

On the Cover: The ethylene signaling pathway known in land plants was recently found to be conserved in *Spirogyra pratensis* (a filamentous Charophycean green alga). Ethylene treatment of *Spirogyra* induces elongation of the cells within the filament, as shown. A transcriptomic analysis of the ethylene response in *Spirogyra* by Van de Poel et al. (pages 533–545) suggests changes in cell wall metabolism, photosynthesis, and abiotic stress responses. The cover image shows confocal microscopy of two *Spirogyra* filaments, one with normal-sized cells (left) and the other with elongated cells (right). To create the image, a confocal section of DAPI-stained (blue) filaments, showing cell walls, was overlaid with the autofluorescence (red) of chlorophyll in the spiral chloroplasts. The image was produced by Dr. Bram Van de Poel.

ON THE INSIDE

Peter V. Minorsky

1

COMMENTARY

The Ever-Closer Union of Signals: Propagating Waves of Calcium and ROS Are Inextricably Linked. Edgar Peiter

3

Hope in Change: The Role of Root Plasticity in Crop Yield Stability. Christopher N. Topp

5

TOPICAL REVIEW

[OPEN] A Tale of Two Sugars: Trehalose 6-Phosphate and Sucrose. Carlos M. Figueroa and John E. Lunn

Trehalose 6-phosphate is a signal of sucrose availability in plants that influences sucrose synthesis in source leaves and the fate of imported sucrose in sink organs, thereby linking growth and development to carbon status.

7

BREAKTHROUGH TECHNOLOGIES

[OPEN] Long-Term Growth of Moss in Microfluidic Devices Enables Subcellular Studies in Development. Carlisle S. Bascom Jr., Shu-Zon Wu, Katherine Nelson, John Oakey, and Magdalena Bezanilla

Microfluidic chambers enable imaging of moss development from early to late developmental stages at cellular and subcellular resolution.

28

[OPEN] Indel Group in Genomes (IGG) Molecular Genetic Markers. Ted W. Toal, Diana Burkart-Waco, Tyson Howell, Mily Ron, Sundaram Kuppu, Anne Britt, Roger Chetelat, and Siobhan M. Brady

Genome-wide molecular markers are produced by a bioinformatics pipeline that analyzes pairs of genomic sequences to find primer pairs that amplify indel-containing regions having a targeted amplicon size and size difference.

38

[OPEN] Codon Optimization to Enhance Expression Yields Insights into Chloroplast Translation. Kwang-Chul Kwon, Hui-Ting Chan, Ileana R. León, Rosalind Williams-Carrier, Alice Barkan, and Henry Daniell

Eukaryotic genes coding for biopharmaceutical proteins expressed in chloroplasts using different codons, but identical regulatory sequences, shed light on key factors that limit or enhance protein synthesis.

62

Continued on next page

RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

The Structure and Catalytic Mechanism of *Sorghum bicolor* Caffeoyl-CoA O-Methyltransferase. *Alexander M. Walker, Steven A. Sattler, Matt Regner, Jeffrey P. Jones, John Ralph, Wilfred Vermerris, Scott E. Sattler, and ChulHee Kang*

The catalytic mechanism and substrate specificity of caffeoyl-CoA O-methyltransferase from Sorghum bicolor deduced from crystal structures, site-directed mutagenesis, and kinetic and thermodynamic analyses. 78

[OPEN] Suppressing Farnesyl Diphosphate Synthase Alters Chloroplast Development and Triggers Sterol-Dependent Induction of Jasmonate- and Fe-Related Responses. *David Manzano, Paola Andrade, Daniel Caudepón, Teresa Altabella, Montserrat Arró, and Albert Ferrer*

Suppressing FPS expression affects chloroplast development, reducing cytosolic and plastidial isoprenoid levels including sterols. 93

[OPEN] FUM2, a Cytosolic Fumarase, Is Essential for Acclimation to Low Temperature in *Arabidopsis thaliana*. *Beth C. Dyson, Matthew A.E. Miller, Regina Feil, Nicholas Ratray, Caroline G. Bowsher, Royston Goodacre, John E. Lunn, and Giles N. Johnson*

Accumulation of fumaric acid, catalyzed by a cytosolic fumarase, is essential for Arabidopsis thaliana to acclimate photosynthesis to low temperature. 118

[OPEN] eIF4A RNA Helicase Associates with Cyclin-Dependent Protein Kinase A in Proliferating Cells and Is Modulated by Phosphorylation. *Maxwell S. Bush, Olivier Pierrat, Candida Nibau, Veronika Mikitova, Tao Zheng, Fiona M. K. Corke, Konstantinos Vlachonasios, Laura K. Mayberry, Karen S. Browning, and John H. Doonan*

CDKA phosphorylation of the RNA helicase, eIF4A, is restricted to proliferating cells and could provide a mechanism that inhibits translation and cell growth in a cell cycle-dependent manner. 128

[OPEN] Oxygen Sensing via the Ethylene Response Transcription Factor RAP2.12 Affects Plant Metabolism and Performance under Both Normoxia and Hypoxia. *Melanie Verena Paul, Srignanakshi Iyer, Carmen Amerhauser, Martin Lehmann, Joost T. van Dongen, and Peter Geigenberger*

Oxygen-regulated stability of the ERF-VII transcription factor RAP2.12 regulates central metabolic processes to sustain growth, development, and anoxia responses. 141

[OPEN] ACYL-ACYL CARRIER PROTEIN DESATURASE2 and 3 Are Responsible for Making Omega-7 Fatty Acids in the Arabidopsis Aleurone. *Fiona M. Bryant, Olaya Munoz-Azcarate, Amélie A. Kelly, Frédéric Beaudoin, Smita Kurup, and Peter J. Eastmond*

Two acyl-acyl carrier protein desaturases are responsible for the tissue-specific production of high levels of omega-7 monounsaturated fatty acids in Arabidopsis aleurone cells. 154

[OPEN] Cell Wall Invertase Promotes Fruit Set under Heat Stress by Suppressing ROS-Independent Cell Death. *Yong-Hua Liu, Christina E. Offler, and Yong-Ling Ruan*

Elevation of cell wall invertase activity by silencing its inhibitor improves tomato fruit set under moderate heat stress via suppressing programmed cell death in a ROS-independent manner. 163

[OPEN] Glucosinolates from Host Plants Influence Growth of the Parasitic Plant *Cuscuta gronovii* and Its Susceptibility to Aphid Feeding. Jason D. Smith, Melkamu G. Woldemariam, Mark C. Mescher, Georg Jander, and Consuelo M. De Moraes

Dodder vines (Cuscuta gronovii) parasitizing Arabidopsis thaliana take up glucosinolate toxins that reduce parasite growth and modulate resistance to aphid herbivores. 181

[OPEN] Chemical Genetics Uncovers Novel Inhibitors of Lignification, Including *p*-Iodobenzoic Acid Targeting CINNAMATE-4-HYDROXYLASE. Dorien Van de Wouwer, Ruben Vanholme, Raphaël Decou, Geert Goeminne, Dominique Audenaert, Long Nguyen, René Höfer, Edouard Pesquet, Bartel Vanholme, and Wout Boerjan

Chemical screening for novel inhibitors of lignification uncovered a compound processed in the plant into two such inhibitors, one of which, p-iodobenzoic acid, inhibits CINNAMATE-4-HYDROXYLASE activity. 198

CELL BIOLOGY

[OPEN] The Potyviral P3 Protein Targets Eukaryotic Elongation Factor 1A to Promote the Unfolded Protein Response and Viral Pathogenesis. Hexiang Luan, M.B. Shine, Xiaoyan Cui, Xin Chen, Na Ma, Pradeep Kachroo, Haijan Zhi, and Aardra Kachroo

Soybean Mosaic Virus P3 targets soybean elongation factor EF1A to induce ER stress, which in turn facilitates SMV pathogenesis and this is linked to EF1A function in translation elongation. 221

[OPEN] Polypeptide Transport-Associated Domains of the Toc75 Channel Protein Are Located in the Intermembrane Space of Chloroplasts. Yih-Lin Chen, Lih-Jen Chen, and Hsou-min Li

The transit-peptide binding domain of the chloroplast outer-membrane protein-translocating channel protrudes into the intermembrane space rather than into the cytosol. 235

[OPEN] S-Adenosylmethionine Synthetase 3 Is Important for Pollen Tube Growth. Yuan Chen, Ting Zou, and Sheila McCormick

Arabidopsis mat3 pollen overaccumulates methionine, germinates poorly, and has short tubes. 244

ECOPHYSIOLOGY AND SUSTAINABILITY

[CC-BY] Stomatal Spacing Safeguards Stomatal Dynamics by Facilitating Guard Cell Ion Transport Independent of the Epidermal Solute Reservoir. Maria Papanatsiou, Anna Amtmann, and Michael R. Blatt

Clustering of stomata suppresses guard cell ion transport independent of ion stores in neighboring epidermal cells. 254

[OPEN] Microoxic Niches within the Thylakoid Stroma of Air-Grown *Chlamydomonas reinhardtii* Protect [FeFe]-Hydrogenase and Support Hydrogen Production under Fully Aerobic Environment. Oded Liran, Rinat Semyatich, Yuval Milrad, Haviva Eilenberg, Iddo Weiner, and Iftach Yacoby

Hydrogen production catalyzed by the extremely anaerobic enzyme [FeFe]-hydrogenase in air-grown microalgae reports on microoxic niches within the thylakoid stroma. 264

GENES, DEVELOPMENT, AND EVOLUTION

[OPEN] The Genome of a Southern Hemisphere Seagrass Species (*Zostera muelleri*). HueyTyng Lee, Agnieszka A. Golicz, Philipp E. Bayer, Yuannian Jiao, Haibao Tang, Andrew H. Paterson, Gaurav Sablok, Rahul R. Krishnaraj, Chon-Kit Kenneth Chan, Jacqueline Batley, Gary A. Kendrick, Anthony W.D. Larkum, Peter J. Ralph, and David Edwards

Adaptation of seagrass to the marine environment involves modification and loss of conserved plant genes. 272

Continued on next page

Evolutionary Co-Option of Floral Meristem Identity Genes for Patterning of the Flower-Like Asteraceae Inflorescence. *Yafei Zhao, Teng Zhang, Suvi K. Broholm, Sari Tähtiharju, Katriina Mouhu, Victor A. Albert, Teemu H. Teeri, and Paula Elomaa*

Highly conserved genes that regulate the identity of single flowers in conventional plant models regulate the unique inflorescence architecture of the evolutionarily successful Asteraceae plant family. 284

[OPEN] Salt Stress Reveals a New Role for ARGONAUTE1 in miRNA Biogenesis at the Transcriptional and Posttranscriptional Levels. *Jakub Dolata, Mateusz Bajczyk, Dawid Bielewicz, Katarzyna Niedojadlo, Janusz Niedojadlo, Halina Pietrykowska, Weronika Walczak, Zofia Szwejkowska-Kulinska, and Artur Jarmolowski*

Arabidopsis ARGONAUTE 1, in addition to its well-known role in mRNA target cleavage and miRNA-mediated translation inhibition, is involved in the cotranscriptional regulation of MIR gene expression. 297

The 5' UTR Intron of Arabidopsis GGT1 Aminotransferase Enhances Promoter Activity by Recruiting RNA Polymerase II. *Miriam Laxa, Kristin Müller, Natalie Lange, Lennart Doering, Jan Thomas Pruscha, and Christoph Peterhänsel*

The 5' UTR intron of GGT1 determines maximum transcript abundance and affects RNA polymerase II binding. 313

[OPEN] eQTL Regulating Transcript Levels Associated with Diverse Biological Processes in Tomato. *Aashish Ranjan, Jessica M. Budke, Steven D. Rowland, Daniel H. Chitwood, Ravi Kumar, Leonela Carriedo, Yasunori Ichihashi, Kristina Zumstein, Julin N. Maloof, and Neelima R. Sinha*

Genetic mapping and coexpression highlights hot spots regulating transcripts linked to diverse biological processes. 328

[OPEN] Origin and Functional Prediction of Pollen Allergens in Plants. *Miaolin Chen, Jie Xu, Deborah Devis, Jianxin Shi, Kang Ren, Iain Searle, and Dabing Zhang*

Prediction and systematic analysis of pollen allergens in model plants suggest that pollen allergens evolved by gene duplication and then functional specification. 341

SPIKE1 Activates ROP GTPase to Modulate Petal Growth and Shape. *Huibo Ren, Xie Dang, Yanqiu Yang, Dingquan Huang, Mengting Liu, Xiaowei Gao, and Deshu Lin*

SPIKE1 activates ROP GTPase proteins to regulate anisotropic cell expansion and petal anisotropic growth by affecting the organization of cortical microtubule arrays in Arabidopsis. 358

[OPEN] Genome-Wide Targets Regulated by the OsMADS1 Transcription Factor Reveals Its DNA Recognition Properties. *Imtiyaz Khanday, Sanjukta Das, Grace L Chongloi, Manju Bansal, Ueli Grossniklaus, and Usha Vijayraghavan*

OsMADS1 binds to many downstream target loci with distinct sequence and biophysical characteristics and likely in combination with other factors to ensure rice floret development. 372

[OPEN] Flowering Time-Regulated Genes in Maize Include the Transcription Factor ZmMADS1. *Philipp Alter, Susanne Bircheneder, Liang-Zi Zhou, Urte Schlüter, Manfred Gahrzt, Uwe Sonnewald, and Thomas Dresselhaus*

ZmMADS1 is activated in leaves during shoot apical meristem transition and acts as a positive flowering time regulator in day-neutral maize. 389

[OPEN] Photoperiod-H1 (Ppd-H1) Controls Leaf Size. *Benedikt Digel, Elahe Tavakol, Gabriele Verderio, Alessandro Tondelli, Xin Xu, Luigi Cattivelli, Laura Rossini, and Maria von Korff*

Photoperiod-H1 controls leaf size by influencing the duration of leaf growth in barley. 405

Continued on next page

[OPEN] Evidence for an Early Origin of Vernalization Responsiveness in Temperate Pooideae Grasses. Meghan McKeown, Marian Schubert, Thomas Marcussen, Siri Fjellheim, and Jill C. Preston

Cold-regulated VRN1 and VRN3 expression is consistent with an early origin of vernalization responsiveness in the temperate Pooideae grasses.

416

[OPEN] Evolutionary Fates and Dynamic Functionalization of Young Duplicate Genes in Arabidopsis Genomes. Jun Wang, Feng Tao, Nicholas C. Marowsky, and Chuanzhu Fan

Conservation, neofunctionalization, and specialization are main evolutionary trajectories for Arabidopsis young duplicate genes, and their relative roles change dynamically over evolutionary time.

427

MEMBRANES, TRANSPORT, AND BIOENERGETICS

[OPEN] Envelope K⁺/H⁺ Antiporters AtKEA1 and AtKEA2 Function in Plastid Development. María Nieves Aranda-Sicilia, Ali Aboukila, Ute Armbruster, Olivier Cagnac, Tobias Schumann, Hans-Henning Kunz, Peter Jahns, María Pilar Rodríguez-Rosales, Heven Sze, and Kees Venema

Antiporters localized to polar microdomains of dividing and developing plastids affect thylakoid membrane formation and chloroplast differentiation.

441

The Low Molecular Weight Protein PsaI Stabilizes the Light-Harvesting Complex II Docking Site of Photosystem I. Magdalena Plöchinger, Salar Torabi, Marjaana Rantala, Mikko Tikkanen, Marjaana Suorsa, Poul-Erik Jensen, Eva Mari Aro, and Jörg Meurer

Loss of plant PsaI Photosystem I subunit destabilizes the binding of PsaL and PsaH subunits of this photosystem and causes nonphotochemical dark-reduction of the plastoquinone pool keeping plants in state 2 in the dark.

450

SIGNALING AND RESPONSE

Cytokinin Regulates the Etioplast-Chloroplast Transition through the Two-Component Signaling System and Activation of Chloroplast-Related Genes. Anne Cortleven, Ingke Marg, Maria V Yamburenko, Hagen Schlicke, Kristine Hill, Bernhard Grimm, G. Eric Schaller, and Thomas Schmölling

Cytokinin regulates chloroplast development during de-etiolation through the two-component signaling system by binding of B-type ARR1s to the promoters of chloroplast-related genes.

464

The DELLA-CONSTANS Transcription Factor Cascade Integrates Gibberellic Acid and Photoperiod Signaling to Regulate Flowering. Houping Wang, Jinjing Pan, Yang Li, Dengji Lou, Yanru Hu, and Diqiu Yu

DELLA proteins physically and genetically interact with CO to modulate flowering under long-days in Arabidopsis.

479

[OPEN] Cytokinins Are Initial Targets of Light in the Control of Bud Outgrowth. Hanaé Roman, Tiffanie Girault, François Barbier, Thomas Péron, Nathalie Brouard, Aleš Pěnčík, Ondřej Novák, Alain Vian, Soulainman Sakr, Jérémy Lothier, José Le Gourrierec, and Nathalie Leduc

Light perception by buds triggers a rapid cytokinin signal that controls major downstream regulators, including sugars, auxin, and strigolactones, of bud outgrowth.

489

[OPEN] Core Mechanisms Regulating Developmentally Timed and Environmentally Triggered Abscission. O. Rahul Patharkar and John C. Walker

A shared module of genes regulates both drought-triggered leaf abscission and developmentally timed floral organ abscission in Arabidopsis.

510

Continued on next page

[OPEN] Auxin Is Rapidly Induced by Herbivore Attack and Regulates a Subset of Systemic, Jasmonate-Dependent Defenses. Ricardo A. R. Machado, Christelle A. M. Robert, Carla C. M. Arce, Abigail P. Ferrieri, Shuqing Xu, Guillermo H. Jimenez-Aleman, Ian T. Baldwin, and Matthias Erb

Herbivory-induced auxin promotes the production of anthocyanins and phenolamides. 521

[OPEN] Transcriptome Profiling of the Green Alga *Spirogyra pratensis* (Charophyta) Suggests an Ancestral Role for Ethylene in Cell Wall Metabolism, Photosynthesis, and Abiotic Stress Responses. Bram Van de Poel, Endymion D. Cooper, Dominique Van Der Straeten, Caren Chang, and Charles F. Delwiche

The plant hormone ethylene regulates predominantly cell wall metabolism, photosynthesis, and abiotic stress responses in the charophyte green alga Spirogyra pratensis. 533

[OPEN] The Systemic Acquired Resistance Regulator OsNPR1 Attenuates Growth by Repressing Auxin Signaling through Promoting IAA-Amido Synthase Expression. Xiaozun Li, Dong-Lei Yang, Li Sun, Qun Li, Bizeng Mao, and Zuhua He

The regulator protein OsNPR1 inhibits rice growth by enhancing the OsGH3.8 amido synthase of rice. 546

A *Brachypodium* UDP-Glycosyltransferase Confers Root Tolerance to Deoxynivalenol and Resistance to *Fusarium* Infection. Jean-Claude Pasquet, Valentin Changenet, Catherine Macadré, Edouard Boex-Fontvoille, Camille Soulhat, Oumaya Bouchabké-Coussa, Marion Dalmais, Vessela Atanasova-Pénichon, Abdelhafid Bendahmane, Patrick Saindrenan, and Marie Dufresne

The UDP-glucosyltransferase Bradi5g03300 conjugates the Fusarium mycotoxin deoxynivalenol into deoxynivalenol-3-O-glucose and confers resistance to primary infection by Fusarium graminearum. 559

SYSTEMS AND SYNTHETIC BIOLOGY

Overexpression of the OsERF71 Transcription Factor Alters Rice Root Structure and Drought Resistance. Dong-Keun Lee, Harin Jung, Geupil Jang, Jin Seo Jeong, Youn Shic Kim, Sun-Hwa Ha, Yang Do Choi, and Ju-Kon Kim

OsERF71 alters root structure to enhance drought resistance. 575

Genome-Scale Metabolic Model for the Green Alga *Chlorella vulgaris* UTEX 395 Accurately Predicts Phenotypes under Autotrophic, Heterotrophic, and Mixotrophic Growth Conditions. Cristal Zuñiga, Chien-Ting Li, Tyler Huelsman, Jennifer Levering, Daniel C. Zielinski, Brian O. McConnell, Christopher P. Long, Eric P. Knoshaug, Michael T. Guarnieri, Maciek R. Antoniewicz, Michael J. Betenbaugh, and Karsten Zengler

Genome-scale metabolic model for Chlorella vulgaris UTEX 395 accurately predicts phenotypes under different growth conditions. 589

[OPEN] Integrative Analyses of Nontargeted Volatile Profiling and Transcriptome Data Provide Molecular Insight into VOC Diversity in Cucumber Plants (*Cucumis sativus*). Guo Wei, Peng Tian, Fengxia Zhang, Hao Qin, Han Miao, Qingwen Chen, Zhongyi Hu, Li Cao, Meijiao Wang, Xingfang Gu, Sanwen Huang, Mingsheng Chen, and Guodong Wang

An integrated volatile detection system coupled with transcriptomic data identifies 85 compounds, including 36 terpenes, from a total of 23 cucumber tissues, and some of the genes responsible for their synthesis. 603

[OPEN] Articles can be viewed online without a subscription.
[CC-BY] Article Free via Creative Commons CC-BY 4.0 license.