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A microscopic image of plant tissue, likely a leaf or stem, showing a complex network of cells. The cells are stained with two different fluorescent dyes: a bright red dye and a bright blue dye. The red staining highlights specific membrane domains, while the blue staining highlights other cellular structures. The overall appearance is a dense, interconnected network of red and blue lines and shapes against a dark background.

**REMORIN1.3 Membrane Domains Facilitate Colonization
by an Oomycete Pathogen**

The electronic form of this issue, available as of July 8, 2014, at www.plantphysiol.org, is considered the journal of record.

On the Cover: Filamentous plant pathogens such as the late blight pathogen *Phytophthora infestans* form digit-like infection structures called haustoria inside plant cells. Haustoria enable the pathogen to feed on its host, and secrete effector proteins that modulate the physiology of the host cell to facilitate infection. Haustoria are enveloped by a specialized plant-derived membrane (the extra-haustorial membrane) the biogenesis of which is poorly understood. In this issue, Bozkurt et al. (pp 1005–1018) used the plant membrane microdomain protein REMORIN1.3, known to accumulate around *P. infestans* haustoria, to reveal discrete extra-haustorial domains labeled by REMORIN1.3 and *P. infestans* effector AVRblb2. SYNAPTOTAGMIN1, another previously identified perih Haustorial protein, localized to subdomains which are mainly not labeled by REMORIN1.3 and AVRblb2. Functional characterization of REMORIN1.3 revealed that it is a susceptibility factor that promotes infection by *P. infestans*. This activity, and REMORIN1.3 recruitment to the EHM, require REM1.3 membrane-binding domain. These results implicate REMORIN1.3 membrane microdomains in plant susceptibility to an oomycete pathogen. The cover shows *Nicotiana benthamiana* epidermal cells expressing fluorescently labeled REMORIN1.3 (blue) infected by *P. infestans* expressing the red fluorescent protein (red). Cover image credits: Sylvain Raffaele.

ON THE INSIDE

Peter Minorsky

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TOPICAL REVIEWS

Epigenetics: Beyond Chromatin Modifications and Complex Genetic Regulation. Steven R. Eichten, Robert J. Schmitz, and Nathan M. Springer

Epigenetics and chromatin modification engage complex gene regulatory systems in plants.

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BREAKTHROUGH TECHNOLOGIES

[W][OPEN]Metabolomic Characterization of Knockout Mutants in Arabidopsis: Development of a Metabolite Profiling Database for Knockout Mutants in Arabidopsis. Atsushi Fukushima, Miyako Kusano, Ramon Francisco Mejia, Mami Iwasa, Makoto Kobayashi, Naomi Hayashi, Akiko Watanabe-Takahashi, Tomoko Narisawa, Takayuki Tohge, Manhoi Hur, Eve Syrkin Wurtele, Basil J. Nikolau, and Kazuki Saito

Metabolomic characterization of 50 Arabidopsis mutants and the database construction offers a functional genomics tool.

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RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

[W]Genetic Control and Evolution of Anthocyanin Methylation. Sofia Provenzano, Cornelis Spelt, Satoko Hosokawa, Noriko Nakamura, Filippa Brugliera, Linda Demelis, Daan P. Geerke, Andrea Schubert, Yoshikazu Tanaka, Francesca Quattrocchio and Ronald Koes

Analysis of anthocyanin methyltransferase genes reveals genetic mechanisms underlying the evolution of anthocyanins with diverse structures.

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[W][OPEN]Lipoate-Protein Ligase and Octanoyltransferase Are Essential for Protein Lipoylation in Mitochondria of Arabidopsis. Ralph Ewald, Christiane Hoffmann, Alexandra Florian, Ekkehard Neuhaus, Alisdair R. Fernie, and Hermann Baurve

Lipoate-protein ligase and octanoyltransferase provide the basal indispensable protein lipoylation network in plant mitochondria.

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^{[C][W]}Cytochrome P450 93G1 Is a Flavone Synthase II That Channels Flavanones to the Biosynthesis of Tricin O-Linked Conjugates in Rice. *Pui Ying Lam, Fu-Yuan Zhu, Wai Lung Chan, Hongjia Liu, and Clive Lo*

The rice cytochrome P450 enzyme CYP93G1 is a phylogenetically unique flavone synthase II that converts flavanones directly to flavones, a key branch point reaction leading to the production of triclin O-linked glycosides and flavanolignans.

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CELL BIOLOGY

^{[W][OPEN]}SALT-OVERLY SENSITIVE5 Mediates Arabidopsis Seed Coat Mucilage Adherence and Organization through Pectins. *Jonathan S. Griffiths, Allen Yi-Lun Tsai, Hui Xue, Cătălin Voiniciuc, Krešimir Šola, Georg J. Seifert, Shawn D. Mansfield, and George W. Haughn*

A fasciclin-like arabinogalactan protein mediates Arabidopsis seed coat mucilage adherence primarily through its influence on pectin.

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^[W]The Plant Membrane-Associated REMORIN1.3 Accumulates in Discrete Perihaustorial Domains and Enhances Susceptibility to *Phytophthora infestans*. *Tolga O. Bozkurt, Annis Richardson, Yasin F. Dagdas, Sébastien Mongrand, Sophien Kamoun, and Sylvain Raffaele*

The plant protein remorin is localized to discrete perihaustorial domains and is recruited as a susceptibility factor enhancing host colonization by the late blight oomycete pathogen.

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^{[W][OPEN]}Endosidin 7 Specifically Arrests Late Cytokinesis and Inhibits Callose Biosynthesis, Revealing Distinct Trafficking Events during Cell Plate Maturation. *Eunsook Park, Sara M. Díaz-Moreno, Destiny J. Davis, Thomas E. Wilkop, Vincent Bulone, and Georgia Drakakaki*

Fluorescent protein markers and a newly discovered specific inhibitor of callose synthesis identify discrete trafficking events during late cytokinesis.

1019

^{[C][W][OPEN]}The Arabidopsis Endosomal Sorting Complex Required for Transport III Regulates Internal Vesicle Formation of the Prevacuolar Compartment and Is Required for Plant Development. *Yi Cai, Xiaohong Zhuang, Caiji Gao, Xiangfeng Wang, and Liwen Jiang*

An Arabidopsis trafficking protein complex is required in the scission of internal vesicles and membrane cargo degradation from both secretory and endocytic pathways.

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GENES, DEVELOPMENT, AND EVOLUTION

^{[W][OPEN]}CYTOKININ OXIDASE/DEHYDROGENASE4 Integrates Cytokinin and Auxin Signaling to Control Rice Crown Root Formation. *Shaopei Gao, Jun Fang, Fan Xu, Wei Wang, Xiaohong Sun, Jinfang Chu, Baodong Cai, Yuqi Feng, and Chengcai Chu*

A rice cytokinin oxidase/dehydrogenase gene promotes crown root formation and growth by mediating the interaction between cytokinin and auxin and is a potential target for the manipulation of rice root architecture.

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^[W]Uncovering Divergence of Rice Exon Junction Complex Core Heterodimer Gene Duplication Reveals Their Essential Role in Growth, Development, and Reproduction. *Pichang Gong and Chaoying He*

Divergence of junction complex genes in rice implicates their importance in cereal growth, development, reproduction, and adaptive evolution.

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[W][OPEN]Floral Transcriptomes in Woodland Strawberry Uncover Developing Receptacle and Anther Gene Networks. Courtney A. Hollender, Chunying Kang, Omar Darwish, Aviva Geretz, Benjamin F. Matthews, Janet Slovin, Nadim Alkharouf, and Zhongchi Liu

Genome-wide gene expression analyses in strawberry flowers identified key regulatory genes of the developing receptacle and anthers. 1062

[W][OPEN]Evolution of the Phosphoenolpyruvate Carboxylase Protein Kinase Family in C_3 and C_4 *Flaveria* spp. Sophia H. Aldous, Sean E. Weise, Thomas D. Sharkey, Daniel M. Waldera-Lupa, Kai Stühler, Julia Mallmann, Georg Groth, Udo Gowik, Peter Westhoff, and Borjana Arsova

Parallel evolution of two functionally linked gene families has resulted in diel regulatory characteristics in the phosphorylation of PEPC that differs between *Flaveria* spp. with C_3 and C_4 photosynthetic types. 1076

[W][OPEN]Auxin-Input Pathway Disruptions Are Mitigated by Changes in Auxin Biosynthetic Gene Expression in *Arabidopsis*. Gretchen M. Spiess, Amanda Hausman, Peng Yu, Jerry D. Cohen, Rebekah A. Rampey, and Bethany K. Zolman

Disruption of multiple auxin-input pathways reveals developmental roles for these auxin forms and a feedback loop necessary for maintaining optimal free hormone levels. 1092

[C][W]The Emerging Role of ROS Signaling during Lateral Root Development. Concepción Manzano, Mercedes Pallero-Baena, Ilda Casimiro, Bert De Rybel, Beata Orman-Ligeza, Gert Van Isterdael, Tom Beeckman, Xavier Draye Pedro Casero, and Juan C. del Pozo

ROS signaling is crucial for lateral root emergence and root growth, and it regulates distinct sets of genes in these processes. 1105

[W]Genome-Wide Association in Tomato Reveals 44 Candidate Loci for Fruit Metabolic Traits. Christopher Sauvage, Vincent Segura, Guillaume Bauchet, Rebecca Stevens, Phuc Thi Do, Zoran Nikoloski, Alisdair R. Fernie, and Mathilde Causse

Genome-wide association sheds light on the genetic architecture of metabolic traits underlying fruit quality in tomato. 1120

[C][W][OPEN]Ribosomal Protein RPL27a Promotes Female Gametophyte Development in a Dose-Dependent Manner. Agustin Zsögön, Dóra Szakonyi, Xiuling Shi, and Mary E. Byrne

The dose of a ribosomal protein affects the level of plant fertility. 1133

MEMBRANES, TRANSPORT, AND BIOENERGETICS

[W]Maintenance of Chloroplast Structure and Function by Overexpression of the Rice *MONOGALACTOSYLDIACYLGLYCEROL SYNTHASE* Gene Leads to Enhanced Salt Tolerance in Tobacco. Shitwen Wang, M. Imtiaz Uddin, Kiyoshi Tanaka, Lina Yin, Zhonghui Shi, Yanhua Qi, Jun'ichi Mano, Kenji Matsui, Norihiro Shimomura, Takeshi Sakaki, Xiping Deng, and Suiqi Zhang

Galactolipids play an important role in plant salt tolerance through maintaining chloroplast structure and function. 1144

[W][OPEN]Suppression of Photosynthetic Gene Expression in Roots Is Required for Sustained Root Growth under Phosphate Deficiency. Jun Kang, Haopeng Yu, Caihuan Tian, Wenkun Zhou, Chuanyou Li, Yuling Jiao, and Dong Liu

Functional disruption of tyrosylprotein sulfotransferase in *Arabidopsis* activates photosynthetic gene expression in roots and enhances inhibition of root growth under phosphate deficiency. 1156

[W][OPEN]Plastidial Expression of Type II NAD(P)H Dehydrogenase Increases the Reducing State of Plastoquinones and Hydrogen Photoproduction Rate by the Indirect Pathway in *Chlamydomonas reinhardtii*. Anthony Baltz, Kieu-Van Dang, Audrey Beyly, Pascaline Auroy, Pierre Richaud, Laurent Cournac, and Gilles Peltier

Nonphotochemical reduction of plastoquinones is the limiting step of hydrogen production by the indirect pathway in Chlamydomonas.

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SIGNALING AND RESPONSE

[W][OPEN]Phosphoproteomic Analyses Reveal Early Signaling Events in the Osmotic Stress Response. Kelly E. Stecker, Benjamin B. Minkoff, and Michael R. Sussman

Rapid changes in protein phosphorylation across abiotic stress, hormone, and pathogen treatments reveal proteins undergoing phosphoregulation in response to dehydration.

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[W][OPEN]The Arabidopsis NUCLEUS- AND PHRAGMOPLAST-LOCALIZED KINASE1-Related Protein Kinases Are Required for Elicitor-Induced Oxidative Burst and Immunity. Daniel Valentin Savatin, Nora Gigli Bisceglia, Lucia Marti, Claudia Fabbri, Felice Cervone, and Giulia De Lorenzo

An Arabidopsis mitogen-activated protein triple kinase subfamily is required for elicitor-triggered immunity and reactive oxygen species (ROS) generation, as well as for response to ROS, but is not required for elicitor/auxin antagonism.

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[C][W][OPEN]The Arabidopsis ZINC FINGER PROTEIN3 Interferes with Abscisic Acid and Light Signaling in Seed Germination and Plant Development. Mary Prathiba Joseph, Csaba Papdi, László Kozma-Bognár, István Nagy, Marta López-Carbonell, Gábor Rigó, Csaba Koncz, and László Szabados

An Arabidopsis zinc finger protein acts as a negative regulator of ABA-suppressed seed germination and modulates plant development, fertility, and hypocotyl elongation under red light.

1203

[W]Strigolactone Hormones and Their Stereoisomers Signal through Two Related Receptor Proteins to Induce Different Physiological Responses in Arabidopsis. Adrian Scaffidi, Mark T. Waters, Yueming K. Sun, Brian W. Skelton, Kingsley W. Dixon, Emilio L. Ghisalberti, Gavin R. Flematti, and Steven M. Smith

Strigolactone hormones signal through a specific receptor to induce particular responses in Arabidopsis, whereas their stereoisomers induce different responses by signaling through a closely related receptor that also perceives karrikins from wildfires.

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[W][OPEN]A Functional Antagonistic Relationship between Auxin and Mitochondrial Retrograde Signaling Regulates *Alternative Oxidase1a* Expression in Arabidopsis. Aneta Ivanova, Simon R. Law, Reena Narsai, Owen Duncan, Jae-Hoon Lee, Botao Zhang, Olivier Van Aken, Jordan D. Radomiljac, Margaretha van der Merwe, KeKe Yi, and James Whelan

The induction of mitochondrial stress response is antagonized by auxin signaling revealing regulation of mitochondrial respiratory pathway gene expression by auxin.

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[W][OPEN]The Putative E3 Ubiquitin Ligase ECERIFERUM9 Regulates Abscisic Acid Biosynthesis and Response during Seed Germination and Postgermination Growth in Arabidopsis. Huayan Zhao, Huoming Zhang, Peng Cui, Feng Ding, Guangchao Wang, Rongjun Li, Matthew A. Jenks, Shiyu Lü, and Liming Xiong

A wax locus negatively regulates ABA response within a small time window during seed germination and also affects ABA levels in seeds.

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[C][W][OPEN]Enhanced Disease Susceptibility1 Mediates Pathogen Resistance and Virulence Function of a Bacterial Effector in Soybean. *Jialin Wang, M.B. Shine, Qing-Ming Gao, Duroy Navarre, Wei Jiang, Chunyan Liu, Qingshan Chen, Guohua Hu, and Aardra Kachroo*

A single gene product mediates in the virulence activity of a bacterial effector.

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[C][W][OPEN]Cotyledon-Generated Auxin Is Required for Shade-Induced Hypocotyl Growth in *Brassica rapa*. *Carl Procko, Charisse Michelle Crenshaw, Karin Ljung, Joseph Patrick Noel, and Joanne Chory*

Shade light perceived in cotyledons induces de novo auxin biosynthesis and transport to hypocotyl cells leading to their elongation.

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[W][OPEN]Temporal Dynamics of Growth and Photosynthesis Suppression in Response to Jasmonate Signaling. *Elham Attaran, Ian T. Major, Jeffrey A. Cruz, Bruce A. Rosa, Abraham J.K. Koo, Jin Chen, David M. Kramer, Sheng Yang He, and Gregg A. Howe*

A combination of real-time fluorescence imaging and high-temporal-resolution RNA sequencing reveals dynamic changes in growth, photosynthesis, and associated global gene expression during jasmonate signaling.

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[W][OPEN]The Ethylene Receptors ETHYLENE RESPONSE1 and ETHYLENE RESPONSE2 Have Contrasting Roles in Seed Germination of Arabidopsis during Salt Stress. *Rebecca L. Wilson, Heejung Kim, Arkadipta Bakshi, and Brad M. Binder*

Specific ethylene receptors have antagonistic roles in seed germination that are mediated by abscisic acid.

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[C][W]The Cysteine²/Histidine²-Type Transcription Factor ZINC FINGER OF ARABIDOPSIS THALIANA6 Modulates Biotic and Abiotic Stress Responses by Activating Salicylic Acid-Related Genes and C-REPEAT-BINDING FACTOR Genes in Arabidopsis. *Haitao Shi, Xin Wang, Tiantian Ye, Fangfang Chen, Jiao Deng, Pingfang Yang, Yansheng Zhang, and Zhulong Chan*

An Arabidopsis C₂H₂-type zinc finger protein increases both biotic and abiotic stress resistances through gene activation, including salicylic acid-related genes.

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SYSTEMS AND SYNTHETIC BIOLOGY

[W]Bottom-up Metabolic Reconstruction of Arabidopsis and Its Application to Determining the Metabolic Costs of Enzyme Production. *Anne Arnold and Zoran Nikoloski*

A large-scale metabolic model of Arabidopsis with three condition-specific biomass compositions is assembled in a bottom-up fashion to estimate the enzyme costs of Rubisco.

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CORRECTION

A Limited Role for Carbonic Anhydrase in C₄ Photosynthesis as Revealed by a *ca1ca2* Double Mutant in Maize. *Studer A.J., Gandin A., Kolbe A.R., Wang L., Cousins A.B., and Brutnell T.P.*

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