

A fluorescence micrograph of plant cells, likely from a leaf. The image shows a large, bright orange-red cell with numerous smaller, bright yellow-green spots scattered throughout its interior. The cell's boundary is visible on the left side, showing a network of green lines. The background is dark, making the glowing cells stand out.

# *Plant Physiology*<sup>®</sup>

April 2014 • Volume 164 • Number 4

[www.plantphysiol.org](http://www.plantphysiol.org)

**Focus Issue on Water**

**Michael R. Blatt,  
François Chaumont, and  
Graham Farquhar, Editors**

The electronic form of this issue, available as of April 8, 2014, at [www.plantphysiol.org](http://www.plantphysiol.org), is considered the journal of record.

**On the Cover:** Guard cells use an elegant signaling pathway to regulate the aperture of stomata, pores that facilitate gas exchange. In response to abscisic acid (ABA), reactive oxygen species (ROS) are produced in a transient burst acting as second messengers to induce stomatal closure. ROS concentrations must be tightly regulated by an antioxidant network that minimizes ROS concentrations, preventing oxidative damage and modulating ROS signaling within the cell. In this issue, Watkins et al. (pp. 1707–1717) test the hypothesis that accumulation of flavonols acts to modulate ROS in guard cells, but not surrounding pavement cells. Flavonol accumulation and ROS levels were visualized by fluorescent dyes, illustrating that flavonols accumulate in guard cells, reducing ROS levels in the wild type. In guard cells of *tt4*, a flavonoid-deficient mutant, ROS levels are elevated over the wild type. The increased ROS in *tt4* was sufficient to enhance ABA-dependent stomatal closure. Watkins et al. also observed increased flavonol accumulation in response to ethylene, resulting in a further reduction of ROS concentrations and inhibited stomatal closure in response to ABA. The cover shows an epifluorescent image of a whole leaf stained with a flavonol-specific fluorescent dye (yellow) and chlorophyll autofluorescence (red) imaged at 100× magnification. Cover image credits: Justin Watkins and Gloria Muday.

## FOCUS ON WATER

### EDITORIAL

*Michael R. Blatt, François Chaumont, and Graham Farquhar*

1553

### TOPICAL REVIEWS

<sup>[C]</sup>Stomatal Size, Speed, and Responsiveness Impact on Photosynthesis and Water Use Efficiency. *Tracy Lawson and Michael R. Blatt*

*Analysis of stomatal parameters highlights strategies to improve stomatal control of gas exchange and transpiration for enhanced water use efficiency without compromising CO<sub>2</sub> uptake for photosynthesis.*

1556

### BREAKTHROUGH TECHNOLOGIES

<sup>[C|W]</sup>Monitoring Plant Drought Stress Response Using Terahertz Time-Domain Spectroscopy. *Norman Born, David Behringer, Sascha Liepelt, Sarah Beyer, Michael Schwerdtfeger, Birgit Ziegenhagen, and Martin Koch*

*A terahertz measurement setup precisely monitors changes in the water status of multiple plants in experiments under controlled environmental conditions.*

1571

### RESEARCH REPORTS

<sup>[OPEN]</sup>Separating Active and Passive Influences on Stomatal Control of Transpiration. *Scott A.M. McAdam and Timothy J. Brodribb*

*Stomatal closure during water stress in the conifer *Metasequoia glyptostroboides* transitions from being entirely passive under moderate water stress to predominantly active, mediated by the level of foliar ABA, under more severe water stress.*

1578

<sup>[W]</sup>Intertissue Signal Transfer of Abscisic Acid from Vascular Cells to Guard Cells. *Takashi Kuromori, Eriko Sugimoto, and Kazuo Shinozaki*

*ABA biosynthetic enzymes expressed in vascular tissues induce stomatal closure, indicating that long-distance ABA signal transfer from the vascular bundle is likely to be mediated by specific transporters.*

1587

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[W][OPEN] Systems Analysis of Guard Cell Membrane Transport for Enhanced Stomatal Dynamics and Water Use Efficiency. *Yizhou Wang, Adrian Hills, and Michael R. Blatt*

*Systems analysis of stomatal kinetics identifies the gating of the dominant K<sup>+</sup> channels as a promising target for genetic manipulations directed to improving water use efficiency in two plant models.* 1593

## UPDATES

Aquaporins: Highly Regulated Channels Controlling Plant Water Relations. *François Chaumont and Stephen D. Tyerman*

*Aquaporins are highly regulated water channels that contribute to the control of water movement at the cell, tissue, and organ levels and, hence, to the overall plant water relations in varying environmental conditions.* 1600

Plant Water Uptake in Drying Soils. *Guillaume Lobet, Valentin Couvreur, Félicien Meunier, Mathieu Javaux, and Xavier Draye*

*Integrative soil-plant system approaches are needed to understand plant water uptake dynamics.* 1619

Genetic and Physiological Controls of Growth under Water Deficit. *François Tardieu, Boris Parent, Cecilio F. Caldeira, and Claude Welcker*

*The sensitivity of expansive growth to water deficit has a large genetic variability, higher than that of photosynthesis, and reflects distinct genetic and physiological controls.* 1628

[C][W] The Roles of Reactive Oxygen Metabolism in Drought: Not So Cut and Dried. *Graham Noctor, Anna Mhamdi, and Christine H. Foyer*

*Reactive oxygen metabolism affects physiology during drought, with implications for the potential roles of antioxidant systems in restricting oxidative stress and in transmitting oxidative stress signals in these conditions.* 1636

[C] Cavitation and Its Discontents: Opportunities for Resolving Current Controversies. *Fulton E. Rockwell, James K. Wheeler, and N. Michele Holbrook*

*An understanding of cavitation and the spread of embolism in plant xylem can be viewed from the perspective of physical models of air seeding, the potential for artifacts to interact with natural variation in xylem structure, and new technologies that could lead to their resolution.* 1649

[C] Biodesalination: A Case Study for Applications of Photosynthetic Bacteria in Water Treatment. *Jaime M. Amezaga, Anna Amtmann, Catherine A. Biggs, Tom Bond, Catherine J. Gandy, Annegret Honsbein, Esther Karunakaran, Linda Lawton, Mary Ann Madsen, Konstantinos Minas, and Michael R. Templeton*

*Current knowledge, methodologies, and public acceptance issues present challenges and opportunities for the use of cyanobacteria in water treatment.* 1661

## RESEARCH ARTICLES

[C][W][OPEN] Abscisic Acid Flux Alterations Result in Differential Abscisic Acid Signaling Responses and Impact Assimilation Efficiency in Barley under Terminal Drought Stress. *Christiane Seiler, Vokkaliga T. Harshavardhan, Palakolanu Sudhakar Reddy, Götz Hensel, Jochen Kumlehn, Lennart Eschen-Lippold, Kalladan Rajesh, Viktor Korzun, Ulrich Wobus, Justin Lee, Gopalan Selvaraj, and Nese Sreenivasulu*

*ABA homeostasis achieved in stress-tolerant lines is closely coupled to readjustment in ABA receptors, which enables this line to maintain a favorable WUE and photoassimilate accumulation when challenged by terminal drought.* 1677

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[W]Vegetative and Sperm Cell-Specific Aquaporins of Arabidopsis Highlight the Vacuolar Equipment of Pollen and Contribute to Plant Reproduction. Michael M. Wudick, Doan-Trung Luu, Colette Tournaire-Roux, Wataru Sakamoto, and Christophe Maurel

*Two pollen-specific aquaporins are localized in the vacuoles of the vegetative and sperm cells, respectively, and contribute to reproduction under adverse environmental conditions.*

1697

[W][OPEN]Ethylene-Induced Flavonol Accumulation in Guard Cells Suppresses Reactive Oxygen Species and Moderates Stomatal Aperture. Justin M. Watkins, Paul J. Hechler, and Gloria K. Muday

*In the epidermis of Arabidopsis leaves, flavonols specifically accumulate in guard cells with enhanced synthesis in the presence of ethylene, where they lower the levels of reactive oxygen species and reduce the rate of stomatal closure.*

1707

[C][W][OPEN]A Hydraulic Model Is Compatible with Rapid Changes in Leaf Elongation under Fluctuating Evaporative Demand and Soil Water Status. Cecilio F. Caldeira, Mickael Bosio, Boris Parent, Linda Jeanguenin, François Chaumont, and François Tardieu

*Changes in evaporative demand or soil water status affect maize leaf growth in less than 1 h, considerably quicker than their effects on transpiration and leaf water potential, consistent with a hydraulic model.*

1718

[C][W][OPEN]Uptake of Water via Branches Helps Timberline Conifers Refill Embolized Xylem in Late Winter.

Stefan Mayr, Peter Schmid, Joan Laur, Sabine Rosner, Katline Charra-Vaskou, Birgit Dämon, and Uwe G. Hacke

*Timberline conifers, which exhibit potentially lethal winter embolism, refill stem xylem with water taken up via branches and water transport to isolated, embolized conduits by active, cellular processes.*

1731

[W][OPEN]The Competition between Liquid and Vapor Transport in Transpiring Leaves. Fulton Ewing Rockwell, N. Michele Holbrook, and Abraham Duncan Stroock

*The competition between internal liquid and vapor transport in transpiring leaves is sensitive to environmental drivers, the sites of evaporation in leaves varying with both leaf structure and external conditions.*

1741

[W][OPEN]Integrated Analysis of the Effects of Cold and Dehydration on Rice Metabolites, Phytohormones, and Gene Transcripts. Kyonoshin Maruyama, Kaoru Urano, Kyouko Yoshiwara, Yoshihiko Morishita, Nozomu Sakurai, Hideyuki Suzuki, Mikiko Kojima, Hitoshi Sakakibara, Daisuke Shibata, Kazuki Saito, Kazuo Shinozaki, and Kazuko Yamaguchi-Shinozaki

*In cold- or dehydration-stressed rice plants, up-regulation of genes related to starch degradation, sucrose metabolism, and the glyoxylate cycle results in the accumulation of sugars and with abscisic acid signaling is inversely related to cytokinin signaling.*

1759

[C][W][OPEN]Leaf Shrinkage with Dehydration: Coordination with Hydraulic Vulnerability and Drought Tolerance. Christine Scoffoni, Christine Vuong, Steven Diep, Hervé Cochard, and Lauren Sack

*Leaf shrinkage is a potential driver of leaf hydraulic vulnerability, especially under mild stress, and carries strong ecological implications.*

1772

[C][W]Down-Regulation of Plasma Intrinsic Protein1 Aquaporin in Poplar Trees Is Detrimental to Recovery from Embolism. Francesca Secchi and Maciej A. Zwieniecki

*Aquaporins are involved in the maintenance of xylem transport system capacity, they promote recovery from stress, and they contribute to the control of stomatal conductance under water stress.*

1789

[W][OPEN]Polarity of Water Transport across Epidermal Cell Membranes in *Tradescantia virginiana*. Hiroshi Wada, Jiong Fei, Thorsten Knipfer, Mark A. Matthews, Greg Gambetta, and Kenneth Shackel

*An outward bias polarizing of water transport appears to be a property of the intact membrane/protein complex of epidermal cells in situ.*

1800



## REGULAR ISSUE

### ON THE INSIDE

*Peter V. Minorsky*

1810

### RESEARCH REPORTS

<sup>[W][OPEN]</sup>A Plastid without a Genome: Evidence from the Nonphotosynthetic Green Algal Genus *Polytomella*.  
*David Roy Smith and Robert W. Lee*

*Genome and transcriptome sequencing of species from the nonphotosynthetic green algal genus *Polytomella* revealed no evidence of a plastid genome or associated gene expression system and presents an example of a primary plastid-bearing lineage without plastid DNA.*

1812

### BIOCHEMISTRY AND METABOLISM

<sup>[W][OPEN]</sup>Two Arabidopsis Loci Encode Novel Eukaryotic Initiation Factor 4E Isoforms That Are Functionally Distinct from the Conserved Plant Eukaryotic Initiation Factor 4E. *Ryan M. Patrick, Laura K. Mayberry, Grace Choy, Lauren E. Woodard, Joceline S. Liu, Allyson White, Rebecca A. Mullen, Toug M. Tanavin, Christopher A. Latz, and Karen S. Browning*

*Brassicaceae-specific divergent forms of RNA cap-binding proteins do not compete with the conserved form in translation initiation.*

1820

<sup>[W]</sup>Pathway-Level Acceleration of Glycogen Catabolism by a Response Regulator in the Cyanobacterium *Synechocystis* Species PCC 6803. *Takashi Osanai, Akira Oikawa, Keiji Numata, Ayuko Kuwahara, Hiroko Iijima, Yoshiharu Doi, Kazuki Saito, and Masami Yokota Hirai*

*Overexpressing a response regulator accelerates glycogen degradation and polyhydroxybutyrate biosynthesis, revealing pathway-level control of primary metabolism in a unicellular cyanobacterium.*

1831

<sup>[C][W]</sup>CELLULOSE SYNTHASE-LIKE A2, a Glucomannan Synthase, Is Involved in Maintaining Adherent Mucilage Structure in Arabidopsis Seed. *Li Yu, Dachuan Shi, Junling Li, Yingzhen Kong, Yanchong Yu, Guohua Chai, Ruiibo Hu, Juan Wang, Michael G. Hahn, and Gongke Zhou*

*Disruption of a glucomannan synthase alters cellulose crystallinity and spatial distribution, yielding thinner adherent mucilage with increased density in seeds of Arabidopsis.*

1842

<sup>[W][OPEN]</sup>Characterization of Rubisco Activase Genes in Maize: An  $\alpha$ -Isoform Gene Functions alongside a  $\beta$ -Isoform Gene. *Zhitong Yin, Zhenliang Zhang, Dexiang Deng, Maoni Chao, Qingsong Gao, Yijun Wang, Zefeng Yang, Yunlong Bian, Derong Hao, and Chentou Xu*

*An  $\alpha$ -isoform Rubisco activase gene contributes to the synthesis of a large polypeptide in maize.*

2096

<sup>[C][W][OPEN]</sup>Flavan-3-ols in Norway Spruce: Biosynthesis, Accumulation, and Function in Response to Attack by the Bark Beetle-Associated Fungus *Ceratocystis polonica*. *Almuth Hammerbacher, Christian Paetz, Louwance P. Wright, Thilo C. Fischer, Joerg Bohlmann, Andrew J. Davis, Trevor M. Fenning, Jonathan Gershenzon, and Axel Schmidt*

*Monomeric and polymeric flavan-3-ols are antifungal defense compounds in Norway spruce (*Picea abies*).*

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### CELL BIOLOGY

<sup>[OPEN]</sup>Histone H2B Monoubiquitination Is Involved in Regulating the Dynamics of Microtubules during the Defense Response to *Verticillium dahliae* Toxins in Arabidopsis. *Min Hu, Bao-Lei Pei, Li-Fan Zhang, and Ying-Zhang Li*

*Histone monoubiquitination plays an important role in regulating the dynamics of microtubules in response to *Verticillium dahliae* toxins.*

1857

[W][OPEN]Specialization of Oleosins in Oil Body Dynamics during Seed Development in Arabidopsis Seeds. Martine Miquel, Ghassen Trigui, Sabine d'Andréa, Zsolt Kelemen, Sébastien Baud, Adeline Berger, Carine Deruyffelaere, Alain Trubuil, Loïc Lepiniec, and Bertrand Dubreucq

Oil body dynamics reveal new roles for oleosins during seed development. 1866

[W]Processing-Body Movement in Arabidopsis Depends on an Interaction between Myosins and DECAPPING PROTEIN1. Alexandra Steffens, Benjamin Jaegle, Achim Tresch, Martin Hülskamp, and Marc Jakob

Intracellular transport of processing bodies along actin involves an evolutionarily conserved mechanism of direct interaction between myosins and the processing body core P1. 1879

[W][OPEN]The Arabidopsis CALLOSE DEFECTIVE MICROSPORO1 Gene Is Required for Male Fertility through Regulating Callose Metabolism during Microsporogenesis. Pingli Lu, Maofeng Chai, Jiange Yang, Gang Ning, Guoliang Wang, and Hong Ma

Accurate regulation of callose metabolism during microsporogenesis is critical for plant male fertility. 1893

[W][OPEN]Divergent Roles for Maize PAN1 and PAN2 Receptor-Like Proteins in Cytokinesis and Cell Morphogenesis. Dena Sutimantanapi, Dianne Pater, and Laurie G. Smith

Leu-rich receptor-like proteins, previously shown to function cooperatively in polarized cell division of the maize leaf epidermis, are shown to have separate roles in other developmental processes involving polarized membrane trafficking. 1905

## ECOPHYSIOLOGY AND SUSTAINABILITY

[C][W]Global Selection on Sucrose Synthase Haplotypes during a Century of Wheat Breeding. Jian Hou, Qiyan Jiang, Chenyang Hao, Yuquan Wang, Hongna Zhang, and Xueyong Zhang

Endosperm starch synthesis pathway is a major target of indirect selection in global wheat breeding for higher yield. 1918

[C][W][OPEN]Genome Structures and Transcriptomes Signify Niche Adaptation for the Multiple-Ion-Tolerant Extremophyte *Schrenkiella parvula*. Dong-Ha Oh, Hyewon Hong, Sang Yeol Lee, Dae-Jin Yun, Hans J. Bohnert, and Maheshi Dassanayake

Genome structural variations in Arabidopsis-related extremophile modify the transcriptome, endowing competence to survive multiple-ion salt stress in its natural habitat. 2123

## GENES, DEVELOPMENT, AND EVOLUTION

[C][W]Additional Amphivasal Bundles in Pedicel Pith Exacerbate Central Fruit Dominance and Induce Self-Thinning of Lateral Fruitlets in Apple. Jean-Marc Celton, Emmanuelle Dheilily, Marie-Charlotte Guillou, Fabienne Simonneau, Marjorie Juchaux, Evelyne Costes, François Laurens, and Jean-Pierre Renou

Amphivasal bundles in dominant fruits support a role in the subsequent self-abcission of lateral fruits. 1930

[W]Interaction between the GROWTH-REGULATING FACTOR and KNOTTED1-LIKE HOMEODOMAIN Families of Transcription Factors. Suzanne J.H. Kuijt, Raffaella Greco, Adamantia Agalou, Jingxia Shao, Corine C.J. 't Hoen, Elin Övernäs, Michela Osnato, Serena Curiale, Donaldo Meynard, Robert van Gulik, Simone de Faria Maraschin, Mirna Atallah, Rolf J. de Kam, Gerda E.M. Lamers, Emmanuel Guiderdoni, Laura Rossini, Annemarie H. Meijer, and Pieter B.F. Ouzwerker

Members of the GRF family are conserved transcriptional regulators in both monocot and dicot plants. 1952

[W]The SLZF2 Cysteine-2/Histidine-2 Repressor-Like Zinc Finger Transcription Factor Regulates Development and Tolerance to Salinity in Tomato and Arabidopsis. *Imène Hichri, Yordan Muhovski, Eva Žitková, Petre I. Dobrev, Jose Manuel Franco-Zorrilla, Roberto Solano, Irene Lopez-Vidriero, Vaclav Motyka, and Stanley Lutts*

*A tomato transcriptional repressor regulates development and salinity response in Arabidopsis and tomato plants.* 1967

[W][OPEN]Arabidopsis VASCULAR-RELATED UNKNOWN PROTEIN1 Regulates Xylem Development and Growth by a Conserved Mechanism That Modulates Hormone Signaling. *Etienne Grienenberger and Carl J. Douglas*

*A family of evolutionarily conserved proteins found in all vascular plants is a potent regulator of hormone-mediated growth and development.* 1991

[W][OPEN]Reduction of Gibberellin by Low Temperature Disrupts Pollen Development in Rice. *Tadashi Sakata, Susumu Oda, Yuta Tsunaga, Hikaru Shomura, Makiko Kawagishi-Kobayashi, Koichiro Aya, Kenichi Saeki, Takashi Endo, Kuniaki Nagano, Mikiko Kojima, Hitoshi Sakakibara, Masao Watanabe, Makoto Matsuoka, and Atsushi Higashitani*

*Gibberellins and expression of their biosynthesis genes decrease in developing anthers on exposure to moderate low temperatures, disrupting pollen development and reducing grain yields.* 2011

## MEMBRANES, TRANSPORT, AND BIOENERGETICS

[W][OPEN]Arabidopsis WRKY45 Transcription Factor Activates PHOSPHATE TRANSPORTER1;1 Expression in Response to Phosphate Starvation. *Hui Wang, Qian Xu, You-Han Kong, Yun Chen, Jun-Ye Duan, Wei-Hua Wu, and Yi-Fang Chen*

*Overexpression of a transcription factor enhances Arabidopsis phosphate uptake by activating transporter expression.* 2020

## SIGNALING AND RESPONSE

[C][W][OPEN]A Dominant Mutation in the Light-Oxygen and Voltage2 Domain Vicinity Impairs Phototropin1 Signaling in Tomato. *Sulabha Sharma, Eros Kharshiang, Ankanagari Srinivas, Kazunori Zikihara, Satoru Tokutomi, Akira Nagatani, Hiroshi Fukayama, Reddaiah Bodanapu, Rajendra K. Behera, Yellamaraju Sreelakshmi, and Rameshwar Sharma*

*A single mutation abolishes phototropin1-specific responses, indicating that the helix region has an essential role in phototropin signaling.* 2030

[W][OPEN]A Positive Feedback Loop between HEAT SHOCK PROTEIN101 and HEAT STRESS-ASSOCIATED 32-KD PROTEIN Modulates Long-Term Acquired Thermotolerance Illustrating Diverse Heat Stress Responses in Rice Varieties. *Meng-yi Lin, Kuo-hsing Chai, Swee-suak Ko, Lin-yun Kuang, Hsu-Sheng Lur, and Yee-yung Charng*

*Rice heat-shock proteins modulate long-term acquired thermotolerance, which can be decoupled from basal thermotolerance in different rice cultivars.* 2045

[C][W][OPEN]Apyrase Suppression Raises Extracellular ATP Levels and Induces Gene Expression and Cell Wall Changes Characteristic of Stress Responses. *Min Hui Lim, Jian Wu, Jianchao Yao, Ignacio F. Gallardo, Jason W. Dugger, Lauren J. Webb, James Huang, Mari L. Salmi, Jawon Song, Greg Clark, and Stanley J. Roux*

*Suppressing the expression of two apyrase genes raises extracellular ATP levels and induces gene expression, growth, and cell wall changes characteristic of stress responses, thus implicating extracellular nucleotides as early signals linking biotic and abiotic stresses to growth inhibition.* 2054

[C][W][OPEN]Arabidopsis VQ MOTIF-CONTAINING PROTEIN29 Represses Seedling Deetiolation by Interacting with PHYTOCHROME-INTERACTING FACTOR1. *Yunliang Li, Yanjun Jing, Junjiao Li, Gang Xu, and Rongcheng Lin*

*A transcriptional regulator interacts with the transcription factor PIF1 to modulate hypocotyl cell growth in response to light.* 2068

[C][W][OPEN]Origin of  $\beta$ -Carotene Rich Plastoglobuli in *Dunaliella bardawil*. *Lital Davidi, Eyal Shimoni, Inna Khozin-Goldberg, Ada Zamir, and Uri Pick*

*The alga Dunaliella bardawil synthesizes storage triacylglycerides in chloroplastic lipid globules from chloroplast membrane lipid and from lipid components in cytoplasmic lipid droplets.*

2139

[C][W]Cyanobacterial Phytochrome2 Regulates the Heterotrophic Metabolism and Has a Function in the Heat and High-Light Stress Response. *Manti Schwarzkopf, Yong Cheol Yoo, Ralph Hückelhoven, Young Mok Park, and Reinhard Korbinian Proels*

*A phytochrome photoreceptor of a cyanobacterial model system regulates heterotrophic metabolism in the course of biofilm formation and has a function in response to heat and high-light stress.*

2157

[C][W]Scavenging Iron: A Novel Mechanism of Plant Immunity Activation by Microbial Siderophores. *Aude Aznar, Nicolas W.G. Chen, Martine Rigault, Nassima Riache, Delphine Joseph, Didier Desmaële, Grégory Mouille, Stéphanie Boutet, Ludivine Soubigou-Taconnat, Jean-Pierre Renou, Sébastien Thomine, Dominique Expert, and Alia Dellagi*

*Strong iron scavengers activate immune responses in Arabidopsis through alteration of heavy-metal distribution, uncovering a connection between defense and heavy-metal homeostasis.*

2167

[C][W]Hydrogen Peroxide Acts Upstream of Nitric Oxide in the Heat Shock Pathway in Arabidopsis Seedlings. *Lei Wang, Yunjing Guo, Lixiu Jia, Hongye Chu, Shuo Zhou, Kunming Chen, Dan Wu, and Liqun Zhao*

*Nitric oxide rescues the sensitivity to heat in the absence of hydrogen peroxide.*

2184

[W][OPEN]A Calcium-Independent Activation of the Arabidopsis SOS2-Like Protein Kinase24 by Its Interacting SOS3-Like Calcium Binding Protein1. *Huixin Lin, Wenming Du, Yongqing Yang, Karen S. Schumaker, and Yan Guo*

*Calcium-independent protein kinase activity is important for inactivating Arabidopsis plasma membrane proton-translocating adenosine triphosphatase.*

2197

[C][W][OPEN]The Leucine-Rich Repeat Receptor-Like Kinase BRASSINOSTEROID INSENSITIVE1-ASSOCIATED KINASE1 and the Cytochrome P450 PHYTOALEXIN DEFICIENT3 Contribute to Innate Immunity to Aphids in Arabidopsis. *David C. Prince, Claire Drurey, Cyril Zipfel, and Saskia A. Hogenhout*

*Aphid-derived protein elicitors trigger distinct plant innate immune responses that are dependent on BAK1 and PAD3.*

2207

[C][W]Ultraviolet-B-Induced Stomatal Closure in Arabidopsis Is Regulated by the UV RESISTANCE LOCUS8 Photoreceptor in a Nitric Oxide-Dependent Mechanism. *Vanesa Tossi, Lorenzo Lamattina, Gareth I. Jenkins, and Raúl O. Cassia*

*The Arabidopsis UV RESISTANCE LOCUS8 (UVR8) photoreceptor increases nitric oxide in response to UV-B, thus promoting stomatal closure.*

2220

## SYSTEMS AND SYNTHETIC BIOLOGY

[W][OPEN]Quantitative Analysis of the Mitochondrial and Plastid Proteomes of the Moss *Physcomitrella patens* Reveals Protein Macrocompartmentation and Microcompartmentation. *Stefanie J. Mueller, Daniel Lang, Sebastian N.W. Hoernstein, Erika G.E. Lang, Christian Schuessele, Anton Schmidt, Melanie Fluck, Desirée Leisibach, Christina Niegl, Andreas D. Zimmer, Andreas Schlosser, and Ralf Reski*

*Protein compartmentation in the moss Physcomitrella patens identifies the postendosymbiotic evolution of plastid and mitochondrial functions and pinpoints intercellular and intracellular organellar heterogeneity.*

2081



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[C][W][OPEN] Elements Required for an Efficient NADP-Malic Enzyme Type C4 Photosynthesis. Yu Wang, Stephen P. Long, and Xin-Guang Zhu

*A systems model of C4 photosynthesis facilitates studies of C4 photosynthesis to quantitatively evaluate the control of different anatomical and biochemical features over light and nitrogen use efficiencies.*

2231

[W][OPEN] Can the Cyanobacterial Carbon-Concentrating Mechanism Increase Photosynthesis in Crop Species? A Theoretical Analysis. Justin M. McGrath and Stephen P. Long

*A model incorporating the full cyanobacterial carbon-concentrating mechanism into C<sub>3</sub> plants indicates that CO<sub>2</sub> uptake rate could be increased by 60%, thus increasing yield during a time when yield growth has stagnated.*

2247

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

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