

A micrograph of a plant tissue section, likely a leaf or stem, showing a dense network of cells. The cells are stained with a red dye, highlighting the lignin content. The staining is particularly prominent in the central and lower-left regions, indicating a higher concentration of lignin in those areas. The overall structure shows a clear cellular organization with distinct cell walls and internal structures.

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Modified Lignin in the Arabidopsis *CYP450 Reductase2* Mutant

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On the Cover: Microscopy image of a cross section of an Arabidopsis stem (diameter of full section, 2 mm). The tissue section has been treated with the Mäule reagent, which gives a red stain to the lignin polymers in the cell wall. Lignin provides strength to the walls. Cover image credits: Lisa Sundin (VIB, Belgium).

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Reinventing the Green Revolution by Harnessing Crop Mutant Resources. Peter Langridge 1682

BREAKTHROUGH TECHNOLOGIES

^{[W][OPEN]}An Optical Clearing Technique for Plant Tissues Allowing Deep Imaging and Compatible with Fluorescence Microscopy. Cherish A. Warner, Meredith L. Biedrzycki, Samuel S. Jacobs, Randall J. Wisser, Jeffrey L. Caplan, and D. Janine Sherrier

An optical clearing technique complements common fluorescent microscopic techniques and enables deep imaging in a wide range of plant tissues. 1684

^{[C][W][OPEN]}Automated Recovery of Three-Dimensional Models of Plant Shoots from Multiple Color Images. Michael P. Pound, Andrew P. French, Erik H. Murchie, and Tony P. Pridmore

A fully automatic approach to 3D plant shoot reconstruction uses multiple images taken with a single camera. 1688

RESEARCH REPORTS

^[W]Intracellular Catalytic Domain of Symbiosis Receptor Kinase Hyperactivates Spontaneous Nodulation in Absence of Rhizobia. Sudip Saha, Ayan Dutta, Avisek Bhattacharya, and Maitrayee DasGupta

Constitutive activity of the intracellular kinase domain of symbiosis receptor kinase hyperactivates nodule organogenesis in a legume. 1699

^[W]Catalytic Subunit Stoichiometry within the Cellulose Synthase Complex. Martine Gonneau, Thierry Desprez, Alain Guillot, Samantha Vernhettes, and Herman Höfte

Three distinct catalytic subunits are present in an equimolecular ratio in the cellulose synthase complex. 1709

UPDATES

Root Architecture Responses: In Search of Phosphate. Benjamin Péret, Thierry Desnos, Ricarda Jost, Satomi Kanno, Oliver Berkowitz, and Laurent Nussaume

Root development alters in response to phosphate availability, which affects the production of cluster roots in a limited number of species. 1713

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Insights into Conifer Giga-Genomes. *Amanda R. De La Torre, Inanc Birol, Jean Bousquet, Pär K. Ingvarsson, Stefan Jansson, Steven J.M. Jones, Christopher I. Keeling, John MacKay, Ove Nilsson, Kermit Ritland, Nathaniel Street, Alvin Yanchuk, Philipp Zerbe, and Jörg Bohlmann*

The sequenced genomes of three conifer species provide the first assemblies of gymnosperm genomes and perspectives on the largest plant genomes sequenced to date.

1724

RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

[W][OPEN]Regulatory Properties of ADP Glucose Pyrophosphorylase Are Required for Adjustment of Leaf Starch Synthesis in Different Photoperiods. *Sam T. Mugford, Olivier Fernandez, Jemima Brinton, Anna Flis, Nicole Krohn, Beatrice Encke, Regina Feil, Ronan Sulpice, John E. Lunn, Mark Stitt, and Alison M. Smith*

The properties of a key enzyme of starch synthesis permit adjustment of this process under different day lengths.

1733

[W][OPEN] β -Amylase1 and β -Amylase3 Are Plastidic Starch Hydrolases in Arabidopsis That Seem to Be Adapted for Different Thermal, pH, and Stress Conditions. *Jonathan D. Monroe, Amanda R. Storm, Elizabeth M. Badley, Michael D. Lehman, Samantha M. Platt, Lauren K. Saunders, Jonathan M. Schmitz, and Catherine E. Torres*

A β -amylase that works during the day and under osmotic stress is more active at high pH and more thermostable than a mesophyll cell β -amylase that works at night and under cold stress.

1748

[W][OPEN]Posttranslational Modifications of FERREDOXIN-NADP⁺ OXIDOREDUCTASE in Arabidopsis Chloroplasts. *Nina Lehtimäki, Minna M. Koskela, Käthe M. Dahlström, Eveliina Pakula, Minna Lintala, Martin Scholz, Michael Hippler, Guy T. Hanke, Anne Rokka, Natalia Battchikova, Tiina A. Salminen, and Paula Mulo*

Enzymes that reduce NADP⁺ photosynthetically are regulated by multiple posttranslational modifications in a partially light-dependent manner.

1764

[W][OPEN]Dual Catalytic Activity of Hydroxycinnamoyl-Coenzyme A Quinate Transferase from Tomato Allows It to Moonlight in the Synthesis of Both Mono- and Dicafeoylquinic Acids. *Andrea Moglia, Sergio Lanteri, Cinzia Comino, Lionel Hill, Daniel Kneveit, Cecilia Cagliero, Patrizia Rubiolo, Stephen Bornemann, and Cathie Martin*

A cytoplasmic enzyme known to synthesise chlorogenic acid in tomato has a second activity synthesising dicafeoyl quinate at low pH and high chlorogenic acid concentrations in the vacuole.

1777

[C][W]Disruption of the CYTOCHROME C OXIDASE DEFICIENT1 Gene Leads to Cytochrome c Oxidase Depletion and Reorchestrated Respiratory Metabolism in Arabidopsis. *Jennifer Dahan, Guillaume Tcherkez, David Macherel, Abdelilah Benamar, Katia Belcram, Martine Quadrado, Nadège Arnal, and Hakim Mireau*

Depletion of the mitochondrial respiratory complex IV activates the alternative respiratory pathway and important switches in metabolic flux.

1788

[W][OPEN]Promoter-Based Integration in Plant Defense Regulation. *Baohua Li, Allison Gaudinier, Michelle Tang, Mallorie Taylor-Teeples, Ngoc T. Nham, Cyrus Ghaffari, Darik Scott Benson, Margaret Steinmann, Jennifer A. Gray, Siobhan M. Brady, and Daniel J. Kliebenstein*

An extensive transcriptional regulatory network modulates plant defense chemistry.

1803

[C][W]Virus-Induced Alterations in Primary Metabolism Modulate Susceptibility to Tobacco rattle virus in Arabidopsis. *Lourdes Fernández-Calvino, Sonia Osorio, M. Luisa Hernández, Ignacio B. Hamada, Francisco J. del Toro, Livia Donaire, Agnés Yu, Regla Bustos, Alisdair R. Fernie, José M. Martínez-Rivas, and César Llave*

Virus infection interferes with primary metabolism by reprogramming gene expression and metabolite content.

1821

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CELL BIOLOGY

[C][W][OPEN] Proteolytic and N-Glycan Processing of Human α 1-Antitrypsin Expressed in *Nicotiana benthamiana*.
Alexandra Castilho, Markus Windwarder, Pia Gattinger, Lukas Mach, Richard Strasser, Friedrich Altmann, and Herta Steinkellner

Eliminating β -hexosaminidase3 activity and terminal sialylation yields a human protease inhibitor that resembles the serum-derived counterpart. 1839

[W][OPEN] Defects in a New Class of Sulfate/Anion Transporter Link Sulfur Acclimation Responses to Intracellular Glutathione Levels and Cell Cycle Control. *Su-Chiung Fang, Chin-Lin Chung, Chun-Han Chen, Cristina Lopez-Paz, and James G. Umen*

A member of a new family of sulfate/anion transporters connects cell size checkpoint function and sulfur stress responses through glutathione homeostasis. 1852

[W][OPEN] Microtubules Contribute to Tubule Elongation and Anchoring of Endoplasmic Reticulum, Resulting in High Network Complexity in Arabidopsis. *Takahiro Hamada, Haruko Ueda, Takashi Kawase, and Ikuko Hara-Nishimura*

Microtubules participate in endoplasmic reticulum (ER) network formation by anchoring ER to cell cortex and supporting slow ER tubules extension. 1869

[C][W][OPEN] Endomembrane Trafficking Protein SEC24A Regulates Cell Size Patterning in Arabidopsis. *Xian Qu, Prerana Rao Chatty, and Adrienne H.K. Roeder*

Mutation of an endomembrane trafficking gene triggers the formation of giant cells through endoreduplication. 1877

ECOPHYSIOLOGY AND SUSTAINABILITY

[W][OPEN] Lipid Biosynthesis and Protein Concentration Respond Uniquely to Phosphate Supply during Leaf Development in Highly Phosphorus-Efficient *Hakea prostrata*. *Thirumurugan Kuppasamy, Patrick Giavalisco, Samuel Arvidsson, Ronan Sulpice, Mark Stitt, Patrick M. Finnegan, Wolf-Rüdiger Scheible, Hans Lambers, and Ricarda Jost*

*The Australian Proteaceae *Hakea prostrata* transcriptionally regulates only a small number of genes to generate polar leaf lipid profiles associated with delayed greening and efficient phosphorus use.* 1891

[C][W][OPEN] Induced Variations in Brassinosteroid Genes Define Barley Height and Sturdiness, and Expand the Green Revolution Genetic Toolkit. *Christoph Dockter, Damian Gruszka, Ilka Braumann, Arnis Druka, Ilze Druka, Jerome Franckowiak, Simon P. Gough, Anna Janeczko, Marzena Kurowska, Joakim Lundqvist, Udda Lundqvist, Marek Marzec, Izabela Matyszczyk, André H. Müller, Jana Oklestkova, Burkhard Schulz, Shakhira Zakhrabekova, and Mats Hansson*

Historic barley short-culm mutants deficient in brassinosteroid genes are attractive targets for development of lodging-resistant crop plants. 1912

[W][OPEN] Gene Regulatory Variation Mediates Flowering Responses to Vernalization along an Altitudinal Gradient in Arabidopsis. *Léonie Suter, Marlene Rüegg, Niklaus Zemp, Lars Hennig, and Alex Widmer*

Flowering time after vernalization and gene expression in flowering time pathways correlate with altitude, suggesting phenological adaptation. 1928

[C][W][OPEN] Reduced Root Cortical Cell File Number Improves Drought Tolerance in Maize. *Joseph G. Chimungu, Kathleen M. Brown, and Jonathan P. Lynch*

Reduced root cortical cell file number substantially reduces root respiration, permitting greater root growth and exploration of deep soil domains, thereby improving water acquisition, plant growth, and yield under drought. 1943

[C][W][OPEN] Large Root Cortical Cell Size Improves Drought Tolerance in Maize. Joseph G. Chimungu, Kathleen M. Brown, and Jonathan P. Lynch

Large cortical cells substantially reduce root respiration, permitting greater root growth and exploration of deep soil, thereby improving water acquisition, plant growth, and yield under drought.

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[C][W] Cotton WRKY1 Mediates the Plant Defense-to-Development Transition during Infection of Cotton by *Verticillium dahliae* by Activating JASMONATE ZIM-DOMAIN1 Expression. Chao Li, Xin He, Xiangyin Luo, Li Xu, Linlin Liu, Ling Min, Li Jin, Longfu Zhu, and Xianlong Zhang

A transcription factor regulates plant development during pathogen infection by attenuating jasmonate signaling.

2179

GENES, DEVELOPMENT, AND EVOLUTION

[W][OPEN] Mutation of the Inducible *ARABIDOPSIS THALIANA* CYTOCHROME P450 REDUCTASE2 Alters Lignin Composition and Improves Saccharification. Lisa Sundin, Ruben Vanholme, Jan Geerinck, Geert Goeminne, René Höfer, Hoon Kim, John Ralph, and Wout Boerjan

Mutation of a cytochrome P450 reductase affects lignin biosynthesis and improves cell wall breakdown, making the enzyme a potential target in cell wall engineering for biofuel production.

1956

[W][OPEN] Nitric Oxide Plays a Role in Stem Cell Niche Homeostasis through Its Interaction with Auxin. Luis Sanz, María Fernández-Marcos, Abelardo Modrego, Daniel R. Lewis, Gloria K. Muday, Stephan Pollmann, Montserrat Dueñas, Celestino Santos-Buelga, and Oscar Lorenzo

Nitric oxide regulation of stem cell decisions in Arabidopsis roots is related to auxin biosynthesis, transport, and signaling.

1972

[W] Identification of Enzymes for Adenosine-to-Inosine Editing and Discovery of Cytidine-to-Uridine Editing in Nucleus-Encoded Transfer RNAs of Arabidopsis. Wenbin Zhou, Daniel Karcher, and Ralph Bock

Enzymes in adenosine-to-inosine editing, a functionally important base modification in tRNAs, indicate an additional type of tRNA editing.

1985

[W] Polar Auxin Transport Is Essential for Medial versus Lateral Tissue Specification and Vascular-Mediated Valve Outgrowth in Arabidopsis Gynoecia. Emma Larsson, Christina J. Roberts, Andrea R. Claes, Robert G. Franks, and Eva Sundberg

Polar transport of the plant hormone auxin in female reproductive organ primordia establishes positional cues for medial versus lateral tissue specification and induces lateral domain outgrowth.

1998

[W][OPEN] Natural Variation in Sensitivity to a Loss of Chloroplast Translation in Arabidopsis. Nicole Parker, Yixing Wang, and David Meinke

Natural variation provides clues to essential chloroplast gene functions and the significance of a duplicated nuclear gene that targets homomeric acetyl-CoA carboxylase to plastids.

2013

[W] The Maize DWARF1 Encodes a GA 3-Oxidase and Is Dual Localized to the Nucleus and Cytosol. Yi Chen, Mingming Hou, Lijuan Liu, Shan Wu, Yun Shen, Kanako Ishiyama, Masatomo Kobayashi, Donald R. McCarty, and Bao-Cai Tan

Bioactive GAs can be synthesized in the cytosol and the nucleus.

2028

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MEMBRANES, TRANSPORT, AND BIOENERGETICS

[^{OPEN}] Acclimation to Very Low CO₂: Contribution of Limiting CO₂ Inducible Proteins, LCIB and LCIA, to Inorganic Carbon Uptake in *Chlamydomonas reinhardtii*. Yingjun Wang and Martin H. Spalding

Two complementary inorganic carbon uptake systems show distinct functions in the CO₂-concentrating mechanism and both are essential for limiting CO₂ acclimation. 2040

[^W][^{OPEN}] Dynamic Balancing of Isoprene Carbon Sources Reflects Photosynthetic and Photorespiratory Responses to Temperature Stress. Kolby Jardine, Jeffrey Chambers, Eliane G. Alves, Andrea Teixeira, Sabrina Garcia, Jennifer Holm, Niro Higuchi, Antonio Manzi, Leif Abrell, Jose D. Fuentes, Lars K. Nielsen, Margaret S. Torn, and Claudia E. Vickers

Uncoupling between photosynthesis and isoprene emissions with temperature reflects the differential temperature sensitivities of photosynthesis and photorespiration. 2051

[^C][^W] Tobacco Nicotine Uptake Permease Regulates the Expression of a Key Transcription Factor Gene in the Nicotine Biosynthesis Pathway. Keita Kato, Tsubasa Shoji, and Takashi Hashimoto

The nicotine transporter NUP1 is required for jasmonate-mediated expression of a transcription factor that affects enzyme expression for the biosynthesis of tobacco alkaloids. 2195

[^W][^{OPEN}] The Minimal CO₂-Concentrating Mechanism of *Prochlorococcus* spp. MED4 Is Effective and Efficient. Brian M. Hopkinson, Jodi N. Young, Anna L. Tansik, and Brian J. Binder

A model of a simple CO₂-concentrating mechanism matches physiological data showing that, despite its simplicity, the system is functional and highly efficient. 2205

SIGNALING AND RESPONSE

[^C][^W] Hydrogen Sulfide Generated by L-Cysteine Desulhydrase Acts Upstream of Nitric Oxide to Modulate Abscisic Acid-Dependent Stomatal Closure. Denise Scuffi, Consolación Álvarez, Natalia Laspina, Cecilia Gotor, Lorenzo Lamattina, and Carlos García-Mata

An L-cysteine desulhydrase is a unique component of ABA signaling in guard cells, mediating H₂S production and acting upstream of nitric oxide to induce stomatal closure. 2065

[^W][^{OPEN}] Abscisic Acid Promotion of Arbuscular Mycorrhizal Colonization Requires a Component of the PROTEIN PHOSPHATASE 2A Complex. Myriam Charpentier, Jongho Sun, Jiangqi Wen, Kirankumar S. Mysore, and Giles E.D. Oldroyd

*ABA promotes arbuscular mycorrhizal colonization in *Medicago truncatula* via a Ser/Thr phosphatase.* 2077

[^{OPEN}] Block of ATP-Binding Cassette B19 Ion Channel Activity by 5-Nitro-2-(3-Phenylpropylamino)-Benzoic Acid Impairs Polar Auxin Transport and Root Gravitropism. Misuk Cho, Elizabeth M. Henry, Daniel R. Lewis, Guosheng Wu, Gloria K. Muday, and Edgar P. Spalding

Studies of an auxin transport protein identify an inhibitor of polar auxin transport and auxin-mediated gravitropism. 2091

[^W][^{OPEN}] A STRESS-RESPONSIVE NAC1-Regulated Protein Phosphatase Gene Rice Protein Phosphatase18 Modulates Drought and Oxidative Stress Tolerance through Abscisic Acid-Independent Reactive Oxygen Species Scavenging in Rice. Jun You, Wei Zong, Honghong Hu, Xianghua Li, Jinghua Xiao, and Lizhong Xiong

A phosphatase gene and its associated transcription factor affect drought and oxidation stress tolerance independent of abscisic acid. 2100

^[W]^[OPEN] *Gigantea* Suppresses *immutans* Variegation by Interactions with Cytokinin and Gibberellin Signaling Pathways. Aarthi Putarjunan and Steve Rodermel

A central component of the circadian clock suppresses variegation in chloroplast biogenesis through synergistic interactions between cytokinin and gibberellin signaling networks.

2115

^[C]^[W] Bacteria-Triggered Systemic Immunity in Barley Is Associated with WRKY and ETHYLENE RESPONSIVE FACTORS But Not with Salicylic Acid. Sanjukta Dey, Marion Wenig, Gregor Langen, Sapna Sharma, Karl G. Kugler, Claudia Knappe, Bettina Hause, Marlies Bichlmeier, Valiollah Babaeizad, Jafargholi Imani, Ingar Janzik, Thomas Stempffl, Ralph Hückelhoven, Karl-Heinz Kogel, Klaus F.X. Mayer, and A. Corina Vlot

Infection of barley with bacteria induces systemic resistance against a secondary Xanthomonas translucens infection and does not appear to be associated with salicylic acid.

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^[W] The Nitrate Transporter MtNPF6.8 (MtNRT1.3) Transports Abscisic Acid and Mediates Nitrate Regulation of Primary Root Growth in *Medicago truncatula*. Anthoni Pellizzaro, Thibault Clochard, Caroline Cukier, Céline Bourdin, Marjorie Juchaux, Françoise Montrichard, Steeve Thany, Valérie Raymond, Elisabeth Planchet, Anis M. Limami, and Marie-Christine Morère-Le Paven

A nitrate transporter transports ABA and regulates primary root growth via an ABA-dependent nitrate signaling pathway.

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CORRECTION

De Novo Genome Assembly of the Economically Important Weed Horseweed Using Integrated Data from Multiple Sequencing Platforms. Peng Y., Lai Z., Lane T., Nageswara-Rao M., Okada M., Jasieniuk M., O'Geen H., Kim R.W., Sammons R.D., Rieseberg L.H., and Stewart, Jr. C.N.

An L-cysteine desulphydrase is a unique component of ABA signaling in guard cells, mediating H₂S production and acting upstream of nitric oxide to induce stomatal closure.

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

^[W] The online version of this article contains Web-only data.

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