

Cover Image: The apparent crystalline structure of carbon nanotubes depends on their chiral symmetry. This symmetry defines all physical properties of the carbon nanotube and controls its growth rate. A larger chiral angle allows the loose ends of the growing nanotube to accept arriving atoms quickly, making for a faster growing tube. See the article by Feng Ding et al. on pages 2506–2509. Images courtesy of Morteza Bankehsaz (Rice University, Houston) and Boris I. Yakobson.

From the Cover

- 2506 Chirality controls nanotube growth
- 2483 Roadblocks to sustainability
- 2515 A cerium and aluminum alloy
- 2537 Anti-malaria drug design
- 2864 Circadian rhythm of DNA repair

Contents

THIS WEEK IN PNAS

- 2473 In This Issue

LETTERS (ONLINE ONLY)

- E18 **Covalent JNK inhibitors?**
David W. Borhani
- E19 **Reply to Borhani: Cys-dependent inhibition of JNK**
Maurizio Pellecchia
- E20 **Ubiquitin-binding motif of human DNA polymerase η is required for correct localization**
Simone Sabbioneda, Catherine M. Green, Marzena Bienko, Patricia Kannouche, Ivan Dikic, and Alan R. Lehmann
- E21 **Reply to Sabbioneda et al.: Role of ubiquitin-binding motif of human DNA polymerase η in translesion synthesis**
Narottam Acharya, Jung-Hoon Yoon, Himabindu Gali, Ildiko Unk, Lajos Haracska, Robert E. Johnson, Jerard Hurwitz, Louise Prakash, and Satya Prakash

EDITORIAL

- 2475 **Darwin at 200**
Francisco J. Ayala and John C. Avise

 Free online through the PNAS open access option.

COMMENTARIES

- 2477 **Spin microscopy's heritage, achievements, and prospects**
John A. Sidles
→ See companion article on page 1313 in issue 5 of volume 106
- 2479 **Temporal tagging of attended objects**
Ernst Niebur
→ See companion article on page 1666 in issue 5 of volume 106
- 2481 **It's all in a day's work: Regulation of DNA excision repair by the circadian clock**
John B. Hogenesch
→ See companion article on page 2864

PERSPECTIVE

- 2483 **Overcoming systemic roadblocks to sustainability: The evolutionary redesign of worldviews, institutions, and technologies**
Rachael Beddoe, Robert Costanza, Joshua Farley, Eric Garza, Jennifer Kent, Ida Kubiszewski, Luz Martinez, Tracy McCowen, Kathleen Murphy, Norman Myers, Zach Ogden, Kevin Stapleton, and John Woodward

PHYSICAL SCIENCES

APPLIED MATHEMATICS

- 2583 **Elongation dynamics shape bursty transcription and translation**
Maciej Dobrzyński and Frank J. Bruggeman

APPLIED PHYSICAL SCIENCES

- 2490 **Reduction of scale invariance of activity fluctuations with aging and Alzheimer's disease: Involvement of the circadian pacemaker**
Kun Hu, Eus J. W. Van Someren, Steven A. Shea, and Frank A. J. L. Scheer
- 2495 **Aligned carbon nanotubes as polarization-sensitive, molecular near-field detectors**
Ertugrul Cubukcu, Fatih Degirmenci, Coskun Kocabas, Mariano A. Zimmler, John A. Rogers, and Federico Capasso

CHEMISTRY

- 2500 **Sialylated multivalent antigens engage CD22 *in trans* and inhibit B cell activation**
Adam H. Courtney, Erik B. Puffer, Jason K. Pontrello, Zhi-Qiang Yang, and Laura L. Kiessling
- 2506 **Dislocation theory of chirality-controlled nanotube growth**
Feng Ding, Avetik R. Harutyunyan, and Boris I. Yakobson
- 2510 **Interference in acetylene intersystem crossing acts as the molecular analog of Young's double-slit experiment**
Mattijs de Groot, Robert W. Field, and Wybren J. Buma

COMPUTER SCIENCES

- 2677 **Alignment-free genome comparison with feature frequency profiles (FFP) and optimal resolutions**
Gregory E. Sims, Se-Ran Jun, Guohong A. Wu, and Sung-Hou Kim

ENGINEERING

- 2515 **Substitutional alloy of Ce and Al**
Qiao-Shi Zeng, Yang Ding, Wendy L. Mao, Wei Luo, Andreas Blomqvist, Rajeev Ahuja, Wenge Yang, Jinfu Shu, Stas V. Sinogeikin, Yue Meng, Dale L. Brewé, Jian-Zhong Jiang, and Ho-kwang Mao

ENVIRONMENTAL SCIENCES

- 2519 **Wildfire responses to abrupt climate change in North America**
J. R. Marlon, P. J. Bartlein, M. K. Walsh, S. P. Harrison, K. J. Brown, M. E. Edwards, P. E. Higuera, M. J. Power, R. S. Anderson, C. Briles, A. Brunelle, C. Carcaillet, M. Daniels, F. S. Hu, M. Lavoie, C. Long, T. Minckley, P. J. H. Richard, A. C. Scott, D. S. Shafer, W. Tinner, C. E. Umbanhowar, Jr., and C. Whitlock

BIOLOGICAL SCIENCES

BIOCHEMISTRY

- 2525 **MEN ϵ / β noncoding RNAs are essential for structural integrity of nuclear paraspeckles**
Yasnory T. F. Sasaki, Takashi Ideue, Miho Sano, Toutai Mituyama, and Tetsuro Hirose

- 2531 **Signals in bacterial β -barrel proteins are functional in eukaryotic cells for targeting to and assembly in mitochondria**
Dirk M. Walther, Drazen Papic, Martine P. Bos, Jan Tommassen, and Doron Rapaport
- 2537 **Structural basis for the inhibition of the essential *Plasmodium falciparum* M1 neutral aminopeptidase**
Sheena McGowan, Corrine J. Porter, Jonathan Lowther, Colin M. Stack, Sarah J. Golding, Tina S. Skinner-Adams, Katharine R. Trenholme, Franka Teuscher, Sheila M. Donnelly, Jolanta Grembecka, Artur Mucha, Pawel Kafarski, Ross DeGori, Ashley M. Buckle, Donald L. Gardiner, James C. Whisstock, and John P. Dalton
- 2543 **Large-scale detection of ubiquitination substrates using cell extracts and protein microarrays**
Yifat Merbl and Marc W. Kirschner
- 2549 **Thirteen posttranslational modifications convert a 14-residue peptide into the antibiotic thiocillin**
Laura C. Wieland Brown, Michael G. Acker, Jon Clardy, Christopher T. Walsh, and Michael A. Fischbach
- 2554 **Crystal structure of human prion protein bound to a therapeutic antibody**
S. V. Antonyuk, C. R. Trevitt, R. W. Strange, G. S. Jackson, D. Sangar, M. Batchelor, S. Cooper, C. Fraser, S. Jones, T. Georgiou, A. Khalili-Shirazi, A. R. Clarke, S. S. Hasnain, and J. Collinge
- 2559 **Principal determinants leading to transition state formation of a protein-protein complex, orientation trumps side-chain interactions**
James R. Horn, Tobin R. Sosnick, and Anthony A. Kossiakoff
- 2565 **The cardiac glycoside binding site on the Na,K-ATPase α 2 isoform plays a role in the dynamic regulation of active transport in skeletal muscle**
T. L. Radzyukevich, J. B. Lingrel, and J. A. Heiny
- 2571 **Following movement of the L1 stalk between three functional states in single ribosomes**
Peter V. Cornish, Dmitri N. Ermolenko, David W. Staple, Lee Hoang, Robyn P. Hickerson, Harry F. Noller, and Taekjip Ha
- 2577 ***Drosophila* hnRNP A1 homologs Hrp36/Hrp38 enhance U2-type versus U12-type splicing to regulate alternative splicing of the *prospero* twintron**
Sumit Borah, Anthony C. Wong, and Joan A. Steitz

BIOPHYSICS

- 2583 **Elongation dynamics shape bursty transcription and translation**
Maciej Dobrzyński and Frank J. Bruggeman
- 2589 **Molecular simulations elucidate the substrate translocation pathway in a glutamate transporter**
Yan Gu, Indira H. Shrivastava, Susan G. Amara, and Ivet Bahar
- 2595 **Urea, but not guanidinium, destabilizes proteins by forming hydrogen bonds to the peptide group**
Woon Ki Lim, Jörg Rösger, and S. Walter Englander

2601 **Rational stabilization of enzymes by computational redesign of surface charge–charge interactions**
Alexey V. Gribenko, Mayank M. Patel, Jiajing Liu, Scott A. McCallum, Chunyu Wang, and George I. Makhatadze

2607 **Identifying essential genes in *Escherichia coli* from a metabolic optimization principle**
Carlotta Martelli, Andrea De Martino, Enzo Marinari, Matteo Marsili, and Isaac Pérez Castillo

2612 **Visualizing breathing motion of internal cavities in concert with ligand migration in myoglobin**
Ayana Tomita, Tokushi Sato, Kouhei Ichiyangi, Shunsuke Nozawa, Hirohiko Ichikawa, Matthieu Chollet, Fumihiko Kawai, Sam-Yong Park, Takayuki Tsuduki, Takahisa Yamato, Shin-ya Koshihara, and Shin-ichi Adachi

2617 **ARNT PAS-B has a fragile native state structure with an alternative β -sheet register nearby in sequence space**
Matthew R. Evans, Paul B. Card, and Kevin H. Gardner

CELL BIOLOGY

2623 **Selective translocation of intracellular Smoothed to the primary cilium in response to Hedgehog pathway modulation**
Yu Wang, Zhe Zhou, Christopher T. Walsh, and Andrew P. McMahon

2629 **Phosphorylation of p53 by I κ B kinase 2 promotes its degradation by β -TrCP**
Yifeng Xia, Roanna C. Padre, Tatiana Hurtado De Mendoza, Virginie Bottero, Vinay B. Tergaonkar, and Inder M. Verma

2635 **Estrogen promotes the survival and pulmonary metastasis of tuberin-null cells**
Jane J. Yu, Victoria A. Robb, Tasha A. Morrison, Eric A. Ariazi, Magdalena Karbowniczek, Aristotelis Astrinidis, Chunrong Wang, Lisa Hernandez-Cuebas, Laura F. Seeholzer, Emmanuelle Nicolas, Harvey Hensley, V. Craig Jordan, Cheryl L. Walker, and Elizabeth P. Henske

2641 **Ndy1/KDM2B immortalizes mouse embryonic fibroblasts by repressing the *Ink4a/Arf* locus**
Alexandros Tzatsos, Raymond Pfau, Sotirios C. Kampranis, and Philip N. Tsichlis

2647 **Stimulated nuclear translocation of NF- κ B and shuttling differentially depend on dynein and the dynactin complex**
Cynthia K. Shrum, Daniel DeFrancisco, and Mollie K. Meffert

2653 **Disruption of the M80-Fe ligation stimulates the translocation of cytochrome *c* to the cytoplasm and nucleus in nonapoptotic cells**
Luiz C. Godoy, Cristina Muñoz-Pinedo, Laura Castro, Simone Cardaci, Christopher M. Schonhoff, Michael King, Verónica Tórtora, Mónica Marín, Qian Miao, Jian Fei Jiang, Alexandr Kapralov, Ronald Jemmerson, Gary G. Silkstone, Jinal N. Patel, James E. Evans, Michael T. Wilson, Douglas R. Green, Valerian E. Kagan, Rafael Radi, and Joan B. Mannick

DEVELOPMENTAL BIOLOGY

2659 **Distinct functions for the catalytic and hemopexin domains of a *Drosophila* matrix metalloproteinase**
Bernadette M. Glasheen, Aashish T. Kabra, and Andrea Page-McCaw

ECOLOGY

2665 **Contrasting size evolution in marine and freshwater diatoms**
E. Litchman, C. A. Klausmeier, and K. Yoshiyama

2671 **Culling experiments demonstrate size-class specific biomass increases with mortality**
A. Schröder, L. Persson, and A. M. de Roos

EVOLUTION

2677 **Alignment-free genome comparison with feature frequency profiles (FFP) and optimal resolutions**
Gregory E. Sims, Se-Ran Jun, Guohong A. Wu, and Sung-Hou Kim

2683 **Tri-split tRNA is a transfer RNA made from 3 transcripts that provides insight into the evolution of fragmented tRNAs in archaea**
Kosuke Fujishima, Junichi Sugahara, Kaoru Kikuta, Reiko Hirano, Asako Sato, Masaru Tomita, and Akio Kanai

GENETICS

2688 **Formation of new chromosomes as a virulence mechanism in yeast *Candida glabrata***
Silvia Poláková, Christian Blume, Julián Álvarez Zárate, Marek Mentel, Dorte Jørck-Ramberg, Jørgen Stenderup, and Jure Piškur

2694 **Genome-wide association study identifies *NRG1* as a susceptibility locus for Hirschsprung's disease**
Maria-Mercè Garcia-Barcelo, Clara Sze-man Tang, Elly Sau-wai Ngan, Vincent Chi-hang Lui, Yan Chen, Man-ting So, Thomas Yuk-yu Leon, Xiao-ping Miao, Cathy Ka-ye Shum, Feng-qin Liu, Ming-yiu Yeung, Zhen-wei Yuan, Wei-hong Guo, Lei Liu, Xiao-bing Sun, Liu-ming Huang, Jin-fa Tou, You-qiang Song, Danny Chan, Kenneth M. C. Cheung, Kenneth Kak-yuen Wong, Stacey S. Cherny, Pak-chung Sham, and Paul Kwong-hang Tam

2700 **Association of *FOXO3A* variation with human longevity confirmed in German centenarians**
Friederike Flachsbart, Amke Caliebe, Rabea Kleindorp, Hélène Blanché, Huberta von Eller-Eberstein, Susanna Nikolaus, Stefan Schreiber, and Almut Nebel





2706 **Mice with mutations of *Dock7* have generalized hypopigmentation and white-spotting but show normal neurological function**
Amanda L. Blasius, Katharina Brandl, Karine Crozat, Yu Xia, Kevin Khovananth, Philippe Krebs, Nora G. Smart, Antonella Zampolli, Zaverio M. Ruggeri, and Bruce A. Beutler

2712 **Oncogenic EGFR signaling cooperates with loss of tumor suppressor gene functions in gliomagenesis**
Haihao Zhu, Jaime Acquaviva, Pranatartiharan Ramachandran, Abraham Boskovitz, Steve Woolfenden, Rolf Pfannl, Roderick T. Bronson, John W. Chen, Ralph Weissleder, David E. Housman, and Al Charest

IMMUNOLOGY

- 2500 **Sialylated multivalent antigens engage CD22 *in trans* and inhibit B cell activation**
Adam H. Courtney, Erik B. Puffer, Jason K. Pontrello, Zhi-Qiang Yang, and Laura L. Kiessling
- 2717 **Integrity of the AID serine-38 phosphorylation site is critical for class switch recombination and somatic hypermutation in mice**
Hwei-Ling Cheng, Bao Q. Vuong, Uttiya Basu, Andrew Franklin, Bjoern Schwer, Jillian Astarita, Ryan T. Phan, Abhishek Datta, John Manis, Frederick W. Alt, and Jayanta Chaudhuri
- 2723 **Perforin-mediated suppression of B-cell lymphoma**
Paul Bolitho, Shayna E. A. Street, Jennifer A. Westwood, Winfried Edelmann, Duncan MacGregor, Paul Waring, William K. Murray, Dale I. Godfrey, Joseph A. Trapani, Ricky W. Johnstone, and Mark J. Smyth
- 2729 **Anti-CTLA-4 therapy results in higher CD4⁺ICOS^{hi} T cell frequency and IFN- γ levels in both nonmalignant and malignant prostate tissues**
Hong Chen, Chrysoula I. Liakou, Ashish Kamat, Curtis Pettaway, John F. Ward, Derek Ng Tang, Jingjing Sun, Achim A. Jungbluth, Patricia Troncoso, Christopher Logothetis, and Padmanee Sharma
- 2735 **MicroRNA-155 modulates the interleukin-1 signaling pathway in activated human monocyte-derived dendritic cells**
Maurizio Ceppi, Patricia M. Pereira, Isabelle Dunand-Sauthier, Emmanuèle Barras, Walter Reith, Manuel A. Santos, and Philippe Pierre
- 2741 **B7-H1 (PD-L1) on T cells is required for T-cell-mediated conditioning of dendritic cell maturation**
 Oezcan Talay, Ching-Hung Shen, Lieping Chen, and Jianzhu Chen
- 2747 **Carboxy-terminal domain of AID required for its mRNA complex formation *in vivo***
Taichiro Nonaka, Tomomitsu Doi, Takae Toyoshima, Masamichi Muramatsu, Tasuku Honjo, and Kazuo Kinoshita
- 2752 **Further evidence for involvement of a noncanonical function of uracil DNA glycosylase in class switch recombination**
Nasim A. Begum, Andre Stanlie, Tomomitsu Doi, Yoko Sasaki, Hai Wei Jin, Yong Sung Kim, Hitoshi Nagaoka, and Tasuku Honjo
- 2758 **The C-terminal region of activation-induced cytidine deaminase is responsible for a recombination function other than DNA cleavage in class switch recombination**
Tomomitsu Doi, Lucia Kato, Satomi Ito, Reiko Shinkura, Min Wei, Hitoshi Nagaoka, Jishu Wang, and Tasuku Honjo
- 2764 **Prevention of autoimmune disease by induction of tolerance to Toll-like receptor 7**
 Tomoko Hayashi, Christine S. Gray, Michael Chan, Rommel I. Tawatao, Lisa Ronacher, Maureen A. McGargill, Sandip K. Datta, Dennis A. Carson, and Maripat Corr
- 2770 **Absence of autophagy results in reactive oxygen species-dependent amplification of RLR signaling**
Michal Caspi Tal, Miwa Sasai, Heung Kyu Lee, Brian Yordy, Gerald S. Shadel, and Akiko Iwasaki
- 2776 **Phosphorylated self-peptides alter human leukocyte antigen class I-restricted antigen presentation and generate tumor-specific epitopes**
Jan Petersen, Stephanie J. Wurzbacher, Nicholas A. Williamson, Sri H. Ramarathinam, Hugh H. Reid, Ashish K. N. Nair, Anne Y. Zhao, Roza Nastovska, Geordie Rudge, Jamie Rossjohn, and Anthony W. Purcell
- 2782 **The G protein-coupled receptor FSHR-1 is required for the *Caenorhabditis elegans* innate immune response**
Jennifer R. Powell, Dennis H. Kim, and Frederick M. Ausubel
- 2788 **Conditional deletion of the MHC class I-related receptor FcRn reveals the sites of IgG homeostasis in mice**
Héctor Pérez Montoyo, Carlos Vaccaro, Martin Hafner, Raimund J. Ober, Werner Mueller, and E. Sally Ward

MEDICAL SCIENCES

- 2794 **Genome-wide association analysis reveals a *SOD1* mutation in canine degenerative myelopathy that resembles amyotrophic lateral sclerosis**
 Tomoyuki Awano, Gary S. Johnson, Claire M. Wade, Martin L. Katz, Gayle C. Johnson, Jeremy F. Taylor, Michele Perloski, Tara Biagi, Izabella Baranowska, Sam Long, Philip A. March, Natasha J. Olby, G. Diane Shelton, Shah Nawaz Khan, Dennis P. O'Brien, Kerstin Lindblad-Toh, and Joan R. Coates
- 2800 **Anti-laminin gamma-1 pemphigoid**
Teruki Dainichi, Sadamu Kurono, Bungo Ohyama, Norito Ishii, Noriko Sanzen, Maria Hayashi, Chisei Shimono, Yukimasa Taniguchi, Hiroshi Koga, Tadashi Karashima, Shinichiro Yasumoto, Detlef Zillikens, Kiyotoshi Sekiguchi, and Takashi Hashimoto
- 2806 **β -Arrestin links endothelin A receptor to β -catenin signaling to induce ovarian cancer cell invasion and metastasis**
Laura Rosanò, Roberta Cianfrocca, Stefano Masi, Francesca Spinella, Valeriana Di Castro, Annamaria Biroccio, Erica Salvati, Maria Rita Nicotra, Pier Giorgio Natali, and Anna Bagnato
- 2812 **The *miR-17~92* cluster collaborates with the Sonic Hedgehog pathway in medulloblastoma**
 Tamar Uziel, Fedor V. Karginov, Suqing Xie, Joel S. Parker, Yong-Dong Wang, Amar Gajjar, Lin He, David Ellison, Richard J. Gilbertson, Gregory Hannon, and Martine F. Roussel
- 2818 **Harnessing Hsp90 function as a powerful, broadly effective therapeutic strategy for fungal infectious disease**
Leah E. Cowen, Sheena D. Singh, Julia R. Köhler, Cathy Collins, Aimee K. Zaas, Wiley A. Schell, Hamza Aziz, Eleftherios Mylonakis, John R. Perfect, Luke Whitesell, and Susan Lindquist
- 2824 **Prognostic gene signatures for non-small-cell lung cancer**
 Paul C. Boutros, Suzanne K. Lau, Melania Pintilie, Ni Liu, Frances A. Shepherd, Sandy D. Der, Ming-Sound Tsao, Linda Z. Penn, and Igor Jurisica
- 2829 **Potassium softens vascular endothelium and increases nitric oxide release**
 H. Oberleithner, C. Callies, K. Kusche-Vihrog, H. Schillers, V. Shahin, C. Riethmüller, G. A. MacGregor, and H. E. de Wardener

2951 **DSCAM functions as a netrin receptor in commissural axon pathfinding**

Guofa Liu, Weiquan Li, Lei Wang, Amar Kar, Kun-Liang Guan, Yi Rao, and Jane Y. Wu

PHYSIOLOGY

2957 **An oxygen-sensitive mechanism in regulation of epithelial sodium channel**

Su Wang, Stephen Publicover, and Yuchun Gu

PSYCHOLOGY

2963 **Early childhood stress is associated with elevated antibody levels to herpes simplex virus type 1**



Elizabeth A. Shirtcliff, Christopher L. Coe, and Seth D. Pollak

CORRECTION

PHYSICS

2968 **Fractalization drives crystalline states in a frustrated spin system**

Suchitra E. Sebastian, N. Harrison, P. Sengupta, C. D. Batista, S. Francoual, E. Palm, T. Murphy, N. Marcano, H. A. Dabkowska, and B. D. Gaulin

ix–xi Author Index

xii Subscription Form

xiii Classified Advertisement