

Functional Plant Biology

Contents

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(See photo of participants in the International Symposium in Memory of Vincent R. Franceschi titled 'Plant Cell: Structure-Function Relations')

Foreword

Physiological, anatomical and biochemical characterisation of photosynthetic types in genus

Cleome (Cleomaceae)

Elena V. Voznesenskaya, Nuria K. Koteyeva, Simon D. X. Chuong, Alexandra N. Ivanova, João Barroca, Lyndley A. Craven and Gerald E. Edwards

247–267

This paper identifies several *Cleome* species (family Cleomaceae) with C₄ and C₄-like intermediate photosynthesis; previously only one C₄ species was known in this family. Detailed physiological, anatomical and biochemical analyses of selected *Cleome* species are provided. The authors describe four structural types: two C₃, C₃–C₄ intermediate and C₄ Kranz type. Cleomaceae is an interesting family for studying the genetic basis of C₄ photosynthesis and its evolution from C₃ species.

Flowers of *Bienertia cycloptera* and *Suaeda aralocaspica* (Chenopodiaceae) complete the life cycle performing single-cell C₄ photosynthesis

Christine N. Boyd, Vincent R. Franceschi, Simon D. X. Chuong, Hossein Akhiani, Olavi Käärts, Monica Smith and Gerald E. Edwards

268–281

Bienertia cycloptera and *Suaeda aralocaspica* have recently been shown to perform C₄ photosynthesis in individual chlorenchyma cells, without having classical Kranz anatomy. Each species has a unique means of spatially separating functions of C₄ in two cytoplasmic compartments. The authors use light and electron microscopy, immunolocalisation and western blots to show that flowers of both species have the unique single-cell C₄ chlorenchyma found in leaves. The importance of flowers as photosynthetic organs is discussed in the context of the habitats of these plants.

PvUPS1 plays a role in source–sink transport of allantoin in French bean (*Phaseolus vulgaris*)

Hélène C. Pélissier and Mechthild Tegeder

282–291

Nodulated tropical legumes receive nitrogen (N) via N-fixing rhizobia, largely in the form of allantoin and allantoic acid, which are translocated to the shoot via the xylem. These authors show that allantoin concentrations in French bean are dependent on N supply and nodulation. *In situ* RNA hybridisation studies have been used to localise the allantoin transporter, *PvUPS1*, to the phloem throughout the plant, and the authors propose that PvUPS1 plays a role in phloem loading and transport of allantoin to developing sinks.

Influence of cucumber mosaic virus infection on the mRNA population present in the phloem translocation stream of pumpkin plants

Roberto Ruiz-Medrano, Jesús Hinojosa Moya, Beatriz Xocostle-Cázares and William J. Lucas

292–301

Suppressive subtractive hybridisation (SSH) analysis is used to identify the mRNA species present in the phloem sap of pumpkin plants infected with cucumber mosaic virus (CMV). None of the mRNAs identified in the SSH library were present in the phloem sap of healthy plants, but the CMV-induced mRNA population represents only 5% of total pumpkin phloem sap mRNAs. The authors conclude that production of viral movement protein in the companion cells does not adversely affect the phloem long-distance trafficking system.

Cover illustration: Vince Franceschi was fascinated by the intricate structures of plants and he spent many hours studying them. He was keen to get everyone involved in plant science, including his niece, Gina Massei. “Zio’s Cell” (zio is the Italian word for uncle) is an example of her rendering of a stained glass of Vince’s drawing of a plant cell. Vince proudly displayed it in the window of his office.

Research note: Reversible birefringence suggests a role for molecular self-assembly in forisome contractility
Winfried S. Peters, Reinhard Schnetter and Michael Knoblauch 302–306

This Research note reports the first characterisation of the dynamic polarisation optical properties of forisomes, ATP-independent contractile protein bodies that act as valves in sieve tubes of faboid legumes. The authors show that reversible contraction is correlated to a reversible loss of birefringence. This finding opens the possibility of monitoring in real time the assembly and disassembly of highly ordered molecular arrays during contraction–expansion cycles.

Research note: Deposition patterns of cellulose microfibrils in flange wall ingrowths of transfer cells indicate clear parallels with those of secondary wall thickenings
Mark J. Talbot, Geoffrey Wasteneys, David W. McCurdy and Christina E. Offler 307–313

Talbot *et al.* use field emission scanning electron microscopy and immunofluorescence microscopy to study the arrangement of cellulose microfibrils and cortical microtubules in flange wall ingrowths of transfer cells in wheat and maize. The parallel organisation of cellulose microfibrils in flange wall ingrowths is similar to that in secondary wall thickening in xylem but differs from that observed in reticulate wall ingrowths, suggesting that the mechanisms controlling these two types of wall ingrowths are fundamentally different.

Review: Nutrient loading of developing seeds
Wen-Hao Zhang, Yuchan Zhou, Katherine E. Dibley, Stephen D. Tyerman, Robert T. Furbank and John W. Patrick 314–331

Nutrient loading of developing seeds is reviewed in a developmental context. An emphasis is placed on identifying key transport and transfer processes, located in the source/path/sink system, that regulate rates of delivery to and within developing seeds. This leads to a focus on membrane transport events and their regulation.

Genetic evidence for difference in the pathways of druse and prismatic calcium oxalate crystal formation in *Medicago truncatula*
Paul A. Nakata and Michele M. McConn 332–338

This study suggests the presence of independent pathways of calcium oxalate formation in *Medicago truncatula*. While current evidence supports a single pathway involving ascorbic acid as the precursor in oxalate biosynthesis, this work presents evidence for more than one pathway of oxalate biosynthesis and calcium oxalate formation in *M. truncatula*. The authors propose a working model showing possible independent pathways of oxalate biosynthesis and calcium oxalate formation.

Research note: Autoradiography utilising labelled ascorbic acid reveals biochemical and morphological details in diverse calcium-oxalate-crystal-forming species
Todd A. Kostman, Nathan M. Tarlyn and Vincent R. Franceschi 339–342

Many plant species accumulate excess calcium as calcium oxalate crystals in crystal idioblast cells. Oxalic acid combines with calcium to form crystals of several morphological forms, but the source of the oxalic acid used is uncertain. Kostman *et al.* test the hypothesis that regardless of crystal morphology, ascorbic acid is the primary precursor of the oxalic acid used in crystal formation. They show that the biochemistry of oxalic acid production is the same for all crystal types.

Viewpoint: Concept of redesigning proteins by manipulating calcium/calmodulin-binding domains to engineer plants with altered traits
Tianbao Yang, Liquan Du and B. W. Poovaiah 343–352

Yang *et al.* describe how structural changes, especially in calcium and calmodulin-binding domains, alter the function of the calmodulin-binding proteins. This is an effective approach in understanding the structure/function relationships and the importance of calcium/calmodulin regulation in plants. This is a potentially powerful tool to redesign proteins with altered calmodulin-binding abilities to improve crop plants with desired traits.

Vacuolar acidity, protein profile, and crystal composition of epidermal bladder cells of the halophyte

Mesembryanthemum crystallinum

Yingzzy Jou, Ya-Ling Wang and

Hungchen Emilie Yen

353–359

Information on protein content and nature and ion content during development, illumination and sodium stress in epidermal bladder cells (EBC) of the halophyte *Mesembryanthemum crystallinum* is presented. The authors provide physiological and biochemical evidence for function of EBCs with a focus on changes in vacuolar pH. They conclude that young EBCs accumulate malic acid, while mature EBCs may be involved with sodium sequestration, water and potassium storage, and defence against herbivores and pathogens.

Hydration of *Cuphea* seeds containing crystallised triacylglycerols

Gayle M. Volk, Jennifer Crane, Ann M. Caspersen,

David Kovach, Candice Gardner and

Christina Walters

360–367

Volk *et al.* determine the effect of various rehydration conditions on viability and cell integrity of seeds of six *Cuphea* species, which differ in the fatty acid composition of storage lipids. The paper provides valuable new information on the amount of water necessary to induce damage in seeds containing crystallised triacylglycerols and on the reversibility of hydration damage. The authors conclude that seeds with 'intermediate' storage physiology can survive conventional storage if they are warmed before planting.

Isolation of dehydration-responsive genes in a drought tolerant common bean cultivar and expression of a group 3 late embryogenesis abundant mRNA in tolerant and susceptible bean cultivars

Blanca E. Barrera-Figueroa, Julián M. Peña-Castro,

Jorge A. Acosta-Gallegos, Roberto Ruiz-Medrano

and Beatriz Xonconostle-Cázares

368–381

This paper provides the first report of the molecular response to water deficit displayed by a drought-tolerant cultivar of common bean. The authors identify genes that are upregulated in a drought-tolerant bean cultivar grown under water stress. Proteins encoded by these genes show putative functions in cellular protection, sugar metabolism and protein synthesis. A new group 3 late embryogenesis abundant gene is cloned and sequenced, and its expression in response to drought characterised in five bean cultivars. The work is of broad interest given the global importance of bean as a staple crop.

Response of mannitol-producing *Arabidopsis thaliana* to abiotic stress

Christine M. Sickler, Gerald E. Edwards, Olavi Kiirats,

Zhifang Gao and Wayne Loescher

382–391

Sickler *et al.* show that expression of a celery gene for mannitol biosynthesis confers substantial salt tolerance in transgenic *Arabidopsis*, increasing shoot fresh weight, leaf number and leaf area in salt-treated transgenic plants. Quantum yield of PSII decreases by 50% in salt-treated wild type plants but is preserved in transformants, and photosynthesis is protected relative to wild type plants, suggesting that mannitol protects against salt-related damage to chloroplasts.