



## COVER

A metaphorical USB cable transmitting genetic information to “reprogram” cells symbolizes the Breakthrough of the Year for 2008. Advances in the burgeoning field of cellular reprogramming have brought scientists closer to the goal of using stem cells to better understand and someday treat disease. See the special section beginning on page 1766.

*Image: Chris Bickel*

## DEPARTMENTS

- 1751 *Science Online*
- 1753 *This Week in Science*
- 1758 *Editors' Choice*
- 1760 *Contact Science*
- 1763 *Random Samples*
- 1765 *Newsmakers*
- 1806 *AAAS News & Notes*
- 1869 *New Products*
- 1870 *Science Careers*

## EDITORIAL

- 1757 *Celebrating a Year of Science*  
by Bruce Alberts  
>> *Breakthrough of the Year section p. 1766*

## SPECIAL SECTION

# Breakthrough of the Year

### WINNER

Reprogramming Cells 1766

### RUNNERS-UP

- Seeing Exoplanets 1768
- Cancer Genes 1769
- New High-Temperature Superconductors 1770
- Watching Proteins at Work 1770
- Water to Burn 1770
- The Video Embryo 1771
- Fat of a Different Color 1771
- Proton's Mass 'Predicted' 1772
- Sequencing Bonanza 1773

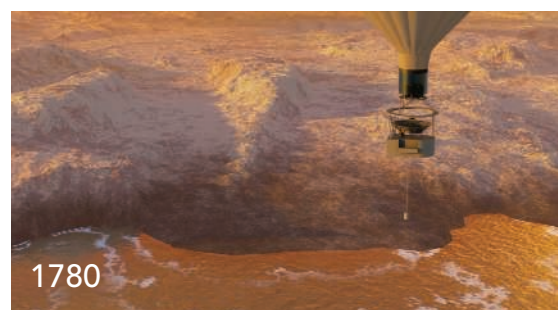
### OTHER FEATURES

- Phenomenon of the Year: European Big Science 1769
- Scorecard: Rating Last Year's Areas to Watch 1770
- Breakdown of the Year: Financial Meltdown 1772
- Areas to Watch 1773

>> *Editorial p. 1757; for related online content, see p. 1751 or go to [www.sciencemag.org/btoy2008/](http://www.sciencemag.org/btoy2008/)*



1769



1780

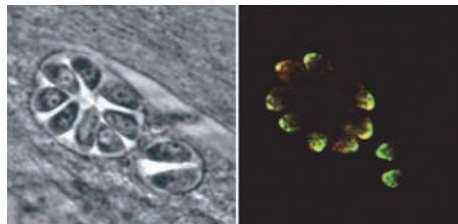
## NEWS OF THE WEEK

- Nobelists Get Energy Portfolio, Raising Hopes and Expectations 1774  
Obama's Choice to Direct EPA Is Applauded
- Signs of Drug Resistance Rattle Experts, Trigger Bold Plan 1776
- DOE Picks Michigan State Lab for Rare-Isotope Accelerator 1777
- SCIENCESCOPE** 1777
- Rangers Assess Toll of Congo Conflict on Threatened Mountain Gorillas 1778
- Report Faults U.S. Strategy for Nanotoxicology Research 1779
- From the *Science Policy Blog* 1779

## NEWS FOCUS

- Europa vs. Titan 1780
- Zack Booth Simpson: An Artist Develops a New Image—With Aid of Bacteria 1782
- Materials Research Society Fall Meeting 1784  
Shortfalls in Electron Production Dim Hopes for MEG Solar Cells  
Protein Chip Promises Cheaper Diagnostics  
Graphene Recipe Yields Carbon Cornucopia
- Does 'Junk Food' Threaten Marine Predators in Northern Seas? 1786

CONTENTS continued >>



## SCIENCE EXPRESS

www.sciencexpress.org

## PALEOCLIMATE

Foraminiferal Isotope Evidence of Reduced Nitrogen Fixation in the Ice Age Atlantic Ocean

H. Ren et al.

Nitrogen fixation in the tropical Atlantic increased during deglaciation and, along with increased denitrification, helped to stabilize the ocean nitrogen reservoir.

10.1126/science.1165787

## PLANT SCIENCE

Glucosinolate Metabolites Required for an *Arabidopsis* Innate Immune Response

N. K. Clay, A. M. Adio, C. Denoux, G. Jander, F. M. Ausubel

10.1126/science.1164627

A Glucosinolate Metabolism Pathway in Living Plant Cells Mediates Broad-Spectrum Antifungal Defense

P. Bednarek et al.

Plant cells defend against fungal attack through an innate immunity pathway in which infection triggers glucosinolate synthesis, stimulating formation of a protective callose.

10.1126/science.1163732

## MICROBIOLOGY

Rapid Membrane Disruption by a Perforin-Like Protein Facilitates Parasite Exit from Host Cells

B. F. C. Kafsack et al.

The human and animal parasite that causes toxoplasmosis escapes from host cells by using a perforin-like protein to make holes in the intracellular vacuole in which it resides.

10.1126/science.1165740

## CELL BIOLOGY

Electron Cryomicroscopy of *E. coli* Reveals Filament Bundles Involved in Plasmid DNA Segregation

J. Salje, B. Zuber, J. Löwe

The actin-like filaments that power movement of DNA during bacterial cell division form small bundles of three to five filaments near the nucleoid.

10.1126/science.1164346

## LETTERS

Making Waves with the Clean Water Act L. S. Fore et al. 1788

The State of Global Hunger J. Sastre

Bird Brains Key to the Functions of Sleep

S. M. H. Gobes and J. J. Bolhuis

Old Seeds Coming in from the Cold F. Gugerli

Response S. Sallon et al.

CORRECTIONS AND CLARIFICATIONS 1790

## TECHNICAL COMMENT ABSTRACTS

## ECOLOGY

Comment on "Declining Wild Salmon Populations in Relation to Parasites from Farm Salmon" 1790

B. E. Riddell, R. J. Beamish, L. J. Richards, J. R. Candy

full text at [www.sciencemag.org/cgi/content/full/322/5909/1790b](http://www.sciencemag.org/cgi/content/full/322/5909/1790b)

Response to Comment on "Declining Wild Salmon Populations in Relation to Parasites from Farm Salmon"

M. Krkošek et al.

full text at [www.sciencemag.org/cgi/content/full/322/5909/1790c](http://www.sciencemag.org/cgi/content/full/322/5909/1790c)

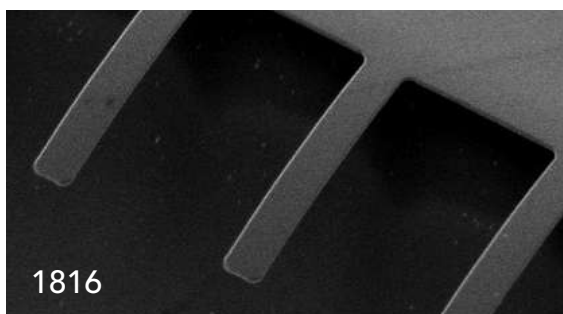
## BOOKS ET AL.

Spiral Jetta A Road Trip Through the Land Art of the American West E. Hogan, reviewed by M. Parrish 1791

The Tragedy of Thomas Hobbes 1792

A. Shaplin, Royal Shakespeare Theatre, London

BROWSINGS 1793



## EDUCATION FORUM

Science Faculty with Education Specialties 1795

S. D. Bush et al.

## POLICY FORUM

Politics and Funding in the U.S. Public Biomedical R&D System 1797

D. Hegde and D. C. Mowery

## PERSPECTIVES

Who's Your Daddy? 1799

R. O. Prum >> Report p. 1826

The Ethical Frontiers of Robotics 1800

N. Sharkey

Now You See Them 1802

F. C. Meldrum and R. P. Sear >> Report p. 1819

From Genetic Association to Genetic Switch 1803

A. M. Michelson >> Report p. 1839

Gene Expression—Where to Start? 1804

S. Buratowski >> Reports pp. 1845, 1849, 1851, and 1855

## REVIEW

## DEVELOPMENTAL BIOLOGY

Nuclear Reprogramming in Cells 1811

J. B. Gurdon and D. A. Melton

## REPORTS

## MATERIALS SCIENCE

Matching Glass-Forming Ability with the Density of the Amorphous Phase 1816

Y. Li, Q. Guo, J. A. Kalb, C. V. Thompson

The change in density during crystallization predicts which copper-zirconium alloys can most easily form a metallic glass.

## MATERIALS SCIENCE

Stable Prenucleation Calcium Carbonate Clusters 1819

D. Gebauer, A. Völkel, H. Cölfen

Even unsaturated solutions contain stable neutral clusters of calcium carbonate, which may aid in crystallization and biomineralization.

>> Perspective p. 1802

CONTENTS continued >>

## REPORTS CONTINUED...

## MATERIALS SCIENCE

- Shock-Wave Exploration of the High-Pressure Phases of Carbon** 1822

*M. D. Knudson, M. P. Desjarlais, D. H. Dolan*

A magnetically driven plate shocks diamond to extreme pressures and temperatures, allowing resolution of its melting regime and a possible higher-pressure phase.

## PALEONTOLOGY

- Avian Paternal Care Had Dinosaur Origin** 1826

*D. J. Varricchio et al.*

The large egg clutches of troodontid and oviraptor dinosaurs and evidence that fossils of brooding dinosaurs were males shows that paternal care was ancestral to birds. >> *Perspective p. 1799*

## PLANETARY SCIENCE

- Orbital Identification of Carbonate-Bearing Rocks on Mars** 1828

*B. L. Ehlmann et al.*

Despite widespread acidic weathering on Mars, detection of carbonate-bearing rocks indicates that nonacidic waters existed in the past.

## PLANT SCIENCE

- The Circadian Clock in *Arabidopsis* Roots Is a Simplified Slave Version of the Clock in Shoots** 1832

*A. B. James et al.*

A simpler plant circadian clock, which normally has three interlocking feedback loops, is used in the roots, with one feedback loop regulating only a few genes.

## PLANT SCIENCE

- A Conserved Molecular Framework for Compound Leaf Development** 1835

*T. Blein et al.*

A family of transcription factors controls the formation of leaflets and lobes in complex leaves in distantly related plants by controlling outgrowth from leaf margins.

## DEVELOPMENTAL BIOLOGY

- Human Fetal Hemoglobin Expression Is Regulated by the Developmental Stage-Specific Repressor *BCL11A*** 1839

*V. G. Sankaran et al.*

A way to reactivate a fetal form of  $\gamma$ -globin in adults—by releasing it from repression by an inhibitor—may prove useful for treating certain genetic anemias. >> *Perspective p. 1803*

## MOLECULAR BIOLOGY

- CRISPR Interference Limits Horizontal Gene Transfer in Staphylococci by Targeting DNA** 1843

*L. A. Marraffini and E. J. Sontheimer*

The small CRISPR RNAs in Staphylococci bacteria that protect against phage infection are complementary to foreign phage DNA and target it for destruction.

## CELL BIOLOGY

- Nascent RNA Sequencing Reveals Widespread Pausing and Divergent Initiation at Human Promoters** 1845

*L. J. Core, J. J. Waterfall, J. T. Lis*

RNA sequencing identifies antisense transcription immediately upstream of genes with transcriptionally engaged RNA polymerase.

>> *Perspective p. 1804*



ADVANCING SCIENCE. SERVING SOCIETY

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 © 2008 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): \$144 (\$74 allocated to subscription). Domestic institutional subscription (51 issues): \$770; Foreign postage extra: Mexico, Caribbean (surface mail) \$55; other countries (air assist delivery) \$85. First class, airmail, student, and emeritus rates on request. Canadian rates with GST available upon request, GST #1254 88122. Publications Mail Agreement Number 1069624. SCIENCE is printed on 30 percent post-consumer recycled paper. 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: \$10.00 current issue, \$15.00 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 \$20.00 per article is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. Science is indexed in the Reader's Guide to Periodical Literature and in several specialized indexes.



1835

## CELL BIOLOGY

- Divergent Transcription from Active Promoters** 1849

*A. C. Seila et al.*

Active genes produce promoter-localized sense and antisense short RNAs, suggesting frequent transcription by divergently oriented RNA polymerase II complexes at mammalian promoters. >> *Perspective p. 1804*

## CELL BIOLOGY

- RNA Exosome Depletion Reveals Transcription Upstream of Active Human Promoters** 1851

*P. Preker et al.*

Highly unstable transcripts exist upstream of active human promoters.

>> *Perspective p. 1804*

## CELL BIOLOGY

- The Antisense Transcriptomes of Human Cells** 1855

*Y. He et al.*

The abundance and nonrandom genomic origin of antisense transcripts in human cells suggest that these RNAs are an important feature of gene regulation. >> *Perspective p. 1804*

## MEDICINE

- Label-Free Biomedical Imaging with High Sensitivity by Stimulated Raman Scattering Microscopy** 1857

*C. W. Freudiger et al.*

Three-dimensional imaging based on stimulated Raman scattering can detect lipids in living cells and monitor the movement of drugs through the skin.

## MEDICINE

- Leukemic Cells Create Bone Marrow Niches That Disrupt the Behavior of Normal Hematopoietic Progenitor Cells** 1861

*A. Colmone et al.*

Cancerous immune cells create abnormal microenvironments in bone marrow that attract normal immune precursor cells, disrupting their function and exacerbating disease.

## NEUROSCIENCE

- Representation of Geometric Borders in the Entorhinal Cortex** 1865

*T. Solstad et al.*

A previously unknown cell type in the brain's cortex encodes geometric boundaries of the nearby environment, perhaps providing a frame of reference.



Printed on  
30% post-consumer  
recycled paper.

CONTENTS continued >>>

## SCIENCE NOW

[www.sciencenow.org](http://www.sciencenow.org)

HIGHLIGHTS FROM OUR DAILY NEWS COVERAGE

### Is That You, Seabiscuit?

A horse can peg another's identity by whinny alone.

### Ancient Battlefield Hints at Roman Persistence

2000-year-old site suggests Romans returned to area of massive defeat.

### Revenge of the Nerds

Intelligence marks a man as a good match.



Science in translation.

## SCIENCE CAREERS

[www.sciencemag.org/career\\_development](http://www.sciencemag.org/career_development)

FREE CAREER RESOURCES FOR SCIENTISTS

### Programs Aim to Train Translational Scientists

*B. Vastag*

New Ph.D. programs in translational medicine provide basic science training and clinical experience.

### A Young Scientist at the Forefront of Cell Reprogramming

*E. Pain*

Curiosity, boldness, and single-mindedness won Austrian scientist Konrad Hochedlinger a place in cell reprogramming, *Science's* Breakthrough of the Year for 2008.

>> *Breakthrough of the Year* section p. 1766 and

[www.sciencemag.org/btoy2008/](http://www.sciencemag.org/btoy2008/)

### Tooling Up: The ABCs of Transitioning to Leadership

*D. Jensen*

"Activator," "behavior," and "consequence" are key concepts in this simple management theory.

### From the Archives: Translational Research Careers

*K. Travis*

Translational researchers are pushing a fundamental change in the way science has operated for decades.

Visualizing gene expression dynamics.

## SCIENCE SIGNALING

[www.sciencesignaling.org](http://www.sciencesignaling.org)

THE SIGNAL TRANSDUCTION KNOWLEDGE ENVIRONMENT

### MEETING REPORT: Ontologies of Cellular Networks

*R. Arp and B. Smith*

A meeting of philosophers and biologists reveals the great diversity in ideas about how pathway information can be organized.

### PODCAST

*J. F. Foley and A. M. VanHook*

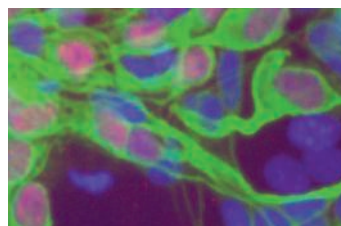
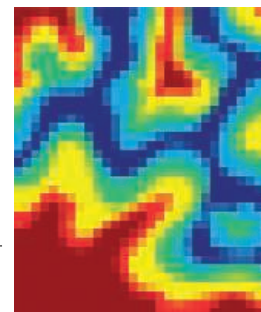
Binding of CD3ε subunits to plasma membrane lipids blocks T cell receptor signaling.

### NETWATCH: GEDI, the Gene Expression Dynamics Inspector

Convert microarray data into visual portraits to identify genes that share dynamic expression profiles; in Bioinformatics Resources.

### NETWATCH: NIH VideoCasting and Podcasting

Watch live and archived NIH-sponsored events; in Web Broadcasts.



## SCIENCE ONLINE FEATURE

### VIDEO: 2008 Breakthrough of the Year

An introduction to some of the work that led studies in reprogramming cells to be tagged the top scientific story for 2008.

>> *Breakthrough of the Year* section p. 1766 and

[www.sciencemag.org/btoy2008/](http://www.sciencemag.org/btoy2008/)

## SCIENCE PODCAST

[www.sciencemag.org/multimedia/podcast](http://www.sciencemag.org/multimedia/podcast)

FREE WEEKLY SHOW

Download the 19 December *Science* Podcast to hear about the breakthroughs and breakdown of the year as well as areas to watch in 2009.



Separate individual or institutional subscriptions to these products may be required for full-text access.

# Science

**322 (5909)**

*Science* **322** (5909), 1753-1869.

**ARTICLE TOOLS**

<http://science.sciencemag.org/content/322/5909>

**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.