On the Cover: Primary reactions of photosynthesis are mediated by three multi-subunit pigment-protein complexes including PSII, cytochrome b_{6f} (Cyt b_{6f}) complex, and PSI, the biogenesis of which requires various nuclear-encoded auxiliary proteins. In this issue, Wang et al. (pp. 1710–1728) study the physiological function of three m-type thioredoxins (TRX \textit{m}1, TRX \textit{m}2, and TRX \textit{m}4) in the biogenesis of photosynthetic complexes in \textit{Arabidopsis thaliana}. Their data demonstrate that three TRX \textit{m} proteins play a redundant role in the regulation of PSII biogenesis via modulating the redox status of PSII core subunits, suggesting a mechanism to assist the assembly of PSII core subunits into PSII complex. The cover shows the phenotypic comparison between triple TRX \textit{m}-silenced plant (left) and the control plant (right). Cover image credits: Peng Wang and Hong-Bin Wang.

ON THE INSIDE

\textit{Peter V. Minorsky}

1483

COMMENTARIES

Cellulose Biosynthesis: Counting the Chains. \textit{Michael C. Jarvis}

1485

TOPICAL REVIEW


Research into the systems biology of roots now encompasses transcriptomic and bioinformatic analysis combined with diverse modeling approaches, in order to relate gene regulatory networks to organ and rhizosphere scale processes, and will ultimately allow researchers to bridge the genotype-to-phenotype gap.

1487

RESEARCH REPORTS

\textit{[W]}A Two-Hybrid-Receptor Assay Demonstrates Heteromer Formation as Switch-On for Plant Immune Receptors. \textit{Markus Albert, Anna Kristina Jehle, Ursula Fürst, Delphine Chinchilla, Thomas Boller, and Georg Felix}

Receptor/coreceptor pairs with swapped cytosolic domains are fully functional, demonstrating importance of heteromer formation as molecular switch-on for intracellular signaling.

1504

\textit{[C][W][OPEN]} Characterization of the Heterotrimeric G-Protein Complex and Its Regulator from the Green Alga \textit{Chara braunii} Expands the Evolutionary Breadth of Plant G-Protein Signaling. \textit{Dieter Hackenberg, Hideloshi Sakayama, Tomoaki Nishiyama, and Sona Pandey}

The presence of a complete repertoire of heterotrimeric G-protein complex components and its regulator in a green alga confirms that the origin of this signaling mechanism in plants is more ancient than previously thought and is not related to the colonization of land by plants.

1510

RESEARCH ARTICLES

BIOCHEMISTRY AND METABOLISM

\textit{[C][W][OPEN]} Proteome Analysis of Peroxisomes from Etiolated Arabidopsis Seedlings Identifies a Peroxisomal Protease Involved in \textit{β}-Oxidation and Development. \textit{Sheng Quan, Pingfang Yang, Gaëlle Cassin-Ross, Navneet Kaur, Robert Switzenberg, Kyaw Aung, Jiying Li, and Jianping Hu}

A proteome analysis of peroxisomes from etiolated Arabidopsis seedlings provides a road map of metabolism in a major peroxisomal variant and uncovers the role for a peroxisomal cysteine protease in \textit{β}-oxidation and development.

1518

Biochemical, histological, and transcriptional characterization of lignification identifies substantial differences in two sugarcane genotypes.


Peak shapes in an x-ray diffractogram of primary cell walls indicated 18-chain microfibrils with mixed cross-sectional shapes and occasional twinning, consistent with a cellulose-synthesizing complex assembled from six CESA trimers.


Plant nucleoside N-ribohydrolases, which exist in two subclasses, play roles in cytokinin conversion and activation as well as in purine and pyrimidine metabolism.

A newly identified cytochrome P450 isoform initiates the synthesis of valuable alkaloids in leaves of Catharanthus roseus by hydroxylating tabersonine.

Deciphering the Responses of Root Border-Like Cells of Arabidopsis and Flax to Pathogen-Derived Elicitors. Barbara Plancot, Catherine Santella, Rim Jaber, Marie Christine Kiefer-Meyer, Marie-Laure Follet-Gueye, Jérôme Leprince, Isabelle Gattin, Céline Souc, Azeddine Driouch, and Maïté Vicré-Gibouin

Root border-like cells of flax and Arabidopsis activate innate immunity responses to elicitors involving both callose deposition and cell wall extensin reorganization.

Chloroplast Phosphoglycerate Kinase Is Involved in the Targeting of Bamboo mosaic virus to Chloroplasts in Nicotiana benthamiana Plants. Shun-Fang Cheng, Ying-Ping Huang, Li-Hung Chen, Yau-Heiu Hsu, and Ching-Hsiu Tsai

The BaMV RNA binds to chloroplast phosphoglycerate kinase and is targeted to chloroplast for replication.


Stress-Induced Cytokinrin Synthesis Increases Drought Tolerance through the Coordinated Regulation of Carbon and Nitrogen Assimilation in Rice. Maria Reguera, Zvi Peleg, Yasser M. Abdel-Tawab, Ellen B. Tumimbang, Carla A. Delatorre, and Eduardo Blumwald

Cytokinrin enhances the capacity of plants to tolerate water deficit by improving carbon and nitrogen assimilation processes during stress.
The Tomato 14-3-3 Protein TFT4 Modulates H⁺ Efflux, Basipetal Auxin Transport, and the PKS5-J3 Pathway in the Root Growth Response to Alkaline Stress. Weifeng Xu, Liguo Jia, Weiming Shi, František Baluška, Herbert J. Kronzucker, Jiasheng Liang, and Jianhua Zhang

A tomato 14-3-3 protein integrates H⁺ efflux, basipetal auxin transport, and the PKS5-J3 pathway in root acclimation to alkaline stress.

GENES, DEVELOPMENT, AND EVOLUTION

The REIL1 and REIL2 Proteins of Arabidopsis thaliana Are Required for Leaf Growth in the Cold. Stefanie Schmidt, Frederik Dethloff, Olga Beine-Golovchuk, and Joachim Kopka

Mutations in evolutionarily conserved zinc finger proteins of Arabidopsis thaliana are silent at optimal growth temperature but arrest leaf growth at 10°C, a response which arises from their roles in the maturation of the eukaryotic ribosome.

The Conserved Chimeric Transcript UPGRADE2 Is Associated with Unreduced Pollen Formation and Is Exclusively Found in Apomictic Boechera Species. Martin Mau, José M. Corral, Heiko Vogel, Michael Melzer, Jörg Fuchs, Markus Kuhlmann, Nico de Storme, Danny Geelen, and Timothy F. Sharbel

A conserved chimeric genomic sequence found exclusively in apomictic Boechera species generates a putative long non-protein-coding transcript with secondary structure folding capability and is highly expressed in antherheads characterized by meiotically unreduced pollen formation.


A single gene characterized by a conserved apomixis-specific polymorphism is exclusively expressed in the ovules of genetically diverse apomictic Boechera species while being repressed in ovules of sexuals.

The F-Box Protein OsFBK12 Targets OsSAMS1 for Degradation and Affects Pleiotropic Phenotypes, Including Leaf Senescence, in Rice. Yuan Chen, Yunyan Xu, Wei Luo, Wenxuan Li, Na Chen, Dajian Zhang, and Kang Chong

An F-box protein in the 26S proteasome pathway targets substrates specific degradation to trigger changes in ethylene levels for the regulation of leaf senescence and grain size.

Multiple Checkpoints for the Expression of the Chloroplast-Encoded Splicing Factor MatK. Stefanie Hertel, Reimo Zoschke, Laura Neumann, Yujiao Qu, Ilka M. Axmann, and Christian Schmitz-Linneweber

Expression of a chloroplast-encoded splicing factor is regulated on the level of mRNA stability and translation, including a possible autoregulatory loop.

Evolution of Bacterial-Like Phosphoprotein Phosphatases in Photosynthetic Eukaryotes Features Ancestral Mitochondrial or Archaeal Origin and Possible Lateral Gene Transfer. R. Glen Uhrig, David Kerk, and Greg B. Moorhead

Bacterial-like phosphoprotein phosphatase genes entered eukaryotes from archaea or with ancestral mitochondrial formation, their various protein types showing important differences in subcellular localization, and differing at specific sequence motifs that could serve as accessory protein-binding sites.

Seedling Lethal1, a Pentatricopeptide Repeat Protein Lacking an E/E⁺ or DYW Domain in Arabidopsis, Is Involved in Plastid Gene Expression and Early Chloroplast Development. Young Jae Pyo, Kwang-Chul Kwon, Anna Kim, and Myeon Haeng Cho

A pentatricopeptide repeat protein is involved in plastid gene expression required for normal chloroplast development.
MEMBRANES, TRANSPORT, AND BIOENERGETICS

Roles of BOR2, a Boron Exporter, in Cross Linking of Rhamnogalacturonan II and Root Elongation under Boron Limitation in Arabidopsis. Kyoko Miwa, Shinji Wakuta, Shigeki Takada, Koji Ide, Junpei Takano, Satoshi Naito, Hiroyuki Omori, Toshiro Matsunaga, and Toru Fujiwara

An efflux-type boron transporter facilitates efficient borate cross-linking of rhamnogalacturonan II in cell walls and root cell elongation under boron deficiency.

Evidence for a Role of Chloroplastic m-Type Thioredoxins in the Biogenesis of Photosystem II in Arabidopsis. Peng Wang, Jun Liu, Bing Liu, Dongru Feng, Qingen Da, Peng Wang, Shengying Shu, Jianbin Su, Yang Zhang, Jinfu Wang, and Hong-Bin Wang

M-type thioredoxins directly regulate the biogenesis of the photosystem II complex.

Aspen SUCROSE TRANSPORTER3 Allocates Carbon into Wood Fibers. Amir Mahboubi, Christine Ratke, András Gorzsás, Manoj Kumar, Ewa J. Mellerowicz, and Totte Niittylä

Reduction of a plasma membrane-localized sucrose transporter decreases carbon allocation to secondary walls of wood fibers.

Rapid Ammonia Gas Transport Accounts for Futile Transmembrane Cycling under NH₃/NH₄⁺ Toxicity in Plant Roots. Devrim Coskun, Dev T. Britto, Mingyuan Li, Alexander Becker, and Herbert J. Kronzucker

Fluxes of NH₃, but not NH₄⁺, account for futile cycling across both plasmalemma and tonoplast in roots of barley, resulting in a thermodynamic NH₃ equilibrium between cytosol, vacuole, and external solution, and aquaporins are likely mediators of these fluxes.

SIGNALING AND RESPONSE

The CALMODULIN-BINDING PROTEIN60 Family Includes Both Negative and Positive Regulators of Plant Immunity. William Truman, Suma Sreekanta, You Lu, Gerit Bethke, Kenichi Tsuda, Fumiaki Katagiri, and Jane Glazebrook

The Arabidopsis gene CBP60a encodes a negative regulator of immunity that represses salicylic acid synthesis and defense gene expression.

An S-Domain Receptor-Like Kinase, OsSIK2, Confers Abiotic Stress Tolerance and Delays Dark-Induced Leaf Senescence in Rice. Li-Juan Chen, Hada Wuriyanghan, Yu-Qin Zhang, Kai-Xuan Duan, Hao-Wei Chen, Qing-Tian Li, Xiang Lu, Si-Jie He, Biao Ma, Wan-Ke Zhang, Qing Lin, Shou-Yi Chen, and Jin-Song Zhang

A receptor-like kinase, part of a family of proteins contributing to plant development and defense, is involved in abiotic stress and the senescence process, integrating stress signals into a developmental program for adaptive growth.

S-Nitrosylation of Ascorbate Peroxidase Is Part of Programmed Cell Death Signaling in Tobacco Bright Yellow-2 Cells. Maria Concetta de Pinto, Vittoria Locato, Alessandra Sgobba, Maria del Carmen Romero-Puertas, Cosimo Gadaleta, Massimo Delledonne, and Laura De Gara

S-Nitrosylation of ascorbate peroxidase is part of the signaling pathway for programmed cell death induction in plants.

GDSL LIPASE1 Modulates Plant Immunity through Feedback Regulation of Ethylene Signaling. Hye Gi Kim, Sun Jae Kwon, Young Jin Jang, Myung Hee Nam, Joo Hee Chung, Yun-Cheol Na, Hongwei Guo, and Ohkmae K. Park

A GDSL lipase regulates ethylene-dependent pathogen resistance and ethylene-salicylic acid signaling interactions in plants.
A WRKY transcription factor regulates the antagonistic interactions between drought and disease resistance pathways by complementary gene suppression and by regulating its own expression via specific DNA elements on the promoters of these genes in guard cells and impacting on drought resistance.