

**On the Cover:** The formation of nanoridges on the surface of epidermal cells of petals requires the cuticular polyester cutin and its main component 10,16-dihydroxy C16:0 in *Arabidopsis thaliana*. Research gave new insights into the relationships between composition and spectroscopic features of cutin and the ultrastructure and surface structure of the cuticle. The studies furthermore suggested that nanoridges that are present on floral organs of many species might have important functions in floral development by diminishing adhesion forces between different organs and thus facilitating the gliding of petals during their fast outgrowth of the floral bud. The image shows the nanoridge-covered petal epidermal surface of *Arabidopsis* wild type. Cryoscanning electron micrograph taken by Antonio Mucciolo.

## ON THE INSIDE

Peter V. Minorsky

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## BREAKTHROUGH TECHNOLOGIES

[OPEN] Validating Genome-Wide Association Candidates Controlling Quantitative Variation in Nodulation. Shaun J. Curtin, Peter Tiffin, Joseph Guhlin, Diana I. Trujillo, Liana T. Burghardt, Paul Atkins, Nicholas J. Baltes, Roxanne Denny, Daniel F. Voytas, Robert M. Stupar, and Nevin D. Young

GWA studies combined with multiple mutagenesis technologies, including CRISPR/Cas9, functionally validate novel candidate genes contributing to phenotypic variation in symbiosis between legume plants and rhizobial bacteria.

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## RESEARCH REPORT

[OPEN] The Plastid Genome of *Polytoma uvella* Is the Largest Known among Colorless Algae and Plants and Reflects Contrasting Evolutionary Paths to Nonphotosynthetic Lifestyles. Francisco Figueroa-Martinez, Aurora M. Nedelcu, David R. Smith, and Adrian Reyes-Prieto

The plastid genome of the nonphotosynthetic green alga *Polytoma uvella* has a reduced coding capacity but is bloated with repeats. This is in striking contrast with its colorless relative, *Polytomella*, that lost its plastid genome.

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## RESEARCH ARTICLES

### BIOCHEMISTRY AND METABOLISM

A  $\beta$ -Ketoacyl-CoA Synthase Is Involved in Rice Leaf Cuticular Wax Synthesis and Requires a CER2-LIKE Protein as a Cofactor. Xiaochen Wang, Yuanyuan Guan, Du Zhang, Xiangbai Dong, Lihong Tian, and Le Qing Qu

WSL4 physically interacts with CER2-like protein, catalyzing the elongation of very-long-chain fatty acids longer than 24 carbons, and is involved in the synthesis of cuticular wax in rice leaf.

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[OPEN] Activation of Mitochondrial Protein Phosphatase SLP2 by MIA40 Regulates Seed Germination. R. Glen Uhrig, Anne-Marie Labandera, Lay-Yin Tang, Nicolas A. Sieben, Marilyn Goudreault, Edward Yeung, Anne-Claude Gingras, Marcus A. Samuel, and Greg B.G. Moorhead

The serine/threonine protein phosphatase SLP2 is mitochondrial intermembrane space localized and redox activated by the oxidoreductase Mia40.

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[CC-BY] Functional Analysis of Cellulose Synthase (CESA) Protein Class Specificity. Manoj Kumar, Ioan Atanassov, and Simon Turner

Reciprocal swap experiments suggest that the class specificity of CESA proteins extends throughout the protein and the degree of specificity differs greatly between different classes of CESA.

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Metabolic Control of Tobacco Pollination by Sugars and Invertases. Marc Goetz, Anne Guivarčh, Jörg Hirsche, Martin Andreas Bauerfeind, María-Cruz González, Tae Kyung Hyun, Seung Hee Eom, Dominique Chriqui, Thomas Engelke, Dominik K. Großkinsky, and Thomas Roitsch

*Invertases and hexose transporters, as essential components of carbohydrate supply, are regulated in a spatiotemporally coordinated manner to maintain functionality of tobacco pollination.* 984

[OPEN]Silencing CHALCONE SYNTHASE in Maize Impedes the Incorporation of Tricin into Lignin and Increases Lignin Content. Nubia B. Eloy, Wannes Voorend, Wu Lan, Marina de Lyra Soriano Saleme, Igor Cesarino, Ruben Vanholme, Rebecca A. Smith, Geert Goeminne, Andreas Pallidis, Kris Morreel, José Nicomedes Jr., John Ralph, and Wout Boerjan

*The maize C2-Idf mutant has reduced levels of soluble flavonoids, reduced incorporation of triclin into the lignin polymer, and higher total lignin that is enriched in  $\beta$ - $\beta$  and  $\beta$ -5 interunit linkages.* 998

[OPEN]Soluble and Membrane-Bound  $\beta$ -Glucosidases Are Involved in Trimming the Xyloglucan Backbone. Javier Sampedro, Elene R. Valdivia, Patricia Fraga, Natalia Iglesias, Gloria Revilla, and Ignacio Zarra

*Two Arabidopsis glucosidases, soluble BGLC1 and GPI-anchored BGLC3, are involved in xyloglucan metabolism and could differentially affect wall-bound and soluble fractions.* 1017

Structural and Biochemical Characterization of Cinnamoyl-CoA Reductases. Steven A. Sattler, Alexander M. Walker, Wilfred Vermerris, Scott E. Sattler, and ChulHee Kang

*In-depth investigation for CCRs from Sorghum bicolor provides information about the critical residues for substrate preference among CCRs.* 1031

[OPEN]The MYB107 Transcription Factor Positively Regulates Suberin Biosynthesis. Mingyue Gou, Guichuan Hou, Huijun Yang, Xuebin Zhang, Yuanheng Cai, Guoyin Kai, and Chang-Jun Liu

*The Arabidopsis MYB107 transcription factor regulates the expression of suberin biosynthetic genes in developing seeds, thereby controlling the synthesis and assembly of seed coat suberin.* 1045

[OPEN]Identification and Characterization of Arabidopsis Seed Coat Mucilage Proteins. Allen Yi-Lun Tsai, Tadashi Kunieda, Jason Rogalski, Leonard J. Foster, Brian E. Ellis, and George W. Haughn

*Arabidopsis seed coat mucilage, an extracellular matrix composed of cell wall carbohydrates, contains a proteome functionally similar to that of cell wall, but also includes proteins unique to mucilage.* 1059

Combined Experimental and Computational Approaches Reveal Distinct pH Dependence of Pectin Methyltransferase Inhibitors. Ludvine Hocq, Fabien Sénéchal, Valérie Lefebvre, Arnaud Lehner, Jean-Marc Domon, Jean-Claude Mollet, Jérémy Dehors, Karine Pageau, Paulo Marcelo, François Guérineau, Kutra Kolšek, Davide Mercadante, and Jérôme Pelloux

*The pH dependence of PME1, proteins that fine-tune the activity of pectin methyltransferases, can be predicted by molecular dynamics simulation and validated in vitro and on pollen tube development.* 1075

[OPEN]SDH6 and SDH7 Contribute to Anchoring Succinate Dehydrogenase to the Inner Mitochondrial Membrane in Arabidopsis thaliana. Christine Schikowsky, Jennifer Senkler, and Hans-Peter Braun

*Solving the complex II puzzle: SDH6 and SDH7 contribute to anchoring succinate dehydrogenase to the inner mitochondrial membrane in Arabidopsis thaliana.* 1094

[OPEN]The Acyl Desaturase CER17 Is Involved in Producing Wax Unsaturated Primary Alcohols and Cutin Monomers. *Xianpeng Yang, Huayan Zhao, Dylan K. Kosma, Pernell Tomasi, John M. Dyer, Rongjun Li, Xiulin Liu, Zhouya Wang, Eugene P. Parsons, Matthew A. Jenks, and Shiyu Lü*

*CER17/ADS4 is involved in unsaturated wax and cutin monomer production in Arabidopsis.* 1109

## CELL BIOLOGY

[OPEN]Capping Protein Modulates Actin Remodeling in Response to Reactive Oxygen Species during Plant Innate Immunity. *Jiejie Li, Lingyan Cao, and Christopher J. Staiger*

*Actin filament capping protein transduces ROS signaling into changes of actin dynamics during plant innate immunity.* 1125

[OPEN]The GET System Inserts the Tail-Anchored Protein, SYP72, into Endoplasmic Reticulum Membranes. *Renu Srivastava, Benjamin E. Zalisko, Robert J. Keenan, and Stephen H. Howell*

*The GET protein insertion system inserts the model tail-anchored protein SYP72 into endoplasmic reticulum membranes in Arabidopsis.* 1137

[OPEN]Connecting the Molecular Structure of Cutin to Ultrastructure and Physical Properties of the Cuticle in Petals of Arabidopsis. *Sylwester Mazurek, Imène Garroum, Jean Daraspe, Damien De Bellis, Vilde Olsson, Antonio Mucciolo, Melinka A. Butenko, Bruno M. Humbel, and Christiane Nawrath*

*GPAT6 and DCR play different roles in structuring the cell wall-cuticle continuum.* 1146

[OPEN]The Pentatricopeptide Repeat Protein EMB2654 Is Essential for Trans-Splicing of a Chloroplast Small Ribosomal Subunit Transcript. *Nader Aryamanesh, Hannes Ruwe, Lilian Vincis Pereira Sanglard, Leila Eshraghi, John D. Bussell, Katharine A. Howell, Ian Small, and Catherine Colas des Francs-Small*

*Binding of the pentatricopeptide repeat protein EMB2654 to one-half of the plastid rps12 intron is essential for trans-splicing, production of plastid ribosomes, and embryogenesis in Arabidopsis.* 1164

## ECOPHYSIOLOGY AND SUSTAINABILITY

[OPEN]Xylem Surfactants Introduce a New Element to the Cohesion-Tension Theory. *H. Jochen Schenk, Susana Espino, David M. Romo, Neda Nima, Aissa Y.T. Do, Joseph M. Michaud, Brigitte Papahadjopoulos-Sternberg, Jinlong Yang, Yi Y. Zuo, Kathy Steppe, and Steven Jansen*

*Lipid-based xylem surfactants affect water transport under negative pressure by coating hydrophobic surfaces and nanobubbles and are hypothesized to reduce embolism under normal pressure conditions.* 1177

[CC-BY]Outside-Xylem Vulnerability, Not Xylem Embolism, Controls Leaf Hydraulic Decline during Dehydration. *Christine Scoffoni, Caetano Albuquerque, Craig R. Brodersen, Shatarra V. Townes, Grace P. John, Megan K. Bartlett, Thomas N. Buckley, Andrew J. McElrone, and Lauren Sack*

*Changes in leaf outside-xylem properties drive leaf and whole-plant hydraulic decline with dehydration, protecting plants from catastrophic embolism in xylem conduits.* 1197

## GENES, DEVELOPMENT, AND EVOLUTION

[<sup>OPEN</sup>]MYB89 Transcription Factor Represses Seed Oil Accumulation. Dong Li, Changyu Jin, Shaowei Duan, Yana Zhu, Shuanghui Qi, Kaige Liu, Chenhao Gao, Haoli Ma, Meng Zhang, Yuncheng Liao, and Mingxun Chen

*An Arabidopsis transcription factor negatively regulates the accumulation of seed oil by targeting WRI1 and several other genes involved in the seed oil biosynthetic pathway.* 1211

[<sup>OPEN</sup>]Physical Mapping of Amplified Copies of the 5-Enolpyruvylshikimate-3-Phosphate Synthase Gene in Glyphosate-Resistant *Amaranthus tuberculatus*. Andrew Dillon, Vijay K. Varanasi, Tatiana V. Danilova, Dal-Hoe Koo, Sridevi Nakka, Dallas E. Peterson, Patrick J. Tranel, Bernd Friebe, Bikram S. Gill, and Mithila Jugulam

*Fluorescence in situ hybridization maps a cluster of EPSPS genes to the pericentromeric region on one pair of homologous chromosomes of glyphosate-resistant *Amaranthus tuberculatus*.* 1226

[<sup>OPEN</sup>]EXTRA-LARGE G PROTEINs Interact with E3 Ligases PUB4 and PUB2 and Function in Cytokinin and Developmental Processes. Yiping Wang, Yingying Wu, Boying Yu, Zhao Yin, and Yiji Xia

*Arabidopsis EXTRA-LARGE G PROTEINs interact with two PUB proteins in mediating the cytokinin response and multiple developmental processes.* 1235

[<sup>OPEN</sup>]Stability of Single-Parent Gene Expression Complementation in Maize Hybrids upon Water Deficit Stress. Caroline Marcon, Anja Paschold, Waqas Ahmed Malik, Andrew Lithio, Jutta A. Baldauf, Lena Altrogge, Nina Opitz, Christa Lanz, Heiko Schoof, Dan Nettleton, Hans-Peter Piepho, and Frank Hochholdinger

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[<sup>OPEN</sup>]The Binding Specificity of the PHD-Finger Domain of VIN3 Moderates Vernalization Response. Dong-Hwan Kim and Sibum Sung

*Vernalization-induced VIN3 enhances the PRC2 activity through its histone binding motif, PHD-finger domain, to mediate proper vernalization response in Arabidopsis.* 1258

[<sup>OPEN</sup>]Forever Young: The Role of Ubiquitin Receptor DA1 and E3 Ligase BIG BROTHER in Controlling Leaf Growth and Development. Hannes Vanhaeren, Youn-Jeong Nam, Liesbeth De Milde, Eunyoung Chae, Veronique Storme, Detlef Weigel, Nathalie Gonzalez, and Dirk Inzé

*The role of DA1 in restricting cell proliferation is conserved in different genetic backgrounds. In addition, DA1 and BB restrict leaf growth and longevity through converging and different mechanisms.* 1269

[<sup>OPEN</sup>]Atypical Protein Phosphatase 2A Gene Families Do Not Expand via Paleopolyploidization. Matthew A. Booker and Alison DeLong

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[OPEN] A Flowering Locus C Homolog Is a Vernalization-Regulated Repressor in *Brachypodium* and Is Cold Regulated in Wheat. Neha Sharma, Philip Ruelens, Mariëlla D'hauw, Thomas Maggen, Niklas Dochy, Sanne Torfs, Kerstin Kaufmann, Antje Rohde, and Koen Geuten

*ODDSOC2/TaAGL33 functions in vernalization-responsive flowering of Poaceae in a similar but unique manner compared to its Arabidopsis homolog, FLOWERING LOCUS C.*

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[OPEN] Resolvase OsGEN1 Mediates DNA Repair by Homologous Recombination. Chong Wang, James D. Higgins, Yi He, Pingli Lu, Dabing Zhang, and Wanqi Liang

*The canonical Holliday junction resolvase OsGEN1 plays an important role in rice pollen development via influence interference-insensitive crossover formation and DNA repair during pollen mitosis processes.*

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## MEMBRANES, TRANSPORT, AND BIOENERGETICS

[OPEN] Sucrose Transporter Localization and Function in Phloem Unloading in Developing Stems.

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*Sorghum sucrose transporters may function to efflux sucrose from the phloem during early internode development and retrieve leaked sucrose to the phloem as internodes mature.*

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CNGC2 Is a  $Ca^{2+}$  Influx Channel That Prevents Accumulation of Apoplastic  $Ca^{2+}$  in the Leaf.

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*Arabidopsis CNGC2 is a  $Ca^{2+}$ -permeable channel that mediates  $Ca^{2+}$  influx into mesophyll cells near minor veins but has no direct role in the hypersensitive response or leaf senescence.*

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Physiological Characterization of a Plant Mitochondrial Calcium Uniporter in Vitro and in

Vivo. Enrico Teardo, Luca Carraretto, Stephan Wagner, Elide Formentin, Smrutisanjita Behera, Sara De Bortoli, Véronique Larosa, Philippe Fuchs, Fiorella Lo Schiavo, Anna Raffaello, Rosario Rizzuto, Alex Costa, Markus Schwarzländer, and Ildiko Szabó

*An Arabidopsis homolog of the mammalian mitochondrial calcium uniporter MCU acts as  $Ca^{2+}$  channel, and its absence impacts mitochondrial function and morphology.*

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## SIGNALING AND RESPONSE

[OPEN] A Subset of Ubiquitin-Conjugating Enzymes Is Essential for Plant Immunity. Bangjun Zhou, Ravi V. Mural, Xuanyang Chen, Matt E. Oates, Richard A. Connor, Gregory B. Martin, Julian Gough, and Lirong Zeng

*The tomato genome encodes 40 ubiquitin-conjugating enzymes (E2), among which members of group III are required for the suppression of host immunity by the AvrPtoB effector and for plant pattern-triggered immunity.*

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[OPEN] AIK1, A Mitogen-Activated Protein Kinase, Modulates Abscisic Acid Responses through the MKK5-MPK6 Kinase Cascade. Kun Li, Fengbo Yang, Guozeng Zhang, Shufei Song, Yuan Li, Dongtao Ren, Yuchen Miao, and Chun-Peng Song

*An Arabidopsis MAPK kinase kinase (MAPKKK), AIK1, modulates ABA signaling by sequentially relaying and amplifying intracellular signals through the AIK1-MKK5-MPK6 cascade.*

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- [OPEN] Defense Responses in Aspen with Altered Pectin Methylesterase Activity Reveal the Hormonal Inducers of Tyloses. *Joanna Leśniewska, David Öhman, Magdalena Krzesłowska, Sunita Kushwah, Maria Barciszewska-Pacak, Leszek A. Kleczkowski, Björn Sundberg, Thomas Moritz, and Ewa J. Mellerowicz*
- Suppression of pectin methyl esterase, and jasmonates in synergy with 1-aminocyclopropane-1-carboxylic acid acting via the ethylene signaling pathway, induces tyloses in intact, healthy aspen plants.* 1409
- [OPEN] Jasmonic Acid Enhances Al-Induced Root Growth Inhibition. *Zhong-Bao Yang, Chunmei He, Yanqi Ma, Marco Herde, and Zhaojun Ding*
- Jasmonate mediates aluminum-induced root growth inhibition through regulation of microtubule polymerization and ALMT1-regulated malate exudation in an auxin-independent manner in Arabidopsis.* 1420
- [OPEN] Nitric Oxide Modulates Histone Acetylation at Stress Genes by Inhibition of Histone Deacetylases. *Alexander Mengel, Alexandra Ageeva, Elisabeth Georgii, Jörg Bernhardt, Keqiang Wu, Jörg Durner, and Christian Lindermayr*
- Nitric oxide may regulate histone acetylation at stress-related genes by inhibiting histone deacetylases.* 1434
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- [OPEN] The OsMYB30 Transcription Factor Suppresses Cold Tolerance by Interacting with a JAZ Protein and Suppressing  $\beta$ -Amylase Expression. *Yan Lv, Mei Yang, Dan Hu, Zeyu Yang, Siqi Ma, Xianghua Li, and Lizhong Xiong*
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## SYSTEMS AND SYNTHETIC BIOLOGY

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- [OPEN] Integrating Omics and Alternative Splicing Reveals Insights into Grape Response to High Temperature. *Jianfu Jiang, Xinna Liu, Chonghuai Liu, Guotian Liu, Shaohua Li, and Lijun Wang*
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## CORRECTIONS

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