



SPECIAL SECTION

Pain research

INTRODUCTION

564 The future of pain research

NEWS

566 Pot and pain *By G. Miller*

569 Primed for pain *By K. Servick*

REVIEWS

572 Pain regulation by non-neuronal cells and inflammation
R.-R. Ji et al.

578 Neural circuits for pain: Recent advances and current views
C. Peirs and R. P. Seal

584 Deconstructing the sensation of pain: The influence of cognitive processes on pain perception
K. Wiech

588 Exploring pain pathophysiology in patients *C. Sommer*

SEE ALSO

► EDITORIAL P. 529 ► PODCAST ► VIDEO

ON THE COVER



A woman holds her hand in ice water, one of several techniques used to measure pain tolerance. Typically, healthy people can submerge their

hands for up to 5 minutes. However, for some of those taking opioids, 10 to 15 seconds is the limit, suggesting opioid-induced hypersensitivity to pain. For more on recent developments in pain research, see the special section beginning on page 564. *Photo: Matthew Rakola*

NEWS

IN BRIEF

530 News at a glance

IN DEPTH

533 SEA ICE SHRINKS IN STEP WITH CARBON EMISSIONS

Models may underestimate the pace of ice loss because they are missing Arctic warming *By W. Cornwall*

► REPORT BY D. NOTZ ET AL.
10.1126/science.aag2345

534 AMBITIOUS WEB FUNDRAISING STARTUP FAILS TO MEET BIG GOALS

Hundreds of scientists paid fees to have their work featured on Benefunder, but very few received donations
By M. Harris

535 CONTROVERSIAL HIV VACCINE STRATEGY GETS A SECOND CHANCE

Modest success in Thailand inspires South Africa trial *By J. Cohen*

536 'FOUR-LEGGED SNAKE' MAY BE ANCIENT LIZARD INSTEAD

Controversy swirls around fossil, which is no longer accessible *By C. Gramling*

537 DATA CHECK: CALIFORNIA RULES U.S. CORPORATE RESEARCH

Survey shows California has widened its lead in state-by-state analysis of what companies spend on research
By J. Mervis

FEATURES

538 MICE MADE EASY

The genome-editing tool CRISPR upends the vital business of creating mutant mice *By J. Cohen*

541 A reporter does CRISPR

By J. Cohen
► VIDEO



INSIGHTS

PERSPECTIVES

544 BUILDING BRIDGES TO REGENERATE AXONS

A secreted factor stimulates glia to mend spinal cord injury

By P. R. Williams and Z. He

► REPORT P. 630

546 A TESTING TIME FOR ANTIMATTER

Precision measurement of antiprotonic helium provides a test of physical laws

By W. Ubachs

► REPORT P. 610

547 MIGRATORY BIRDS UNDER THREAT

Habitat degradation and loss, illegal killings, and climate change threaten European migratory bird populations

By F. Bairlein

549 HOW TOBACCO SMOKE CHANGES THE (EPI)GENOME

Distinct mutation types are found in diverse cancers associated with smoking

By G. P. Pfeifer

► REPORT P. 618

550 DEEP-SEA CORALS FEEL THE FLOW

Uranium isotope data from deep-water corals help to resolve conflicting results from shallow-water corals

By Y. Yokoyama and T. M. Esat

► REPORT P. 626

552 TIPS FOR BATTLING BILLION-DOLLAR BEETLES

Tiny insecticidal proteins (Tips) kill pests that evolved resistance to engineered corn *By B. E. Tabashnik*

► REPORT P. 634

553 A RADICAL APPROACH TO POSTTRANSLATIONAL MUTAGENESIS

Introducing diverse protein side chains via carbon-carbon bond-forming reactions *By R. Hofmann and J. W. Bode*

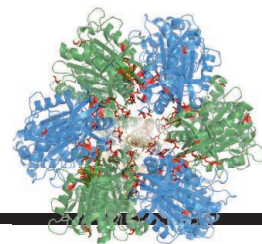
► RESEARCH ARTICLE P. 597; REPORT P. 623

POLICY FORUM

555 WATER STRATEGIES FOR THE NEXT ADMINISTRATION

Water policy offers opportunity for nonpartisan agreement *By P. H. Gleick*

CONTENTS



599
Protein mutations
that rescue defects

4 NOVEMBER 2016 • VOLUME 354 • ISSUE 6312

SCIENCE PRIZE ESSAY

557 ONE BRAIN, MANY GENOMES
Single-cell genomic techniques shed light on somatic mutations in brain development and neurologic disorders
By G. D. Evrony

BOOKS ET AL.

559 AGAINST ALL ODDS
A geologist revels in the unlikely reality of life on Earth
By J. S. Schneiderman

560 PRICELESS

A cautionary tome probes the cost of black box algorithms
By B. Nalebuff

LETTERS

561 OIL EXTRACTION IMPERILS AFRICA'S GREAT LAKES
By E. Verheyen et al.

562 TIME FOR RESPONSIBLE PEATLAND AGRICULTURE
By L. S. Wijedasa et al.

562 PROTECTING CHINA'S SOIL BY LAW
By J. Wang et al.

RESEARCH

IN BRIEF

593 From *Science* and other journals

RESEARCH ARTICLES

596 SCIENCE COMMUNITY
Quantifying the evolution of individual scientific impact
R. Sinatra et al.
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT:
dx.doi.org/10.1126/science.aaf5239

597 CHEMICAL BIOLOGY
Posttranslational mutagenesis: A chemical strategy for exploring protein side-chain diversity
T. H. Wright et al.
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT:
dx.doi.org/10.1126/science.aag1465
► PERSPECTIVE P. 553; REPORT P. 623

598 SYSTEMS BIOLOGY
A transcription factor hierarchy defines an environmental stress response network
L. Song et al.
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT:
dx.doi.org/10.1126/science.aag1550

599 YEAST GENETICS
Exploring genetic suppression interactions on a global scale
J. van Leeuwen et al.
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT:
dx.doi.org/10.1126/science.aag0839

REPORTS

600 OPTICS
Microresonator soliton dual-comb spectroscopy
M.-G. Suh et al.

603 OPTICAL PROCESSING
A coherent Ising machine for 2000-node optimization problems
T. Inagaki et al.
► REPORT P. 614

606 QUANTUM GASES
Universal space-time scaling symmetry in the dynamics of bosons across a quantum phase transition
L. W. Clark et al.

610 PHYSICS
Buffer-gas cooling of antiprotonic helium to 1.5 to 1.7 K, and antiproton-to-electron mass ratio
M. Hori et al.
► PERSPECTIVE P. 546

614 OPTICAL PROCESSING
A fully programmable 100-spin coherent Ising machine with all-to-all connections
P. L. McMahon et al.
► REPORT P. 603

618 CANCER ETIOLOGY
Mutational signatures associated with tobacco smoking in human cancer
L. B. Alexandrov et al.
► PERSPECTIVE P. 549

623 CHEMICAL BIOLOGY
A chemical biology route to site-specific authentic protein modifications
A. Yang et al.
► PERSPECTIVE P. 553; RESEARCH ARTICLE P. 597

626 OCEAN CHEMISTRY
Ocean mixing and ice-sheet control of seawater ²³⁴U/²³⁸U during the last deglaciation
T. Chen et al.
► PERSPECTIVE P. 550

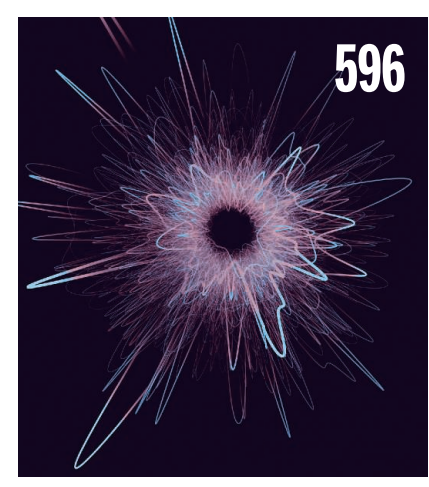
630 NEUROREGENERATION
Injury-induced *ctgfa* directs glial bridging and spinal cord regeneration in zebrafish
M. H. Mokalled et al.
► PERSPECTIVE P. 544

634 PLANT SCIENCE
A selective insecticidal protein from *Pseudomonas* for controlling corn rootworms
U. Schellenberger et al.
► PERSPECTIVE P. 552

DEPARTMENTS

529 EDITORIAL
Forecasting the opioid epidemic
By Donald S. Burke
► PAIN RESEARCH SECTION P. 564

674 WORKING LIFE
The beauty of outreach
By Pierfrancesco Riccardi



Science Staff526
New Products..... 641
Science Careers 642

PHOTO: SINATRA ET AL.
SCIENCE (ISSN 0036-8075) is published weekly on Friday, except the last week in December, by the American Association for the Advancement of Science, 1200 New York Avenue, NW, Washington, DC 20005. Periodicals mail postage (publication No. 484460) paid at Washington, DC, and additional mailing offices. Copyright © 2016 by the American Association for the Advancement of Science. The title SCIENCE is a registered trademark of the AAAS. Domestic individual membership and subscription (51 issues): \$165 (\$74 allocated to subscription). Domestic institutional subscription (51 issues): \$1522; foreign postage extra: Mexico, Caribbean (surface mail) \$55; other countries (air assist delivery) \$89. First class, airmail, student, and emeritus rates on request. Canadian rates with GST available upon request. GST #R125488122. Publications Mail Agreement Number 1069624. Printed in the U.S.A.
Change of address: Allow 4 weeks, giving old and new addresses and 8-digit account number. Postmaster: Send change of address to AAAS, P.O. Box 96178, Washington, DC 20090-6178. Single-copy sales: \$15.00 current issue, \$20.00 back issue prepaid includes surface postage; bulk rates on request. Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by AAAS to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that \$35.00 per article is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. The identification code for Science is 0036-8075. Science is indexed in the Reader's Guide to Periodical Literature and in several specialized indexes.

Downloaded from <http://science.sciencemag.org/> on June 24, 2018

Science

354 (6312)

Science **354** (6312), 529-641.

ARTICLE TOOLS

<http://science.sciencemag.org/content/354/6312>

PERMISSIONS

<http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. 2017 © The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works. The title *Science* is a registered trademark of AAAS.