

TM
p71/1c

VOLUME 26

NUMBER 12

DECEMBER 2014

The background of the cover is a dense, intricate embroidery of various green leaves and ferns on a light-colored fabric. The leaves vary in shape, including large ovate leaves with prominent veins, smaller fern fronds, and delicate, feathery leaves. The embroidery uses different shades of green thread to create depth and texture.

T H E
PLANT
C E L L

REGULATION OF HETEROPHYLLY IN NORTH AMERICAN LAKE CRESS

www.plantcell.org

T H E
PLANT
C E L L

Volume 26 Number 12 December 2014

The electronic form of this issue, available at www.plantcell.org, is the journal of record.

ON THE COVER



Many plants alter the shape of their leaves depending on the environment, in a phenomenon called heterophylly. Nakayama et al. (pages 4733–4748) show that heterophylly in the North American lake cress *Rorippa aquatica* (Brassicaceae) is mediated by *KNOX1*-dependent regulation of gibberellin (GA) level. The *KNOX*-GA regulatory module responsible for species-to-species variation seems to have been recruited to determine the differential leaf morphology within a single species as well. The cover illustration by artist Sadamu Yoshizawa depicts the extent of heterophyllic morphological variation in *R. aquatica*.

EDITORIAL

- Plant Physiology* and *The Plant Cell* Go Online Only** 4561
Cathie Martin and Mike Blatt
- A Hopefully Not Too Long Goodbye** 4562
Cathie Martin


IN BRIEF

- A World Beyond *Arabidopsis*: Updates on Small RNAs in Plant Development** 4564
Nancy R. Hofmann
- DNA Methylation in Maize: Toto, I've a Feeling We're Not in *Arabidopsis* Anymore** 4565
Jennifer Mach
- Membrane Bound: C2-Domain Abscisic Acid-Related Proteins Help Abscisic Acid Receptors Get Where They Need to Go** 4566
Jennifer Lockhart
- Examining the Molecular Basis of Heterophylly in North American Lake Cress** 4567
Kathleen L. Farquharson

REVIEW

- Phytochromes: An Atomic Perspective on Photoactivation and Signaling** 4568
E. Sethe Burgie and Richard D. Vierstra

LARGE-SCALE BIOLOGY ARTICLES

- An Atlas of Soybean Small RNAs Identifies Phased siRNAs from Hundreds of Coding Genes**  4584
Siwaret Arikrit, Rui Xia, Atul Kakrana, Kun Huang, Jixian Zhai, Zhe Yan, Oswaldo Valdés-López, Silvas Prince, Theresa A. Musket, Henry T. Nguyen, Gary Stacey, and Blake C. Meyers
- Genetic Perturbation of the Maize Methylome**  4602
Qing Li, Steven R. Eichten, Peter J. Hermanson, Virginia M. Zaunbrecher, Jawon Song, Jennifer Wendt, Heidi Rosenbaum, Thelma F. Madzima, Amy E. Sloan, Ji Huang, Daniel L. Burgess, Todd A. Richmond, Karen M. McGinnis, Robert B. Meeley, Olga N. Danilevskaya, Matthew W. Vaughn, Shawn M. Kaeppler, Jeffrey A. Jeddelloh, and Nathan M. Springer

Федеральное государственное
бюджетное учреждение науки
Центральная научная библиотека
Уральского отделения
Российской академии наук (ЦНБ УрО РАН)

EDITORIAL BOARD

Editor in Chief

Cathie Martin

Coeditors

Sarah M. Assmann

Jody Banks

Alice Barkan

Sebastian Bednarek

James Birchler

Ulla Bonas

Christopher Bowler

Judy Callis

XiaoFeng Cao

Vincenzo De Luca

Xing Wang Deng

Xinnian Dong

Allan Downie

Alisdair Fernie

Pascal Genschik

Jean T. Greenberg

Thomas Guilfoyle

Herman R. Höfte

David Jackson

Regine Kahmann

Martin Kater

Daniel J. Kliebenstein

William Lucas

Blake Meyers

Ortrun Mittelsten Scheid

Giles Oldroyd

Michael Palmgren

Markus Pauly

Scott C. Peck

Barry Pogson

Zhaohui Qin

Karin Schumacher

David Smyth

Chris J. Staiger

Keiko Sugimoto

Managing Editor

Patti Lockhart

Senior Features Editor

Nancy A. Eckardt

Features Editor

Mary Williams

Science Editors

Greg Bertoni

Kathleen L. Farquharson

Nancy R. Hofmann

Jennifer Lockhart

Jennifer M. Mach

Production Manager

Susan L. Entwistle

Manuscript Manager

Annette Kessler

Publications Director

Nancy A. Winchester

Publisher

American Society of

Plant Biologists

Executive Director,

Crispin Taylor

Editorial Office

15501 Monona Drive

Rockville, Maryland 20855-2768

Telephone: 301/296-0908

Fax: 301/279-2996

<http://www.aspb.org>

Online at www.plantcell.org

Integrated Network Analysis Identifies Fight-Club Nodes as a Class of Hubs Encompassing Key Putative Switch Genes That Induce Major Transcriptome Reprogramming during Grapevine Development [W|OPEN](#) 4617

Maria Concetta Palumbo, Sara Zenoni, Marianna Fasoli, Mélanie Massonnet, Lorenzo Farina, Filippo Castiglione, Mario Pezzotti, and Paola Paci

Dissecting the Phenotypic Components of Crop Plant Growth and Drought Responses Based on High-Throughput Image Analysis [W|OPEN](#) 4636

Dijun Chen, Kerstin Neumann, Swetlana Friedel, Benjamin Kilian, Ming Chen, Thomas Altmann, and Christian Klukas

***Arabidopsis* Ensemble Reverse-Engineered Gene Regulatory Network Discloses Interconnected Transcription Factors in Oxidative Stress** [W](#) 4656

Vanessa Vermeirssen, Inge De Clercq, Thomas Van Parys, Frank Van Breusegem, and Yves Van de Peer

The Root Hair “Infectome” of *Medicago truncatula* Uncovers Changes in Cell Cycle Genes and Reveals a Requirement for Auxin Signaling in Rhizobial Infection [W|OPEN](#) 4680

Andrew Breakspear, Chengwu Liu, Sonali Roy, Nicola Stacey, Christian Rogers, Martin Trick, Giulia Morieri, Kirankumar S. Mysore, Jiangqi Wen, Giles E.D. Oldroyd, J. Allan Downie, and Jeremy D. Murray

RESEARCH ARTICLES

The *dicer-like1* Homolog *fuzzy tassel* Is Required for the Regulation of Meristem Determinacy in the Inflorescence and Vegetative Growth in Maize [W|OPEN](#) 4702

Beth E. Thompson, Christine Basham, Reza Hammond, Queying Ding, Atul Kakrana, Tzoo-Fen Lee, Stacey A. Simon, Robert Meeley, Blake C. Meyers, and Sarah Hake

Transcriptomic Analyses Indicate That Maize Ligule Development Recapitulates Gene Expression Patterns That Occur during Lateral Organ Initiation [W|OPEN](#) 4718

Robyn Johnston, Minghui Wang, Qi Sun, Anne W. Sylvester, Sarah Hake, and Michael J. Scanlon

Regulation of the KNOX-GA Gene Module Induces Heterophyllic Alteration in North American Lake Cress [W](#) 4733

Hokuto Nakayama, Naomi Nakayama, Sumer Seiki, Mikiko Kojima, Hitoshi Sakakibara, Neelima Sinha, and Seisuke Kimura

Site-Specific N-Glycosylation of the S-Locus Receptor Kinase and Its Role in the Self-Incompatibility Response of the Brassicaceae [C|W](#) 4749

Masaya Yamamoto, Titima Tantikanjana, Takeshi Nishio, Mikhail E. Nasrallah, and June B. Nasrallah

Proteasome-Mediated Degradation of FRIGIDA Modulates Flowering Time in *Arabidopsis* during Vernalization [C|W](#) 4763

Xiangyang Hu, Xiangxiang Kong, Chuntao Wang, Lan Ma, Jinjie Zhao, Jingjing Wei, Xiaoming Zhang, Gary J. Loake, Ticao Zhang, Jinling Huang, and Yongping Yang

Soybean miR172c Targets the Repressive AP2 Transcription Factor NNC1 to Activate *ENOD40* Expression and Regulate Nodule Initiation [C|W](#) 4782

Youning Wang, Lixiang Wang, Yanmin Zou, Liang Chen, Zhaoming Cai, Senlei Zhang, Fang Zhao, Yinping Tian, Qiong Jiang, Brett J. Ferguson, Peter M. Gresshoff, and Xia Li

- C2-Domain Abscisic Acid-Related Proteins Mediate the Interaction of PYR/PYL/RCAR Abscisic Acid Receptors with the Plasma Membrane and Regulate Abscisic Acid Sensitivity in *Arabidopsis*** [C](#)[W](#) 4802
Lesia Rodriguez, Miguel Gonzalez-Guzman, Maira Diaz, Americo Rodrigues, Ana C. Izquierdo-Garcia, Marta Peirats-Llobet, Maria A. Fernandez, Regina Antoni, Daniel Fernandez, Jose A. Marquez, Jose M. Mulet, Armando Albert, and Pedro L. Rodriguez
- Cell Differentiation and Development in *Arabidopsis* Are Associated with Changes in Histone Dynamics at the Single-Cell Level** [W](#)[I](#)[O](#)[P](#)[E](#)[N](#) 4821
Stefanie Rosa, Vardis Ntoukakis, Nobuko Ohmido, Ali Pendle, Rita Abranches, and Peter Shaw
- The *Arabidopsis* Cellulose Synthase Complex: A Proposed Hexamer of CESA Trimers in an Equimolar Stoichiometry** [W](#) 4834
Joseph L. Hill, Jr., Mustafa B. Hammudi, and Ming Tien
- BEL1-LIKE HOMEODOMAIN6 and KNOTTED ARABIDOPSIS THALIANA7 Interact and Regulate Secondary Cell Wall Formation via Repression of *REVOLUTA*** [C](#)[W](#) 4843
Yuanyuan Liu, Shijun You, Mallorie Taylor-Teeple, Wenhua L. Li, Mathias Schuetz, Siobhan M. Brady, and Carl J. Douglas
- A NAP-AAO3 Regulatory Module Promotes Chlorophyll Degradation via ABA Biosynthesis in *Arabidopsis* Leaves** [W](#)[I](#)[O](#)[P](#)[E](#)[N](#) 4862
Jiading Yang, Eric Worley, and Michael Udvardi
- Stress-Induced Chloroplast Degradation in *Arabidopsis* Is Regulated via a Process Independent of Autophagy and Senescence-Associated Vacuoles** [W](#) 4875
Songhu Wang and Eduardo Blumwald
- The *Arabidopsis thaliana* Homolog of the Helicase RTEL1 Plays Multiple Roles in Preserving Genome Stability** [C](#)[W](#) 4889
Julia Recker, Alexander Knoll, and Holger Puchta
- Accessible DNA and Relative Depletion of H3K9me2 at Maize Loci Undergoing RNA-Directed DNA Methylation** [W](#)[I](#)[O](#)[P](#)[E](#)[N](#) 4903
Jonathan I. Gent, Thelma F. Madzima, Rechien Bader, Matthew R. Kent, Xiaoyu Zhang, Maïke Stam, Karen M. McGinnis, and R. Kelly Dawe
- RHON1 Mediates a Rho-Like Activity for Transcription Termination in Plastids of *Arabidopsis thaliana*** [C](#)[W](#) 4918
Wei Chi, Baoye He, Nikolay Manavski, Juan Mao, Daili Ji, Congming Lu, Jean David Rochaix, Jörg Meurer, and Lixin Zhang
- MicroRNA408 Is Critical for the *HY5-SPL7* Gene Network That Mediates the Coordinated Response to Light and Copper** [C](#)[W](#) 4933
Huiyong Zhang, Xin Zhao, Jigang Li, Huaqing Cai, Xing Wang Deng, and Lei Li
- Arabidopsis* DPB3-1, a DREB2A Interactor, Specifically Enhances Heat Stress-Induced Gene Expression by Forming a Heat Stress-Specific Transcriptional Complex with NF-Y Subunits** [C](#)[W](#) 4954
Hikaru Sato, Junya Mizoi, Hidenori Tanaka, Kyonosin Maruyama, Feng Qin, Yuriko Osakabe, Kyoko Morimoto, Teppei Otori, Kazuya Kusakabe, Maika Nagata, Kazuo Shinozaki, and Kazuko Yamaguchi-Shinozaki
- The *Arabidopsis* Abiotic Stress-Induced TSPO-Related Protein Reduces Cell-Surface Expression of the Aquaporin PIP2;7 through Protein-Protein Interactions and Autophagic Degradation** [C](#)[W](#)[I](#)[O](#)[P](#)[E](#)[N](#) 4974
Charles Hachez, Vasko Veljanovski, Hagen Reinhardt, Damien Guillaumot, Celine Vanhee, François Chaumont, and Henri Batoko

Ran Li, Berhane T. Weldegergis, Jie Li, Choonyun Jung, Jing Qu, Yanwei Sun, Hongmei Qian, ChuanSia Tee, Joop J.A. van Loon, Marcel Dicke, Nam-Hai Chua, Shu-Sheng Liu, and Jian Ye

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

 Online version contains Web-only data.

 Articles can be viewed online without a subscription.



© 2015 American Society of Plant Biologists. All rights reserved. Printed on acid-free paper effective with Volume 1, Number 1, January 1989. Printed in the United States of America.

The Plant Cell (ISSN 1040-4651, online ISSN 1532-298X) is published monthly (one volume per year) by the American Society of Plant Biologists, 15501 Monona Drive, Rockville, MD 20855-2768, and is produced by Dartmouth Journal Services, Waterbury, VT. The institutional price for the print and online versions is based on type of institution; contact institution@aspb.org. Single copies may be purchased for \$40 each, plus \$10 shipping (U.S.) or \$12 (outside U.S.). Members of the American Society of Plant Biologists may subscribe to *The Plant Cell* for \$240. Nonmember individuals may subscribe for \$500. Students may subscribe for \$165. For matters regarding subscriptions, contact Suzanne Cholwek, ASPB, 15501 Monona Drive, Rockville, MD 20855-2768; telephone 301/296-0926; fax 301/251-6740; e-mail scholwek@aspb.org. Notify ASPB in writing within 3 months (domestic) or 6 months (foreign) of issue date, and defective copies or copies lost in the mail will be replaced. Send all inquiries regarding display advertising to FASEB AdNet, 9650 Rockville Pike, Bethesda, MD 20814-3998; telephone 301/634-7791; fax 301/634-7153; e-mail adnet@faseb.org. Periodicals postage paid at Rockville, MD 20850, and at additional mailing offices.

Postmaster: Send address changes to *The Plant Cell*, American Society of Plant Biologists, 15501 Monona Drive, Rockville, MD 20855-2768. The online version of *The Plant Cell* is available at www.plantcell.org.

Permission to Reprint: Permission to make digital or hard copies of part or all of a work published in *The Plant Cell* is granted without fee for personal or classroom use provided that copies are not made or distributed for profit or commercial advantage and that copies bear the full citation and the following notice on the first page: "Copyright American Society of Plant Biologists." For all other kinds of copying, request permission in writing from Nancy A. Winchester, Publications Director, ASPB headquarters.