

On the Cover: Sorghum is a self-pollinated crop with cultivated varieties that span 5 races and over 25 species of wild relatives, providing tremendous genetic diversity for examining physiological and biochemical mechanisms at the population level. The continuous advancement of genomic resources in sorghum and related crops, such as rice and maize, allows for genome-scale analysis of complex traits and discovery of associated genetic and molecular elements. These resources were used to identify genetic targets for modification of seed element composition. Identification of genes and QTL that impact element traits in the grains of major cereals, including sorghum, is fundamental to developing breeding and selection strategies aimed at increasing seed nutritional quality. The cover shows a small cross section of the breadth of diversity found in sorghum panicles from more than 45,000 accessions maintained by the U.S. National Plant Germplasm System at Griffin, GA. Cover image credit: Nadia Shakoor, Donald Danforth Plant Science Center, Saint Louis, Missouri

ON THE INSIDE

Peter V. Minorsky

1897

EDITORIAL

[^{OPEN}] Does the Anonymous Voice Have a Place in Scholarly Publishing? *Jaime A. Teixeira da Silva and Michael R. Blatt*

1899

TOPICAL REVIEW

Nonphotochemical Chlorophyll Fluorescence Quenching: Mechanism and Effectiveness in Protecting Plants from Photodamage. *Alexander V. Ruban*

Knowledge about the mechanism of non-photochemical chlorophyll fluorescence quenching adds to an understanding of its effectiveness at protecting plants from photodamage.

1903

BREAKTHROUGH TECHNOLOGIES

[^{OPEN}] Oligonucleotide-Mediated Genome Editing Provides Precision and Function to Engineered Nucleases and Antibiotics in Plants. *Noel J. Sauer, Javier Narváez-Vásquez, Jerry Mozoruk, Ryan B. Miller, Zachary J. Warburg, Melody J. Woodward, Yohannes A. Mihiret, Tracey A. Lincoln, Rosa E. Segami, Steven L. Sanders, Keith A. Walker, Peter R. Beetham, Christian R. Schöpke, and Greg F.W. Gocal*

Precise genome editing enables an herbicide tolerance trait in a commercially relevant crop by improving the outcome of DNA double strand break repair using single-stranded oligonucleotides.

1917

RESEARCH REPORT

GIPS: A Software Guide to Sequencing-Based Direct Gene Cloning in Forward Genetics Studies. *Han Hu, Weitao Wang, Zhongxu Zhu, Jianhua Zhu, Deyong Tan, Zhipeng Zhou, Chuanzao Mao, and Xin Chen*

A software tool incorporating a range of experimental and data analysis choices in a sequencing-based forward genetics study aids in the design of an optimal procedure for gene identification.

1929

Continued on next page

RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

[^{OPEN}] A Picrinine N-Methyltransferase Belongs to a New Family of γ -Tocopherol-Like Methyltransferases Found in Medicinal Plants That Make Biologically Active Monoterpenoid Indole Alkaloids. *Dylan Levac, Paulo Cázares, Fang Yu, and Vincenzo De Luca*

Tocopherol-like methyltransferases in the Apocynaceae family of angiosperms are monoterpenoid indole alkaloid (MIA)-N-methyltransferases that contribute to chemical and biological diversity of the plants. 1935

Modulation of Protein S-Nitrosylation by Isoprene Emission in Poplar. *Elisa Vanzo, Juliane Merl-Pham, Violeta Velikova, Andrea Ghirardo, Christian Lindermayr, Stefanie M. Hauck, Jörg Bernhardt, Katharina Riedel, Jörg Durner, and Jörg-Peter Schnitzler*

Isoprene emission modulates stress-induced NO production and S-nitrosylation pattern in poplar. 1945

[^{OPEN}] A Glycosyltransferase from *Nicotiana glauca* Pollen Mediates Synthesis of a Linear (1,5)- α -L-Arabinan When Expressed in Arabidopsis. *Edwin R. Lampugnani, Yin Ying Ho, Isabel E. Moller, Poh-Ling Koh, John F. Golz, Antony Bacic, and Ed Newbigin*

A type II transmembrane protein from tobacco pollen is associated with (1,5)- α -arabinan synthesis. 1962

[^{OPEN}] The Type II NADPH Dehydrogenase Facilitates Cyclic Electron Flow, Energy-Dependent Quenching, and Chlororespiratory Metabolism during Acclimation of *Chlamydomonas reinhardtii* to Nitrogen Deprivation. *Shai I. Saroussi, Tyler M. Wittkopp, and Arthur R. Grossman*

A NADPH dehydrogenase is critical for balancing electron flow between energy-dissipating and energy-generating pathways during the acclimation to photoautotrophic nitrogen deprivation. 1975

[^{OPEN}] Integration of Experiments across Diverse Environments Identifies the Genetic Determinants of Variation in *Sorghum bicolor* Seed Element Composition. *Nadia Shakoob, Greg Ziegler, Brian P. Dilkes, Zachary Brenton, Richard Boyles, Erin L. Connolly, Stephen Kresovich, and Ioan Baxter*

Genome-wide association analysis identifies novel alleles controlling seed element accumulation. 1989

[^{OPEN}] Composition, Assembly, and Trafficking of a Wheat Xylan Synthase Complex. *Nan Jiang, Richard E. Wiemels, Aaron Soya, Rebekah Whitley, Michael Held, and Ahmed Faik*

A xylan synthase engages an unusual regulatory mechanism linking ER complex assembly with forward trafficking. 1999

CELL BIOLOGY

[^{OPEN}] Suppression of Chloroplastic Alkenal/One Oxidoreductase Represses the Carbon Catabolic Pathway in Arabidopsis Leaves during Night. *Daisuke Takagi, Kentaro Ifuku, Ken-ichi Ikeda, Kanako Ikeda Inoue, Pyoyun Park, Masahiro Tamoi, Hironori Inoue, Katsuhiko Sakamoto, Ryota Saito, and Chikahiro Miyake*

Suppressing a chloroplast oxidoreductase decreases carbon utilization during the night, and inhibits plant growth. 2024

[^{OPEN}] Posttranslational Control of ALA Synthesis Includes GluTR Degradation by Clp Protease and Stabilization by GluTR-Binding Protein. *Janina Apitz, Kenji Nishimura, Judith Schmied, Anja Wolf, Boris Hedtke, Klaas J. van Wijk, and Bernhard Grimm*

The protease post-translationally fine-tunes a key enzyme in the synthesis of 5-Aminolevulinic acid during photoperiodic growth.

2040

Lipid Droplet-Associated Proteins (LDAPs) Are Required for the Dynamic Regulation of Neutral Lipid Compartmentation in Plant Cells. *Satinder K. Gidda, Sunjung Park, Michal Pyc, Olga Yurchenko, Yingqi Cai, Peng Wu, David W. Andrews, Kent D. Chapman, John M. Dyer, and Robert T. Mullen*

Lipid droplet-associated proteins play different roles in various physiological contexts and during plant stress responses.

2052

ECOPHYSIOLOGY AND SUSTAINABILITY

The Contribution of Carbon and Water in Modulating Wood Formation in Black Spruce Saplings. *Annie Deslauriers, Jian-Guo Huang, Lorena Balducci, Marilène Beaulieu, and Sergio Rossi*

During wood formation, water availability is the most important factor for cell production, while carbon is more important to sustain the differentiation of living cells.

2072

[^{OPEN}] Herb Hydraulics: Inter- and Intraspecific Variation in Three *Ranunculus* Species. *Markus Nolf, Andrea Rosani, Andrea Ganthaler, Barbara Beikircher, and Stefan Mayr*

Small herbaceous species are vulnerable to water stress but adjusted to their habitat conditions and internally coordinated to avoid hydraulic failure.

2085

GENES, DEVELOPMENT AND EVOLUTION

Large-Scale Analyses of Angiosperm Nucleotide-Binding Site-Leucine-Rich Repeat Genes Reveal Three Anciently Diverged Classes with Distinct Evolutionary Patterns. *Zhu-Qing Shao, Jia-Yu Xue, Ping Wu, Yan-Mei Zhang, Yue Wu, Yue-Yu Hang, Bin Wang, and Jian-Qun Chen*

Three ancient classes of genes encoding leucine-rich repeat proteins diverged into at least 23 lineages in the common ancestor of angiosperm, from which all current gene repertoires evolved through dynamic expansion.

2095

[^{OPEN}] WHITE PANICLE1, a Val-tRNA Synthetase Regulating Chloroplast Ribosome Biogenesis in Rice, Is Essential for Early Chloroplast Development. *Yunlong Wang, Chunming Wang, Ming Zheng, Jia Lyu, Yang Xu, Xiaohui Li, Mei Niu, Wuhua Long, Di Wang, HaiYang Wang, William Terzaghi, Yihua Wang, and Jianmin Wan*

The White Panicle1 gene, encoding a Val-tRNA synthetase, plays an essential role in early chloroplast development.

2110

[^{OPEN}] Evolution of VRN2/Ghd7-Like Genes in Vernalization-Mediated Repression of Grass Flowering. *Daniel P. Woods, Meghan A. McKeown, Yinxin Dong, Jill C. Preston, and Richard M. Amasino*

Despite widespread vernalization responsiveness in the grass subfamily Pooideae, the flowering repressor VERNALIZATION2 evolved more recently in core members of this subfamily.

2124

Auxin-Independent NAC Pathway Acts in Response to Explant-Specific Wounding and Promotes Root Tip Emergence during de Novo Root Organogenesis in Arabidopsis. Xiaodong Chen, Jingfei Cheng, Lyuqin Chen, Guifang Zhang, Hai Huang, Yijing Zhang, and Lin Xu

Wounding induces expression of the NAC1 transcription factor that affects root tip emergence during de novo regeneration of adventitious root. 2136

A Developmental Switch of Gene Expression in the Barley Seed Mediated by HvVP1 (Viviparous-1) and HvGAMYB Interactions. Zamira Abraham, Raquel Iglesias-Fernández, Manuel Martínez, Ignacio Rubio-Somoza, Isabel Díaz, Pilar Carbonero, and Jesús Vicente-Carbajosa

Two barley transcription factors interact to serve as a gene expression switch at key stages of seed development: maturation and germination. 2146

[^{OPEN}]Homodimerization of Ehd1 Is Required to Induce Flowering in Rice. Lae-Hyeon Cho, Jinmi Yoon, Richa Pasriga, and Gynheung An

Homodimerization of an inducer of florigen gene expression, Ehd1, promotes flowering, but can be interrupted by the response regulator OsRR1. 2159

[^{OPEN}]expVIP: a Customizable RNA-seq Data Analysis and Visualization Platform. Philippa Borrill, Ricardo Ramirez-Gonzalez, and Cristobal Uauy

expVIP is an adaptable platform to create an integrated gene expression interface for any species with a transcriptome assembly. 2172

Genome-Wide Association Mapping and Genomic Prediction Elucidate the Genetic Architecture of Morphological Traits in Arabidopsis. Rik Kooke, Willem Kruijjer, Ralph Bours, Frank Becker, André Kuhn, Henri van de Geest, Jaap Buntjer, Timo Doeswijk, José Guerra, Harro Bouwmeester, Dick Vreugdenhil, and Joost J. B. Keurentjes

Integration of genome wide association mapping and genomic prediction increases resolution of genetic architecture and uncovers missing heritability of quantitative traits in plants. 2187

[^{OPEN}]A *Medicago truncatula* Cystathionine- β -Synthase-like Domain-Containing Protein Is Required for Rhizobial Infection and Symbiotic Nitrogen Fixation. Senjuti Sinharoy, Chengwu Liu, Andrew Breakspear, Dian Guan, Sarah Shailes, Jin Nakashima, Shulan Zhang, Jiangqi Wen, Ivone Torres-Jerez, Giles Oldroyd, Jeremy D. Murray, and Michael K. Udvardi

A Cystathionine- β -Synthase like protein, exclusively expressed during *Medicago-Rhizobium* symbiosis, is required for infection thread propagation and bacterial endocytosis. 2204

[^{OPEN}]A Predictive Coexpression Network Identifies Novel Genes Controlling the Seed-to-Seedling Phase Transition in *Arabidopsis thaliana*. Anderson Tadeu Silva, Pamela A. Ribone, Raquel L. Chan, Wilco Ligterink, and Henk W.M. Hilhorst

A seed-to-seedling gene coexpression network reveals homeodomain leucine zipper I transcription factor AtHB13 as a novel key regulator affecting primary root length during late seedling establishment. 2218

Transcriptome Profiling of Tiller Buds Provides New Insights into PhyB Regulation of Tillering and Indeterminate Growth in Sorghum. *Tesfamichael H. Kebrom and John E. Mullet*

Buds of a phytochrome B mutant express high levels of the flowering regulators TFL1, TPPI, and gibberellic acid oxidase and become dormant, whereas wild-type buds with higher cytokinin/sugar induce a SWEET transporter, cell wall invertases, and grow into tillers.

2232

[OPEN]Environmental Regulation of Heterosis in the Allopolyploid *Arabidopsis suecica*. *Erik M. Solhaug, Jacie Ihinger, Maria Jost, Veronica Gamboa, Blaine Marchant, Denise Bradford, R.W. Doerge, Anand Tyagi, Amy Replogle, and Andreas Madlung*

An allopolyploid's level of hybrid vigor may depend on environmental and ecological conditions.

2251

MEMBRANES, TRANSPORT AND BIOENERGETICS

[OPEN]AtK1 and CIPK23 Synergistically Modulate AKT1-Mediated Low-Potassium Stress Responses in *Arabidopsis*. *Xue-Ping Wang, Li-Mei Chen, Wen-Xin Liu, Li-Ke Shen, Feng-Liu Wang, Yuan Zhou, Ziding Zhang, Wei-Hua Wu, and Yi Wang*

Protein kinase CIPK23 and channel subunit AtK1 are both crucial for the modulation of potassium channel AKT1 as well as for the response to low-potassium stress.

2264

SIGNALING AND RESPONSE

[OPEN]Nitric Oxide, Ethylene, and Auxin Cross Talk Mediates Greening and Plastid Development in Deetioliating Tomato Seedlings. *Nielda K.G. Melo, Ricardo E. Bianchetti, Bruno S. Lira, Paulo M.R. Oliveira, Rafael Zuccarelli, Devisson L.O. Dias, Diego Demarco, Lazaro E.P. Peres, Magdalena Rossi, and Luciano Freschi*

Light-evoked cotyledon greening and chloroplast differentiation in deetioliating tomato seedlings are orchestrated by regulatory feedback loops involving phytochromes, nitric oxide, auxins, and ethylene.

2278

[OPEN]LLM-Domain Containing B-GATA Factors Control Different Aspects of Cytokinin-Regulated Development in *Arabidopsis thaliana*. *Quirin L. Ranftl, Emmanouil Bastakis, Carina Klermund, and Claus Schwechheimer*

Six Arabidopsis LLM-domain B-GATA transcription factors control greening, hypocotyl elongation, phyllotaxy, floral organ initiation, branching, flowering time and senescence.

2295

PUB1 Interacts with the Receptor Kinase DMI2 and Negatively Regulates Rhizobial and Arbuscular Mycorrhizal Symbioses through Its Ubiquitination Activity in *Medicago truncatula*. *Tatiana Vernié, Sylvie Camut, Céline Camps, Céline Rembliere, Fernanda de Carvalho-Niebel, Malick Mbengue, Ton Timmers, Virginie Gascioli, Richard Thompson, Christine le Signor, Benoit Lefebvre, Julie Cullimore, and Christine Hervé*

The E3 ubiquitin ligase PUB1 is a common negative regulator for both rhizobial and arbuscular mycorrhizal symbioses and interacts with a key receptor kinase.

2312

[OPEN]Spore Density Determines Infection Strategy by the Plant Pathogenic Fungus *Plectosphaerella cucumerina*. *Pierre Pétriacq, Joost H.M. Stassen, and Jurriaan Ton*

A plant-pathogenic fungus alters its infection strategy, depending on initial spore density on the leaf surface and intensity of the corresponding plant immune.

2325

- [OPEN] Salt Stress and Ethylene Antagonistically Regulate Nucleocytoplasmic Partitioning of COP1 to Control Seed Germination. Yanwen Yu, Juan Wang, Hui Shi, Juntao Gu, Jingao Dong, Xing Wang Deng, and Rongfeng Huang
Salt stress and ethylene antagonistically regulate the nucleocytoplasmic partitioning of the COP1 E3 ligase, thereby suppressing seed germination. 2340
- [OPEN] A Co-Opted Hormonal Cascade Activates Dormant Adventitious Root Primordia upon Flooding in *Solanum dulcamara*. Thikra Dawood, Xinping Yang, Eric J.W. Visser, Tim A.H. te Beek, Philip R. Kensche, Simona M. Cristescu, Sangseok Lee, Kristýna Floková, Duy Nguyen, Celestina Mariani, and Ivo Rieu
Soil flooding reactivates dormant adventitious root primordia via ethylene-induced reduction in ABA level. 2351
- A Signaling Cascade from miR444 to RDR1 in Rice Antiviral RNA Silencing Pathway. Huacai Wang, Xiaoming Jiao, Xiaoyu Kong, Sadia Hamera, Yao Wu, Xiaoying Chen, Rongxiang Fang, and Yongsheng Yan
Micro-RNA miR444 and its MADS-box targets directly alter RNA-dependent RNA polymerase transcription in antiviral defense. 2365
- [OPEN] SUMO Is a Critical Regulator of Salt Stress Responses in Rice. Anjil Kumar Srivastava, Cunzin Zhang, Gary Yates, Mark Bailey, Adrian Brown, and Ari Sadanandom
The OsOTS1 SUMO protease acts in the nucleus to promote root growth and confer salt tolerance. 2378
- [OPEN] The Thioredoxin GbNRX1 Plays a Crucial Role in Homeostasis of Apoplastic Reactive Oxygen Species in Response to *Verticillium dahliae* Infection in Cotton. Yuan-Bao Li, Li-Bo Han, Hai-Yun Wang, Jie Zhang, Shu-Tao Sun, De-Qin Feng, Chun-Lin Yang, Yong-Duo Sun, Nai-Qin Zhong, and Gui-Xian Xia
*The root apoplast secretome of *Gossypium barbadense* actively changes upon infection, and a thioredoxin plays an important role in apoplastic ROS balance.* 2392
- Herbivore-Triggered Electrophysiological Reactions: Candidates for Systemic Signals in Higher Plants and the Challenge of Their Identification. Matthias R. Zimmermann, Axel Mithöfer, Torsten Will, Hubert H. Felle, and Alexandra C.U. Furch
Feeding caterpillars trigger various types of electrophysiological reactions with diverse voltage patterns that are specific for plant species. 2407
- [OPEN] The Mechanistic Underpinnings of an *ago1*-Mediated, Environmentally Dependent, and Stochastic Phenotype. G. Alex Mason, Tzitziki Lemus, and Christine Queitsch
Perturbation of AGO1, a key enzyme in microRNA metabolism, sensitizes seedlings to stochastic instances of cell death due to up-regulated jasmonate signaling. 2420
- [OPEN] Arabidopsis MYC Transcription Factors Are the Target of Hormonal Salicylic Acid/Jasmonic Acid Cross Talk in Response to *Pieris brassicae* Egg Extract. André Schmiesing, Aurélie Emonet, Caroline Gouhier-Darimont, and Philippe Reymond
Repression of the jasmonic acid pathway by insect eggs is associated with degradation of transcription factors that control defense gene activation. 2432

[^{OPEN}] AtPDCD5 Plays a Role in Programmed Cell Death after UV-B Exposure in Arabidopsis.

María Lorena Falcone Ferreyra, Romina Casadevall, Lucio D'Andrea, Hamada AbdElgawad, Gerrit T.S. Beemster, and Paula Casati

A programmed cell death protein, by its interaction with histone acetyltransferases, has an important role during DNA damage responses induced by UV-B radiation in Arabidopsis.

2444

[^{OPEN}] HsfA2 Controls the Activity of Developmentally and Stress-Regulated Heat Stress Protection

Mechanisms in Tomato Male Reproductive Tissues. Sotirios Fragkostefanakis, Anida Mesihovic, Stefan Simm, Marine Josephine Paupière, Yangjie Hu, Puneet Paul, Shravan Kumar Mishra, Bettina Tschiersch, Klaus Theres, Arnaud Bovy, Enrico Schleiff, and Klaus-Dieter Scharf

A heat stress transcription factor is involved in tomato pollen thermotolerance, contributing to stress responses as well as the abundance of chaperones in the priming program activated during microsporogenesis.

2461

Two bHLH Transcription Factors, bHLH34 and bHLH104, Regulate Iron Homeostasis in

Arabidopsis thaliana. Xiaoli Li, Huimin Zhang, Qin Ai, Gang Liang, and Diqiu Yu

Two transcription factors positively regulate Fe homeostasis by activating the transcription of the Ib subgroup bHLH genes.

2478

SYSTEMS AND SYNTHETIC BIOLOGY

[^{OPEN}] Arabidopsis Small Rubber Particle Protein Homolog SRPs Play Dual Roles as Positive Factors for

Tissue Growth and Development and in Drought Stress Responses. Eun Yu Kim, Ki Youl Park, Young Sam Seo, and Woo Taek Kim

A small rubber particle protein homolog plays dual roles as positive factors in post-germination growth and the drought stress tolerance response

2494

HvPap-1 C1A Protease and HvCPI-2 Cystatin Contribute to Barley Grain Filling and

Germination. Mercedes Diaz-Mendoza, Jose D. Dominguez-Figueroa, Blanca Velasco-Arroyo, Ines Cambra, Pablo Gonzalez-Melendi, Angeles Lopez-Gonzalvez, Antonia Garcia, Goetz Hensel, Jochen Kumlehn, Isabel Diaz, and Manuel Martinez

Over-expressing or silencing proteases or their inhibitors alter the metabolite composition of the grain and modify the germination process in barley

2511

CORRECTION

Hirano T., Munnik T., and Sato M.H. Phosphatidylinositol 3-Phosphate 5-Kinase, FAB1/PIKfyve Kinase Mediates Endosome Maturation to Establish Endosome-Cortical Microtubule Interaction in Arabidopsis.

2525

[^{OPEN}] Articles can be viewed online without a subscription.