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Functional Plant Biology

Contents

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Foreword

Review: Starch breakdown: recent discoveries suggest distinct pathways and novel mechanisms
Samuel C. Zeeman, Thierry Delatte, Gaëlle Messerli, Martin Umhang, Michaela Stettler, Tabea Mettler, Sebastian Streb, Heike Reinhold and Oliver Kötting 465–473

This review discusses recent developments on the biochemistry of transitory starch degradation and provides a succinct overview of the current understanding of the starch degradation pathway in *Arabidopsis* leaves. It focuses on the intraplastidial path of starch mobilisation and presents current models of starch breakdown.

Review: Transporters in starch synthesis
Thomas Martin and Frank Ludewig 474–479

Biosynthesis of starch is an active research field, and our knowledge of the mechanisms governing import and export of carbon building blocks and energy from and into plastids may be incomplete. This review provides a comprehensive overview of carrier proteins involved in starch synthesis. The authors focus on transporters of the plastid inner envelope membrane, discussing their roles in the context of starch synthesis. Current knowledge of the additional functions of these transporters is also examined.

A mutant of rice lacking the leaf large subunit of ADP glucose pyrophosphorylase has drastically reduced leaf starch content but grows normally
Sandrine Rösti, Brendan Fahy and Kay Denyer 480–489

The work by Rösti *et al*. adds to our understanding of the relationship between genes, proteins and function in the starch biosynthesis pathway, as well as providing novel insights into photosynthetic partitioning. The results reveal basic differences between cereal crop plants and models, such as *Arabidopsis*, in leaf carbohydrate metabolism.

Downregulation of neutral invertase activity in sugarcane cell suspension cultures leads to a reduction in respiration and growth and an increase in sucrose accumulation
Debra Rossouw, Sue Bosch, Jens Kossman, Frederik C. Botha and Jan-Hendrik Groenewald 490–498

Neutral invertase (NI) has been implicated in the energetically wasteful cycling of sucrose in sugarcane. This study aims to investigate the metabolic effects of down regulating NI activity by antisense technology. The authors show that reduced NI activity has a profound influence on carbohydrate partitioning and cell viability. The utility of sugarcane suspension cell cultures as a model for metabolic engineering of sugarcane plants is proposed.

Regulation of invertase: a ‘suite’ of transcriptional and post-transcriptional mechanisms
Li-Fen Huang, Philip N. Bocock, John M. Davis and Karen E. Koch 499–507

Invertase is known to be regulated at the transcript and/or post-transcriptional levels by, for example, hormones, sugars, pathogens, oxygen and proteinaceous inhibitors. Recent research has linked several new modes of regulation to the invertases. This review highlights this recent work and summarises what is known about these regulatory mechanisms.

Cover illustration: Intracellular localisation of tomato fructokinase 3 (LeFRK3::GFP) in plastids and stromules (tubular extensions of the plastid membrane) in tobacco protoplasts. The autofluorescence of the chloroplasts is red and the fusion LeFRK3::GFP protein is green (see Granot pp. 564–570).

Metabolic control of seedling development by invertases
Katharina B. Bonfig, Susanne Berger, Tahira Fatima, Mari-Cruz González and Thomas Roitsch 508–516

Bonfig *et al*. employ a transgenic approach to investigate the crucial roles of vacuolar and cell-wall invertases in seedling development, expressing invertase inhibitors in *Arabidopsis* and tobacco to impair enzyme activity. Ectopic expression of invertase inhibitors in early seedling development reduces seedling growth, and expression of two vacuolar invertases and a cell-wall invertase are strongly expressed during seedling development, showing that invertase activity is necessary for normal seedling development.

Molecular and kinetic characterisation of sugarcane pyrophosphate: fructose-6-phosphate 1-phosphotransferase and its possible role in the sucrose accumulation phenotype
Jan-Hendrik Groenewald and Frederik Botha 517–525

Groenewald and Botha investigate the inverse correlation between activity of pyrophosphate: fructose-6-phosphate 1-phosphotransferase (PFP) and sucrose content in sugarcane internodes in an effort to elucidate the role of PFP in sucrose accumulation. They purify and characterise PFP from sugarcane and report its kinetics characteristics. Several differences between sugarcane PFP and those of other plants suggest that low levels of sugarcane PFP might increase sucrose accumulation by limiting glycolytic carbon flux and increasing the concentration of sucrose synthesis precursors.

Review: Multilevel genomics analysis of carbon signalling during low carbon availability: coordinating the supply and utilisation of carbon in a fluctuating environment
Mark Stitt, Yves Gibon, John E. Lunn and Maria Piques 526–549

This review lays out, in a very understandable way, important new insights into starch synthesis regulation. It summarises a decade of work that has led to fundamental insights into carbon metabolism, and emphasises the physiological significance of carbon starvation. The authors use *Arabidopsis* to explore how the balance between supply of carbon, accumulated as starch during the day, and utilisation at night is achieved in plants.

Gene families and evolution of trehalose metabolism in plants
John E. Lunn 550–563

Lunn describes phylogenetic analyses of the main enzymes of trehalose metabolism across a diverse range of flowering and non-flowering plants, as well as green algae. This analysis offers new insights into the origins of the gene families encoding these enzymes and should provide a useful framework for future studies aimed at understanding the function of trehalose metabolism in plants.

Role of tomato hexose kinases
David Granot 564–570

This review summarises our current knowledge of tomato hexokinase (HXK) and fructokinase (FRK) enzymes. Several HXK and FRK isozymes have been identified in various plant species, raising the question of the role of each isozyme. To date tomato is the only plant species from which multiple HXK and FRK genes have been isolated, offering the opportunity to study the roles of individual hexose phosphorylating enzymes. Future directions in hexokinase research are explored.
