

On the Cover: Parasitic plants form a specialized organ, the haustorium, to penetrate the host and obtain nutrition. At initiation, hairs proliferate on the surface of the haustorium. These hairs resemble root hairs and are widely observed on the roots of parasitic plants, including economically important parasitic family Orobanchaceae. In pp. 1492–1503, Cui et al. performed a forward genetic screen in the facultative parasitic plant *Phtheirospermum japonicum* to identify mutants with altered haustorial morphologies. They identified three mutants that are defective in formation of haustorial hairs. Characterization of these mutants shows that haustorial hairs are controlled by the root hair developmental program and support parasitism through tight interactions with host plant roots. The cover shows a fluorescent image of *P. japonicum* haustorial hairs covering the surface of a haustorium, which is induced by a host-derived chemical 2,6-dimethoxy-*p*-benzoquinone (DMBQ). Cover image credits: S. Cui, S. Yoshida and K. Shirasu (RIKEN Center for Sustainable Resource Science, Yokohama, Japan).

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When Is Science ‘Ultimately Unreliable’? *Michael R. Blatt* 1171

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Trichome Formation: Gibberellins on the Move. *Yuling Jiao* 1174

BREAKTHROUGH TECHNOLOGIES

[OPEN] Quantitative 3D Analysis of Plant Roots Growing in Soil Using Magnetic Resonance Imaging.
Dagmar van Dusschoten, Ralf Metzner, Johannes Kochs, Johannes A. Postma, Daniel Pflugfelder, Jonas Bühler, Ulrich Schurr, and Siegfried Jahnke

Magnetic resonance imaging (MRI) enables nondestructive 3D imaging and quantification of roots or root system architecture in soil and is suited for automated and routine measurements of root development. 1176

Affinity Purification and Characterization of Functional Tubulin from Cell Suspension Cultures of Arabidopsis and Tobacco. *Takashi Hotta, Satoshi Fujita, Seiichi Uchimura, Masahiro Noguchi, Taku Demura, Etsuko Muto, and Takashi Hashimoto*

New methods allow for efficient affinity purification of polymerization-competent tubulin from tobacco and Arabidopsis cell cultures. 1189

UPDATE

SIGNALING AND RESPONSE

Auxin and Cellular Elongation. *Silvia Melina Velasquez, Elke Barbez, Jürgen Kleine-Vehn, and José M. Estevez*

Multiple modes of auxin action are integrated as a crucial growth regulator in the single cell model of the root hair. 1206

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RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

^[OPEN] PSR1 Is a Global Transcriptional Regulator of Phosphorus Deficiency Responses and Carbon Storage Metabolism in *Chlamydomonas reinhardtii*. Amit K. Bajhaya, Andrew P. Dean, Leo A.H. Zeef, Rachel E. Webster, and Jon K. Pittman

A transcription factor induced by phosphate starvation regulates metabolism genes to enhance starch biosynthesis in microalgae.

1216

Grapevine Plasticity in Response to an Altered Microclimate: Sauvignon Blanc Modulates Specific Metabolites in Response to Increased Berry Exposure. Philip R. Young, Hans A. Eyeghe-Bickong, Kari du Plessis, Erik Alexandersson, Dan A. Jacobson, Zelmari Coetzee, Alain Deloire, and Melané A. Vivier

Grapevine responds to increased exposure in the bunch zone by up-regulating photoprotective carotenoids in the early developmental stages and volatile terpenoids in the later ripening stages of the berries in a proposed mechanism of antioxidant homeostasis maintenance.

1235

Deficiency of Starch Synthase IIIa and IVb Alters Starch Granule Morphology from Polyhedral to Spherical in Rice Endosperm. Yoshiko Toyosawa, Yasushi Kawagoe, Ryo Matsushima, Naoko Crofts, Masahiro Ogawa, Masako Fukuda, Toshihiro Kumamaru, Yozo Okazaki, Miyako Kusano, Kazuki Saito, Kiminori Toyooka, Mayuko Sato, Yongfeng Ai, Jay-Lin Jane, Yasunori Nakamura, and Naoko Fujita

Deficiency of starch synthases IIIa and IVb, which elongate the long chains of amylopectin, drastically changes starch granule morphology from polyhedral to spherical in rice endosperm.

1255

^[OPEN] Analysis of the Rice ADP-Glucose Transporter (OsBT1) Indicates the Presence of Regulatory Processes in the Amyloplast Stroma That Control ADP-Glucose Flux into Starch. Bilal Cakir, Shota Shiraishi, Aytug Tuncel, Hiroaki Matsusaka, Ryosuke Satoh, Salvinder Singh, Naoko Crofts, Yuko Hosaka, Naoko Fujita, Seon-Kap Hwang, Hikaru Satoh, and Thomas W. Okita

Rice lines with enhanced ADPglc synthesis and import into amyloplasts reveal additional barriers within the stroma that restrict maximum carbon flow into starch.

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^[OPEN] Glutaredoxin S15 Is Involved in Fe-S Cluster Transfer in Mitochondria Influencing Lipic Acid-Dependent Enzymes, Plant Growth, and Arsenic Tolerance in Arabidopsis. Elke Ströher, Julia Grassl, Chris Carrie, Ricarda Fenske, James Whelan, and A. Harvey Millar

The Fe-S binding monothiol GrxS15 is localized to mitochondria; its absence slows growth and respiration and increases arsenic susceptibility.

1284

ALA10, a Phospholipid Flippase, Controls FAD2/FAD3 Desaturation of Phosphatidylcholine in the ER and Affects Chloroplast Lipid Composition in *Arabidopsis thaliana*. César Botella, Emeline Sautron, Laurence Boudiere, Morgane Michaud, Emmanuelle Dubots, Yoshiki Yamaryo-Botté, Catherine Albrieux, Eric Marechal, Maryse A. Block, and Juliette Jouhet

The ALA10 phospholipid flippase reduces phosphatidylcholine desaturation and stimulates galactolipid-to-phosphatidylcholine ratio in photosynthetic tissues.

1300

[OPEN] MdMYB1 Regulates Anthocyanin and Malate Accumulation by Directly Facilitating Their Transport into Vacuoles in Apples. *Da-Gang Hu, Cui-Hui Sun, Qi-Jun Ma, Chun-Xiang You, Lailiang Cheng, and Yu-Jin Hao*

An MYB transcription factor influences organ coloration and acidity by activating the expression of the genes encoding vacuolar proton pump subunits as well as anthocyanin transporters and malate transporters.

1315

[OPEN] Acylsugar Acylhydrolases: Carboxylesterase-Catalyzed Hydrolysis of Acylsugars in Tomato Trichomes. *Anthony L. Schillmiller, Karin Gilgallon, Banibrata Ghosh, A. Daniel Jones, and Robert L. Last*

Acylsugar acylhydrolases are carboxylesterases that catalyze the hydrolysis of specific acyl chains from acylsugars found in trichomes.

1331

[OPEN] A Specific Transcriptome Signature for Guard Cells from the C₄ Plant *Gynandropsis gynandra*. *Sylvain Aubry, Olga Aresheva, Ivan Reyna-Llorens, Richard D. Smith-Unna, Julian M. Hibberd, and Bernard Genty*

Transcript profiling from closely related C₃ and C₄ species identifies a core guard cell signature as well as two patterns of gene expression associated with C₄ photosynthesis across the C₄ leaf.

1345

Structural Redesigning Arabidopsis Lignins into Alkali-Soluble Lignins through the Expression of *p*-Coumaroyl-CoA:Monolignol Transferase PMT. *Richard Sibout, Philippe Le Bris, Frédéric Legée, Laurent Cézard, Hugues Renault, and Catherine Lapierre*

*Arabidopsis lignins, which are genetically *p*-coumaroylated up to the grass lignin level, display dramatic structural changes that make them more amenable to solubilization in alkali at room temperature.*

1358

Xyloglucan Metabolism Differentially Impacts the Cell Wall Characteristics of the Endosperm and Embryo during Arabidopsis Seed Germination. *Julien Sechet, Anne Frey, Delphine Effroy-Cuzzi, Adeline Berger, François Perreau, Gwendal Cueff, Delphine Charif, Loïc Rajjou, Grégory Mouille, Helen M. North, and Annie Marion-Poll*

During germination, defective xylose trimming alters xyloglucan anisotropic localization in cell walls during hypocotyl elongation and decreases endosperm resistance to radicle protrusion

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CELL BIOLOGY

TOPP4 Regulates the Stability of PHYTOCHROME INTERACTING FACTOR5 during Photomorphogenesis in Arabidopsis. *Jing Yue, Qianqian Qin, Siyuan Meng, Huiting Jing, Xiaoping Gou, Jia Li, and Suiwen Hou*

A type 1 protein phosphatase, TOPP4, participates in the phyB signaling pathway by dephosphorylating PIF5 and controlling the stability of PIF5 in seedlings.

1381

[OPEN] Functional Analysis of Cellulose and Xyloglucan in the Walls of Stomatal Guard Cells of Arabidopsis. *Yue Rui and Charles T. Anderson*

Sufficient cellulose and xyloglucan production controls proper guard cell expansion and allows for cellulose reorganization as stomata open or close.

1398

[OPEN] Nuclear Function of Subclass I Actin-Depolymerizing Factor Contributes to Susceptibility in Arabidopsis to an Adapted Powdery Mildew Fungus. *Noriko Inada, Takumi Higaki, and Seiichiro Hasezawa*

The nuclear localization of subclass I actin-depolymerizing factor is critical for the susceptibility against an adapted powdery mildew.

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[OPEN] Enhanced Stomatal Conductance by a Spontaneous Arabidopsis Tetraploid, Me-0, Results from Increased Stomatal Size and Greater Stomatal Aperture. Keina Monda, Hiromitsu Araki, Satoru Kuhara, Genki Ishigaki, Ryo Akashi, Juntaro Negi, Mikiko Kojima, Hitoshi Sakakibara, Sho Takahashi, Mimi Hashimoto-Sugimoto, Nobuharu Goto, and Koh Iba

The Arabidopsis tetraploid ecotype, Me-0, overcomes the handicap of stomatal opening that is typical for tetraploid plants and achieves a high stomatal conductance. 1435

Amyloplast Membrane Protein SUBSTANDARD STARCH GRAIN6 Controls Starch Grain Size in Rice Endosperm. Ryo Matsushima, Masahiko Maekawa, Miyako Kusano, Katsura Tomita, Hideki Kondo, Hideki Nishimura, Naoko Crofts, Naoko Fujita, and Wataru Sakamoto

Starch grain size is an important factor for industrial applications of starch and is affected by a novel amyloplast membrane protein. 1445

ECOPHYSIOLOGY AND SUSTAINABILITY

[OPEN] Water Deficit Enhances C Export to the Roots in Arabidopsis thaliana Plants with Contribution of Sucrose Transporters in Both Shoot and Roots. Mickaël Durand, Benoît Porcheron, Nils Hennion, Laurence Maurousset, Rémi Lemoine, and Nathalie Pourtau

Mild water deficit enhances C export to the roots and modifies root architecture, with a subset of sucrose transporters involved in both shoot and roots. 1460

[OPEN] Climate and Developmental Plasticity: Interannual Variability in Grapevine Leaf Morphology. Daniel H. Chitwood, Susan M. Rundell, Darren Y. Li, Quaneisha L. Woodford, Tommy T. Yu, Jose R. Lopez, Daniel Greenblatt, Julie Kang, and Jason P. Londo

Changes in climate alter specific shape features of grapevine leaves, regardless of evolutionary or developmental context. 1480

GENES, DEVELOPMENT AND EVOLUTION

[OPEN] Haustorial Hairs Are Specialized Root Hairs That Support Parasitism in the Facultative Parasitic Plant Phtheirospermum japonicum. Songkui Cui, Takanori Wakatake, Kei Hashimoto, Simon B. Saucet, Kiminori Toyooka, Satoko Yoshida, and Ken Shirasu

Isolation and analysis of parasitic plant mutants with defects in haustorial hair development shows that these specialized root hairs are important for tight interactions with the host plant roots. 1492

Response of Organ Structure and Physiology to Autotetraploidization in Early Development of Energy Willow Salix viminalis. Dénes Dudits, Katalin Török, András Cseri, Kenny Paul, Anna V. Nagy, Bettina Nagy, László Sass, Györgyi Ferenc, Radomira Vankova, Petre Dobrev, Imre Vass, and Ferhan Ayaydin

Enlarged leaf size, stem diameter, and root system of autotetraploid energy willows are associated with changes in hormonal status and the efficiency of photosynthesis. 1504

[OPEN] Cis-Regulatory Elements Determine Germline Specificity and Expression Level of an Isopentenyltransferase Gene in Sperm Cells of Arabidopsis. Jinghua Zhang, Tong Yuan, Xiaomeng Duan, Xiaoping Wei, Tao Shi, Jia Li, Scott D. Russell, and Xiaoping Gou

A regulatory region consisting of duplicated motifs activates gene expression in plant male gamete. 1524

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[OPEN] Genome-Wide Characterization of Maize Small RNA Loci and Their Regulation in the *required to maintain repression6-1 (rmr6-1)* Mutant and Long-Term Abiotic Stresses. Alice Lunardon, Cristian Forestan, Silvia Farinati, Michael J. Axtell, and Serena Varotto

Agronomically realistic, long-term drought stress mis-regulates some miRNAs and induces the down-regulation of a set of small RNA loci in the maize leaf.

1535

[OPEN] The Dynamics of Transcript Abundance during Cellularization of Developing Barley Endosperm. Runxuan Zhang, Matthew R. Tucker, Rachel A Burton, Neil J. Shirley, Alan Little, Jenny Morris, Linda Milne, Kelly Houston, Pete E. Hedley, Robbie Waugh, and Geoffrey B. Fincher

Gene transcript profiles during barley endosperm cellularization reveal functional modules, coexpression networks, and regulatory genes, all of which align with cell wall changes in developing grain.

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[OPEN] H3K36ac Is an Evolutionary Conserved Plant Histone Modification That Marks Active Genes. Walid Mahrez, Minerva Susana Trejo Arellano, Jordi Moreno-Romero, Miyuki Nakamura, Huan Shu, Paolo Nanni, Claudia Köhler, Wilhelm Gruissem, and Lars Hennig

Profiling of histone H3 modifications by MS/MS identified the H3K36ac histone modification, which is introduced at the first 500 bp of active Arabidopsis genes and is conserved in gymnosperms and angiosperms.

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[OPEN] The *tae-miR408*-Mediated Control of *TaTOC1* Genes Transcription Is Required for the Regulation of Heading Time in Wheat. Xiang Yu Zhao, Po Hong, Ji Yun Wu, Xiang Bin Chen, Xing Guo Ye, Yan You Pan, Jian Wang, and Xian Sheng Zhang

A wheat microRNA promotes heading by negatively regulating expression of homologs of the clock gene TOC1.

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[OPEN] Evolutionary Dynamics of the Leucine-Rich Repeat Receptor-Like Kinase (LRR-RLK) Subfamily in Angiosperms. Iris Fischer, Anne Diévert, Gaetan Droc, Jean-François Dufayard, and Nathalie Chantret

Phylogenetic analysis of leucine-rich repeat-containing receptor-like kinases demonstrates the dynamic nature of gene duplication, loss, and selection in this family.

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[OPEN] Defective Tapetum Cell Death 1 (DTC1) Regulates ROS Levels by Binding to Metallothionein during Tapetum Degeneration. Jakyung Yi, Sunok Moon, Yang-Seok Lee, Lu Zhu, Wanqi Liang, Dabing Zhang, Ki-Hong Jung, and Gynheung An

Timely production of superoxides is essential for initiation of tapetum degeneration in rice.

1611

[OPEN] TEMPRANILLO Reveals the Mesophyll as Crucial for Epidermal Trichome Formation. Luis Matías-Hernández, Andrea E. Aguilar-Jaramillo, Michela Osnato, Roy Weinstain, Eilon Shani, Paula Suárez-López, and Soraya Pelaz

TEMPRANILLO repress epidermal trichome initiation by controlling gibberellin accumulation in the mesophyll as well as by acting as link between GA and CK signaling in the epidermis.

1624

[OPEN] Tonoplast Aquaporins Facilitate Lateral Root Emergence. Hagen Reinhardt, Charles Hachez, Manuela Désirée Bienert, Azeez Beebo, Kamal Swarup, Ute Vofß, Karim Bouhidel, Lorenzo Frigerio, Jan K. Schjoerring, Malcolm J. Bennett, and Francois Chaumont

Aquaporins located in the vacuolar membrane contribute to the proper development of lateral roots.

1640

[OPEN] Combined Chlorophyll Fluorescence and Transcriptomic Analysis Identifies the P3/P4 Transition as a Key Stage in Rice Leaf Photosynthetic Development. *Julia C. van Campen, Muhammad N. Yaapar, Supatthra Narawatthana, Christoph Lehmeier, Samart Wanchana, Vivek Thakur, Caspar Chater, Steve Kelly, Stephen A. Rolfe, W. Paul Quick, and Andrew J. Fleming*

A combined transcriptomic and physiological analysis of rice leaf development identifies the stage (P3/P4 transition) when photosynthetic competence is first established. 1655

[OPEN] SEUSS Integrates Gibberellin Signaling with Transcriptional Inputs from the SHR-SCR-SCL3 Module to Regulate Middle Cortex Formation in the Arabidopsis Root. *Xue Gong, Miguel A. Flores-Vergara, Jing Han Hong, Huangwei Chu, Jun Lim, Robert G. Franks, Zhongchi Liu, and Jian Xu*

The transcription factor SEU promotes middle cortex formation through a network of transcription factor interactions. 1675

MEMBRANES, TRANSPORT AND BIOENERGETICS

[OPEN] Nitrogen Use Efficiency Is Mediated by Vacuolar Nitrate Sequestration Capacity in Roots of *Brassica napus*. *Yong-Liang Han, Hai-Xing Song, Qiong Liao, Yin Yu, Shao-Fen Jian, Joe Eugene Lepo, Qiang Liu, Xiang-Min Rong, Chang Tian, Jing Zeng, Chun-Yun Guan, Abdelbagi M. Ismail, and Zhen-Hua Zhang*

Nitrogen use efficiency is mediated by vacuolar nitrate sequestration capacity in roots 1684

SIGNALING AND RESPONSE

Arabidopsis *HY1*-Modulated Stomatal Movement: An Integrative Hub Is Functionally Associated with *ABI4* in Dehydration-Induced ABA Responsiveness. *Yanjie Xie, Yu Mao, Xingliang Duan, Heng Zhou, Diwen Lai, Yihua Zhang, and Wenbiao Shen*

The heme oxygenase HY1 functions negatively and acts upstream in drought-induced ABA signaling, and this cascade depends on RbohD-derived ROS production in the regulation of stomatal closure. 1699

Phosphatidylinositol 3-Kinase Promotes V-ATPase Activation and Vacuolar Acidification and Delays Methyl Jasmonate-Induced Leaf Senescence. *Jian Liu, Yingbin Ji, Jun Zhou, and Da Xing*

Phosphatidylinositol 3-kinase promotes proton pump activation, resulting in vacuolar acidification and stomatal closing, thereby delaying methyl jasmonate-induced leaf senescence. 1714

[OPEN] Comprehensive Profiling of Ethylene Response Factor Expression Identifies Ripening-Associated *ERF* Genes and Their Link to Key Regulators of Fruit Ripening in Tomato. *Mingchun Liu, Bruna Lima Gomes, Isabelle Mila, Eduardo Purgatto, Lázaro E.P. Peres, Pierre Frasse, Elie Maza, Mohamed Zouine, Jean-Paul Roustan, Mondher Bouzayen, and Julien Pirrello*

A small subset of ethylene response factor genes emerge as main actors in controlling fruit ripening via both ethylene-dependent and ripening-impaired mechanisms. 1732

Chloroplast Activity and 3' phosphadenosine 5' phosphate Signaling Regulate Programmed Cell Death in Arabidopsis. *Quentin Bruggeman, Christelle Mazubert, Florence Prunier, Raphaël Lugan, Kai Xun Chan, Su Yin Phua, Barry James Pogson, Anja Krieger-Liszkay, Marianne Delarue, Moussa Benhamed, Catherine Bergounioux, and Cécile Raynaud*

Chloroplasts modulate programmed cell death via at least two different pathways: photosynthetic activity is required for cell death while a retrograde signal negatively regulates cell death and plant innate immunity. 1745

Singlet Oxygen-Induced Cell Death in Arabidopsis under High-Light Stress Is Controlled by OXI1 Kinase. *Leonard Shumbe, Anne Chevalier, Bertrand Legeret, Ludovine Tacconnat, Fabien Monnet, and Michel Havaux*

The AGC kinase Oxidative Signal Inducible1 regulates ¹O₂-induced cell death in plants exposed to excess light energy. 1757

[OPEN] Light-Inducible MiR163 Targets *PXMT1* Transcripts to Promote Seed Germination and Primary Root Elongation in Arabidopsis. *Pil Joong Chung, Bong Soo Park, Huan Wang, Jun Liu, In-Cheol Jang, and Nam-Hai Chua*

*The microRNA MiR163 targets the methyl-transferase gene *PXMT1* at the early stage of light responses to promote seed germination and root development.* 1772

[OPEN] Root Type-Specific Reprogramming of Maize Pericycle Transcriptomes by Local High Nitrate Results in Disparate Lateral Root Branching Patterns. *Peng Yu, Jutta A. Baldauf, Andrew Lithio, Caroline Marcon, Dan Nettleton, Chunjian Li, and Frank Hochholdinger*

Root type-specific lateral root branching and pericycle-specific transcriptome reprogramming highlight diverse foraging strategies of maize roots in heterogeneous nitrate environments. 1783

The Wheat Mediator Subunit TaMED25 Interacts with the Transcription Factor TaEIL1 to Negatively Regulate Disease Resistance against Powdery Mildew. *Jie Liu, Tianren Zhang, Jizeng Jia, and Jiaqiang Sun*

A conserved Mediator complex subunit physically interacts with the transcription factor ETHYLENE INSENSITIVE3-LIKE1 (TaEIL1) to promote ETHYLENE RESPONSE FACTOR1 (TaERF1) expression and repress powdery mildew resistance. 1799

GUN1 Controls Accumulation of the Plastid Ribosomal Protein S1 at the Protein Level and Interacts with Proteins Involved in Plastid Protein Homeostasis. *Luca Tadini, Paolo Pesaresi, Tatjana Kleine, Fabio Rossi, Arthur Guljamow, Frederik Sommer, Timo Mühlhaus, Michael Schroda, Simona Masiero, Mathias Pribil, Maxi Rothbart, Boris Hedtke, Bernhard Grimm, and Dario Leister*

The gene product associated with a so-called Genomes UNcoupled (gun) mutant interacts with proteins involved in plastid protein homeostasis. 1817

The DELLA Protein SLR1 Integrates and Amplifies Salicylic Acid- and Jasmonic Acid-Dependent Innate Immunity in Rice. *David De Vleeschauwer, Hamed Soren Seifi, Osvaldo Filipe, Ashley Haeck, Son Nguyen Huu, Kristof Demeestere, and Monica Höfte*

A growth-inhibiting protein boosts the action of the defense-related plant hormones salicylic acid and jasmonic acid, rendering rice plants more resistant to pathogen attack. 1831

SYSTEMS AND SYNTHETIC BIOLOGY

[OPEN] Combined Large-Scale Phenotyping and Transcriptomics in Maize Reveals a Robust Growth Regulatory Network. *Joke Baute, Dorota Herman, Frederik Coppens, Jolien De Block, Bram Slabbinck, Matteo Dell'Acqua, Mario Enrico Pè, Steven Maere, Hilde Nelissen, and Dirk Inzé*

Combining in-depth phenotyping with transcript profiling in maize recombinant inbred lines untangles the genetic control of complex traits. 1848

[OPEN] Production and Characterization of Synthetic Carboxysome Shells with Incorporated Luminal Proteins. *Fei Cai, Susan L. Bernstein, Steven C. Wilson, and Cheryl A. Kerfeld*

Synthetic carboxysome shells, containing all of the key component proteins provide a platform for fundamental studies of shell permeability and metabolic modeling of organelle function. 1868

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FamNet: A Framework to Identify Multiplied Modules Driving Pathway Expansion in Plants. *Colin Ruprecht, Amelie Mendrinna, Takayuki Tohge, Arun Sampathkumar, Sebastian Klie, Alisdair R. Fernie, Zoran Nikoloski, Staffan Persson, and Marek Mutwil*

Gene module multiplication drives pathway expansion in plants.

1878

RETRACTION

Nie S., Yue H., and Xing D. (2015) A Potential Role for Mitochondrial Produced Reactive Oxygen Species in Salicylic Acid-Mediated Plant Acquired Thermotolerance.

1895

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