

The electronic form of this issue, available as of November 12, 2007, at [www.plantphysiol.org](http://www.plantphysiol.org), is considered the journal of record.

**On the Cover:** In situ hybridization with the thioredoxin *m* (*TRX m*) antisense probe of a flower longitudinal section. The chloroplastic *TRX m* signal is prominent in pollen grains, tapetal cells of the anthers, and connective tissue. The two signals in pollen grains appeared to be localized in the generative cell and the tube cell, the latter of which is involved in the process of forming the pollen tube for pollination. The pollen grain cells contain several organelles, endoplasmic reticulum, and plastids with starch used in pollen tube formation and storage substances such as the lipids, proteins, and vitamins. Until recently, the function of the chloroplastic *f* and *m* isoforms in carbon metabolism was very well established in the chloroplast of photosynthetic tissues. The precise function of these proteins in floral organs is not yet clear; however, it appears evident that chloroplastic *TRXs* are localized in heterotrophic tissues and are likely involved in redox regulation of some processes related to ovule and pollen grain maturation, fertilization, and embryo formation. In situ hybridization micrograph image by Juan de Dios Barajas-López.

## ON THE INSIDE

Peter V. Minorsky

573

## GENOME ANALYSIS

<sup>[W][OA]</sup>Transcriptomic and Proteomic Analyses of Pericycle Cells of the Maize Primary Root. Diana Dembinsky, Katrin Woll, Muhammad Saleem, Yan Liu, Yan Fu, Lisa A. Borsuk, Tobias Lamkemeyer, Claudia Fladerer, Johannes Madlung, Brad Barbazuk, Alfred Nordheim, Dan Nettleton, Patrick S. Schnable, and Frank Hochholdinger

575

## SCIENTIFIC CORRESPONDENCE

Extracellular ATP Induces Nitric Oxide Production in Tomato Cell Suspensions. Noelia P. Foresi, Ana M. Laxalt, Claudia V. Tonón, Claudia A. Casalongué, and Lorenzo Lamattina

589

<sup>[W]</sup>Genome-Wide Annotation of Remorins, a Plant-Specific Protein Family: Evolutionary and Functional Perspectives. Sylvain Raffaele, Sébastien Mongrand, Pascal Gamas, Andreas Niebel, and Thomas Ott

593

## RESEARCH ARTICLES

### BIOCHEMICAL PROCESSES AND MACROMOLECULAR STRUCTURES

<sup>[W][OA]</sup>Early Steps in Proanthocyanidin Biosynthesis in the Model Legume *Medicago truncatula*. Yongzhen Pang, Gregory J. Peel, Elane Wright, Zengyu Wang, and Richard A. Dixon

601

<sup>[C]</sup>Unraveling the Difference between Invertases and Fructan Exohydrolases: A Single Amino Acid (Asp-239) Substitution Transforms Arabidopsis Cell Wall Invertase1 into a Fructan 1-Exohydrolase. Katrien Le Roy, Willem Lammens, Maureen Verhaest, Barbara De Coninck, Anja Rabijns, André Van Laere, and Wim Van den Ende

616

Continued on next page

- <sup>[W]</sup>Reduced Expression of Succinyl-Coenzyme A Ligase Can Be Compensated for by Up-Regulation of the  $\gamma$ -Aminobutyrate Shunt in Illuminated Tomato Leaves. *Claudia Studart-Guimarães, Aaron Fait, Adriano Nunes-Nesi, Fernando Carrari, Björn Usadel, and Alisdair R. Fernie* 626
- <sup>[W]</sup>Alteration of Organic Acid Metabolism in Arabidopsis Overexpressing the Maize C<sub>4</sub> NADP-Malic Enzyme Causes Accelerated Senescence during Extended Darkness. *Holger Fahnenstich, Mariana Saigo, Michaela Niessen, María I. Zanor, Carlos S. Andreo, Alisdair R. Fernie, María F. Drincovich, Ulf-Ingo Flügge, and Verónica G. Maurino* 640
- <sup>[W][OA]</sup>The Cytochrome P450 Enzyme CYP96A15 Is the Midchain Alkane Hydroxylase Responsible for Formation of Secondary Alcohols and Ketones in Stem Cuticular Wax of Arabidopsis. *Stephen Greer, Miao Wen, David Bird, Xuemin Wu, Lacey Samuels, Ljerka Kunst, and Reinhard Jetter* 653
- <sup>[OA]</sup>Biosynthesis of Phytosterol Esters: Identification of a Sterol O-Acyltransferase in Arabidopsis. *Qilin Chen, Lee Steinhauer, Joe Hammerlindl, Wilf Keller, and Jitao Zou* 974
- <sup>[W][OA]</sup>Vitamin Levels, Stress Response, Enzyme Activity, and Gene Regulation of Arabidopsis Lines Mutant in the Pyridoxine/Pyridoxamine 5'-Phosphate Oxidase (PDX3) and the Pyridoxal Kinase (SOS4) Genes Involved in the Vitamin B<sub>6</sub> Salvage Pathway. *Eugenia González, David Daneshmandi, and Margaret E. Daub* 985

## BIOENERGETICS AND PHOTOSYNTHESIS

- <sup>[W][OA]</sup>Distinct Functions for the Two PsbP-Like Proteins PPL1 and PPL2 in the Chloroplast Thylakoid Lumen of Arabidopsis. *Seiko Ishihara, Atsushi Takabayashi, Kunio Ido, Tsuyoshi Endo, Kentaro Ifuku, and Fumihiko Sato* 668
- <sup>[W][OA]</sup>Lateral CO<sub>2</sub> Diffusion inside Dicotyledonous Leaves Can Be Substantial: Quantification in Different Light Intensities. *James I.L. Morison, Tracy Lawson, and Gabriel Cornic* 680
- Dual Role of the Plastid Terminal Oxidase in Tomato. *Maryam Shahbazi, Matthias Gilbert, Anne-Marie Labouré, and Marcel Kuntz* 691
- Photoprotection in the Lichen *Parmelia sulcata*: The Origins of Desiccation-Induced Fluorescence Quenching. *John Veerman, Sergej Vasil'ev, Gavin D. Paton, Justin Ramanauskas, and Doug Bruce* 997
- <sup>[OA]</sup>The Role of Phosphoenolpyruvate Carboxylase during C<sub>4</sub> Photosynthetic Isotope Exchange and Stomatal Conductance. *Asaph B. Cousins, Irene Baroli, Murray R. Badger, Alexander Ivakov, Peter J. Lea, Richard C. Leegood, and Susanne von Caemmerer* 1006
- <sup>[C][W][OA]</sup>Transcriptional Regulation of the Respiratory Genes in the Cyanobacterium *Synechocystis* sp. PCC 6803 during the Early Response to Glucose Feeding. *Sanghyeob Lee, Jee-Youn Ryu, Soo Youn Kim, Jae-Heung Jeon, Ji Young Song, Hyung-Taeg Cho, Sang-Bong Choi, Doil Choi, Nicole Tandeau de Marsac, and Youn-Il Park* 1018

## CELL BIOLOGY AND SIGNAL TRANSDUCTION

- <sup>[OA]</sup>Functional Sieve Element Protoplasts. *Jens B. Hafke, Alexandra C.U. Furch, Marco U. Reitz, and Aart J.E. van Bel* 703

## DEVELOPMENT AND HORMONE ACTION

- <sup>[C][W]</sup>Phage-Type RNA Polymerase RPOTmp Transcribes the *rrn* Operon from the PC Promoter at Early Developmental Stages in Arabidopsis. *Florence Courtois, Livia Merendino, Emilie Demarsy, Régis Mache, and Silva Lerbs-Mache* 712
- <sup>[W][OA]</sup>*yucca6*, a Dominant Mutation in Arabidopsis, Affects Auxin Accumulation and Auxin-Related Phenotypes. *Jeong Im Kim, Altanbadralt Sharkhuu, Jing Bo Jin, Pinghua Li, Jae Cheol Jeong, Dongwon Baek, Sang Yeol Lee, Joshua J. Blakeslee, Angus S. Murphy, Hans J. Bohnert, Paul M. Hasegawa, Dae-Jin Yun, and Ray A. Bressan* 722
- <sup>[W][OA]</sup>Participation of the Arabidopsis bHLH Factor GL3 in Trichome Initiation Regulatory Events. *Kengo Morohashi, Mingzhe Zhao, Manli Yang, Betsy Read, Alan Lloyd, Rebecca Lamb, and Erich Grotewold* 736

Continued on next page

- [W][OA] Global Expression Profiling Applied to the Analysis of Arabidopsis Stamen Development. *Márcio Alves-Ferreira, Frank Wellmer, Aline Banhara, Vijaya Kumar, José Luis Riechmann, and Elliot M. Meyerowitz* 747
- [W][OA] Loss of Stability: A New Look at the Physics of Cell Wall Behavior during Plant Cell Growth. *Chunfang Wei and Philip M. Lintilhac* 763
- [C][W] Genetic Characterization of Mutants Resistant to the Antiauxin *p*-Chlorophenoxyisobutyric Acid Reveals That *AAR3*, a Gene Encoding a DCN1-Like Protein, Regulates Responses to the Synthetic Auxin 2,4-Dichlorophenoxyacetic Acid in Arabidopsis Roots. *Kamal Kanti Biswas, Chiharu Ooura, Kanako Higuchi, Yuji Miyazaki, Vinh Van Nguyen, Abidur Rahman, Hirofumi Uchimiya, Tomohiro Kiyosue, Tomokazu Koshihara, Atsushi Tanaka, Issay Narumi, and Yutaka Oono* 773
- [W] Cytokinins in the Bryophyte *Physcomitrella patens*: Analyses of Activity, Distribution, and Cytokinin Oxidase/Dehydrogenase Overexpression Reveal the Role of Extracellular Cytokinins. *Klaus von Schwartzenberg, Marta Fernández Núñez, Hanna Blaschke, Petre I. Dobrev, Ondrej Novák, Václav Motyka, and Miroslav Strnad* 786
- [W][OA] The Ubiquitin-Specific Protease Subfamily UBP3/UBP4 Is Essential for Pollen Development and Transmission in Arabidopsis. *Jed H. Doelling, Allison R. Phillips, Gulsum Soyler-Ogretim, Jasen Wise, Jennifer Chandler, Judy Callis, Marisa S. Otegui, and Richard D. Vierstra* 801
- [W][OA] Genetic and Molecular Regulation by DELLA Proteins of Trichome Development in Arabidopsis. *Yinbo Gan, Hao Yu, Jinrong Peng, and Pierre Broun* 1031
- [W][OA] Phytochrome Induces Rapid PIF5 Phosphorylation and Degradation in Response to Red-Light Activation. *Yu Shen, Rajnish Khanna, Christine M. Carle, and Peter H. Quail* 1043

## ENVIRONMENTAL STRESS AND ADAPTATION TO STRESS

- [OA] *STRESS RESPONSE SUPPRESSOR1* and *STRESS RESPONSE SUPPRESSOR2*, Two DEAD-Box RNA Helicases That Attenuate Arabidopsis Responses to Multiple Abiotic Stresses. *Pragya Kant, Surya Kant, Michal Gordon, Ruth Shaked, and Simon Barak* 814
- [W][OA] Rice P<sub>1B</sub>-Type Heavy-Metal ATPase, OsHMA9, Is a Metal Efflux Protein. *Sichul Lee, Yu-Young Kim, Youngsook Lee, and Gynheung An* 831
- [W][OA] Characterization of *AtALMT1* Expression in Aluminum-Inducible Malate Release and Its Role for Rhizotoxic Stress Tolerance in Arabidopsis. *Yuriko Kobayashi, Owen A. Hoekenga, Hirotaka Itoh, Midori Nakashima, Shoichiro Saito, Jon E. Shaff, Lyza G. Maron, Miguel A. Piñeros, Leon V. Kochian, and Hiroyuki Koyama* 843
- [W] *AtREV1*, a Y-Family DNA Polymerase in Arabidopsis, Has Deoxynucleotidyl Transferase Activity in Vitro. *Shinya Takahashi, Ayako N. Sakamoto, Atsushi Tanaka, and Kikuo Shimizu* 1052
- Polyamines Improve K<sup>+</sup>/Na<sup>+</sup> Homeostasis in Barley Seedlings by Regulating Root Ion Channel Activities. *Fugeng Zhao, Chun-Peng Song, Jiaqian He, and Hui Zhu* 1061

## PLANTS INTERACTING WITH OTHER ORGANISMS

- [W] A Central Role of Abscisic Acid in Drought Stress Protection of *Agrobacterium*-Induced Tumors on Arabidopsis. *Marina Efetova, Jürgen Zeier, Markus Riederer, Chil-Woo Lee, Nadja Stingl, Martin Mueller, Wolfram Hartung, Rainer Hedrich, and Rosalia Deeken* 853
- [OA] A Nonclassical Arabinogalactan Protein Gene Highly Expressed in Vascular Tissues, *AGP31*, Is Transcriptionally Repressed by Methyl Jasmonic Acid in Arabidopsis. *Chenggang Liu and Mona C. Mehdy* 863
- [W] A Proteinaceous Elicitor Sm1 from the Beneficial Fungus *Trichoderma virens* Is Required for Induced Systemic Resistance in Maize. *Slavica Djonović, Walter A. Vargas, Michael V. Kolomiets, Michelle Horndeski, Aric Wiest, and Charles M. Kenerley* 875
- [W][OA] Hydrogen Peroxide Generation by the Pepper Extracellular Peroxidase CaPO2 Activates Local and Systemic Cell Death and Defense Response to Bacterial Pathogens. *Hyong Woo Choi, Young Jin Kim, Sung Chul Lee, Jeum Kyu Hong, and Byung Kook Hwang* 890

## WHOLE PLANT AND ECOPHYSIOLOGY

- The Silver Lining of a Viral Agent: Increasing Seed Yield and Harvest Index in Arabidopsis by Ectopic Expression of the Potato Leaf Roll Virus Movement Protein. *Kristin Kronberg, Florian Vogel, Twan Rutten, Mohammed-Reza Hajirezaei, Uwe Sonnewald, and Daniel Hofius* 905
- Genotypic Difference in Silicon Uptake and Expression of Silicon Transporter Genes in Rice. *Jian Feng Ma, Naoki Yamaji, Kazunori Tamai, and Namiki Mitani* 919

## SYSTEMS BIOLOGY, MOLECULAR BIOLOGY, AND GENE REGULATION

- <sup>[W]</sup><sup>[OA]</sup>CIRCADIAN CLOCK ASSOCIATED1 Transcript Stability and the Entrainment of the Circadian Clock in Arabidopsis. *Esther Yakir, Dror Hilman, Miriam Hassidim, and Rachel M. Green* 925
- <sup>[OA]</sup>Wild-Type Opaque2 and Defective opaque2 Polypeptides Form Complexes in Maize Endosperm Cells and Bind the Opaque2-Zein Target Site. *Floriana Gavazzi, Barbara Lazzari, Pietro Ciceri, Elisabetta Gianazza, and Angelo Viotti* 933
- <sup>[OA]</sup>Localization in Roots and Flowers of Pea Chloroplastic Thioredoxin *f* and Thioredoxin *m* Proteins Reveals New Roles in Nonphotosynthetic Organs. *Juan de Dios Barajas-López, Antonio Jesús Serrato, Adela Olmedilla, Ana Chueca, and Mariam Sahrawy* 946
- <sup>[W]</sup><sup>[OA]</sup>Differential Expansion and Expression of  $\alpha$ - and  $\beta$ -Tubulin Gene Families in *Populus*. *Rodney V. Oakley, Yuh-Shuh Wang, Wusirika Ramakrishna, Scott A. Harding, and Chung-Jui Tsai* 961
- <sup>[W]</sup>Transcription Factor RAP2.2 and Its Interacting Partner SINAT2: Stable Elements in the Carotenogenesis of Arabidopsis Leaves. *Ralf Welsch, Dirk Maass, Tanja Voegel, Dean DellaPenna, and Peter Beyer* 1073

## CORRECTIONS

- CYP71B15 (PAD3) Catalyzes the Final Step in Camalexin Biosynthesis. *R. Schuhegger, M. Nafisi, M. Mansourova, B.L. Petersen, C.E. Olsen, A. Svatoš, B.A. Halkier, and E. Glawischnig* 1086

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

<sup>[W]</sup> Indicates Web-only data.

<sup>[OA]</sup> Open Access articles can be viewed online without a subscription.