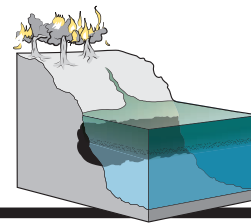


CONTENTS



1529

A deadly oxygen-phosphorus cycle

23 DECEMBER 2016 • VOLUME 354 • ISSUE 6319

SPECIAL SECTION

Breakthrough of the Year

WINNER

1516 The cosmos aquiver

1517 People's choice

RUNNERS-UP

1518 The exoplanet next door

1518 Artificial intelligence ups its game

1519 Killing old cells to stay young

1520 Mind-reading great apes

1520 Proteins by design

1521 Mouse eggs made in the lab

1522 A single wave of migration from Africa peopled the globe

1522 Genome sequencing in the hand and bush

1523 Metalenses, megapromise

OTHER FEATURES

1523 Scorecard for 2016

1524 Areas to watch in 2017

1525 Breakdowns of the year

SEE ALSO

► PODCAST; VIDEO; QUIZ; EDITORIAL P. 1507

ON THE COVER



Star trails arc above a 4-kilometer-long arm of the Laser Interferometer Gravitational-Wave Observatory (LIGO) detector in Hanford, Washington (for more on the photograph,

see <http://scim.ag/2gGRzG7>). Early this year, LIGO scientists announced that their two detectors—the second is in Livingston, Louisiana—had recorded a minuscule quiver in spacetime, generated by black holes colliding in the distant universe. The feat, *Science's* 2016 Breakthrough of the Year, confirmed a century-old prediction by Albert Einstein and opened a new window on the universe. See page 1516.

Photo: © Rich Frishman

NEWS

IN BRIEF

1508 News at a glance

IN DEPTH

1510 XPRIZE FINALISTS MULL PAYLOADS TO THE MOON

Science experiments take a back seat to commercial aims for five teams planning launches *By D. Clery*

1511 IN INDIA, ELITE INSTITUTES IN SHADY JOURNALS

Predatory publishers draw papers from faculty at top research centers *By P. Pulla*

1512 NEW BLOOD TESTS MAKE STRIDES IN DETECTING PRION DISEASE

Long after the European mad cow outbreak, researchers hope to screen blood supplies for misfolded proteins *By K. Servick*

► 10.1126/scitranslmed.aaf6188;

10.1126/scitranslmed.aag1257

1513 SCIENTISTS FLAG NEW CAUSES FOR SURGE IN METHANE LEVELS

Swelling tropical wetlands and a decline in a natural atmospheric detergent are leading suspects *By P. Voosen*

1514 CRITICS ASSAIL PAPER CLAIMING HARM FROM CANCER VACCINE

Vaccination rates fall as antivax campaigns gather steam *By D. Normile*

1515 LIKE BIRDS, INSECTS MAY TRAVEL IN SYNC WITH THE SEASONS

Long-term radar studies reveal masses of winged migrants *By E. Pennisi*

► REPORT P. 1584

INSIGHTS

POLICY FORUM

1526 EXPAND INNOVATION FINANCE VIA CROWDFUNDING

Crowdfunding attracts venture capital to new regions *By O. Sorenson et al.*

1515 & 1584



PERSPECTIVES

1529 OCEANS ON THE EDGE OF ANOXIA

Environmental crises can tip the ocean into O₂ depletion *By A. J. Watson*

1530 A STITCH IN TIME SAVES NINE...BILLION

Acting now to limit global temperature change will help to ensure global food security *By E. A. Fulton*

► REPORT P. 1591

1532 OPTICAL CIRCULATORS REACH THE QUANTUM LEVEL

The spin state of a single atom can route light signals in different directions *By W. J. Munro and K. Nemoto*

► REPORT P. 1577

1533 THE "TAO" OF INTEGUMENTS

Hair follicle and sweat gland fates can be switched by morphogens at specific skin regions or developmental stages

By Y. C. Lai and C.-M. Chuong

► REPORT P. 1551

1534 "PHENO" MENAL VALUE FOR HUMAN HEALTH

Rare genetic variants are linked to electronic health record phenotypes at a population scale *By D. J. Rader and S. M. Damrauer*

► RESEARCH ARTICLES PP. 1549 & 1550

1536 MORE THAN A DAY IN THE LIFE OF A COMET

Learning how a comet evolves can reveal the nature of the early solar system *By N. Dello Russo*

► REPORTS PP. 1563 & 1566

CONTENTS



1533 & 1551

The yin and yang
of hair and sweat

23 DECEMBER 2016 • VOLUME 354 • ISSUE 6319

BOOKS ET AL.

1538 TOMORROW'S ARSENAL

Two authors probe the technologies transforming warfare *By N. Al-Rodhan*

1539 DIVINING SCIENCE

A new tome argues that the ancient Babylonians deserve greater recognition in scientific histories *By A. Robinson*

LETTERS

1541 FOREST VALUE: MORE THAN COMMERCIAL

By C. Paul and T. Knoke

1541 RESPONSE

By C. B. Barrett et al.

1542 IRAN'S SCIENCE LANDSCAPE IN CONTEXT

By R. Mansouri

1543 TECHNICAL COMMENT ABSTRACTS

1543 ERRATA

RESEARCH

IN BRIEF

1546 From *Science* and other journals

RESEARCH ARTICLES

HUMAN GENETICS

1549 Distribution and clinical impact of functional variants in 50,726 whole-exome sequences from the DiscovEHR Study *F. E. Dewey et al.*
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT: dx.doi.org/10.1126/science.aaf6814

1550 Genetic identification of familial hypercholesterolemia within a single U.S. health care system *N. S. Abul-Husn et al.*
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT: dx.doi.org/10.1126/science.aaf7000
► PERSPECTIVE P. 1534

1551 CELL FATE DECISIONS

Spatiotemporal antagonism in mesenchymal-epithelial signaling in sweat versus hair fate decision *C. P. Lu et al.*
RESEARCH ARTICLE SUMMARY; FOR FULL TEXT: dx.doi.org/10.1126/science.aah6102
► PERSPECTIVE P. 1533

1552 STRUCTURAL BIOLOGY

A three-dimensional movie of structural changes in bacteriorhodopsin *E. Nango et al.*

1557 TOPOLOGICAL MATTER

Majorana bound state in a coupled quantum-dot hybrid-nanowire system *M. T. Deng et al.*

REPORTS

COMETARY SCIENCE

1563 Seasonal exposure of carbon dioxide ice on the nucleus of comet 67P/Churyumov-Gerasimenko *G. Filacchione et al.*

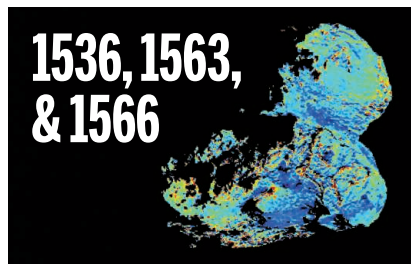
1566 Rosetta's comet 67P/Churyumov-Gerasimenko sheds its dusty mantle to reveal its icy nature *S. Fornasier et al.*
► PERSPECTIVE P. 1536

1570 CATALYSIS

Selective oxidative dehydrogenation of propane to propene using boron nitride catalysts *J. T. Grant et al.*

1573 QUANTUM ELECTRONICS

Suppressing relaxation in superconducting qubits by quasiparticle pumping *S. Gustavsson et al.*



1577 QUANTUM OPTICS

Quantum optical circulator controlled by a single chirally coupled atom *M. Scheucher et al.*
► PERSPECTIVE P. 1532

1580 NANOMATERIALS

Emergence of hierarchical structural complexities in nanoparticles and their assembly *C. Zeng et al.*

1584 MIGRATION

Mass seasonal bioflows of high-flying insect migrants *G. Hu et al.*
► NEWS STORY P. 1515; VIDEO

1587 BRAIN RESEARCH

Active cortical dendrites modulate perception *N. Takahashi et al.*

1591 FISHERIES

Large benefits to marine fisheries of meeting the 1.5°C global warming target *W. W. L. Cheung et al.*
► PERSPECTIVE P. 1530

1594 PLANT SCIENCE

Precursor processing for plant peptide hormone maturation by subtilisin-like serine proteinases *K. Schardon et al.*

1597 STRUCTURAL BIOLOGY

Crystal structure of unlinked NS2B-NS3 protease from Zika virus *Z. Zhang et al.*

DEPARTMENTS

1507 EDITORIAL

Awesome universal chirp *By Jeremy Berg*
► BREAKTHROUGH OF THE YEAR SECTION P. 1516

1666 WORKING LIFE

Rescuing my time from science *By Luca Rinaldi*

Science Staff	1504
AAAS News & Notes	1544
New Products	1601
Science Careers	1602

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.

Science

354 (6319)

Science **354** (6319), 1507-1666.

ARTICLE TOOLS

<http://science.sciencemag.org/content/354/6319>

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.