

The electronic form of this issue, available as of September 11, 2012, at [www.plantphysiol.org](http://www.plantphysiol.org), is considered the journal of record.

**On the Cover:** The cover of this Focus Issue devoted to Ubiquitin in Plant Biology depicts the stylized ubiquitin/proteasome system, which attaches multiple ubiquitin residues to a substrate protein and is then degraded by the 26S proteasome. These events are shown against the background of a confocal scanning laser micrograph of a tobacco (*Nicotiana tabacum*) leaf that visualizes chloroplast autofluorescence (purple signal) and the nucleocytoplasmic partition of the transiently expressed cyan fluorescent protein fluorescent marker (blue signal). This issue highlights the roles of ubiquitin and ubiquitin-like modifiers in all different aspects of plant development and morphogenesis, hormonal and environmental responses, chromatin remodeling and histone modifications, and plant-pathogen interactions. Cover design by Stanislav V. Kozlovsky (Moscow State University, Russia) and Vitaly Citovsky (State University of New York, Stony Brook).

## FOCUS ISSUE ON UBIQUITIN IN PLANT BIOLOGY

### EDITORIALS

Focus on Ubiquitin in Plant Biology. *Bonnie Bartel and Vitaly Citovsky* 1

### UPDATES

The Expanding Universe of Ubiquitin and Ubiquitin-Like Modifiers. *Richard D. Vierstra* 2

Ubiquitination during Plant Immune Signaling. *Daniel Marino, Nemo Peeters, and Susana Rivas* 15

The U-Box E3 Ligase SPL11/PUB13 Is a Convergence Point of Defense and Flowering Signaling in Plants. *Jinling Liu, Wei Li, Yuese Ning, Gautam Shirsekar, Yuhui Cai, Xuli Wang, Liangying Dai, Zhilong Wang, Wende Liu, and Guo-Liang Wang* 28

The COP9 Signalosome: Its Regulation of Cullin-Based E3 Ubiquitin Ligases and Role in Photomorphogenesis. *Cynthia D. Nezames and Xing Wang Deng* 38

Ubiquitin-Mediated Control of Plant Hormone Signaling. *Dior R. Kelley and Mark Estelle* 47

Ubiquitin on the Move: The Ubiquitin Modification System Plays Diverse Roles in the Regulation of Endoplasmic Reticulum- and Plasma Membrane-Localized Proteins. *Damian D. Guerra and Judy Callis* 56

The Role of the Ubiquitin-Proteasome System in *Agrobacterium tumefaciens*-Mediated Genetic Transformation of Plants. *Shimpei Magori and Vitaly Citovsky* 65

Ubiquitin and Plant Viruses, Let's Play Together! *Catherine Alcaide-Loridan and Isabelle Jupin* 72

Gibberellin Signaling: A Theme and Variations on DELLA Repression. *Amber L. Hauvermale, Tohru Ariizumi, and Camille M. Steber* 83

### RESEARCH ARTICLES

<sup>[C][W][OA]</sup>SMALL ACIDIC PROTEIN1 Acts with RUB Modification Components, the COP9 Signalosome, and AXR1 to Regulate Growth and Development of Arabidopsis. *Akari Nakasone, Masayuki Fujiwara, Yoichiro Fukao, Kamal Kanti Biswas, Abidur Rahman, Maki Kawai-Yamada, Issay Narumi, Hirofumi Uchimiya, and Yutaka Oono* 93

<sup>[C][W][OA]</sup>A Ubiquitin Ligase of Symbiosis Receptor Kinase Involved in Nodule Organogenesis. *Songli Yuan, Hui Zhu, Honglan Gou, Weiwei Fu, Lijing Liu, Tao Chen, Danxia Ke, Heng Kang, Qi Xie, Zonglie Hong, and Zhongming Zhang* 106

<sup>[W][OA]</sup>The Light-Response BTB1 and BTB2 Proteins Assemble Nuclear Ubiquitin Ligases That Modify Phytochrome B and D Signaling in Arabidopsis. *Matthew J. Christians, Derek J. Gingerich, Zhihua Hua, Timothy D. Lauer, and Richard D. Vierstra* 118

*Continued on next page*

- [C][W][OA] A Synthetic Approach Reveals Extensive Tunability of Auxin Signaling. Kyle A. Havens, Jessica M. Guseman, Seunghye S. Jang, Edith Pierre-Jerome, Nick Bolten, Eric Klavins, and Jennifer L. Nemhauser 135

## REGULAR ISSUE

### ON THE INSIDE

- Peter V. Minorsky 143

### UPDATES

- Canopy Light and Plant Health. Carlos L. Ballaré, Carlos A. Mazza, Amy T. Austin, and Ronald Pierik 145

- Reactive Oxygen Species and Autophagy in Plants and Algae. María Esther Pérez-Pérez, Stéphane D. Lemaire, and José L. Crespo 156

### GENOME ANALYSIS

- [W][OA] Characterizing Regulatory and Functional Differentiation between Maize Mesophyll and Bundle Sheath Cells by Transcriptomic Analysis. Yao-Ming Chang, Wen-Yu Liu, Arthur Chun-Chieh Shih, Meng-Ni Shen, Chen-Hua Lu, Mei-Yeh Jade Lu, Hui-Wen Yang, Tzi-Yuan Wang, Sean C.-C. Chen, Stella Maris Chen, Wen-Hsiung Li, and Maurice S.B. Ku 165

### BREAKTHROUGH TECHNOLOGIES

- [C][W][OA] Integration of Bioinformatics and Synthetic Promoters Leads to the Discovery of Novel Elicitor-Responsive cis-Regulatory Sequences in Arabidopsis. Jeannette Koschmann, Fabian Machens, Marlies Becker, Julia Niemeyer, Jutta Schulze, Lorenz Bülow, Dietmar J. Stahl, and Reinhard Hehl 178

### BIOINFORMATICS

- [W][OA] Application of the Gini Correlation Coefficient to Infer Regulatory Relationships in Transcriptome Analysis. Chuang Ma and Xiangfeng Wang 192

### BIOCHEMICAL PROCESSES AND MACROMOLECULAR STRUCTURES

- [W][OA] Synergistic Interactions between Carotene Ring Hydroxylases Drive Lutein Formation in Plant Carotenoid Biosynthesis. Rena F. Quinlan, Maria Shumskaya, Louis M.T. Bradbury, Jesús Beltrán, Chunhui Ma, Edward J. Kennelly, and Eleanore T. Wurtzel 204

- [W][OA] A Cytosolic Acyltransferase Contributes to Triacylglycerol Synthesis in Sucrose-Rescued Arabidopsis Seed Oil Catabolism Mutants. M. Luisa Hernández, Lynne Whitehead, Zhesi He, Valeria Gazda, Alison Gilday, Ekaterina Kozhevnikova, Fabián E. Vaistij, Tony R. Larson, and Ian A. Graham 215

- [C][OA] Arabidopsis ETHE1 Encodes a Sulfur Dioxygenase That Is Essential for Embryo and Endosperm Development. Meghan M. Holdorf, Heather A. Owen, Sarah Rhee Lieber, Li Yuan, Nicole Adams, Carole Dabney-Smith, and Christopher A. Makaroff 226

- [W][OA] Identification of an Arabidopsis Fatty Alcohol:Caffeoyl-Coenzyme A Acyltransferase Required for the Synthesis of Alkyl Hydroxycinnamates in Root Waxes. Dylan K. Kosma, Isabel Molina, John B. Ohlrogge, and Mike Pollard 237

- [W][OA] A Structural Basis for the Biosynthesis of the Major Chlorogenic Acids Found in Coffee. Laura A. Lallemand, Chloe Zubieta, Soon Goo Lee, Yechun Wang, Samira Acajjaoui, Joanna Timmins, Sean McSweeney, Joseph M. Jez, James G. McCarthy, and Andrew A. McCarthy 249

- [C][W][OA] Toward Stable Genetic Engineering of Human O-Glycosylation in Plants. Zhang Yang, Eric P. Bennett, Bodil Jørgensen, Damian P. Drew, Emma Arigi, Ulla Mandel, Peter Ulvskov, Steven B. Levery, Henrik Clausen, and Bent L. Petersen 450

Continued on next page

**BIOENERGETICS AND PHOTOSYNTHESIS**

- [W]Chlorophyll *b* Reductase Plays an Essential Role in Maturation and Storability of Arabidopsis Seeds. Saori Nakajima, Hisashi Ito, Ryouichi Tanaka, and Ayumi Tanaka 261
- [W]Photosynthetic Adaptation to Length of Day Is Dependent on S-Sulfocysteine Synthase Activity in the Thylakoid Lumen. María Ángeles Bermúdez, Jeroni Galmés, Inmaculada Moreno, Philip M. Mullineaux, Cecilia Gotor, and Luis C. Romero 274
- [OA]Photosystem II Photoinactivation, Repair, and Protection in Marine Centric Diatoms. Hongyan Wu, Suzanne Roy, Meriem Alami, Beverley R. Green, and Douglas A. Campbell 464

**CELL BIOLOGY AND SIGNAL TRANSDUCTION**

- [C][W][OA]The Mediator Complex Subunit PFT1 Interferes with COP1 and HY5 in the Regulation of Arabidopsis Light Signaling. Cornelia Klose, Claudia Büche, Aurora Piñas Fernandez, Eberhard Schäfer, Eva Zwick, and Thomas Kretsch 289
- [C][W]Rice Mitogen-Activated Protein Kinase Interactome Analysis Using the Yeast Two-Hybrid System. Raksha Singh, Mi-Ok Lee, Jae-Eun Lee, Jihyun Choi, Ji Hun Park, Eun Hye Kim, Ran Hee Yoo, Jung-Il Cho, Jong-Seong Jeon, Randeep Rakwal, Ganesh Kumar Agrawal, Jae Sun Moon, and Nam-Soo Jwa 477

**DEVELOPMENT AND HORMONE ACTION**

- [W]Inhibition of Tiller Bud Outgrowth in the *tin* Mutant of Wheat Is Associated with Precocious Internode Development. Tesfamichael H. Kebrom, Peter M. Chandler, Steve M. Swain, Rod W. King, Richard A. Richards, and Wolfgang Spielmeyer 308
- [C][W][OA]Cytokinin Activity of cis-Zeatin and Phenotypic Alterations Induced by Overexpression of Putative cis-Zeatin-O-glucosyltransferase in Rice. Toru Kudo, Nobue Makita, Mikiko Kojima, Hiroki Tokunaga, and Hitoshi Sakakibara 319
- [W][OA]Functional Characterization of the GATA Transcription Factors GNC and CGA1 Reveals Their Key Role in Chloroplast Development, Growth, and Division in Arabidopsis. Yi-Hsuan Chiang, Yan O. Zubo, Wiebke Tapken, Hyo Jung Kim, Ann M. Lavanway, Louisa Howard, Marinus Pilon, Joseph J. Kieber, and G. Eric Schaller 332
- [W][OA]Ligand-Induced Alterations in the Phosphorylation State of Ethylene Receptors in Tomato Fruit. Yusuke Kamiyoshihara, Denise M. Tieman, Donald J. Huber, and Harry J. Klee 488

**ENVIRONMENTAL STRESS AND ADAPTATION TO STRESS**

- [W]The Subcellular Localization of Tubby-Like Proteins and Participation in Stress Signaling and Root Colonization by the Mutualist *Piriformospora indica*. Marco Uwe Reitz, Jeff Kweku Bissie, Kathleen Zocher, Agnès Attard, Ralph Hückelhoven, Katja Becker, Jafargholi Imani, Ruth Eichmann, and Patrick Schäfer 349
- [C][W]Lipid Profiling of the Arabidopsis Hypersensitive Response Reveals Specific Lipid Peroxidation and Fragmentation Processes: Biogenesis of Pimelic and Azelaic Acid. Maria Zoeller, Nadja Stingl, Markus Krischke, Agnes Fekete, Frank Waller, Susanne Berger, and Martin J. Mueller 365
- [W][OA]Unique Drought Resistance Functions of the Highly ABA-Induced Clade A Protein Phosphatase 2Cs. Govinal Badiger Bhaskara, Thao Thi Nguyen, and Paul E. Verslues 379
- [W]The Rice Monovalent Cation Transporter OsHKT2;4: Revisited Ionic Selectivity. Ali Sassi, Delphine Mieulet, Imran Khan, Bertrand Moreau, Isabelle Gaillard, Hervé Sentenac, and Anne-Aliénor Véry 498

**PLANTS INTERACTING WITH OTHER ORGANISMS**

- [C][W][OA]LYK4, a Lysin Motif Receptor-Like Kinase, Is Important for Chitin Signaling and Plant Innate Immunity in Arabidopsis. Jinrong Wan, Kiwamu Tanaka, Xue-Cheng Zhang, Geon Hui Son, Laurent Brechenmacher, Tran Hong Nha Nguyen, and Gary Stacey 396
- [W]The Lateral Organ Boundaries Domain Transcription Factor LBD20 Functions in *Fusarium* Wilt Susceptibility and Jasmonate Signaling in Arabidopsis. Louise F. Thatcher, Jonathan J. Powell, Elizabeth A.B. Aitken, Kemal Kazan, and John M. Manners 407

Continued on next page

**SYSTEMS BIOLOGY, MOLECULAR BIOLOGY, AND GENE REGULATION**

- <sup>[C][W][OA]</sup>Ectopic Expression of Rubisco Subunits in Maize Mesophyll Cells Does Not Overcome Barriers to Cell Type-Specific Accumulation. *Katia Wostrikoff, Aimee Clark, Shirley Sato, Tom Clemente, and David Stern* 419
- <sup>[C][W]</sup>Characterization of SOC1's Central Role in Flowering by the Identification of Its Upstream and Downstream Regulators. *Richard G.H. Immink, David Posé, Silvia Ferrario, Felix Ott, Kerstin Kaufmann, Felipe Leal Valentim, Stefan de Folter, Froukje van der Wal, Aalt D.J. van Dijk, Markus Schmid, and Gerco C. Angenent* 433
- <sup>[C][W][OA]</sup>Formation of Complex Extrachromosomal T-DNA Structures in *Agrobacterium tumefaciens*-Infected Plants. *Kamy Singer, Yoel M. Shibolet, Jianming Li, and Tzvi Tzfira* 511
- <sup>[W]</sup>A Mathematical Model for BRASSINOSTEROID INSENSITIVE1-Mediated Signaling in Root Growth and Hypocotyl Elongation. *G. Wilma van Esse, Simon van Mourik, Hans Stigter, Colette A. ten Hove, Jaap Molenaar, and Sacco C. de Vries* 523
- Availability of Rubisco Small Subunit Up-Regulates the Transcript Levels of Large Subunit for Stoichiometric Assembly of Its Holoenzyme in Rice. *Yuji Suzuki and Amane Makino* 533
- <sup>[C][W]</sup>MEDIATOR25 Acts as an Integrative Hub for the Regulation of Jasmonate-Responsive Gene Expression in Arabidopsis. *Volkan Çevik, Brendan N. Kidd, Peijun Zhang, Claire Hill, Steve Kiddle, Katherine J. Denby, Eric B. Holub, David M. Cahill, John M. Manners, Peer M. Schenk, Jim Beynon, and Kemal Kazan* 541
- <sup>[C][W][OA]</sup>Roles of Four Arabidopsis U-Box E3 Ubiquitin Ligases in Negative Regulation of Abscisic Acid-Mediated Drought Stress Responses. *Dong Hye Seo, Moon Young Ryu, Fabien Jammes, Jae Hwan Hwang, Michelle Turek, Bin Goo Kang, June M. Kwak, and Woo Taek Kim* 556

<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.