

## From the Cover

- E11188 **Flavonols and oxidative damage in pollen**  
 E11111 **Immunity against recurrent skin infections**  
 11964 **Histone tails and chromatin condensation**  
 11982 **Global warming and mountaintop extinctions**  
 12000 **Evolution of costly mutualism**

## Contents

### THIS WEEK IN PNAS

11857 **In This Issue**

### LETTERS (ONLINE ONLY)

- E10999 **Is "choline and geranate" an ionic liquid or deep eutectic solvent system?**  
*Robin D. Rogers and Gabriela Gurau*
- E11000 **Reply to Rogers and Gurau: Definitions of ionic liquids and deep eutectic solvents**  
*Amrita Banerjee, Kelly Ibsen, Tyler Brown, Renwei Chen, Christian Agatemor, and Samir Mitragotri*
- E11002 **Tagging the musical beat: Neural entrainment or event-related potentials?**  
*Giacomo Novembre and Gian Domenico Iannetti*
- E11004 **Reply to Novembre and Iannetti: Conceptual and methodological issues**  
*Tomas Lenc, Peter E. Keller, Manuel Varlet, and Sylvie Nozaradan*

### NEWS FEATURE—An in-depth look at trending science issues

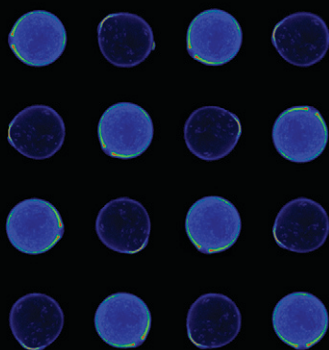
- 11859 **Exposing the exposome to elucidate disease**  
*Carolyn Beans*

### QNAS

- 11863 **QnAs with Emilio F. Moran**  
*Tinsley H. Davis*  
 → See Inaugural Article on page 11891

### COMMENTARIES

- 11865 **Macrophages and innate immune memory against *Staphylococcus* skin infections**  
*Jonas D. Van Belleghem and Paul L. Bollyky*  
 → See companion article on page E11111
- 11868 **Linker histones as liquid-like glue for chromatin**  
*Eric B. Gibbs and Richard W. Kriwacki*  
 → See companion article on page 11964



**Cover image:** Pictured are tomato pollen grains stained with two sensors of reactive oxygen species (ROS). Regulation of ROS levels is required for proper pollen development. Joëlle K. Muhlemann et al. report that plant metabolites called flavonols act as antioxidants to regulate ROS levels and prevent oxidative damage in pollen. The authors demonstrated that ROS levels are elevated in pollen during heat stress, and the presence of flavonols minimizes the negative effects of elevated temperature on pollen and plant reproduction. The findings may guide future metabolic engineering strategies to enhance crop yields at elevated temperatures. See the article by Muhlemann et al. on pages E11188–E11197. Image courtesy of Joëlle K. Muhlemann.

- 11871 Escalator to extinction**  
Mark C. Urban  
→ See companion article on page 11982
- 11874 Evolution of bacterial trade in a two-species community**  
Jennifer M. Farrell and Sam P. Brown  
→ See companion article on page 12000
- 11876 Inhibition of tumor growth by agonists of growth hormone-releasing hormone**  
Hippokratris Kiaris and Ioulia Chatzistamou  
→ See companion article on page 12028

## PNAS PLUS

- 11879 Significance Statements**  
Brief statements written by the authors about the significance of their papers.

## PERSPECTIVE

- 11883 Quantifying resilience of humans and other animals**  
Marten Scheffer, J. Elizabeth Bolhuis, Denny Borsboom, Timothy G. Buchman, Sanne M. W. Gijzel, Dave Goulson, Jan E. Kammenga, Bas Kemp, Ingrid A. van de Leemput, Simon Levin, Carmel Mary Martin, René J. F. Melis, Egbert H. van Nes, L. Michael Romero, and Marcel G. M. Olde Rikkert

## INAUGURAL ARTICLE

- 11891 Sustainable hydropower in the 21st century**  
Emilio F. Moran, Maria Claudia Lopez, Nathan Moore, Norbert Müller, and David W. Hyndman  
→ See QnAs on page 11863

## PHYSICAL SCIENCES

### APPLIED PHYSICAL SCIENCES

- 11899 Bulk electronic transport impacts on electron transfer at conducting polymer electrode–electrolyte interfaces**  
Kosala Wijeratne, Ujwala Ail, Robert Brooke, Mikhail Vagin, Xianjie Liu, Mats Fahlman, and Xavier Crispin
- 11905 Acoustic phonon lifetimes limit thermal transport in methylammonium lead iodide**  
Aryeh Gold-Parker, Peter M. Gehring, Jonathan M. Skelton, Ian C. Smith, Dan Parshall, Jarvist M. Frost, Hemamala I. Karunadasa, Aron Walsh, and Michael F. Toney

### BIOPHYSICS AND COMPUTATIONAL BIOLOGY

- E11043 Coupled molecular dynamics mediate long- and short-range epistasis between mutations that affect stability and aggregation kinetics**  
Haoran Yu and Paul A. Dalby
- E11053 Evolution of weak cooperative interactions for biological specificity**  
Ang Gao, Krishna Shrinivas, Paul Lepeudry, Hiroshi I. Suzuki, Phillip A. Sharp, and Arup K. Chakraborty
- 11911 Deciphering the structure of the condensin protein complex**  
Dana Krepel, Ryan R. Cheng, Michele Di Pierro, and José N. Onuchic

- 11917 Optimal molecular crowding accelerates group II intron folding and maximizes catalysis**  
Bishnu P. Paudel, Erica Fiorini, Richard Börner, Roland K. O. Sigel, and David S. Rueda

- 11923 Arginine-rich cell-penetrating peptides induce membrane multilamellarity and subsequently enter via formation of a fusion pore**  
Christoph Allolio, Aniket Magarkar, Piotr Jurkiewicz, Katarína Baxová, Matti Javanainen, Philip E. Mason, Radek Sachl, Marek Cebecauer, Martin Hof, Dominik Horinek, Veronika Heinz, Reinhard Rachel, Christine M. Ziegler, Adam Schröfel, and Pavel Jungwirth

## CHEMISTRY

- 11929 Intrinsic anion diffusivity in lead halide perovskites is facilitated by a soft lattice**  
Minliang Lai, Amael Obliger, Dylan Lu, Christopher S. Kley, Connor G. Bischak, Qiao Kong, Teng Lei, Letian Dou, Naomi S. Ginsberg, David T. Limmer, and Peidong Yang

## EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

- E11005 Ocean circulation, ice shelf, and sea ice interactions explain Dansgaard-Oeschger cycles**  
Niklas Boers, Michael Ghil, and Denis-Didier Rousseau

## ENGINEERING

- E11015 A flexible organic reflectance oximeter array**  
Yasser Khan, Donggeon Han, Adrien Pierre, Jonathan Ting, Xingchun Wang, Claire M. Lochner, Gianluca Bovo, Nir Yaacobi-Gross, Chris Newsome, Richard Wilson, and Ana C. Arias

## SUSTAINABILITY SCIENCE

- 11935 Peculiarly pleasant weather for US maize**  
Ethan E. Butler, Nathaniel D. Mueller, and Peter Huybers
- 12069 A multiscale approach to balance trade-offs among dam infrastructure, river restoration, and cost**  
Samuel G. Roy, Emi Uchida, Simone P. de Souza, Ben Blachly, Emma Fox, Kevin Gardner, Arthur J. Gold, Jessica Jansujwicz, Sharon Klein, Bridie McGreavy, Weiwei Mo, Sean M. C. Smith, Emily Vogler, Karen Wilson, Joseph Zydlewski, and David Hart

## SOCIAL SCIENCES

### ANTHROPOLOGY

- 11941 An abundance of developmental anomalies and abnormalities in Pleistocene people**  
Erik Trinkaus

### PSYCHOLOGICAL AND COGNITIVE SCIENCES

- 11947 Awareness of what is learned as a characteristic of hippocampus-dependent memory**  
Christine N. Smith and Larry R. Squire
- 12063 Functional connectivity in central executive network protects youth against cardiometabolic risks linked with neighborhood violence**  
Gregory E. Miller, Edith Chen, Casey C. Armstrong, Ann L. Carroll, Sekine Ozturk, Kelsey J. Rydland, Gene H. Brody, Todd B. Parrish, and Robin Nusslock

## SUSTAINABILITY SCIENCE

- 11891 Sustainable hydropower in the 21st century**  
Emilio F. Moran, Maria Claudia Lopez, Nathan Moore, Norbert Müller, and David W. Hyndman  
→ See QnAs on page 11863

## BIOLOGICAL SCIENCES

### ANTHROPOLOGY

- 11941 An abundance of developmental anomalies and abnormalities in Pleistocene people**  
Erik Trinkaus

### APPLIED BIOLOGICAL SCIENCES

- E11025 Engineering the protein secretory pathway of *Saccharomyces cerevisiae* enables improved protein production**  
Mingtao Huang, Guokun Wang, Jiufu Qin, Dina Petranovic, and Jens Nielsen

### BIOCHEMISTRY

- E11033 Combinatorial regulation of hepatic cytoplasmic signaling and nuclear transcriptional events by the OGT/REV-ERB $\alpha$  complex**  
Alexandre Berthier, Manjula Vinod, Geoffrey Porez, Agata Steenackers, Jérémy Alexandre, Nao Yamakawa, Céline Gheeraert, Maheul Ploton, Xavier Maréchal, Julie Dubois-Chevalier, Agnès Hovasse, Christine Schaeffer-Reiss, Sarah Cianféroni, Christian Rolando, Fabrice Bray, Hélène Duez, Jérôme Eeckhoutte, Tony Lefebvre, Bart Staels, and Philippe Lefebvre

- 11911 Deciphering the structure of the condensin protein complex**  
Dana Krepel, Ryan R. Cheng, Michele Di Pierro, and José N. Onuchic

- 11917 Optimal molecular crowding accelerates group II intron folding and maximizes catalysis**  
Bishnu P. Paudel, Erica Fiorini, Richard Börner, Roland K. O. Sigel, and David S. Rueda

- 11953 Crystal structure of heme A synthase from *Bacillus subtilis***  
Satomi Niwa, Kazuki Takeda, Masayuki Kosugi, Erika Tsutsumi, Tatsushi Mogi, and Kunio Miki

- 11958 Crystal structure of human mARC1 reveals its exceptional position among eukaryotic molybdenum enzymes**  
Christian Kubitz, Florian Bittner, Carsten Ginsel, Antje Havemeyer, Bernd Clement, and Axel J. Scheidig

### BIOPHYSICS AND COMPUTATIONAL BIOLOGY

- E11043 Coupled molecular dynamics mediate long- and short-range epistasis between mutations that affect stability and aggregation kinetics**  
Haoran Yu and Paul A. Dalby

- 11964 Highly disordered histone H1–DNA model complexes and their condensates**  
Abigail L. Turner, Matthew Watson, Oscar G. Wilkins, Laura Cato, Andrew Travers, Jean O. Thomas, and Katherine Stott  
→ See Commentary on page 11868

- 11970 Allosteric landscapes of eukaryotic cytoplasmic Hsp70s are shaped by evolutionary tuning of key interfaces**  
Wenli Meng, Eugenia M. Clerico, Natalie McArthur, and Lila M. Gierasch

- 11976 Self-cleavage of the *glmS* ribozyme core is controlled by a fragile folding element**  
Andrew Savinov and Steven M. Block

### CELL BIOLOGY

- E11053 Evolution of weak cooperative interactions for biological specificity**  
Ang Gao, Krishna Shrinivas, Paul Lepeudry, Hiroshi I. Suzuki, Phillip A. Sharp, and Arup K. Chakraborty

### DEVELOPMENTAL BIOLOGY

- E11061 Polypyrimidine tract-binding protein blocks miRNA-124 biogenesis to enforce its neuronal-specific expression in the mouse**  
Kyu-Hyeon Yeom, Simon Mitchell, Anthony J. Linares, Sika Zheng, Chia-Ho Lin, Xiao-Jun Wang, Alexander Hoffmann, and Douglas L. Black

- E11071 Silencing of retrotransposon-derived imprinted gene *RTL1* is the main cause for postimplantational failures in mammalian cloning**  
Dawei Yu, Jing Wang, Huiying Zou, Tao Feng, Lei Chen, Jia Li, Xiaolan Qi, Zhifang Li, Xiaoyue Duan, Chunlong Xu, Liang Zhang, Xi Long, Jing Lan, Chao Chen, Chao Wang, Xinyu Xu, Jilong Ren, Yiqiang Zhao, Xiaoxiang Hu, Zhengxing Lian, Hongsheng Men, Dengke Pan, Ning Li, Mario R. Capecchi, Xuguang Du, Yaofeng Zhao, and Sen Wu

### ECOLOGY

- 11982 Climate change causes upslope shifts and mountaintop extirpations in a tropical bird community**  
Benjamin G. Freeman, Micah N. Scholer, Viviana Ruiz-Gutierrez, and John W. Fitzpatrick  
→ See Commentary on page 11871

- 11988 Habitat choice meets thermal specialization: Competition with specialists may drive suboptimal habitat preferences in generalists**  
Staffan Jacob, Estelle Laurent, Bart Haegeman, Romain Bertrand, Jérôme G. Prunier, Delphine Legrand, Julien Cote, Alexis S. Chaine, Michel Loreau, Jean Clobert, and Nicolas Schtickzelle

- 11994 Decomposition responses to climate depend on microbial community composition**  
Sydney I. Glassman, Claudia Weihe, Junhui Li, Michaeline B. N. Albright, Caitlin I. Looby, Adam C. Martiny, Kathleen K. Treseder, Steven D. Allison, and Jennifer B. H. Martiny

### EVOLUTION

- E11081 Behavior-dependent *cis* regulation reveals genes and pathways associated with bower building in cichlid fishes**  
Ryan A. York, Chinar Patil, Kawther Abdilleh, Zachary V. Johnson, Matthew A. Conte, Martin J. Genner, Patrick T. McGrath, Hunter B. Fraser, Russell D. Fernald, and J. Todd Strelman

- 12000 Evolution of bidirectional costly mutualism from byproduct consumption**  
William R. Harcombe, Jeremy M. Chacón, Elizabeth M. Adamowicz, Lon M. Chubiz, and Christopher J. Marx  
→ See Commentary on page 11874

- 12005 Unique pelvic fin in a tetrapod-like fossil fish, and the evolution of limb patterning**  
Jonathan E. Jeffery, Glenn W. Storrs, Timothy Holland, Clifford J. Tabin, and Per E. Ahlberg

- 12011 Inclusive fitness consequences of dispersal decisions in a cooperatively breeding bird, the long-tailed tit (*Aegithalos caudatus*)**  
Jonathan P. Green and Ben J. Hatchwell

- 12017 The geographic mosaic of coevolution in mutualistic networks**  
Lucas P. Medeiros, Guilherme Garcia, John N. Thompson, and Paulo R. Guimarães Jr.

#### GENETICS

- E11091 Human-like hyperplastic prostate with low ZIP1 induced solely by Zn deficiency in rats**  
Louise Y. Fong, Ruiyan Jing, Karl J. Smalley, Zi-Xuan Wang, Cristian Taccioli, Sili Fan, Hongping Chen, Hansjuerg Alder, Kay Huebner, John L. Farber, Oliver Fiehn, and Carlo M. Croce

- E11101 Criticality in tumor evolution and clinical outcome**  
Erez Persi, Yuri I. Wolf, Mark D. M. Leiserson, Eugene V. Koonin, and Eytan Ruppin

#### IMMUNOLOGY AND INFLAMMATION

- E11111 Protective immunity in recurrent *Staphylococcus aureus* infection reflects localized immune signatures and macrophage-conferred memory**  
Liana C. Chan, Maura Rossetti, Lloyd S. Miller, Scott G. Filler, Colin W. Johnson, Hong K. Lee, Huiyuan Wang, David Gjertson, Vance G. Fowler Jr., Elaine F. Reed, Michael R. Yeaman, and the MRSA Systems Immunobiology Group  
→ See Commentary on page 11865

- 12023 Site-selective chemoenzymatic glycoengineering of Fab and Fc glycans of a therapeutic antibody**  
John P. Giddens, Joseph V. Lomino, David J. DiLillo, Jeffrey V. Ravetch, and Lai-Xi Wang

#### MEDICAL SCIENCES

- E11015 A flexible organic reflectance oximeter array**  
Yasser Khan, Donggeon Han, Adrien Pierre, Jonathan Ting, Xingchun Wang, Claire M. Lochner, Gianluca Bovo, Nir Yaacobi-Gross, Chris Newsome, Richard Wilson, and Ana C. Arias

- E11120 Expression of ABCA4 in the retinal pigment epithelium and its implications for Stargardt macular degeneration**  
Tamara L. Lenis, Jane Hu, Sze Yin Ng, Zhichun Jiang, Shanta Sarfare, Marcia B. Lloyd, Nicholas J. Esposito, William Samuel, Cynthia Jaworski, Dean Bok, Silvia C. Finnemann, Monte J. Radeke, T. Michael Redmond, Gabriel H. Travis, and Roxana A. Radu

- E11128 Oncogenic role of SFRP2 in p53-mutant osteosarcoma development via autocrine and paracrine mechanism**  
Huensuk Kim, Seungyeul Yoo, Ruoji Zhou, An Xu, Jeffrey M. Bernitz, Ye Yuan, Andreia M. Gomes, Michael G. Daniel, Jie Su, Elizabeth G. Demicco, Jun Zhu, Kateri A. Moore, Dung-Fang Lee, Ihor R. Lemischka, and Christoph Schaniel

- E11138 Vorinostat, a pan-HDAC inhibitor, abrogates productive HPV-18 DNA amplification**  
N. Sanjib Banerjee, Dianne W. Moore, Thomas R. Broker, and Louise T. Chow

- 12028 Agonists of growth hormone-releasing hormone (GHRH) inhibit human experimental cancers in vivo by down-regulating receptors for GHRH**  
Andrew V. Schally, Haibo Wang, Jinlin He, Renzhi Cai, Wei Sha, Petra Popovics, Roberto Perez, Irving Vidaurre, and Xianyang Zhang  
→ See Commentary on page 11876

- 12034 NOXA genetic amplification or pharmacologic induction primes lymphoma cells to BCL2 inhibitor-induced cell death**  
Yuxuan Liu, Patrizia Mondello, Tatiana Erazo, Neeta Bala Tannan, Zahra Asgari, Elisa de Stanchina, Gouri Nanjangud, Venkatraman E. Seshan, Shenqiu Wang, Hans-Guido Wendel, and Anas Younes

#### MICROBIOLOGY

- 12040 Evolution of drug resistance in an antifungal-naive chronic *Candida lusitanae* infection**  
Elora G. Demers, Amy R. Biermann, Sawyer Masonjones, Alex W. Crocker, Alix Ashare, Jason E. Stajich, and Deborah A. Hogan

#### NEUROSCIENCE

- E11148 Inhibition of HDAC3 reverses Alzheimer's disease-related pathologies in vitro and in the 3xTg-AD mouse model**  
Karolina J. Janczura, Claude-Henry Volmar, Gregory C. Sartor, Sunil J. Rao, Natalie R. Ricciardi, Guerline Lambert, Shaun P. Brothers, and Claes Wahlestedt

- E11158 Face cells in orbitofrontal cortex represent social categories**  
Elodie Barat, Sylvia Wirth, and Jean-René Duhamel

- E11168 Autocrine signaling by an *Aplysia* neurotrophin forms a presynaptic positive feedback loop**  
Iksung Jin, Hiroshi Udo, Russell Nicholls, Huixiang Zhu, Eric R. Kandel, and Robert D. Hawkins

- 11947 Awareness of what is learned as a characteristic of hippocampus-dependent memory**  
Christine N. Smith and Larry R. Squire

#### PHARMACOLOGY

- 12046 Structure-guided development of selective M3 muscarinic acetylcholine receptor antagonists**  
Hongtao Liu, Josefa Hofmann, Inbar Fish, Benjamin Schaaque, Katrin Eitel, Amelie Bartuschat, Jonas Kaindl, Hannelore Ramm, Ashutosh Banerjee, Harald Hübner, Mary J. Clark, Sandra G. Vincent, John T. Fisher, Markus R. Heinrich, Kunio Hirata, Xiangyu Liu, Roger K. Sunahara, Brian K. Shoichet, Brian K. Kobilka, and Peter Gmeiner

#### PHYSIOLOGY

- 12051 Engineering selectivity into RGK GTPase inhibition of voltage-dependent calcium channels**  
Akil A. Puckerin, Donald D. Chang, Zunaira Shuja, Papiya Choudhury, Joachim Scholz, and Henry M. Colecraft

#### PLANT BIOLOGY

- E11178 *Arabidopsis thaliana* NGATHA1 transcription factor induces ABA biosynthesis by activating NCED3 gene during dehydration stress**  
Hikaru Sato, Hironori Takasaki, Fuminori Takahashi, Takamasa Suzuki, Satoshi Iuchi, Nobutaka Mitsuda, Masaru Ohme-Takagi, Miho Ikeda, Mitsunori Seo, Kazuko Yamaguchi-Shinozaki, and Kazuo Shinozaki

- E11188 Flavonols control pollen tube growth and integrity by regulating ROS homeostasis during high-temperature stress**  
Joëlle K. Muhlemann, Trenton L. B. Younts, and Gloria K. Muday

- 12057 C<sub>4</sub> photosynthesis and climate through the lens of optimality**  
Haoran Zhou, Brent R. Helliker, Matthew Huber, Ashley Dicks, and Erol Akçay

PSYCHOLOGICAL AND COGNITIVE SCIENCES

- 12063** Functional connectivity in central executive network protects youth against cardiometabolic risks linked with neighborhood violence

Gregory E. Miller, Edith Chen, Casey C. Armstrong, Ann L. Carroll, Sekine Ozturk, Kelsey J. Rydland, Gene H. Brody, Todd B. Parrish, and Robin Nusslock

SUSTAINABILITY SCIENCE

- 12069** A multiscale approach to balance trade-offs among dam infrastructure, river restoration, and cost

Samuel G. Roy, Emi Uchida, Simone P. de Souza, Ben Blachly, Emma Fox, Kevin Gardner, Arthur J. Gold, Jessica Jansujwicz, Sharon Klein, Bridie McGreavy, Weiwei Mo, Sean M. C. Smith, Emily Vogler, Karen Wilson, Joseph Zydlewski, and David Hart

---

**CORRECTION (ONLINE ONLY)**

PSYCHOLOGICAL AND COGNITIVE SCIENCES

- E11198** Default mode network can support the level of detail in experience during active task states

Mladen Sormaz, Charlotte Murphy, Hao-ting Wang, Mark Hymers, Theodoros Karapanagiotidis, Giulia Poerio, Daniel S. Margulies, Elizabeth Jefferies, and Jonathan Smallwood

---

**SI CORRECTION (ONLINE ONLY)**

NEUROSCIENCE

- E11199** Yin-and-yang bifurcation of opioidergic circuits for descending analgesia at the midbrain of the mouse

Jong-Hyun Kim, Gireesh Gangadharan, Junweon Byun, Eui-Ju Choi, C. Justin Lee, and Hee-Sup Shin