitrogen to non-legume species; two papers on fundamental biology of nodulation are presented here. A range of technical papers show how capacity-building in legume research is moving forward.

This issue is neither a proceedings of the meeting nor an encyclopedia of legume research, as space and availability issues restricted its content. However, for the interested reader we hope that it provides an indication of the conceptual and technical depths available in this emerging field of plant biology.

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