

The electronic form of this issue, available as of November 11, 2011, at www.plantphysiol.org, is considered the journal of record.

On the Cover: Maintaining proper ratios among cell types in the vascular tissue is essential for plant growth and development, not only because both the xylem and the phloem are indispensable for long-distance transport of water and nutrients but also because other cell types play important roles as well. As the site of lateral root formation, the pericycle increases the length and complexity of the root system, but not all pericycle cells can produce lateral roots. Instead, evidence suggests that the pericycle consists of two cell types—one abutting the xylem, and the other associated with the phloem—and that only the xylem-associated pericycle can form lateral roots. The phytohormones auxin and cytokinin are known to be antagonistic to each other in vascular tissue patterning. Auxin is required for xylem differentiation and lateral root formation, whereas cytokinin promotes phloem specification but inhibits lateral root formation. SHORT-ROOT (SHR) is an important regulator of root morphogenesis in Arabidopsis. In addition to its well-characterized role in ground tissue patterning, SHR also controls stem cell renewal, vascular tissue patterning, and lateral root formation, but the underlying mechanisms remain unclear. In this issue, Cui et al. (1221–1231) report dissecting the SHR developmental pathway by a method (chromatin immunoprecipitation followed by microarray analysis) that reveals the genome-wide locations of SHR direct targets. Their results indicate that SHR promotes the formation of xylem and xylem-associated pericycle by reducing the level of cytokinin through a CYTOKININ OXIDASE. In the *shr* mutant, the cytokinin level is elevated, and the xylem domain and associated pericycle are diminished, whereas the phloem domain and associated pericycle are enlarged. The image shows clusters of SHR direct targets that are preferentially expressed in the quiescent center (upper panel) or the pericycle (lower panel), as well as the expression pattern of a cell type-specific GFP marker for the phloem-associated pericycle at increasing concentrations of exogenous cytokinin (from left to right: 0, 0.5, and 1 μ M). Cover design and images by H. Cui.

ON THE INSIDE

Peter V. Minorsky

971

BREAKTHROUGH TECHNOLOGIES

^{[W][OA]}Brush and Spray: A High-Throughput Systemic Acquired Resistance Assay Suitable for Large-Scale Genetic Screening. *Beibei Jing, Shaohua Xu, Mo Xu, Yan Li, Shuxin Li, Jinmei Ding, and Yuelin Zhang*

973

SCIENTIFIC CORRESPONDENCE

^[W]Capturing Metabolite Channeling in Metabolic Flux Phenotypes. *Thomas C.R. Williams, Lee J. Sweetlove, and R. George Ratcliffe*

981

RESEARCH ARTICLES

BIOCHEMICAL PROCESSES AND MACROMOLECULAR STRUCTURES

^[W]Dispersed Benzoxazinone Gene Cluster: Molecular Characterization and Chromosomal Localization of Glucosyltransferase and Glucosidase Genes in Wheat and Rye. *Masayuki Sue, Chihiro Nakamura, and Taiji Nomura*

985

^{[W][OA]}Identification of Enzyme Activity Quantitative Trait Loci in a *Solanum lycopersicum* × *Solanum pennellii* Introgression Line Population. *Marie-Caroline Steinhauser, Dirk Steinhauser, Yves Gibon, Marie Bolger, Stéphanie Arrivault, Björn Usadel, Dani Zamir, Alisdair R. Fernie, and Mark Stitt*

998

^{[W][OA]}Structural and Functional Assays of AtTLP18.3 Identify Its Novel Acid Phosphatase Activity in Thylakoid Lumen. *Hsin-Yi Wu, Mao-Sen Liu, Tsan-Piao Lin, and Yi-Sheng Cheng*

1015

Continued on next page

- ^{[W][OA]}Targeted Enhancement of Glutamate-to- γ -Aminobutyrate Conversion in Arabidopsis Seeds Affects Carbon-Nitrogen Balance and Storage Reserves in a Development-Dependent Manner. *Aaron Fait, Adriano Nunes Nesi, Ruthie Angelovici, Martin Lehmann, Phuong Anh Pham, Luhua Song, Richard P. Haslam, Johnathan A. Napier, Gad Galili, and Alisdair R. Fernie* 1026
- ^{[C][W][OA]}Identification of Essential Subunits in the Plastid-Encoded RNA Polymerase Complex Reveals Building Blocks for Proper Plastid Development. *Sebastian Steiner, Yvonne Schröter, Jeannette Pfalz, and Thomas Pfannschmidt* 1043
- ^{[W][OA]}Molecular and Biochemical Basis for Stress-Induced Accumulation of Free and Bound *p*-Coumaraldehyde in Cucumber. *Marina Varbanova, Katie Porter, Fachuang Lu, John Ralph, Ray Hammerschmidt, A. Daniel Jones, and Brad Day* 1056
- ^[W]Tyrosine Aminotransferase Contributes to Benzylisoquinoline Alkaloid Biosynthesis in Opium Poppy. *Eun-Jeong Lee and Peter J. Facchini* 1067
- ^{[C][W][OA]}The *glossyhead1* Allele of *ACC1* Reveals a Principal Role for Multidomain ACETYL-COENZYME A CARBOXYLASE in the Biosynthesis of Cuticular Waxes by Arabidopsis. *Shiyu Lü, Huayan Zhao, Eugene P. Parsons, Changcheng Xu, Dylan K. Kosma, Xiaojing Xu, Daiyin Chao, Gregory Lohrey, Dhinoth K. Bangarusamy, Guangchao Wang, Ray A. Bressan, and Matthew A. Jenks* 1079
- BIOENERGETICS AND PHOTOSYNTHESIS**
- ^{[W][OA]}Multiple Lines of Evidence Localize Signaling, Morphology, and Lipid Biosynthesis Machinery to the Mitochondrial Outer Membrane of Arabidopsis. *Owen Duncan, Nicolas L. Taylor, Chris Carrie, Holger Eubel, Szymon Kubiszewski-Jakubiak, Botao Zhang, Reena Narsai, A. Harvey Millar, and James Whelan* 1093
- ^{[W][OA]}A Deficiency in the Flavoprotein of Arabidopsis Mitochondrial Complex II Results in Elevated Photosynthesis and Better Growth in Nitrogen-Limiting Conditions. *Daniela Fuentes, Marco Meneses, Adriano Nunes-Nesi, Wagner L. Araújo, Rodrigo Tapia, Isabel Gómez, Loreto Holuigue, Rodrigo A. Gutiérrez, Alisdair R. Fernie, and Xavier Jordana* 1114
- CELL BIOLOGY AND SIGNAL TRANSDUCTION**
- ^[W]Expression of Enzymes Involved in Chlorophyll Catabolism in Arabidopsis Is Light Controlled. *Agnieszka Katarzyna Banaś, Justyna Łabuz, Olga Sztatelman, Halina Gabryś, and Leszek Fiedor* 1497
- DEVELOPMENT AND HORMONE ACTION**
- ^{[C][W][OA]}Molecular Dissection of the Roles of Phytochrome in Photoperiodic Flowering in Rice. *Asami Osugi, Hironori Itoh, Kyoko Ikeda-Kawakatsu, Makoto Takano, and Takeshi Izawa* 1128
- ^{[W][OA]}Root-Localized Phytochrome Chromophore Synthesis Is Required for Photoregulation of Root Elongation and Impacts Root Sensitivity to Jasmonic Acid in Arabidopsis. *Stephanie E. Costigan, Sankalpi N. Warnasooriya, Brock A. Humphries, and Beronda L. Montgomery* 1138
- ^{[W][OA]}Key Proliferative Activity in the Junction between the Leaf Blade and Leaf Petiole of Arabidopsis. *Yasunori Ichihashi, Kensuke Kawade, Takeshi Usami, Gorou Horiguchi, Taku Takahashi, and Hirokazu Tsukaya* 1151
- ^[W]Oligogalacturonide-Auxin Antagonism Does Not Require Posttranscriptional Gene Silencing or Stabilization of Auxin Response Repressors in Arabidopsis. *Daniel V. Savatin, Simone Ferrari, Francesca Sicilia, and Giulia De Lorenzo* 1163
- ^{[C][W][OA]}*SUN* Regulates Vegetative and Reproductive Organ Shape by Changing Cell Division Patterns. *Shan Wu, Han Xiao, Antonio Cabrera, Tea Meulia, and Esther van der Knaap* 1175
- ^{[W][OA]}The Multiple Contributions of Phytochromes to the Control of Internode Elongation in Rice. *Masao Iwamoto, Seiichiro Kiyota, Atsushi Hanada, Shinjiro Yamaguchi, and Makoto Takano* 1187
- ^{[C][W]}Cell Fate in the Arabidopsis Root Epidermis Is Determined by Competition between WEREWOLF and CAPRICE. *Sang-Kee Song, Kook Hui Ryu, Yeon Hee Kang, Jae Hyo Song, Young-Hee Cho, Sang-Dong Yoo, John Schiefelbein, and Myeong Min Lee* 1196
- ^{[W][OA]}Hormonal Regulation of Lateral Root Development in Arabidopsis Modulated by *MIZ1* and Requirement of *GNOM* Activity for *MIZ1* Function. *Tepei Moriwaki, Yutaka Miyazawa, Akie Kobayashi, Mayumi Uchida, Chiaki Watanabe, Nobuharu Fujii, and Hideyuki Takahashi* 1209
- ^{[W][OA]}Genome-Wide Direct Target Analysis Reveals a Role for *SHORT-ROOT* in Root Vascular Patterning through Cytokinin Homeostasis. *Hongchang Cui, Yueling Hao, Mikhail Kovtun, Viktor Stolc, Xing-Wang Deng, Hitoshi Sakakibara, and Mikiko Kojima* 1221

ENVIRONMENTAL STRESS AND ADAPTATION TO STRESS

- [C][W] GeBP/GPL Transcription Factors Regulate a Subset of CPR5-Dependent Processes. *Daniel Perazza, Frédéric Laporte, Claudine Balagué, Florian Chevalier, Shanterika Remo, Mickaël Bourge, John Larkin, Michel Herzog, and Gilles Vachon* 1232
- [C][W][OA] Arabidopsis HsfB1 and HsfB2b Act as Repressors of the Expression of Heat-Inducible Hsfs But Positively Regulate the Acquired Thermotolerance. *Miho Ikeda, Nobutaka Mitsuda, and Masaru Ohme-Takagi* 1243
- [W] Arabidopsis Roots and Shoots Show Distinct Temporal Adaptation Patterns toward Nitrogen Starvation. *Anne Krapp, Richard Berthomé, Mathilde Orsel, Stéphanie Mercey-Boutet, Agnes Yu, Loren Castaings, Samira Elftieh, Hilary Major, Jean-Pierre Renou, and Françoise Daniel-Vedele* 1255
- [W][OA] The Arabidopsis Purple Acid Phosphatase AtPAP10 Is Predominantly Associated with the Root Surface and Plays an Important Role in Plant Tolerance to Phosphate Limitation. *Liangsheng Wang, Zheng Li, Weiqiang Qian, Wanli Guo, Xiang Gao, Lingling Huang, Han Wang, Huifen Zhu, Jia-Wei Wu, Daowen Wang, and Dong Liu* 1283
- [C][W][OA] Spatiotemporal Analysis of Copper Homeostasis in *Populus trichocarpa* Reveals an Integrated Molecular Remodeling for a Preferential Allocation of Copper to Plastocyanin in the Chloroplasts of Developing Leaves. *Karl Ravet, Forest L. Danford, Alysha Dihle, Marco Pittarello, and Marinus Pilon* 1300
- [C][W] Dissecting the Role of CHITINASE-LIKE1 in Nitrate-Dependent Changes in Root Architecture. *Christian Hermans, Silvana Porco, Filip Vandenbussche, Sascha Gille, Jérôme De Pessemier, Dominique Van Der Straeten, Nathalie Verbruggen, and Daniel R. Bush* 1313

GENETICS, GENOMICS, AND MOLECULAR EVOLUTION

- [W][OA] Chromosomes Carrying Meiotic Avoidance Loci in Three Apomictic Eudicot *Hieracium* Subgenus *Pilosella* Species Share Structural Features with Two Monocot Apomicts. *Takashi Okada, Kanae Ito, Susan D. Johnson, Karsten Oelkers, Go Suzuki, Andreas Houben, Yasuhiko Mukai, and Anna M. Koltunow* 1327
- [W][OA] In-Depth Temporal Transcriptome Profiling Reveals a Crucial Developmental Switch with Roles for RNA Processing and Organelle Metabolism That Are Essential for Germination in Arabidopsis. *Reena Narsai, Simon R. Law, Chris Carrie, Lin Xu, and James Whelan* 1342

PLANTS INTERACTING WITH OTHER ORGANISMS

- [W][OA] Soybean Homologs of MPK4 Negatively Regulate Defense Responses and Positively Regulate Growth and Development. *Jian-Zhong Liu, Heidi D. Horstman, Edward Braun, Michelle A. Graham, Chunquan Zhang, Duroy Navarre, Wen-Li Qiu, Yeunsook Lee, Dan Nettleton, John H. Hill, and Steven A. Whitham* 1363
- [W][OA] Stress-Responsive Mitogen-Activated Protein Kinases Interact with the EAR Motif of a Poplar Zinc Finger Protein and Mediate Its Degradation through the 26S Proteasome. *Louis-Philippe Hamel, Meriem Benchabane, Marie-Claude Nicole, Ian T. Major, Marie-Josée Morency, Gervais Pelletier, Nathalie Beaudoin, Jen Sheen, and Armand Séguin* 1379
- [C][W][OA] Tomato SlSnRK1 Protein Interacts with and Phosphorylates β C1, a Pathogenesis Protein Encoded by a Geminivirus β -Satellite. *Qingtang Shen, Zhou Liu, Fengming Song, Qi Xie, Linda Hanley-Bowdoin, and Xueping Zhou* 1394
- [C][W] N-Acyl-Homoserine Lactone Confers Resistance toward Biotrophic and Hemibiotrophic Pathogens via Altered Activation of AtMPK6. *Adam Schikora, Sebastian T. Schenk, Elke Stein, Alexandra Molitor, Alga Zuccaro, and Karl-Heinz Kogel* 1407
- [W][OA] Glutamine Synthetase Is a Molecular Target of Nitric Oxide in Root Nodules of *Medicago truncatula* and Is Regulated by Tyrosine Nitration. *Paula M. Melo, Liliana S. Silva, Isa Ribeiro, Ana R. Seabra, and Helena G. Carvalho* 1505

WHOLE PLANT AND ECOPHYSIOLOGY

- [W][OA] Transcriptome Response to Embolism Formation in Stems of *Populus trichocarpa* Provides Insight into Signaling and the Biology of Refilling. *Francesca Secchi, Matthew E. Gilbert, and Maciej A. Zwieniecki* 1419
- [W][OA] Phloem Loading Strategies and Water Relations in Trees and Herbaceous Plants. *Qiushi Fu, Lailiang Cheng, Yangdong Guo, and Robert Turgeon* 1518
- [C][W][OA] Green Light Induces Shade Avoidance Symptoms. *Tingting Zhang, Stefanie A. Maruhnich, and Kevin M. Folta* 1528

SYSTEMS BIOLOGY, MOLECULAR BIOLOGY, AND GENE REGULATION

- [W][OA] RNA PROCESSING FACTOR3 Is Crucial for the Accumulation of Mature *ccmC* Transcripts in Mitochondria of Arabidopsis Accession Columbia. *Christian Jonietz, Joachim Forner, Tatjana Hildebrandt, and Stefan Binder* 1430
- [W][OA] Light-Dependent Regulation of *DEL1* Is Determined by the Antagonistic Action of E2Fb and E2Fc. *Barbara Berckmans, Tim Lammens, Hilde Van Den Daele, Zoltan Magyar, Laszlo Bögre, and Lieven De Veylder* 1440
- [C][W][OA] Dissection of the Transcriptional Program Regulating Secondary Wall Biosynthesis during Wood Formation in Poplar. *Ruiqin Zhong, Ryan L. McCarthy, Chanhui Lee, and Zheng-Hua Ye* 1452
- [W][OA] Toward the Storage Metabolome: Profiling the Barley Vacuole. *Takayuki Tohge, Magali Schnell Ramos, Adriano Nunes-Nesi, Marek Mutwil, Patrick Giavalisco, Dirk Steinhauser, Maja Schellenberg, Lothar Willmitzer, Staffan Persson, Enrico Martinoia, and Alisdair R. Fernie* 1469
- [W][OA] From Model to Crop: Functional Analysis of a *STAY-GREEN* Gene in the Model Legume *Medicago truncatula* and Effective Use of the Gene for Alfalfa Improvement. *Chuanen Zhou, Lu Han, Catalina Pislariu, Jin Nakashima, Chunxiang Fu, Qingzhen Jiang, Li Quan, Elison B. Blancaflor, Yuhong Tang, Joseph H. Bouton, Michael Udvardi, Guangmin Xia, and Zeng-Yu Wang* 1483
- [W][OA] A Role for Protein Kinase Casein Kinase2 α -Subunits in the Arabidopsis Circadian Clock. *Sheen X. Lu, Hongtao Liu, Stephen M. Knowles, Jian Li, Ligeng Ma, Elaine M. Tobin, and Chentao Lin* 1537
- [OA] A Novel Plant in Vitro Assay System for Pre-mRNA Cleavage during 3' -End Formation. *Hongwei Zhao, Jun Zheng, and Qingshun Quinn Li* 1546
- [W] A New Insight into Application for Barley Chromosome Addition Lines of Common Wheat: Achievement of Stigmasterol Accumulation. *Jianwei Tang, Kiyoshi Ohyama, Kanako Kawaura, Hiromi Hashinokuchi, Yoko Kamiya, Masashi Suzuki, Toshiya Muranaka, and Yasunari Ogihara* 1555
- [W][OA] The Tomato MADS-Box Transcription Factor RIPENING INHIBITOR Interacts with Promoters Involved in Numerous Ripening Processes in a COLORLESS NONRIPENING-Dependent Manner. *Catherine Martel, Julia Vrebalov, Petra Tafelmeyer, and James J. Giovannoni* 1568

[C] Some figures in this article are displayed in color online but in black and white in the print edition.

[W] Indicates Web-only data.

[OA] Open Access articles can be viewed online without a subscription.