

**On the Cover:** Fruits, like many vegetative tissues of plants that contribute to human diets, show accelerated decay following the ripening transition. Ripening control therefore has enormous relevance for both plant biology and food security. Tomato is used by researchers across the globe as a model for fruit development and ripening. In this issue, Yang et al. (pp. 1690–1702) identify 11 putative RNA editing factors that are related to tomato fruit ripening. They used virus-induced gene silencing and CRISPR/Cas9-mediated gene editing to show that the RNA editing factor SIORRM4 is involved in ripening. The results demonstrate that SIORRM4 is linked to fruit ripening through its regulation of respiratory rate and ethylene production. SIORRM4 affects mitochondrial transcript editing and core subunit accumulation that are critical for mitochondrial function. Despite the recognized importance of RNA editing in plants, this is one of the few to examine this major posttranscriptional modification in fleshy fruit ripening. The image shows tomato fruit ripening, with the first row in each panel corresponding to normal tomato fruit ripening, and the second and third rows showing ripening of two *slorrm4* mutants in cv Micro-Tom. Photo by Yongfang Yang.

## ON THE INSIDE

Peter V. Minorsky

1497

## COMMENTARY

The Next Generation of Training for Arabidopsis Researchers: Bioinformatics and Quantitative Biology. Joanna Friesner, Sarah M. Assmann, Ruth Bastow, Julia Bailey-Serres, Jim Beynon, Volker Brendel, C. Robin Buell, Alexander Bucksch, Wolfgang Busch, Taku Demura, Jose R. Dinneny, Colleen J. Doherty, Andrea L. Eveland, Pascal Falter-Braun, Malia A. Gehan, Michael Gonzales, Erich Grotewold, Rodrigo Gutierrez, Ute Kramer, Gabriel Krouk, Shisong Ma, R.J. Cody Markelz, Molly Megraw, Blake C. Meyers, James A.H. Murray, Nicholas J. Provart, Sue Rhee, Roger Smith, Edgar P. Spalding, Crispin Taylor, Tracy K. Teal, Keiko U. Torii, Chris Town, Matthew Vaughn, Richard Vierstra, Doreen Ware, Olivia Wilkins, Cranos Williams, and Siobhan M. Brady

*Training for experimental plant biologists needs to combine bioinformatics, quantitative approaches, computational biology, and training in the art of collaboration, best achieved through fully integrated curriculum development.*

1499

## UPDATE

<sup>[OPEN]</sup>Floral Metabolism of Sugars and Amino Acids: Implications for Pollinators' Preferences and Seed and Fruit Set. Monica Borghi and Alisdair R. Fernie

*New discoveries open up future directions in the study of the primary metabolism of flowers.*

1510

## RESEARCH REPORTS

<sup>[OPEN]</sup>Arabidopsis  $\beta$ -Amylase2 Is a  $K^+$ -Requiring, Catalytic Tetramer with Sigmoidal Kinetics. Jonathan D. Monroe, Jillian S. Breault, Lauren E. Pope, Catherine E. Torres, Tewaldemedhine B. Gebrejesus, Christopher E. Berndsen, and Amanda R. Storm

*An unusual  $\beta$ -amylase from Arabidopsis (BAM2) is catalytically active in the presence of  $K^+$ , exhibits sigmoidal kinetics, functions as a tetramer, and has a putative secondary carbohydrate-binding site.*

1525

Gibberellin Induces an Increase in Cytosolic  $Ca^{2+}$  via a DELLA-Independent Signaling Pathway. Kanako Okada, Takeshi Ito, Jutarou Fukazawa, and Yohsuke Takahashi

*The gibberellin-induced increases in cytosolic  $Ca^{2+}$  are promoted via a DELLA-independent signaling pathway.*

1536

Continued on next page

## RESEARCH ARTICLES

### BIOCHEMISTRY AND METABOLISM

[OPEN] Mechanisms of Phosphorus Acquisition and Lipid Class Remodeling under P Limitation in a Marine Microalga. Alice Mühlroth, Per Winge, Aimen El Assimi, Juliette Jouhet, Eric Maréchal, Martin F. Hohmann-Marriott, Olav Vadstein, and Atle M. Bones

*Corresponding lipidomic and transcriptomic data uncover the mechanism of P recycling and lipid class remodeling under P limitation in the alga Nannochloropsis oceanica.* 1543

[OPEN] Flavan-3-ols Are an Effective Chemical Defense against Rust Infection. Chhana Ullah, Sybille B. Unsicker, Christin Fellenberg, C. Peter Constabel, Axel Schmidt, Jonathan Gershenzon, and Almuth Hammerbacher

*Poplar synthesizes catechin and proanthocyanidins as antifungal defenses against the foliar rust fungus (Melampsora larici-populina).* 1560

[CC-BY] Regular Motifs in Xylan Modulate Molecular Flexibility and Interactions with Cellulose Surfaces. Antonio Martínez-Abad, Jennie Berglund, Guillermo Toriz, Paul Gatenholm, Gunnar Henriksson, Mikael Lindström, Jakob Wohler, and Francisco Vilaplana

*The presence of regular glycosidic motifs in xylan modulates its molecular flexibility and the affinity toward hydrophobic and hydrophilic cellulose microfibril surfaces in secondary plant cell walls.* 1579

[OPEN] Gradients in Wall Mechanics and Polysaccharides along Growing Inflorescence Stems. Pyae Phyoe, Tuo Wang, Sarah N. Kiemle, Hugh O'Neill, Sai Venkatesh Pingali, Mei Hong, and Daniel J. Cosgrove

*Gradients in growth rate and cell wall compliances resemble gradients in pectin properties, suggesting that high growth rate is enabled by hydrated, highly mobile pectins with weakened cellulose interactions in Arabidopsis.* 1593

### CELL BIOLOGY

[OPEN] Multifunctional RNA Binding Protein OsTudor-SN in Storage Protein mRNA Transport and Localization. Hong-Li Chou, Li Tian, Toshihiro Kumamaru, Shigeki Hamada, and Thomas W. Okita

*OsTudor-SN is a key player in regulating storage protein mRNA transport due to its multidomain structure.* 1608

[OPEN] The Rubisco Chaperone BSD2 May Regulate Chloroplast Coverage in Maize Bundle Sheath Cells. Coralie Salesse, Robert Sharwood, Wataru Sakamoto, and David Stern

*Cell-type-specific and overexpression of the chloroplast chaperone BSD2 in maize identified dual functions in Rubisco assembly and regulation of chloroplast coverage in BS cells.* 1624

### ECOPHYSIOLOGY AND SUSTAINABILITY

Leaf and Plant Age Affects Photosynthetic Performance and Photoprotective Capacity. Ludwik W. Bielczynski, Mateusz K. Łacki, Iris Hoefnagels, Anna Gambin, and Roberta Croce

*The ages of both the plant and the leaf influence the light tolerance and photosynthetic activity between leaves on Arabidopsis rosettes through the vegetative stage of growth.* 1634

[OPEN]Storage Compartments for Capillary Water Rarely Refill in an Intact Woody Plant. *Thorsten Knipfer, Italo F. Cuneo, J. Mason Earles, Clarissa Reyes, Craig R. Brodersen, and Andrew J. McElrone*

*Visualization of refilling dynamics in Laurus nobilis revealed that both capillary water storage and vessel refilling play minor roles under in vivo conditions.* 1649

Abscisic Acid Modulates Seed Germination via ABA INSENSITIVE5-Mediated PHOSPHATE1. *Yun Huang, Mi-Mi Sun, Qing Ye, Xiao-Qing Wu, Wei-Hua Wu, and Yi-Fang Chen*

*Arabidopsis PHO1 modulates ABA-mediated seed germination and is a key target of transcription factor ABI5.* 1661

## GENES, DEVELOPMENT, AND EVOLUTION

[OPEN]Genome-Wide Identification of Medicago Peptides Involved in Macronutrient Responses and Nodulation. *Thomas C. de Bang, Peter K. Lundquist, Xinbin Dai, Clarissa Boschiero, Zhaohong Zhuang, Pooja Pant, Ivone Torres-Jerez, Sonali Roy, Joaquina Nogales, Vijaykumar Veerappan, Rebecca Dickstein, Michael K. Udvardi, Patrick X. Zhao, and Wolf-Rüdiger Scheible*

*Genome-wide annotation and RNA-seq analysis identify small secreted peptides responsive to nodulation and macronutrient limitations regulating root and nodule development in Medicago truncatula.* 1669

The RNA Editing Factor SIORRM4 Is Required for Normal Fruit Ripening in Tomato. *Yongfang Yang, Guoning Zhu, Rui Li, Shijie Yan, Daqi Fu, Benzong Zhu, Huiqin Tian, Yunbo Luo, and Hongliang Zhu*

*SIORRM4 is necessary for timely fruit ripening, mitochondrial health, and RNA editing in tomato.* 1690

Two SUMO Proteases SUMO PROTEASE RELATED TO FERTILITY1 and 2 Are Required for Fertility in Arabidopsis. *Linpo Liu, Ying Jiang, Xiaomei Zhang, Xu Wang, Yanbing Wang, Yuzhen Han, George Coupland, Jing Bo Jin, Iain Searle, Yong-Fu Fu, and Fulu Chen*

*SUMO proteases regulate plant fertility through multiple pathways.* 1703

[OPEN]Extreme Suppression of Lateral Floret Development by a Single Amino Acid Change in the VRS1 Transcription Factor. *Shun Sakuma, Udda Lundqvist, Yusuke Kakei, Venkatasubbu Thirulogachandar, Takako Suzuki, Kiyosumi Hori, Jianzhong Wu, Akemi Tagiri, Twan Rutten, Ravi Koppolu, Yukihisa Shimada, Kelly Houston, William T.B. Thomas, Robbie Waugh, Thorsten Schnurbusch, and Takao Komatsuda*

*Extreme suppression of lateral floret development in deficiens barley is the result of a single amino acid substitution in the homeodomain-leucine zipper class I transcription factor VRS1.* 1720

## MEMBRANES, TRANSPORT, AND BIOENERGETICS

Cylindrical Inclusion Protein of Turnip Mosaic Virus Serves as a Docking Point for the Intercellular Movement of Viral Replication Vesicles. *Nooshin Movahed, Camilo Patarroyo, Jiaqi Sun, Hojatollah Vali, Jean-François Laliberté, and Huanquan Zheng*

*Two plasmodesmata-localized potyviral proteins of Turnip mosaic virus compose a minimum complex serving as a docking point for plasmodesmata targeting and intercellular movement of replication vesicles.* 1732

[OPEN]Altered Expression of a Malate-Permeable Anion Channel, OsALMT4, Disrupts Mineral Nutrition. *Jie Liu, Meixue Zhou, Emmanuel Delhaize, and Peter R. Ryan*

*Increased expression of a malate-permeable anion channel induced malate release from cells, which altered malate and Mn compartmentation in rice leaves leading to increased sensitivity to Mn.* 1745

## SIGNALING AND RESPONSE

[<sup>OPEN</sup>]The Distinct Roles of Class I and II RPD3-Like Histone Deacetylases in Salinity Stress Response. *Minoru Ueda, Akihiro Matsui, Maho Tanaka, Tomoe Nakamura, Takahiro Abe, Kaori Sako, Taku Sasaki, Jong-Myong Kim, Akihiro Ito, Norikazu Nishino, Hiroaki Shimada, Minoru Yoshida, and Motoaki Seki*

*Deficiency in a class I HDAC (HDA19) suppresses sensitivity to salinity stress induced by deficiencies of class II HDACs.* 1760

[<sup>OPEN</sup>]A Violaxanthin Deepoxidase Interacts with a Viral Suppressor of RNA Silencing to Inhibit Virus Amplification. *Ling Chen, Zhaoling Yan, Zihao Xia, Yuqin Cheng, Zhiyuan Jiao, Biao Sun, Tao Zhou, and Zaifeng Fan*

*Maize violaxanthin deepoxidase interacts with the HC-Pro protein of Sugarcane mosaic virus to attenuate its RNA-silencing suppression activity, contributing to decreased viral accumulation.* 1774

DELLA1-Mediated Gibberellin Signaling Regulates Cytokinin-Dependent Symbiotic Nodulation. *Camille Fonouni-Farde, Anna Kisiala, Mathias Brault, R.J. Neil Emery, Anouck Diet, and Florian Frugier*

*DELLA1-mediated GA signaling interplays with the CRE1-dependent cytokinin pathway to regulate symbiotic nodulation in the Medicago truncatula model legume.* 1795

[<sup>OPEN</sup>]Abscisic Acid-Induced Reactive Oxygen Species Are Modulated by Flavonols to Control Stomata Aperture. *Justin M. Watkins, Jordan M. Chapman, and Gloria K. Muday*

*Ethylene-regulated synthesis of flavonol antioxidants modulates ABA-induced guard cell closure, light-induced guard cell opening, and leaf transpiration.* 1807

[<sup>OPEN</sup>]Deubiquitinating Enzyme OTU5 Contributes to DNA Methylation Patterns and Is Critical for Phosphate Nutrition Signals. *Ming-Ren Yen, Der-Fen Suen, Fei-Man Hsu, Yi-Hsiu Tsai, Hongyong Fu, Wolfgang Schmidt, and Pao-Yang Chen*

*The deubiquitinase OTU5 coordinates Pi deficiency signals on DNA methylation, H3K4 and H3K27 trimethylation, and gene expression, resulting in Pi-dependent root phenotypes of otu5 mutants.* 1826

[<sup>OPEN</sup>]Phosphorylation of Arabidopsis MAP Kinase Phosphatase 1 (MKP1) Is Required for PAMP Responses and Resistance against Bacteria. *Lingyan Jiang, Jeffrey C. Anderson, Marina A. González Besteiro, and Scott C. Peck*

*Phosphorylation of MKP1 is required for its function(s) in a subset of PAMP responses and for resistance to bacterial growth.* 1839

Host-Induced Gene Silencing of the MAPKK Gene *PsFUZ7* Confers Stable Resistance to Wheat Stripe Rust. *Xiaoguo Zhu, Tuo Qi, Qian Yang, Fuxin He, Chenglong Tan, Wei Ma, Ralf Thomas Voegelé, Zhensheng Kang, and Jun Guo*

*Transgenic wheat expressing a double-stranded RNA targeting MAPKK gene PsFUZ7 from Puccinia striiformis f. sp. tritici exhibits strong resistance to stripe rust.* 1853

[<sup>OPEN</sup>]CIRCADIAN CLOCK ASSOCIATED1 (CCA1) and the Circadian Control of Stomatal Aperture. *Miriam Hassidim, Yuri Dakhiya, Adi Turjeman, Duaa Hussien, Ekaterina Shor, Ariane Anidjar, Keren Goldberg, and Rachel M. Green*

*Stomatal guard cells are controlled by a modified circadian oscillator to ensure correct daylength-dependent regulation of stomatal aperture.* 1864

Continued from preceding page

[<sup>OPEN</sup>]The E3 Ligase TaSAP5 Alters Drought Stress Responses by Promoting the Degradation of DRIP Proteins. Ning Zhang, Yujing Yin, Xinye Liu, Shaoming Tong, Jiewen Xing, Yuan Zhang, Ramesh N. Pudake, Edenys Miranda Izquierdo, Huiru Peng, Mingming Xin, Zhaorong Hu, Zhongfu Ni, Qixin Sun, and Yingyin Yao

*TaSAP5 is a kind of A20/AN1 ubiquitin E3 ligase and could enhance drought tolerance of wheat and Arabidopsis by promoting the degradation of DREB2A INTERACTING PROTEIN.*

1878

## SYSTEMS AND SYNTHETIC BIOLOGY

[<sup>OPEN</sup>]The Arabidopsis DNA Methylome Is Stable under Transgenerational Drought Stress. Deep R. Ganguly, Peter A. Crisp, Steven R. Eichten, and Barry J. Pogson

*Notwithstanding evidence of transgenerational drought-induced memory in one of six traits examined, the Arabidopsis methylome is relatively impervious to drought stress.*

1893

[<sup>CC-BY</sup>] Article free via Creative Commons CC-BY 4.0 license.

[<sup>OPEN</sup>] Articles can be viewed without a subscription.