

**On the Cover:** Plants integrate many types of information from the environment as well as endogenous developmental cues in their decisions to grow branches. Insufficient key nutrients (e.g. phosphorous and nitrogen) can cause an inhibition of branching, as can poor light quality (e.g. shading by surrounding plants). In this issue, Drummond et al. (pp. 735–751) analyzed the effects of both altered light and nutrients on the branch growth of petunia (*Petunia hybrida*) and examined the input of the strigolactone hormone pathway in these responses. The authors show that both strigolactone biosynthesis and signaling are regulated by changes in the environment in an organ-specific manner. The cover image shows actively growing branches on a wild-type petunia plant grown under sufficient nutrient and light conditions. One leaf was removed from the branch on the right side of the image to allow for a better view of the growing branches. Image credits: Bart Janssen and Tim Holmes (New Zealand Institute for Plant and Food Research, Auckland, New Zealand).

## ON THE INSIDE

*Peter V. Minorsky* 381

## TOPICAL REVIEW

Photosynthetic Energy Conversion Efficiency: Setting a Baseline for Gauging Future Improvements in Important Food and Biofuel Crops. *Rebecca A. Slattery and Donald R. Ort*

*Solar energy conversion efficiency in important food and biofuel crops provides a baseline for future improvements in conversion efficiency.* 383

Vesicles versus Tubes: Is Endoplasmic Reticulum–Golgi Transport in Plants Fundamentally Different from Other Eukaryotes? *David G. Robinson, Federica Brandizzi, Chris Hawes, and Akihiko Nakano*

*Four leading cell biologists reflect on the controversial nature of the vector for transport between the ER and Golgi apparatus in higher plants.* 393

## UPDATES

Root Hair Development in the Grasses: What We Already Know and What We Still Need to Know. *Marek Marzec, Michael Melzer, and Iwona Szarejko*

*A combination of histological and molecular studies uncovers mechanisms of root hair development in monocots.* 407

## RESEARCH ARTICLES

### BIOCHEMISTRY AND METABOLISM

[<sup>OPEN</sup>]INTERMEDIATE CLEAVAGE PEPTIDASE55 Modifies Enzyme Amino Termini and Alters Protein Stability in Arabidopsis Mitochondria. *Shaobai Huang, Clark J. Nelson, Lei Li, Nicolas L. Taylor, Elke Ströher, Jakob Peteriet, and A. Harvey Millar*

*A mitochondrial protease alters the stability of proteins in Arabidopsis by removal of a single amino acid from their sequence.* 415

[<sup>OPEN</sup>]Biphenyl 4-Hydroxylases Involved in Aucuparin Biosynthesis in Rowan and Apple Are Cytochrome P450 736A Proteins. *Debabrata Sircar, Mariam M. Gaid, Cornelia Chizzali, Dennis Reckwell, David Kaufholdt, Till Beuerle, Giovanni A.L. Broggin, Henryk Flachowsky, Benye Liu, Robert Hänsch, and Ludger Beerhues*

*A membrane-bound hydroxylase contributes to the biosynthesis of defense compounds in apple and related species.* 428

*Continued on next page*

Subunit Q Is Required to Stabilize the Large Complex of NADPH Dehydrogenase in *Synechocystis* sp. Strain PCC 6803. *Jiaohong Zhao, Weiqiong Rong, Fudan Gao, Teruo Ogawa, and Weimin Ma*

*A single-transmembrane subunit of NADPH dehydrogenase is involved in respiration and cyclic electron transport around photosystem I but not in CO<sub>2</sub> uptake.* 443

[OPEN]Suppression of Dwarf and *irregular xylem* Phenotypes Generates Low-Acetylated Biomass Lines in *Arabidopsis*. *Matthieu Bensussan, Valérie Lefebvre, Aloïse Ducamp, Jacques Trouverie, Emilie Gineau, Marie-Noëlle Fortabat, Alexia Guillebaux, Aurélie Baldy, Delphine Naquin, Stéphane Herbette, Catherine Lapierre, Gregory Mouille, Christine Horlow, and Mylène Durand-Tardif*

*Inactivation of ubiquitin-ligase3 suppresses dwarfism and irregular xylem in an Arabidopsis mutant, generating a line with low acetylated biomass and high glucose release after cellulolysis.* 452

[OPEN]Volatile Glycosylation in Tea Plants: Sequential Glycosylations for the Biosynthesis of Aroma  $\beta$ -Primeverosides Are Catalyzed by Two *Camellia sinensis* Glycosyltransferases. *Shoji Ohgami, Eiichiro Ono, Manabu Horikawa, Jun Murata, Koujirou Totsuka, Hiromi Toyonaga, Yukie Ohba, Hideo Dohra, Tatsuo Asai, Kenji Matsui, Masaharu Mizutani, Naoharu Watanabe, and Toshiyuki Ohnishi*

*Two glycosyltransferases catalyze sequential glycosylations of volatiles important for tea aroma quality, leading to stable accumulation of the volatiles as water-soluble compounds.* 464

<sup>13</sup>C Tracking after <sup>13</sup>CO<sub>2</sub> Supply Revealed Diurnal Patterns of Wood Formation in Aspen. *Amir Mahboubi, Pernilla Linden, Mattias Hedenström, Thomas Moritz, and Totte Niittylä*

*<sup>13</sup>C incorporation provides insight into the temporal dynamics of wood formation in hybrid aspen.* 478

## CELL BIOLOGY

[OPEN]The SLOW GROWTH3 Pentatricopeptide Repeat Protein Is Required for the Splicing of Mitochondrial *NADH Dehydrogenase Subunit7* Intron 2 in *Arabidopsis*. *Wei-Yu Hsieh, Jo-Chien Liao, Chiung-Yun Chang, Thomas Harrison, Christina Boucher, and Ming-Hsiun Hsieh*

*Incomplete splicing of a mitochondrial gene affects plant growth and development.* 490

[OPEN]Unidirectional Movement of Cellulose Synthase Complexes in *Arabidopsis* Seed Coat Epidermal Cells Deposit Cellulose Involved in Mucilage Extrusion, Adherence, and Ray Formation. *Jonathan S. Griffiths, Krešimir Šola, Rekha Kushwaha, Patricia Lam, Mizuki Tateno, Robin Young, Cătălin Voiniciuc, Gillian Dean, Shawn D. Mansfield, Seth DeBolt, and George W. Haughn*

*Two cellulose synthases interact to synthesize Arabidopsis seed coat mucilage cellulose in a unidirectional manner and promote mucilage adherence and expansion.* 502

## ECOPHYSIOLOGY AND SUSTAINABILITY

Studies on the Tempo of Bubble Formation in Recently Cavitated Vessels: A Model to Predict the Pressure of Air Bubbles. *Yujie Wang, Ruihua Pan, and Melvin T. Tyree*

*An ideal gas model of air bubble dynamics in vessels informs an understanding of the tempo of embolism formation in stems.* 521

**Bisphosphonate Inhibitors Reveal a Large Elasticity of Plastidic Isoprenoid Synthesis Pathway in Isoprene-Emitting Hybrid Aspen.** *Bahtijor Rasulov, Eero Talts, Astrid Kännaste, and Ülo Niinemets*

*The level of end products from the plastidic isoprenoid synthesis pathway is surprisingly constant because plastids can store large amounts of pathway intermediates.*

532

**GENES, DEVELOPMENT, AND EVOLUTION**

**[OPEN] The Presence of Fucogalactoxyloglucan and Its Synthesis in Rice Indicates Conserved Functional Importance in Plants.** *Lifeng Liu, Jonathan Paulitz, and Markus Pauly*

*A tissue-specific cell wall fucogalactoxyloglucan is present in rice.*

549

**[OPEN] An Evolutionarily Conserved DOF-CONSTANS Module Controls Plant Photoperiodic Signaling.** *Eva Lucas-Reina, Francisco J. Romero-Campero, José M. Romero, and Federico Valverde*

*We show that an algal transcription factor is involved in photoperiod response, a function conserved in angiosperms despite the wide diversification of these proteins.*

561

**[OPEN] Genome-Wide Association of Carbon and Nitrogen Metabolism in the Maize Nested Association Mapping Population.** *Nengyi Zhang, Yves Gibon, Jason G. Wallace, Nicholas Lepak, Pinghua Li, Lauren Dedow, Charles Chen, Yoon-Sup So, Karl Kremling, Peter J. Bradbury, Thomas Brutnell, Mark Stitt, and Edward S. Buckler*

*Genetic variants of maize identify genes and regions that control core carbon and nitrogen metabolism.*

575

**TRANSPARENT TESTA GLABRA1 and GLABRA1 Compete for Binding to GLABRA3 in Arabidopsis.** *Martina Pesch, Ilka Schultheiß, Karsten Klopffleisch, Joachim F. Uhrig, Manfred Koegl, Christoph S. Clemen, Rüdiger Simon, Stefanie Weidtkamp-Peters, and Martin Hülskamp*

*A set of three transcriptional activators form alternative protein complexes that differentially activate downstream genes.*

584

**An R2R3-MYB Transcription Factor Regulates Eugenol Production in Ripe Strawberry Fruit Receptacles.** *Laura Medina-Puche, Francisco Javier Molina-Hidalgo, Maaïke Boersma, Robert C. Schuurink, Irene López-Vidriero, Roberto Solano, José-Manuel Franco-Zorrilla, José Luis Caballero, Rosario Blanco-Portales, and Juan Muñoz-Blanco*

*A ripening-related transcription factor affects the phenylpropanoid synthesis pathway and the biosynthesis of eugenol in the strawberry fruit.*

598

**MEMBRANES, TRANSPORT, AND BIOENERGETICS**

**STATE TRANSITION7-Dependent Phosphorylation Is Modulated by Changing Environmental Conditions, and Its Absence Triggers Remodeling of Photosynthetic Protein Complexes.** *Sonja Verena Bergner, Martin Scholz, Kerstin Trompelt, Johannes Barth, Philipp Gäbelein, Janina Steinbeck, Huidan Xue, Sophie Clowez, Geoffrey Fucile, Michel Goldschmidt-Clermont, Christian Fufezan, and Michael Hippler*

*The absence of a chloroplast protein kinase leads to remodeling of photosynthetic protein complexes, uncovering an intricate protein phosphorylation network.*

615

Continued from preceding page

[<sup>OPEN</sup>]Down-Regulating CsHT1, a Cucumber Pollen-Specific Hexose Transporter, Inhibits Pollen Germination, Tube Growth, and Seed Development. *Jintao Cheng, Zhenyu Wang, Fengzhen Yao, Lihong Gao, Si Ma, Xiaolei Sui, and Zhenxian Zhang*

*A hexose transporter affects seed number and seed size in cucumber by controlling pollen tube growth.* 635

Induction of Photosynthetic Carbon Fixation in Anoxia Relies on Hydrogenase Activity and Proton-Gradient Regulation-Like1-Mediated Cyclic Electron Flow in *Chlamydomonas reinhardtii*. *Damien Godaux, Benjamin Bailleul, Nicolas Berne, and Pierre Cardol*

*Photosynthesis and growth in anoxia depends on hydrogenase-dependent linear electron flow.* 648

## SIGNALING AND RESPONSE

[<sup>OPEN</sup>]SOS2-LIKE PROTEIN KINASE5, an SNF1-RELATED PROTEIN KINASE3-Type Protein Kinase, Is Important for Abscisic Acid Responses in Arabidopsis through Phosphorylation of ABSCISIC ACID-INSENSITIVE5. *Xiaona Zhou, Hongmei Hao, Yuguo Zhang, Yili Bai, Wenbo Zhu, Yunxia Qin, Feifei Yuan, Feiyi Zhao, Mengyao Wang, Jingjiang Hu, Hong Xu, Aiguang Guo, Huixian Zhao, Yang Zhao, Cuiling Cao, Yongqing Yang, Karen S. Schumaker, Yan Guo, and Chang Gen Xie*

*A salt sensitive-like protein kinase and phosphorylation of its unique target affect ABA inhibition of seed germination.* 659

The Arabidopsis MYB96 Transcription Factor Is a Positive Regulator of *ABSCISIC ACID-INSENSITIVE4* in the Control of Seed Germination. *Kyounghee Lee, Hong Gil Lee, Seongmun Yoon, Hyun Uk Kim, and Pil Joon Seo*

*An ABA-associated transcription factor regulates lipid mobilization specifically in the embryo to determine proper timing for seed germination.* 677

The Apoplastic Copper AMINE OXIDASE1 Mediates Jasmonic Acid-Induced Protoxylem Differentiation in Arabidopsis Roots. *Sandip A. Ghuge, Andrea Carucci, Renato A. Rodrigues-Pousada, Alessandra Tisi, Stefano Franchi, Paraskevi Tavladoraki, Riccardo Angelini, and Alessandra Cona*

*The differentiation of wood cells in Arabidopsis can be triggered by the plant hormone methyl jasmonate acting via hydrogen peroxide.* 690

[<sup>OPEN</sup>]Lysine Residues Are Not Required for Proteasome-Mediated Proteolysis of the Auxin/Indole Acidic Acid Protein IAA1. *Jonathan Gilkerson, Dior R. Kelley, Raymond Tam, Mark Estelle, and Judy Callis*

*Ubiquitin attachment to nonlysine sites on a transcriptional repressor implies a diversity in ubiquitination linkages.* 708

[<sup>OPEN</sup>]Plants Actively Avoid State Transitions upon Changes in Light Intensity: Role of Light-Harvesting Complex II Protein Dephosphorylation in High Light. *Nageswara Rao Mekala, Marjaana Suorsa, Marjaana Rantala, Eva-Mari Aro, and Mikko Tikkanen*

*Phosphorylation state changes with light intensity maintain the excitation balance between photosystems by suppressing state transitions.* 721

[<sup>OPEN</sup>]Environmental Control of Branching in Petunia. *Revel S.M. Drummond, Bart J. Janssen, Zhiwei Luo, Carla Oplaat, Susan E. Ledger, Mark W. Wohlert, and Kimberley C. Snowden*

*Nutrient availability and light quality regulate branching by the production and perception of strigolactone.* 735

Continued on next page

Continued from preceding page

[[OPEN](#)] Algal Dual-Specificity Tyrosine Phosphorylation-Regulated Kinase, Triacylglycerol Accumulation Regulator1, Regulates Accumulation of Triacylglycerol in Nitrogen or Sulfur Deficiency. *Masataka Kajikawa, Yuri Sawaragi, Haruka Shinkawa, Takashi Yamano, Akira Ando, Misako Kato, Masafumi Hirono, Naoki Sato, and Hideya Fukuzawa*

*A tyrosine-phosphorylation-regulated kinase positively regulates triacylglycerol accumulation in N and S deficiency but negatively regulates photosynthesis in N deficiency.*

752

[[OPEN](#)] Articles can be viewed without a subscription.