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Freeze/Thaw Event on Norway Spruce in Tyrolean Timberline



The electronic form of this issue, available as of February 6, 2014, at www.plantphysiol.org, is considered the journal of record.

On the Cover: Trees growing at the alpine timberline are exposed to excessive drought stress during winter. The lack of water uptake due to ice formation in the xylem of conifers and water losses over crown parts exposed to the atmosphere causes water deficits, a phenomenon called frost drought. In combination with freeze-thaw events, this drought stress causes embolism. In this issue, Charrier et al. (pp. 992–998) analyzed relations between freeze-thaw-induced loss of conductivity, ultrasonic emissions, minimal temperature, anatomy, and drought resistance in angiosperms, suggesting that gas segregation and air seeding are both involved in embolism development. The cover shows Norway spruce (*Picea abies*) during winter at the alpine timberline exposed to excessive frost drought stress (the 15th of December 2009, Birgitz Köpfl, Tyrol, Austria). Cover image credits: Katline Charra-Vaskou.

ON THE INSIDE

Peter V. Minorsky

497

TOPICAL REVIEWS

The Role of Target of Rapamycin Signaling Networks in Plant Growth and Metabolism. Yan Xiong and Jen Sheen

Recent breakthroughs and large-scale profiling are unraveling TOR signaling in plant growth, proliferation, and metabolism.

499

BREAKTHROUGH TECHNOLOGIES

[W][OPEN]MAKER-P: A Tool Kit for the Rapid Creation, Management, and Quality Control of Plant Genome Annotations.

Michael S. Campbell, MeiYee Law, Carson Holt, Joshua C. Stein, Gaurav D. Moghe, David E. Hufnagel, Jikai Lei, Rujira Achavanantakun, Dian Jiao, Carolyn J. Lawrence, Doreen Ware, Shin-Han Shiu, Kevin L. Childs, Yanni Sun, Ning Jiang, and Mark Yandell

MAKER-P annotates the entire Arabidopsis and maize genomes in less than 3 h with comparable quality to the current TAIR10 and maize V2 annotation builds.

513

[W][OPEN]Selected Reaction Monitoring to Determine Protein Abundance in Arabidopsis Using the Arabidopsis

Proteotypic Predictor. Nicolas L. Taylor, Ricarda Fenske, Ian Castleden, Tiago Tomaz, Clark J. Nelson, and A. Harvey Millar

Selected reaction monitoring mass spectrometry and prediction quantifies protein abundance in knockout and complemented lines of Arabidopsis when antibodies are unavailable.

525

[W][OPEN]Mesoporous Silica Nanoparticle-Mediated Intracellular Cre Protein Delivery for Maize Genome Editing via

loxP Site Excision. Susana Martin-Ortigosa, David J. Peterson, Justin S. Valenstein, Victor S.-Y. Lin, Brian G. Trewyn, L. Alexander Lyznik, and Kan Wang

A recombinase protein loaded into mesoporous silica nanoparticles was delivered through the biolistic method to maize tissues, leading to site-specific recombination.

537

RESEARCH REPORTS

[W][OPEN]Extensive Functional Pleiotropy of REVOLUTA Substantiated through Forward Genetics. Ilga Porth,

Jaroslav Klápště, Athena D. McKown, Jonathan La Mantia, Richard C. Hamelin, Oleksandr Skyba, Faride Unda, Michael C. Friedmann, Quentin C.B. Cronk, Jürgen Ehrling, Robert D. Guy, Shawn D. Mansfield, Yousry A. El-Kassaby, and Carl J. Douglas

A “functional hypothesis” model is presented for the extensive functional pleiotropy of a poplar class III homeodomain-leucine zipper transcription factor in modulating extensive phenotypic variability.

548

Continued on next page

BIOCHEMISTRY AND METABOLISM

[W][OPEN] Overexpression of an Isoprenyl Diphosphate Synthase in Spruce Leads to Unexpected Terpene Diversion Products That Function in Plant Defense. *Raimund Nagel, Aileen Berasategui, Christian Paetz, Jonathan Gershenzon, and Axel Schmidt*

Overexpression and increases in prenyl diphosphate content lead to terpene diversion products functioning in conifer defense. 555

[W][OPEN] Two Fatty Acid Desaturases, STEAROYL-ACYL CARRIER PROTEIN Δ^9 -DESATURASE6 and FATTY ACID DESATURASE3, Are Involved in Drought and Hypoxia Stress Signaling in Arabidopsis Crown Galls. *Joern Klinkenberg, Hanna Faist, Stefanie Saupe, Sophie Lambertz, Markus Kruschke, Nadja Stingl, Agnes Fekete, Martin J. Mueller, Ivo Feussner, Rainer Hedrich, and Rosalia Deeken*

Two desaturase genes respond to drought and hypoxia stress in Arabidopsis crown galls. 570

[C][OPEN] Chemically Induced Conditional Rescue of the *Reduced Epidermal Fluorescence8* Mutant of Arabidopsis Reveals Rapid Restoration of Growth and Selective Turnover of Secondary Metabolite Pools. *Jeong Im Kim, Peter N. Ciesielski, Bryon S. Donohoe, Clint Chapple, and Xu Li*

Activation of the wild-type gene in an Arabidopsis phenylpropanoid mutant at different developmental stages has distinct impacts on metabolic changes and plant growth. 584

[C][W][OPEN] Functions of Multiple Genes Encoding ADP-Glucose Pyrophosphorylase Subunits in Maize Endosperm, Embryo, and Leaf. *Binqun Huang, Tracie A. Hennen-Bierwoagen, and Alan M. Myers*

Mutational analysis of maize genes encoding a plastidial pyrophosphorylase demonstrates that cytosolic and amyloplast enzymes both contribute to endosperm starch content. 596

[W][OPEN] Heterologous Expression of Methylketone Synthase1 and Methylketone Synthase2 Leads to Production of Methylketones and Myristic Acid in Transgenic Plants. *Geng Yu and Eran Pichersky*

Heterologous expression of two wild tomato genes affects methylketone production in Arabidopsis, tobacco, and cultivated tomato plants but with adverse effects to the plants. 612

[C][W][OPEN] Analyses of Tomato Fruit Brightness Mutants Uncover Both Cutin-Deficient and Cutin-Abundant Mutants and a New Hypomorphic Allele of *GDSL Lipase*. *Johann Petit, Cécile Bres, Daniel Just, Virginie Garcia, Jean-Philippe Mauxion, Didier Marion, Bénédicte Bakan, Jérôme Joubès, Frédéric Domergue, and Christophe Rothan*

Opposite changes in the cutin polyester component in tomato fruit cuticle mutants lead to increased fruit glossiness. 888

[C][W] Double Knockout Mutants of Arabidopsis Grown under Normal Conditions Reveal that the Plastidial Phosphorylase Isozyme Participates in Transitory Starch Metabolism. *Irina Malinova, Sebastian Mahlow, Saleh Alseekh, Tom Orawetz, Alisdair R. Fernie, Otto Baumann, Martin Steup, and Joerg Fettke*

A plastidial phosphorylase isozyme participates in starch metabolism and integrates with central carbon metabolism in the entire cell biology. 907

[C][W][OPEN] A Carbon-Nitrogen Lyase from *Leucaena leucocephala* Catalyzes the First Step of Mimosine Degradation. *Vishal Singh Negi, Jon-Paul Bingham, Qing X. Li, and Dulal Borthakur*

A carbon-nitrogen lyase from the tree legume Leucaena leucocephala degrades the toxin mimosine. 922

[C][W]5-Carvone Suppresses Cellulase-Induced Capsidiol Production in *Nicotiana tabacum* by Interfering with Protein Isoprenylation. Alexandre Huchelmann, Clément Gastaldo, Mickaël Veinante, Ying Zeng, Dimitri Heintz, Denis Tritsch, Hubert Schaller, Michel Rohmer, Thomas J. Bach, and Andréa Hemmerlin

In cellulase-elicited Nicotiana tabacum leaves, a monoterpene controls the biosynthesis of capsidiol, a sesquiterpene phytoalexin, by inhibiting the modification of proteins with a geranylgeranyl group.

935

CELL BIOLOGY

[W]Amyloplast-Localized SUBSTANDARD STARCH GRAIN4 Protein Influences the Size of Starch Grains in Rice Endosperm. Ryo Matsushima, Masahiko Maekawa, Miyako Kusano, Hideki Kondo, Naoko Fujita, Yasushi Kawagoe, and Wataru Sakamoto

A novel amyloplast-localized protein, SSG4, influences the size of starch grains in rice endosperm.

623

[W][OPEN]The Potato Tuber Mitochondrial Proteome. Fernanda Salvato, Jesper E. Havelund, Mingjie Chen, R. Shyama Prasad Rao, Adelina Rogowska-Wrzesinska, Ole N. Jensen, David R. Gang, Jay J. Thelen, and Ian Max Møller

A high-coverage potato tuber mitochondrial proteome uncovers many new proteins and functions, especially in coenzyme and iron metabolism, and many posttranslational modifications.

637

[W][OPEN]The Endoplasmic Reticulum Binding Protein BiP Displays Dual Function in Modulating Cell Death Events. Humberto H. Carvalho, Priscila A. Silva, Giselle C. Mendes, Otávio J.B. Brustolini, Maiana R. Pimenta, Bianca C. Gouveia, Maria Anete S. Valente, Humberto J.O. Ramos, Juliana R.L. Soares-Ramos, and Elizabeth P.B. Fontes

The endoplasmic reticulum binding protein BiP can function as a positive and negative modulator of cell death events in plant cells.

654

[W]Gibberellic Acid-Induced Aleurone Layers Responding to Heat Shock or Tunicamycin Provide Insight into the N-Glycoproteome, Protein Secretion, and Endoplasmic Reticulum Stress. Gregorio Barba-Espín, Plaipol Dedoitsakul, Per Häggglund, Birte Svensson, and Christine Finnie

Overlapping responses of the aleurone layer proteome to tunicamycin and heat shock identify components of the plant protein secretory machinery.

951

[C][W]Cold-Induced Cysts of the Photosynthetic Dinoflagellate *Lingulodinium polyedrum* Have an Arrested Circadian Bioluminescence Rhythm and Lower Levels of Protein Phosphorylation. Sougata Roy, Louis Letourneau, and David Morse

Protein hypophosphorylation may mediate the decrease of metabolic activities and the arrest of the circadian bioluminescence rhythm observed in cold-induced cysts of the photosynthetic dinoflagellate Lingulodinium polyedrum.

966

ECOPHYSIOLOGY AND SUSTAINABILITY

[W]Low Temperature-Responsive Changes in the Anther Transcriptome's Repeat Sequences Are Indicative of Stress Sensitivity and Pollen Sterility in Rice Strains. Seiya Ishiguro, Kei Ogasawara, Kaien Fujino, Yutaka Sato, and Yuji Kishima

Low-temperature stress in the rice anther causes genome-wide transcriptional changes, including repeat-sequence expression levels that coordinate pollen sterility.

671

[C][W]Identification of a Hydrolyzable Tannin, Oenothin B, as an Aluminum-Detoxifying Ligand in a Highly Aluminum-Resistant Tree, *Eucalyptus camaldulensis*. Ko Tahara, Koh Hashida, Yuichiro Otsuka, Seiji Ohara, Katsumi Kojima, and Kenji Shinohara

A hydrolyzable tannin isolated from roots of an aluminum-resistant eucalypt species can form nonphytotoxic complexes with aluminum ions.

683

^[CIW]Plantation Forestry under Global Warming: Hybrid Poplars with Improved Thermotolerance Provide New Insights on the in Vivo Function of Small Heat Shock Protein Chaperones. Irene Merino, Angela Contreras, Zhong-Ping Jing, Fernando Gallardo, Francisco M. Cánovas, and Luis Gómez

The development of poplars with enhanced thermotolerance sheds new light on the biological function of a major family of stress-responsive proteins.

978

Freeze-Thaw Stress: Effects of Temperature on Hydraulic Conductivity and Ultrasonic Activity in Ten Woody Angiosperms. Guillaume Charrier, Katline Charra-Vaskou, Jun Kasuga, Hervé Cochard, Stefan Mayr, and Thierry Améglio

Gas segregation and air seeding are both involved in embolism development in angiosperms.

992

GENES, DEVELOPMENT, AND EVOLUTION

^{[CIW][OPEN]}Interaction of Photoperiod and Vernalization Determines Flowering Time of *Brachypodium distachyon*. Thomas S. Ream, Daniel P. Woods, Christopher J. Schwartz, Claudia P. Sanabria, Jill A. Mahoy, Eric M. Walters, Heidi F. Kaepler, and Richard M. Amasino

The temperate grass, Brachypodium distachyon, is a useful model for studying gene networks controlling flowering.

694

^[CIW]microRNA319a-Targeted *Brassica rapa* ssp. *pekinensis* TCP Genes Modulate Head Shape in Chinese Cabbage by Differential Cell Division Arrest in Leaf Regions. Yanfei Mao, Feijie Wu, Xiang Yu, Jinjuan Bai, Weili Zhong, and Yuke He

microRNA-targeted BrpTCP genes modulate the head shape in B. rapa by differential cell division arrest in leaf regions.

710

^{[W][OPEN]}TAP46 Plays a Positive Role in the ABSCISIC ACID INSENSITIVE5-Regulated Gene Expression in Arabidopsis. Rongbin Hu, Yinfeng Zhu, Guoxin Shen, and Hong Zhang

A protein phosphatase 2A-associated protein, regulates ABA-regulated gene expression in Arabidopsis.

721

^{[W][OPEN]}Grain Number, Plant Height, and Heading Date7 Is a Central Regulator of Growth, Development, and Stress Response. Xiaoyu Weng, Lei Wang, Jia Wang, Yong Hu, Hao Du, Caiguo Xu, Yongzhong Xing, Xianghua Li, Jinghua Xiao, and Qifa Zhang

A protein associated with light signaling regulates a range of functions in growth and development in response to environmental cues to maximize the reproductive success of the rice plant.

735

^[CIW]Deciphering the *Physalis floridana* Double-Layered-Lantern1 Mutant Provides Insights into Functional Divergence of the GLOBOSA Duplicates within the Solanaceae. Ji-Si Zhang, Zhichao Li, Jing Zhao, Shaohua Zhang, Hui Quan, Man Zhao, and Chaoying He

A single gene mutation yields novel morphologies and uncovers a divergent pattern of paralogous genes within the Solanaceae.

748

^[W]Intron-Mediated Alternative Splicing of WOOD-ASSOCIATED NAC TRANSCRIPTION FACTOR1B Regulates Cell Wall Thickening during Fiber Development in *Populus* species. Yunjun Zhao, Jiayan Sun, Peng Xu, Rui Zhang and Laigeng Li

Alternative splicing of a transcription factor generates two isoforms which play antagonistic roles in regulating cell wall thickening during fiber cell differentiation in planta.

765

^[CIW]ARABIDOPSIS THALIANA HOMEBOX25 Uncovers a Role for Gibberellins in Seed Longevity. Eduardo Bueso, Jesús Muñoz-Bertomeu, Francisco Campos, Veronique Brunaud, Liliam Martínez, Enric Sayas, Patricia Ballester, Lynne Yenush, and Ramón Serrano

A transcription factor increases gibberellin biosynthesis and improves seed longevity.

999

Continued on next page

[C][W][OPEN] *MicroRNA156*: A Potential Graft-Transmissible MicroRNA That Modulates Plant Architecture and Tubercization in *Solanum tuberosum* ssp. *andigena*. Sneha Bhogale, Ameya S. Mahajan, Bhavani Natarajan, Mohit Rajabhoj, Hirekodathakallu V. Thulasiram, and Anjan K. Banerjee

The microRNA miR156 is a potential graft-transmissible signal regulating potato development. 1011

[C][W] Methyl Jasmonate-Elicited Transcriptional Responses and Pentacyclic Triterpene Biosynthesis in Sweet Basil. Rajesh Chandra Misra, Protiti Maiti, Chandan Singh Chanotiya, Karuna Shanker, and Sumit Ghosh

Transcript and metabolite analysis of the methyl jasmonate-elicited sweet basil identified the genes involved in the biosynthesis of the medicinally important pentacyclic triterpenes. 1028

MEMBRANES, TRANSPORT, AND BIOENERGETICS

[W][OPEN] SWEET17, a Facilitative Transporter, Mediates Fructose Transport across the Tonoplast of Arabidopsis Roots and Leaves. Woei-Jiun Guo, Reka Nagy, Hsin-Yi Chen, Stefanie Pfrunder, Ya-Chi Yu, Diana Santelia, Wolf B. Frommer, and Enrico Martinoia

SWEET17 plays a key role in facilitating fructose transport in response to metabolic demand. 777

[C][W] Specificity of the Cyanobacterial Orange Carotenoid Protein: Influences of Orange Carotenoid Protein and Phycobilisome Structures. Denis Jallet, Adrien Thurotte, Ryan L. Leverenz, François Perreau, Cheryl A. Kerfeld, and Diana Kirilovsky

In cyanobacteria, the binding properties of a carotenoid energy quencher and the structure of the core of phycobilisome antenna determine the amplitude of photoprotection and the specificity of the mechanism. 790

[C][W][OPEN] Flavodiiron Protein Flv2/Flv4-Related Photoprotective Mechanism Dissipates Excitation Pressure of PSII in Cooperation with Phycobilisomes in Cyanobacteria. Luca Bersanini, Natalia Battchikova, Martina Jokel, Ateeq Rehman, Imre Vass, Yagut Allahverdiyeva, and Eva-Mari Aro

A flavodiiron protein operon encodes for an alternative electron transfer mechanism at the PSII acceptor side and is dependent on functional phycobilisomes. 805

[C][W][OPEN] A Nodule-Specific Lipid Transfer Protein AsE246 Participates in Transport of Plant-Synthesized Lipids to Symbiosome Membrane and Is Essential for Nodule Organogenesis in Chinese Milk Vetch. Lei Lei, Ling Chen, Xiaofeng Shi, Yixing Li, Jianyun Wang, Dasong Chen, Fuli Xie, and Youguo Li

A nodule-specific lipid transfer protein contributes to transport to the symbiosome membrane and is required for effective legume-rhizobium symbiosis. 1045

[C][W][OPEN] Noninvasive Evaluation of Heavy Metal Uptake and Storage in Micoralgae Using a Fluorescence Resonance Energy Transfer-Based Heavy Metal Biosensor. Sathish Rajamani, Moacir Torres, Vanessa Falcao, Jaime Ewalt Gray, Daniel A. Coury, Pio Colepicolo, and Richard Sayre

A noninvasive system enables quantification of metal uptake and storage in micoralgae. 1059

SIGNALING AND RESPONSE

[W][OPEN] Sterol-Dependent Induction of Plant Defense Responses by a Microbe-Associated Molecular Pattern from *Trichoderma viride*. Miya Sharfman, Maya Bar, Silvia Schuster, Meirav Leibman, and Adi Avni

Modulating the synthesis of sterols affects the ability of a fungal protein to induce plant innate immunity. 819

[W][OPEN]A Conserved KIN17 Curved DNA-Binding Domain Protein Assembles with SQUAMOSA PROMOTER-BINDING PROTEIN-LIKE7 to Adapt Arabidopsis Growth and Development to Limiting Copper Availability. *Antoni Garcia-Molina, Shuping Xing, and Peter Huijser*

An Arabidopsis homolog of KIN17 physically interacts with the transcription factor SPL7 to prevent impaired plant growth during periods of limited copper availability.

828

[C][W][OPEN]Both PHYTOCHROME RAPIDLY REGULATED1 (PAR1) and PAR2 Promote Seedling Photomorphogenesis in Multiple Light Signaling Pathways. *Peng Zhou, Meifang Song, Qinghua Yang, Liang Su, Pei Hou, Lin Guo, Xu Zheng, Yulin Xi, Fanhua Meng, Yang Xiao, Li Yang, and Jianping Yang*

Both PAR1 and PAR2, encoding bHLH transcription factors, enhance seedling deetiolation under far-red, red, and blue light conditions.

841

[W]Two Young MicroRNAs Originating from Target Duplication Mediate Nitrogen Starvation Adaptation via Regulation of Glucosinolate Synthesis in *Arabidopsis thaliana*. *Hua He, Gang Liang, Yang Li, Fang Wang, and Diqiu Yu*

Two recently evolved microRNAs enhance plant nitrogen starvation adaptation via regulation of glucosinolate synthesis.

853

[C][W][OPEN]The Compromised Recognition of Turnip Crinkle Virus1 Subfamily of Microrchidia ATPases Regulates Disease Resistance in Barley to Biotrophic and Necrotrophic Pathogens. *Gregor Langen, Sabrina von Einem, Aline Koch, Jafargholi Imani, Subhash B. Pai, Murlu Manohar, Katrin Ehlers, Hyong Woo Choi, Martina Claar, Rebekka Schmidt, Hyung-Gon Mang, Yogendra Bordiya, Hong-Gu Kang, Daniel F. Klessig, and Karl-Heinz Kogel*

Barley microrchidia ATPases bind to DNA, have endonuclease activity, and regulate plant immunity.

866

[W][OPEN]The Carbon/Nitrogen Regulator ARABIDOPSIS TOXICOS EN LEVADURA31 Controls Papilla Formation in Response to Powdery Mildew Fungi Penetration by Interacting with SYNTAXIN OF PLANTS121 in Arabidopsis. *Shugo Maekawa, Noriko Inada, Shigetaka Yasuda, Yoichiro Fukao, Masayuki Fujiwara, Takeo Sato, and Junji Yamaguchi*

The plasma membrane-localized carbon/nitrogen nutrient regulator ATL31 positively controls papilla formation in response to powdery mildew fungi by interacting with a vesicle-trafficking protein.

879

[C][W]A Wheat Allene Oxide Cyclase Gene Enhances Salinity Tolerance via Jasmonate Signaling. *Yang Zhao, Wei Dong, Naibo Zhang, Xinghui Ai, Mengcheng Wang, Zhigang Huang, Langtao Xiao, and Guangmin Xia*

A jasmonic acid biosynthesis enzyme enhances wheat salinity tolerance.

1068

[C][W][OPEN]Multiple Rice MicroRNAs Are Involved in Immunity against the Blast Fungus *Magnaporthe oryzae*. *Yan Li, Yuan-Gen Lu, Yi Shi, Liang Wu, Yong-Ju Xu, Fu Huang, Xiao-Yi Guo, Yong Zhang, Jing Fan, Ji-Qun Zhao, Hong-Yu Zhang, Pei-Zhou Xu, Jian-Min Zhou, Xian-Jun Wu, Ping-Rong Wang, and Wen-Ming Wang*

*Multiple microRNAs differentially responsive to the infection of the blast fungus *Magnaporthe oryzae* and identify two that elevated resistance to the disease.*

1077

[C][W][OPEN]Arabidopsis PECTIN METHYLESTERASEs Contribute to Immunity against *Pseudomonas syringae*. *Gerit Bethke, Rachael E. Grundman, Suma Sreekanta, William Truman, Fumiaki Katagiri, and Jane Glazebrook*

Arabidopsis plants with mutations in PECTIN METHYLESTERASEs are impaired in resistance to a bacterial pathogen.

1093

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