

On the Cover: The plant circadian clock has emerged as an important regulator of plant defense. This cover image shows a generalist herbivore *Spodoptera littoralis* feeding on a wild tobacco *Nicotiana attenuata* leaf. Li et al. found that silencing of the circadian clock gene *ZEITLUPE* (*ZTL*) attenuates nicotine biosynthesis and thereby, resistance to *S. littoralis*. Furthermore, *ZTL* directly interacts with JASMONATE ZIM domain (JAZ) proteins, a component of jasmonate co-receptor, thereby regulating a JAZ-MYC2 module that is required for nicotine biosynthesis. Picture by Dr Danny Kessler, Max Planck Institute for Chemical Ecology.

ON THE INSIDE

Peter V. Minorsky 435

COMMENTARIES

A Spotlight on Photobiology. Charlotte M. M. Gommers and Scott Hayes 437

Adjusting Boron Transport by Two-Step Tuning of Levels of the Efflux Transporter BOR1. Magdalena M. Julkowska 439

Live-Cell Imaging of Mobile RNAs in Plants. Leonor C. Boavida 441

Powering Epigenetics through the 1C Pathway. Lisa Smith and Nathaniel Butler 443

Natural Variation Reveals Interplay between C4 Biology and Water Use Efficiency. Maria Papanatsiou 445

BREAKTHROUGH TECHNOLOGIES

[OPEN]GS^{yellow}, a Multifaceted Tag for Functional Protein Analysis in Monocot and Dicot Plants.

Nienke Besbrugge, Jelle Van Leene, Dominique Eeckhout, Bernard Cannoot, Shubhada R. Kulkarni, Nancy De Winne, Geert Persiau, Eveline Van De Slijke, Michiel Bontinck, Stijn Aesaert, Francis Impens, Kris Gevaert, Daniel Van Damme, Mieke Van Lijsebettens, Dirk Inzé, Klaas Vandepoele, Hilde Nelissen, and Geert De Jaeger

GS^{yellow}, a multifunctional tandem affinity purification tag, enables the simultaneous study of protein localization, protein complex membership, and chromatin binding sites in single transgenic plant lines of *Arabidopsis thaliana* and *Zea mays*. 447

Structure-Function Analysis of Chloroplast Proteins via Random Mutagenesis Using Error-Prone PCR.

Louis Dumas, Francesca Zito, Pascaline Auroy, Xenie Johnson, Gilles Peltier, and Jean Alric

A novel method of studying chloroplast proteins, which combines error-prone PCR with mutant complementation, is demonstrated using *petD* in *Chlamydomonas reinhardtii*. 465

[OPEN]Plant Hormonomics: Multiple Phytohormone Profiling by Targeted Metabolomics. Jan Šimura,

Ioanna Antoniadis, Jitka Šíroková, Danuše Tarkowská, Miroslav Strnad, Karin Ljung, and Ondřej Novák

A method for concurrent quantification of a large number of metabolites representing the metabolic flux of seven major classes of plant hormones provides a simple and sensitive tool for phytohormone studies. 476

Continued on next page

- [CC-BY] Identification of Functional Single-Nucleotide Polymorphisms Affecting Leaf Hair Number in *Brassica rapa*.
Wenting Zhang, Shirin Mirlohi, Xiaorong Li, and Yuke He
Functional SNPs for leaf hair number in *Brassica rapa* are selected and nonfunctional SNPs excluded by
intensive mutagenesis and genetic transformation. 490

RESEARCH REPORTS

- [CC-BY] Natural Variation within a Species for Traits Underpinning C₄ Photosynthesis. Gregory Reeves,
Pallavi Singh, Timo A. Rossberg, E.O. Deedi Sogbohossou, M. Eric Schranz, and Julian M. Hibberd
The C₄ species *Gynandropsis gynandra* exhibits natural variation in traits important for C₄ photosynthesis. 504

- [OPEN] Commelinid Monocotyledon Lignins Are Acylated by *p*-Coumarate. Steven D. Karlen,
Heather C.A. Free, Dharshana Padmakshan, Bronwen G. Smith, John Ralph, and Philip J. Harris
p-Coumarate acylates the γ -hydroxyls of lignin side chains, particularly on syringyl units, throughout all
orders and various families of commelinid monocotyledons. 513

- [CC-BY] Variable Effects of C-Terminal Fusions on FLS2 Function: Not All Epitope Tags Are Created Equal.
Charlotte H. Hurst, Dionne Turnbull, Sally M. Myles, Kerry Leslie, Nana F. Keinath, and Piers A. Hemsley
Complementation analysis reveals that C-terminal epitope tags have varied and unpredictable effects
on FLS2 function. 522

RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

- Screening for Biologically Annotated Drugs That Trigger Triacylglycerol Accumulation in the
Diatom *Phaeodactylum*. Melissa Conte, Josselin Lupette, Khawla Seddiki, Coline Meï, Lina-Juana Dolch,
Valérie Gros, Caroline Barette, Fabrice Rébeillé, Juliette Jouhet, and Eric Maréchal
A phenotypic screen identifies drugs, including the endocrine disruptor ethynylestradiol that trigger oil
accumulation in the diatom *Phaeodactylum*, as well as found genes and pathways for metabolic engineering. 532

- [OPEN] Development Defects of Hydroxy-Fatty Acid-Accumulating Seeds Are Reduced by Castor
Acyltransferases. Daniel Lunn, Gracen A. Smith, James G. Wallis, and John Browse
Developmental defects caused by the accumulation of hydroxy-fatty acid in seed are reduced by the
expression of castor acyltransferases. 553

- [OPEN] RAPTOR Controls Developmental Growth Transitions by Altering the Hormonal and
Metabolic Balance. Mohamed A. Salem, Yan Li, Krzysztof Bajdzienko, Joachim Fisahn,
Mutsumi Watanabe, Rainer Hoefgen, Mark Aurel Schöttler, and Patrick Giavalisco
RAPTOR1B positively regulates vegetative growth and development in *Arabidopsis* by controlling
metabolic and hormonal integrity. 565

- A Specific Glycogen Mobilization Strategy Enables Rapid Awakening of Dormant Cyanobacteria
from Chlorosis. Sofia Doello, Alexander Klotz, Alexander Makowka, Kirstin Gutekunst,
and Karl Forchhammer
Rapid reanimation of a photosynthetic bacterium following nitrogen starvation is facilitated by anticipation
and requires two parallel routes of glycogen catabolism and a particular glycogen phosphorylase paralog. 594

CELL BIOLOGY

- [OPEN] Selective Targeting of Mobile mRNAs to Plasmodesmata for Cell-to-Cell Movement.
Kai-Ren Luo, Nien-Chen Huang, and Tien-Shin Yu
mRNA live-cell imaging reveals that plasmodesmata targeting is crucial for determining mobile mRNA movement. 604

Continued on next page

[OPEN] Making Epidermal Bladder Cells Bigger: Developmental- and Salinity-Induced Endopolyploidy in a Model Halophyte. Bronwyn J. Barkla, Timothy Rhodes, Kieu-Nga T. Tran, Chathura Wijesinghege, John C. Larkin, and Maheshi Dassanayake

Salinity-induced endopolyploidy in Mesembryanthemum crystallinum plays a role in leaf development and the enlargement of epidermal bladder cells to increase their sodium storage capacity.

615

ECOPHYSIOLOGY AND SUSTAINABILITY

[OPEN] The Tomato Mitogen-Activated Protein Kinase SIMPK1 Is as a Negative Regulator of the High-Temperature Stress Response. Haidong Ding, Jie He, Yuan Wu, Xiaoxia Wu, Cailin Ge, Yijun Wang, Silin Zhong, Edgar Peiter, Jiansheng Liang, and Weifeng Xu

Tomato mitogen-activated protein kinase SIMPK1 negatively regulates high-temperature tolerance by regulating antioxidant defense, and the phosphorylation of substrate SISPRH1 is involved in this pathway.

633

GENES, DEVELOPMENT, AND EVOLUTION

[OPEN] METHIONINE ADENOSYLTRANSFERASE4 Mediates DNA and Histone Methylation.

Jingjing Meng, Lishuan Wang, Jingyi Wang, Xiaowen Zhao, Jinkui Cheng, Wenxiang Yu, Dan Jin, Qing Li, and Zhizhong Gong

MAT4 is an essential gene in Arabidopsis that plays key roles in regulating DNA and histone modifications as well as plant growth and development.

652

[OPEN] The Receptor-Like Kinase AtVRLK1 Regulates Secondary Cell Wall Thickening.

Cheng Huang, Rui Zhang, Jinshan Gui, Yu Zhong, and Laigeng Li

AtVRLK1 functions as a signaling component in coordinating cell elongation and cell wall thickening during growth and development.

671

[OPEN] The Pentatricopeptide Repeat Protein SOT5/EMB2279 Is Required for Plastid *rpl2* and *trnK* Intron Splicing. Weihua Huang, Yajuan Zhu, Wenjuan Wu, Xuan Li, Delin Zhang, Ping Yin, and Jirong Huang

*The Arabidopsis pentatricopeptide repeat protein SOT5 has a critical role in both plastid *rpl2* and *trnK* intron splicing and leaf development.*

684

FLOURY SHRUNKEN ENDOSPERM1 Connects Phospholipid Metabolism and Amyloplast Development in Rice. Wuhua Long, Yunlong Wang, Susong Zhu, Wen Jing, Yihua Wang, Yulong Ren, Yunlu Tian, Shijia Liu, Xi Liu, Liangming Chen, Di Wang, Mingsheng Zhong, Yuanyan Zhang, Tingting Hu, Jianping Zhu, Yuanyuan Hao, Xiaopin Zhu, Wenwei Zhang, Chunming Wang, Wenhua Zhang, and Jianmin Wan

The FLOURY SHRUNKEN ENDOSPERM1 gene, encoding a phospholipase-like protein, plays an important role in phospholipid metabolism and amyloplast development in rice endosperm.

698

[OPEN] OsMADS6 Controls Flower Development by Activating Rice FACTOR OF DNA METHYLATION LIKE1. Juhong Tao, Wanqi Liang, Gynheung An, and Dabing Zhang

OsFDML1, a rice homolog of Arabidopsis FACTOR OF DNA METHYLATION1, is directly targeted by OsMADS6 and regulates floral organ specification and meristem determination in rice.

713

[OPEN] A Rice Glutamyl-tRNA Synthetase Modulates Early Anther Cell Division and Patterning. Xiujuan Yang, Gang Li, Yuesheng Tian, Yu Song, Wanqi Liang, and Dabing Zhang

OsERS1, a glutamyl-tRNA synthetase, modulates early rice anther development through affecting metabolic homeostasis and redox status.

728

MEMBRANES, TRANSPORT, AND BIOENERGETICS

[OPEN] Elucidation of the Mechanisms of Long-Distance mRNA Movement in a *Nicotiana benthamiana*/Tomato Heterograft System. Chao Xia, Yi Zheng, Jing Huang, Xiangjun Zhou, Rui Li, Manrong Zha, Shujuan Wang, Zhiqiang Huang, Hai Lan, Robert Turgeon, Zhangjun Fei, and Cankui Zhang

Messenger RNA is degraded as it moves through the tomato phloem, and the mobility of a transcript cannot be reliably predicted based on its abundance in the Nicotiana benthamiana leaf or on whether it harbors a tRNA-like structural motif.

745

[OPEN] Boron-Dependent Translational Suppression of the Borate Exporter *BOR1* Contributes to the Avoidance of Boron Toxicity. Izumi Aibara, Tatsuya Hirai, Koji Kasai, Junpei Takano, Hitoshi Onouchi, Satoshi Naito, Toru Fujiwara, and Kyoko Miwa

Upstream open reading frames in the 5' untranslated region of BOR1, a borate transporter, control boron-dependent translational suppression that, alongside BOR1 degradation, contributes to the avoidance of boron toxicity in plants.

759

SIGNALING AND RESPONSE

The *MicroRNA390*/TRANS-ACTING SHORT INTERFERING RNA3 Module Mediates Lateral Root Growth under Salt Stress via the Auxin Pathway. Fu He, Changzheng Xu, Xiaokang Fu, Yun Shen, Li Guo, Mi Leng, and Keming Luo

The miR390/TAS3/ARF4 module is involved in the regulation of lateral root development under salt stress in poplar by auxin signaling.

775

[OPEN] *Medicago* Plants Control Nodulation by Regulating Proteolysis of the Receptor-Like Kinase DMI2. Huairong Pan, Christina Stonoha-Arther, and Dong Wang

The symbiotic receptor DMI2 in Medicago undergoes constitutive degradation by the proteasome, which is blocked upon rhizobia inoculation.

792

[OPEN] Cytokinin Targets Auxin Transport to Promote Shoot Branching. Tanya Waldie and Ottoline Leyser

Cytokinin promotes shoot branching in part by promoting plasma membrane accumulation of PIN3, PIN4, and PIN7 auxin exporters in the shoot.

803

[OPEN] Auxin Efflux Carrier ZmPGP1 Mediates Root Growth Inhibition under Aluminum Stress. Maolin Zhang, Xiaoduo Lu, Cuiling Li, Bing Zhang, Chunyi Zhang, Xian-sheng Zhang, and Zhaojun Ding

ZmPGP1 controls local auxin accumulation in root tips and regulates root growth under Al stress in maize.

819

[CC-BY] ZEITLUPE in the Roots of Wild Tobacco Regulates Jasmonate-Mediated Nicotine Biosynthesis and Resistance to a Generalist Herbivore. Ran Li, Lucas Cortés Llorca, Meredith C. Schuman, Yang Wang, Lanlan Wang, Youngsung Joo, Ming Wang, Daniel Giddings Vassão, and Ian T. Baldwin

ZEITLUPE in the roots of Nicotiana attenuata interacts with JASMONATE ZIM domain proteins and subsequently regulates JA-mediated nicotine biosynthesis and herbivore resistance.

833

[CC-BY] Auxin Contributes to the Intraorgan Regulation of Gene Expression in Response to Shade. Sujung Kim, Nobuyoshi Mochizuki, Ayumi Deguchi, Atsushi J. Nagano, Tomomi Suzuki, and Akira Nagatani

Many genes are preferentially up-regulated by shade stimulus in the vasculature of Arabidopsis thaliana cotyledons, some of which are regulated by newly synthesized auxin in the mesophyll and/or epidermis.

847

[CC-BY] Article free via Creative Commons CC-BY 4.0 license.

[OPEN] Articles can be viewed without a subscription.