

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

On the Cover: A canopy of rye (*Secale cereale*) growing at the Plant Breeding Institute (Cambridge, UK). Leaves are displayed in an array that distributes sunlight across a surface much greater than the land area. Carbon dioxide uptake requires gas exchange between surrounding air and the intercellular airspaces through stomatal pores and the inevitable loss of water via transpiration. Breeding tries to maximize the allocation of the products of photosynthesis into the harvested organ, in this case the grain. Photo taken by John R. Evans.

EDITORIALS

Founders Review 2011 1

FOUNDERS REVIEW

Ascorbate and Glutathione: The Heart of the Redox Hub. *Christine H. Foyer and Graham Noctor* 2

FOCUS ISSUE ON ENHANCING PHOTOSYNTHESIS

EDITORIALS

Enhancing Photosynthesis. *John R. Evans and Susanne von Caemmerer* 19

UPDATES

^[W]The Prospect of Using Cyanobacterial Bicarbonate Transporters to Improve Leaf Photosynthesis in C₃ Crop Plants. *G. Dean Price, Murray R. Badger, and Susanne von Caemmerer* 20

^[W]Advancing Our Understanding and Capacity to Engineer Nature's CO₂-Sequestering Enzyme, Rubisco. *Spencer M. Whitney, Robert L. Houtz, and Hernan Alonso* 27

Increasing Photosynthetic Carbon Assimilation in C₃ Plants to Improve Crop Yield: Current and Future Strategies. *Christine A. Raines* 36

Do Metabolite Transport Processes Limit Photosynthesis? *Andrea Bräutigam and Andreas P.M. Weber* 43

Photorespiration Redesigned. *Christoph Peterhansel and Veronica G. Maurino* 49

The Path from C₃ to C₄ Photosynthesis. *Udo Gowik and Peter Westhoff* 56

Carbohydrate Export from the Leaf: A Highly Regulated Process and Target to Enhance Photosynthesis and Productivity. *Elizabeth A. Ainsworth and Daniel R. Bush* 64

^[W]The Importance of Energy Balance in Improving Photosynthetic Productivity. *David M. Kramer and John R. Evans* 70

^[W]Optimizing Antenna Size to Maximize Photosynthetic Efficiency. *Donald R. Ort, Xinguang Zhu (朱新广), and Anastasios Melis* 79

Manipulation of Photoprotection to Improve Plant Photosynthesis. *Erik H. Murchie and Krishna K. Niyogi* 86

Understanding Oxidative Stress and Antioxidant Functions to Enhance Photosynthesis. *Christine H. Foyer and Shigeru Shigeoka* 93

Targeting Mitochondrial Metabolism and Machinery as a Means to Enhance Photosynthesis. *Adriano Nunes-Nesi, Wagner L. Araujo, and Alisdair R. Fernie* 101

Leaf Functional Anatomy in Relation to Photosynthesis. *Ichiro Terashima, Yuko T. Hanba, Danny Tholen, and Ülo Niinemets* 108

^[W]Does Enhanced Photosynthesis Enhance Growth? Lessons Learned from CO₂ Enrichment Studies. *Miko U.F. Kirschbaum* 117

Continued on next page

Photosynthesis, Grain Yield, and Nitrogen Utilization in Rice and Wheat. *Amane Makino* 125

RESEARCH ARTICLES

^[OA]The *GDC1* Gene Encodes a Novel Ankyrin Domain-Containing Protein That Is Essential for Grana Formation in Arabidopsis. *Yong-Lan Cui, Qi-Shi Jia, Qian-Qian Yin, Guan-Nan Lin, Meng-Meng Kong, and Zhong-Nan Yang* 130

^{[W][OA]}An mRNA Blueprint for C₄ Photosynthesis Derived from Comparative Transcriptomics of Closely Related C₃ and C₄ Species. *Andrea Bräutigam, Kaisa Kajala, Julia Wullenweber, Manuel Sommer, David Gagneul, Katrin L. Weber, Kevin M. Carr, Udo Gowik, Janina Maß, Martin J. Lercher, Peter Westhoff, Julian M. Hibberd, and Andreas P.M. Weber* 142

^{[W][OA]}Genetic Variation in Biomass Traits among 20 Diverse Rice Varieties. *Courtney E. Jahn, John K. McKay, Ramil Mauleon, Janice Stephens, Kenneth L. McNally, Daniel R. Bush, Hei Leung, and Jan E. Leach* 157

REGULAR ISSUE

ON THE INSIDE

Peter V. Minorsky 169

UPDATES

Update on Mechanisms of Plant Cell Wall Biosynthesis: How Plants Make Cellulose and Other (1 → 4)-β-D-Glycans. *Nicholas C. Carpita* 171

GENOME ANALYSIS

^{[C][W][OA]}Signaling Pathways Mediating the Induction of Apple Fruitlet Abscission. *Alessandro Botton, Giulia Eccher, Claudio Forcato, Alberto Ferrarini, Maura Begheldo, Monica Zermiani, Stefano Moscatello, Alberto Battistelli, Riccardo Velasco, Benedetto Ruperti, and Angelo Ramina* 185

^{[C][W]}Unraveling the Evolution of Auxin Signaling. *Ive De Smet, Ute Vofß, Steffen Lau, Michael Wilson, Ning Shao, Ruth E. Timme, Ranjan Swarup, Ian Kerr, Charlie Hodgman, Ralph Bock, Malcolm Bennett, Gerd Jürgens, and Tom Beeckman* 209

BREAKTHROUGH TECHNOLOGIES

^{[C][OA]}Release of Hormones from Conjugates: Chloroplast Expression of β-Glucosidase Results in Elevated Phytohormone Levels Associated with Significant Increase in Biomass and Protection from Aphids or Whiteflies Conferred by Sucrose Esters. *Shuangxia Jin, Anderson Kanagaraj, Dheeraj Verma, Theo Lange, and Henry Daniell* 222

^{[W][OA]}Leaf Extraction and Analysis Framework Graphical User Interface: Segmenting and Analyzing the Structure of Leaf Veins and Areoles. *Charles A. Price, Olga Symonova, Yuriy Mileyko, Troy Hillely, and Joshua S. Weitz* 236

^{[W][OA]}Mechanical Properties of Plant Cell Walls Probed by Relaxation Spectra. *Steen Laugesen Hansen, Peter Martin Ray, Anders Ola Karlsson, Bodil Jørgensen, Bernhard Borkhardt, Bent Larsen Petersen, and Peter Ulvskov* 246

BIOINFORMATICS

^{[C][OA]}MASCP Gator: An Aggregation Portal for the Visualization of Arabidopsis Proteomics Data. *Hiren J. Joshi, Matthias Hirsch-Hoffmann, Katja Baerenfaller, Wilhelm Gruissem, Sacha Baginsky, Robert Schmidt, Waltraud X. Schulze, Qi Sun, Klaas J. van Wijk, Volker Egelhofer, Stefanie Wienkoop, Wolfram Weckwerth, Christophe Bruley, Norbert Rolland, Tetsuro Toyoda, Hirofumi Nakagami, Alexandra M. Jones, Steven P. Briggs, Ian Castleden, Sandra K. Tanz, A. Harvey Millar, and Joshua L. Heazlewood* 259

Continued on next page

- [C][W][OA] Genome-Wide Computational Function Prediction of Arabidopsis Proteins by Integration of Multiple Data Sources. *Yiannis A.I. Kourmpetis, Aalt D.J. van Dijk, Roeland C.H.J. van Ham, and Cajo J.F. ter Braak* 271

BIOCHEMICAL PROCESSES AND MACROMOLECULAR STRUCTURES

- [OA] Biosynthesis of the Cyanogenic Glucosides Linamarin and Lotaustralin in Cassava: Isolation, Biochemical Characterization, and Expression Pattern of CYP71E7, the Oxime-Metabolizing Cytochrome P450 Enzyme. *Kirsten Jørgensen, Anne Vinther Morant, Marc Morant, Niels Bjerg Jensen, Carl Erik Olsen, Rubini Kannangara, Mohammed Saddik Motawia, Birger Lindberg Møller, and Søren Bak* 282
- [C][W][OA] Reverse-Genetic Analysis of the Two Biotin-Containing Subunit Genes of the Heteromeric Acetyl-Coenzyme A Carboxylase in Arabidopsis Indicates a Unidirectional Functional Redundancy. *Xu Li, Hilal Ilarslan, Libuse Brachova, Hui-Rong Qian, Ling Li, Ping Che, Eve Syrkin Wurtele, and Basil J. Nikolau* 293
- [OA] Selenium Accumulation, Distribution, and Speciation in Spineless Prickly Pear Cactus: A Drought- and Salt-Tolerant, Selenium-Enriched Nutraceutical Fruit Crop for Biofortified Foods. *Gary S. Bañuelos, Sirine C. Fakra, Spencer S. Walse, Matthew A. Marcus, Soo In Yang, Ingrid J. Pickering, Elizabeth A.H. Pilon-Smits, and John L. Freeman* 315
- [W][OA] Callose Synthase GSL7 Is Necessary for Normal Phloem Transport and Inflorescence Growth in Arabidopsis. *D.H. Paul Barratt, Katharina Kölling, Alexander Graf, Marilyn Pike, Grant Calder, Kim Findlay, Samuel C. Zeeman, and Alison M. Smith* 328
- [C][W][OA] Two Oxidosqualene Cyclases Responsible for Biosynthesis of Tomato Fruit Cuticular Triterpenoids. *Zhonghua Wang, Ortwin Guhling, Ruonan Yao, Fengling Li, Trevor H. Yeats, Jocelyn K.C. Rose, and Reinhard Jetter* 540

CELL BIOLOGY AND SIGNAL TRANSDUCTION

- [W][OA] A Mutation in Arabidopsis *SEEDLING PLASTID DEVELOPMENT1* Affects Plastid Differentiation in Embryo-Derived Tissues during Seedling Growth. *Nicholas J. Ruppel, Charles A. Logsdon, Craig W. Whippo, Kentaro Inoue, and Roger P. Hangarter* 342
- [W][OA] Plastids Contain a Second Sec Translocase System with Essential Functions. *Courtney A. Skalitzky, Jonathan R. Martin, Jessica H. Harwood, John J. Beirne, Benjamin J. Adamczyk, Gregory R. Heck, Kenneth Cline, and Donna E. Fernandez* 354
- [C][W][OA] Involvement of Arabidopsis RACK1 in Protein Translation and Its Regulation by Abscisic Acid. *Jianjun Guo, Shucui Wang, Oliver Valerius, Hardy Hall, Qingning Zeng, Jian-Feng Li, David J. Weston, Brian E. Ellis, and Jin-Gui Chen* 370
- [W][OA] The Arabidopsis Calcium-Dependent Protein Kinase, CPK6, Functions as a Positive Regulator of Methyl Jasmonate Signaling in Guard Cells. *Shintaro Munemasa, Mohammad Anwar Hossain, Yoshimasa Nakamura, Izumi C. Mori, and Yoshiyuki Murata* 553
- [C][W][OA] Maturation Stress Generation in Poplar Tension Wood Studied by Synchrotron Radiation Microdiffraction. *Bruno Clair, Tancrede Alméras, Gilles Pilate, Delphine Jullien, Junji Sugiyama, and Christian Riekel* 562

DEVELOPMENT AND HORMONE ACTION

- [C][W][OA] SHORT-ROOT Regulates Primary, Lateral, and Adventitious Root Development in Arabidopsis. *Mikaël Lucas, Ranjan Swarup, Ivan A. Paponov, Kamal Swarup, Ilda Casimiro, David Lake, Benjamin Peret, Susan Zappala, Stefan Mairhofer, Morag Whitworth, Jiehua Wang, Karin Ljung, Alan Marchant, Goran Sandberg, Michael J. Holdsworth, Klaus Palme, Tony Pridmore, Sacha Mooney, and Malcolm J. Bennett* 384
- [W][OA] Xyloglucan *endo*-Transglycosylase-Mediated Xyloglucan Rearrangements in Developing Wood of Hybrid Aspen. *Nobuyuki Nishikubo, Junko Takahashi, Alexandra A. Roos, Marta Derba-Maceluch, Kathleen Piens, Harry Brumer, Tuula T. Teeri, Henrik Stålbrand, and Ewa J. Mellerowicz* 399

ENVIRONMENTAL STRESS AND ADAPTATION TO STRESS

- [W] Role of AtPol ζ , AtRev1, and AtPol η in UV Light-Induced Mutagenesis in Arabidopsis. *Mayu Nakagawa, Shinya Takahashi, Atsushi Tanaka, Issay Narumi, and Ayako N. Sakamoto* 414

- [C][W] Expression of *StMYB1R-1*, a Novel Potato Single MYB-Like Domain Transcription Factor, Increases Drought Tolerance. Dongjin Shin, Seok-Jun Moon, Seyoun Han, Beom-Gi Kim, Sang Ryeol Park, Seong-Kon Lee, Hye-Jin Yoon, Hye Eun Lee, Hawk-Bin Kwon, Dongwon Baek, Bu Young Yi, and Myung-Ok Byun 421
- [W] Transient Proliferation of Proanthocyanidin-Accumulating Cells on the Epidermal Apex Contributes to Highly Aluminum-Resistant Root Elongation in Camphor Tree. Hiroki Osawa, Izuki Endo, Yukari Hara, Yuki Matsushima, and Takeshi Tange 433
- [C][W][OA] Manganese Limitation Induces Changes in the Activity and in the Organization of Photosynthetic Complexes in the Cyanobacterium *Synechocystis* sp. Strain PCC 6803. Eitan Salomon and Nir Keren 571
- [C][OA] Induction of *BAP1* by a Moderate Decrease in Temperature Is Mediated by *ICE1* in Arabidopsis. Ying Zhu, Huijun Yang, Hyung-Gon Mang, and Jian Hua 580

PLANTS INTERACTING WITH OTHER ORGANISMS

- [C][W][OA] The Pepper Mannose-Binding Lectin Gene *CaMBL1* Is Required to Regulate Cell Death and Defense Responses to Microbial Pathogens. In Sun Hwang and Byung Kook Hwang 447
- [W][OA] Low Oleic Acid-Derived Repression of Jasmonic Acid-Inducible Defense Responses Requires the WRKY50 and WRKY51 Proteins. Qing-Ming Gao, Srivathsa Venugopal, Duroy Navarre, and Aardra Kachroo 464
- [W] Proteasome Activity Imaging and Profiling Characterizes Bacterial Effector Syringolin A. Izabella Kolodziejek, Johana C. Misas-Villamil, Farnusch Kaschani, Jérôme Clerc, Christian Gu, Daniel Krahn, Sherry Niessen, Martijn Verdoes, Lianne I. Willems, Hermen S. Overkleeft, Markus Kaiser, and Renier A.L. van der Hoorn 477
- [W][OA] Two Host Cytoplasmic Effectors Are Required for Pathogenesis of *Phytophthora sojae* by Suppression of Host Defenses. Tingli Liu, Wenwu Ye, Yanyan Ru, Xinyu Yang, Biao. Gu, Kai Tao, Shan Lu, Suomeng Dong, Xiaobo Zheng, Weixing Shan, Yuanchao Wang, and Daolong Dou 490
- [W][OA] Cyanide, a Coproduct of Plant Hormone Ethylene Biosynthesis, Contributes to the Resistance of Rice to Blast Fungus. Shigemi Seo, Ichiro Mitsuhashi, Jiao Feng, Takayoshi Iwai, Morifumi Hasegawa, and Yuko Ohashi 502
- [C][W][OA] Manipulating Broad-Spectrum Disease Resistance by Suppressing Pathogen-Induced Auxin Accumulation in Rice. Jing Fu, Hongbo Liu, Yu Li, Huihui Yu, Xianghua Li, Jinghua Xiao, and Shiping Wang 589

WHOLE PLANT AND ECOPHYSIOLOGY

- [OA] Stable Isotopes Reveal the Contribution of Corticular Photosynthesis to Growth in Branches of *Eucalyptus miniata*. Lucas A. Cernusak and Lindsay B. Hutley 515
- [W] Unexpected Presence of Graminan- and Levan-Type Fructans in the Evergreen Frost-Hardy Eudicot *Pachysandra terminalis* (Buxaceae): Purification, Cloning, and Functional Analysis of a 6-SST/6-SFT Enzyme. Wim Van den Ende, Marlies Coopman, Stefan Clerens, Rudy Vergauwen, Katrien Le Roy, Willem Lammens, and André Van Laere 603

SYSTEMS BIOLOGY, MOLECULAR BIOLOGY, AND GENE REGULATION

- [W][OA] Comparative Functional Genomic Analysis of *Solanum* Glandular Trichome Types. Eric T. McDowell, Jeremy Kapteyn, Adam Schmidt, Chao Li, Jin-Ho Kang, Anne Descour, Feng Shi, Matthew Larson, Anthony Schillmiller, Lingling An, A. Daniel Jones, Eran Pichersky, Carol A. Soderlund, and David R. Gang 524

[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.