

T H E
PLANT
C E L L

Volume 23 Number 11 November 2011

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

ON THE COVER



Glycyrrhizin, extracted from the roots of licorice plants, is a powerful sweetening agent with a wide range of pharmacological properties. In addition to applications as a natural sweetener, it is included in certain traditional medicines because it enhances liver function and exhibits antiviral activity. However, large-scale production of glycyrrhizin is a considerable challenge. Seki et al. (pages 4112–4123) identified a cytochrome P450 monooxygenase, CYP72A154, that is important in the biosynthesis of glycyrrhizin. The authors show that genetically modified yeast can produce glycyrrhetic acid (a glycyrrhizin intermediate and the active form of glycyrrhizin) through combinatorial expression of CYP72A154 and two previously acquired pathway enzymes, providing proof of concept for engineering the production of high-value triterpenoid products in yeast. The cover image of dried licorice root was taken by Kiminori Toyooka.

IN BRIEF

- A Role for Plant AURORA Kinases in Formative Cell Division** 3867
Nancy R. Hofmann
- Unpuréeing the Tomato: Layers of Information Revealed by Microdissection and High-Throughput Transcriptome Sequencing** 3868
Jennifer Mach
- YUC and TAA1/TAR Proteins Function in the Same Pathway for Auxin Biosynthesis** 3869
Nancy R. Hofmann
- Retrograde Signaling: A New Candidate Signaling Molecule** 3870
Nancy A. Eckardt




COMMENTARY

- Cautionary Notes on the Use of C-Terminal BAK1 Fusion Proteins for Functional Studies** 3871
Vardis Ntoukakis, Benjamin Schwessinger, Cécile Segonzac, and Cyril Zipfel

REVIEW

- C₄ Cycles: Past, Present, and Future Research on C₄ Photosynthesis** 3879
Jane A. Langdale

LARGE-SCALE BIOLOGY ARTICLES

- Tissue- and Cell-Type Specific Transcriptome Profiling of Expanding Tomato Fruit Provides Insights into Metabolic and Regulatory Specialization and Cuticle Formation**   3893
Antonio J. Matas, Trevor H. Yeats, Gregory J. Buda, Yi Zheng, Subhasish Chatterjee, Takayuki Tohge, Lalit Ponnala, Avital Adato, Asaph Aharoni, Ruth Stark, Alisdair R. Fernie, Zhangjun Fei, James J. Giovannoni, and Jocelyn K.C. Rose
- Plastid Proteome Assembly without Toc159: Photosynthetic Protein Import and Accumulation of N-Acetylated Plastid Precursor Proteins**   3911
Sylvain Bischof, Katja Baerenfaller, Thomas Wildhaber, Raphael Troesch, Pierre-Alexandre Vidi, Bernd Roschitzki, Matthias Hirsch-Hoffmann, Lars Hennig, Felix Kessler, Wilhelm Gruißem, and Sacha Baginsky

EDITORIAL BOARD

Editor in Chief

Cathie Martin

Coeditors

Sarah M. Assmann

Jody Banks

David Baum

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

Patricia Leon

Clive Lloyd

William Lucas

Blake Meyers

Ortrun Mittelsten Scheid

Joseph Noel

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 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

RESEARCH ARTICLES

- Regulation of Compound Leaf Development in *Medicago truncatula* by Fused Compound Leaf1, a Class M KNOX Gene** [C](#) [W](#) 3929
Jianling Peng, Jianbin Yu, Hongliang Wang, Yingqing Guo, Guangming Li, Guihua Bai, and Rujin Chen
- A Small-Molecule Screen Identifies L-Kynurenine as a Competitive Inhibitor of TAA1/TAR Activity in Ethylene-Directed Auxin Biosynthesis and Root Growth in *Arabidopsis*** [C](#) [W](#) 3944
Wenrong He, Javier Brumos, Hongjiang Li, Yusi Ji, Meng Ke, Xinqi Gong, Qinglong Zeng, Wenyang Li, Xinyan Zhang, Fengying An, Xing Wen, Pengpeng Li, Jinfang Chu, Xiaohong Sun, Cunyu Yan, Nieng Yan, De-Yu Xie, Natasha Raikhel, Zhenbiao Yang, Anna N. Stepanova, Jose M. Alonso, and Hongwei Guo
- The *Arabidopsis* YUCCA1 Flavin Monooxygenase Functions in the Indole-3-Pyruvic Acid Branch of Auxin Biosynthesis** [W](#) 3961
Anna N. Stepanova, Jeonga Yun, Linda M. Robles, Ondrej Novak, Wenrong He, Hongwei Guo, Karin Ljung, and Jose M. Alonso
- Functional Profiling Identifies Genes Involved in Organ-Specific Branches of the PIF3 Regulatory Network in *Arabidopsis*** [C](#) [W](#) 3974
Maria Sentandreu, Guiomar Martín, Nahuel González-Schain, Pablo Leivar, Judit Soy, James M. Tepperman, Peter H. Quail, and Elena Monte
- Evidence for a SAL1-PAP Chloroplast Retrograde Pathway That Functions in Drought and High Light Signaling in *Arabidopsis*** [C](#) [W](#) [O](#) [A](#) 3992
Gonzalo M. Estavillo, Peter A. Crisp, Wannarat Pornsiriwong, Markus Wirtz, Derek Collinge, Chris Carrie, Estelle Giraud, James Whelan, Pascale David, Hélène Javot, Charles Brearley, Rüdiger Hell, Elena Marin, and Barry J. Pogson
- Arabidopsis* α Aurora Kinases Function in Formative Cell Division Plane Orientation** [W](#) 4013
Daniël Van Damme, Bert De Rybel, Gustavo Gudesblat, Dmitri Demidov, Wim Grunewald, Ive De Smet, Andreas Houben, Tom Beeckman, and Eugenia Russinova
- AXY8 Encodes an α -Fucosidase, Underscoring the Importance of Apoplastic Metabolism on the Fine Structure of *Arabidopsis* Cell Wall Polysaccharides** [W](#) [O](#) [A](#) 4025
Markus Günl, Lutz Neumetzler, Florian Kraemer, Amancio de Souza, Alex Schultink, Maria Pena, William S. York, and Markus Pauly
- O-Acetylation of *Arabidopsis* Hemicellulose Xyloglucan Requires AXY4 or AXY4L, Proteins with a TBL and DUF231 Domain** [W](#) [O](#) [A](#) 4041
Sascha Gille, Amancio de Souza, Guangyan Xiong, Monique Benz, Kun Cheng, Alex Schultink, Ida-Barbara Reca, and Markus Pauly
- Euchromatic Subdomains in Rice Centromeres Are Associated with Genes and Transcription** [W](#) 4054
Yufeng Wu, Shinji Kikuchi, Huihuang Yan, Wenli Zhang, Heidi Rosenbaum, A. Leonardo Iniguez, and Jiming Jiang
- Transcriptional Regulation of *Arabidopsis* LEAFY COTYLEDON2 Involves RLE, a cis-Element That Regulates Trimethylation of Histone H3 at Lysine-27** [W](#) 4065
Nathalie Berger, Bertrand Dubreucq, François Roudier, Christian Dubos, and Loïc Lepiniec
- Transcriptomic Analysis Reveals Calcium Regulation of Specific Promoter Motifs in *Arabidopsis*** [W](#) 4079
Helen J. Whalley, Alexander W. Sargeant, John F.C. Steele, Tim Lacoere, Rebecca Lamb, Nigel J. Saunders, Heather Knight, and Marc R. Knight
- The Phosphoglucan Phosphatase Like Sex Four2 Dephosphorylates Starch at the C3-Position in *Arabidopsis*** [W](#) [O](#) [A](#) 4096
Diana Santelia, Oliver Kötting, David Seung, Mario Schubert, Matthias Thalman, Sylvain Bischof, David A. Meekins, Andy Lutz, Nicola Patron, Matthew S. Gentry, Frédéric H.-T. Allain, and Samuel C. Zeeman

Triterpene Functional Genomics in Licorice for Identification of CYP72A154 Involved in the Biosynthesis of Glycyrrhizin   

4112

Hikaru Seki, Satoru Sawai, Kiyoshi Ohyama, Masaharu Mizutani, Toshiyuki Ohnishi, Hiroshi Sudo, Ery Odette Fukushima, Tomoyoshi Akashi, Toshio Aoki, Kazuki Saito, and Toshiya Muranaka

The *Arabidopsis* Glucosyltransferase UGT76B1 Conjugates Isoleucic Acid and Modulates Plant Defense and Senescence   

4124


Veronica von Saint Paul, Wei Zhang, Basem Kanawati, Birgit Geist, Theresa Faus-Keßler, Philippe Schmitt-Kopplin, and Anton R. Schäffner

Programmed Cell Death Occurs Asymmetrically during Abscission in Tomato   

4146

Tal Bar-Dror, Marina Dermastia, Aleš Kladnik, Magda Tušek Žnidarič, Maruša Pompe Novak, Shimon Meir, Shaul Burd, Sonia Philosoph-Hadas, Naomi Ori, Lilian Sonego, Martin B. Dickman, and Amnon Lers

 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.

 Open Access articles can be viewed online without a subscription.



© 2011 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 1531-298X) 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. A subscription includes both *The Plant Cell* and *Plant Physiology*; single copies may be purchased for \$95 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 \$185. Nonmember individuals may subscribe for \$375. 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.

This information is current as of April 16, 2021

Permissions	https://www.copyright.com/ccc/openurl.do?sid=pd_hw1532298X&issn=1532298X&WT.mc_id=pd_hw1532298X
eTOCs	Sign up for eTOCs at: http://www.plantcell.org/cgi/alerts/ctmain
CiteTrack Alerts	Sign up for CiteTrack Alerts at: http://www.plantcell.org/cgi/alerts/ctmain
Subscription Information	Subscription Information for <i>The Plant Cell</i> and <i>Plant Physiology</i> is available at: http://www.aspb.org/publications/subscriptions.cfm