

SPECIAL SECTION

Food Security

INTRODUCTION

797 Feeding the Future

NEWS

- 798 From One Farmer, Hope—and Reason for Worry
- 800 Getting More Drops To the Crops
- 801 China's Push to Add by Subtracting Fertilizer
- 802 Sowing the Seeds for the Ideal Crop
- 804 Armed and Dangerous
- 806 Holding Back a Torrent of Rats
- 807 Spoiling for a Fight With Mold
- 808 Dialing Up Knowledge—and Harvests
- 809 What It Takes to Make That Meal
- 810 Could Less Meat Mean More Food?
>> *Science Podcast*
- 811 For More Protein, Filet of Cricket

REVIEWS

812 Food Security: The Challenge of Feeding 9 Billion People
H. C. J. Godfray et al.

818 Breeding Technologies to Increase Crop Production in a Changing World
M. Tester and P. Langridge

PERSPECTIVES

- 822 Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems
M. Herrero et al.
- 825 Measuring Food Insecurity
C. B. Barrett
>> *Science Podcast*
- 828 Precision Agriculture and Food Security
R. Gebbers and V. I. Adamchuk
- 831 African Green Revolution Needn't Be a Mirage
G. Ejeta
- 833 Radically Rethinking Agriculture for the 21st Century
N. V. Fedoroff et al.
>> *Science Podcast*

>> *Editorial p. 761; Policy Forum p. 784; Science Express Report by J. H. Guo et al.; Science Podcast, Science Careers, audio slideshow, and other online features at www.sciencemag.org/special/foodsecurity/*

EDITORIAL

761 Reaping the Benefits of Crop Research
David Baulcombe
>> *Food Security section p. 797*

NEWS OF THE WEEK

766 New Delay of Large Hadron Collider Might Not Keep Its Rival on the Job

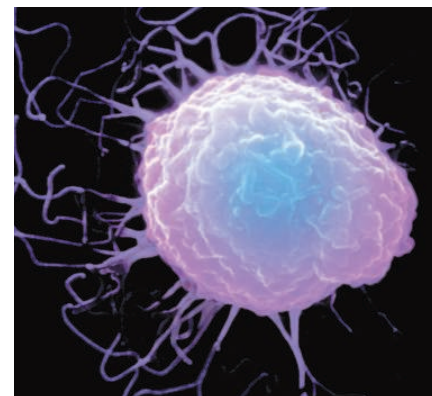
- 767 After Acrimonious Debate, India Rejects GM Eggplant
- 768 From *Science's* Online Daily News Site
- 768 IPCC Seeks 'Broader Community Engagement' to Correct Errors
- 768 Bement to Leave NSF Before Term Ends
- 769 From the *Science* Policy Blog
- 770 Proposed Revisions to Psychiatry's Canon Unveiled
- 770 DSM-V at a Glance



COVER

Bags of rice await export from India to Europe. As the global population climbs to a projected peak of some 9 billion in 2050, concerns about food security are growing. A special section beginning on page 797 examines the causes of food insecurity and some solutions, and the implications of climate change and energy use for feeding the world.

Photo: Simon Rawles/Alamy



page 772

NEWS FOCUS

- 772 Replacing an Immune System Gone Haywire
- 775 Down-to-Earth Science Fiction
- 776 Society for Integrative and Comparative Biology Meeting
Racing Crash-Happy Cockroaches
Rattan Stuck in a Growth Mode
Koalas Calling
- 778 Lights! Camera! Science?

LETTERS

- 780 Stop Listening to Scientists?
K. R. Gurney
Carbon Calculations to Consider
B. Sørensen
Response
T. D. Searchinger et al.

781 CORRECTIONS AND CLARIFICATIONS

BOOKS ET AL.

- 782 The Language of Life
F. S. Collins, reviewed by T. Harris
- 783 The Coral Thief
R. Stott, reviewed by R. Milner

CONTENTS continued >>

DEPARTMENTS

- 757 This Week in *Science*
- 762 Editors' Choice
- 764 *Science* Staff
- 765 Random Samples
- 887 New Products
- 888 *Science* Careers

POLICY FORUM

- 784 Sustainability and Global Seafood
M. D. Smith et al.
>> Food Security section p. 797

PERSPECTIVES

- 787 Propelling Progeny
D. J. Pickup
>> Report p. 873
- 788 Ultracold Chemistry
J. M. Hutson
>> Report p. 853
- 789 CO Prefers the Aisle Seat
M. S. Altman
>> Report p. 850
- 790 Ice Age Rhythms
R. L. Edwards
>> Report p. 860
- 791 Genetic Control of Hotspots
V. G. Cheung et al.
>> Brevia p. 835; Research Article p. 836;
Report p. 876
- 793 Feasting on Minerals
D. K. Newman
- 794 Radical Ligands Confer Nobility
on Base-Metal Catalysts
P. J. Chirik and K. Wieghardt

BREVIA

- 835 *Prdm9* Controls Activation of
Mammalian Recombination Hotspots
E. D. Parvanov et al.
Genome recombination during meiosis is
likely controlled by a chromatin-modifying
enzyme.
>> Perspective p. 791; Research Article p. 836;
Report p. 876

RESEARCH ARTICLE

- 836 PRDM9 Is a Major Determinant
of Meiotic Recombination Hotspots
in Humans and Mice
F. Baudat et al.
A chromatin-modifying enzyme is implicated
in the determination of recombination loci
within the genome.
>> Perspective p. 791; Brevia p. 835;
Report p. 876

REPORTS

- 840 Resonance Fluorescence
of a Single Artificial Atom
O. Astafiev et al.
A superconducting circuit can exhibit
quantum optical behavior, acting like
an artificial atom.

- 843 Spin-Dependent Quantum Interference
Within a Single Magnetic Nanostructure
H. Oka et al.

Magnetization modulation is observed on
a cobalt nanoisland using spin-polarized
scanning tunneling microscopy.

- 846 Multiple Functional Groups of Varying
Ratios in Metal-Organic Frameworks
H. Deng et al.

The adsorption characteristics for mixed
linkers can exceed that expected from just
combining the single-linker compounds.

- 850 Break-Up of Stepped Platinum Catalyst
Surfaces by High CO Coverage
F. Tao et al.

Stepped platinum surfaces break up into
nanometer-scale clusters at high carbon
monoxide surface coverages.

>> Perspective p. 789

- 853 Quantum-State Controlled
Chemical Reactions of Ultracold
Potassium-Rubidium Molecules
S. Ospelkaus et al.

Reactions mediated by quantum mechanical
tunneling are observed, even in a sample of
molecules cooled almost to a standstill.

>> Perspective p. 788

- 857 Low-Frequency Modes of Aqueous Alkali
Halide Solutions: Glimpsing the Hydrogen
Bonding Vibration

I. A. Heisler and S. R. Meech

An optical scattering technique is used to map
the weak bonding interaction between water
and dissolved halide ions.

- 860 Sea-Level Highstand 81,000 Years Ago
in Mallorca

J. A. Dorale et al.

Measurements from the island of Mallorca
indicate that past sea levels were much higher
than had been assumed.

>> Perspective p. 790

- 863 A Genetic Variant BDNF Polymorphism
Alters Extinction Learning in Both Mouse
and Human

F. Soliman et al.

A common genetic variation affecting fear
learning and extinction operates through
the same pathways in mice and men.

- 866 *Vibrio cholerae* VpsT Regulates Matrix
Production and Motility by Directly
Sensing Cyclic di-GMP

P. V. Krasteva et al.

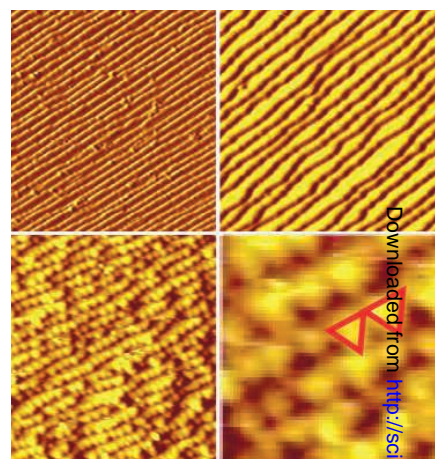
A bacterial signaling molecule induces
the dimerization and activation of a
biofilm-promoting transcription factor.

- 869 Darwinian Evolution of Prions in Cell Culture
J. Li et al.

When propagated in vitro, prion strains
demonstrate adaptability and selection.



pages 791, 835, 836, & 876



pages 789 & 850

- 873 Repulsion of Superinfecting Virions:
A Mechanism for Rapid Virus Spread
V. Doceul et al.

Early in infection, vaccinia virus exploits
the actin cytoskeleton to promote rapid
cell-to-cell spread.

>> Perspective p. 787

- 876 Drive Against Hotspot Motifs in Primates
Implicates the *PRDM9* Gene in Meiotic
Recombination

S. Myers et al.

Bioinformatics identifies a
chromatin-modifying enzyme as a factor
in determining recombination hotspots.

>> Perspective p. 791; Brevia p. 835;
Research Article p. 836

- 879 The *Lmo2* Oncogene Initiates Leukemia in
Mice by Inducing Thymocyte Self-Renewal

M. P. McCormack et al.

Expression of an oncogene confers
self-renewal activity to committed T cells
in the thymus long before disease onset.

- 883 A Composite of Multiple Signals
Distinguishes Causal Variants
in Regions of Positive Selection

S. R. Grossman et al.

Combining statistical methods detects signals
of selection with increased sensitivity and a
lower false-positive rate.

CONTENTS continued >>

SCIENCEONLINE

SCIENCEEXPRESS

www.sciencexpress.org

Dark Matter Search Results from the CDMS II Experiment

The CDMS II Collaboration

Details of possible, but unlikely, detection events produced by dark matter are reported.
10.1126/science.1186112

A Stratified Redox Model for the Ediacaran Ocean

C. Li et al.

Geological records in China indicate that ocean chemistry may explain the delay in life's biggest diversification period.
10.1126/science.1182369

Light-Controlled Self-Assembly of Semiconductor Nanoparticles into Twisted Ribbons

S. Srivastava et al.

The photooxidation of CdS nanoparticles within CdTe nanoparticle ribbons causes surface stresses that lead to twisting.
10.1126/science.1177218

Doc2b Is a High-Affinity Ca²⁺ Sensor for Spontaneous Neurotransmitter Release

A. J. Groffen et al.

Spontaneous synaptic vesicle fusion is triggered by soluble proteins that compete with synaptotagmins to induce membrane curvature.
10.1126/science.1183765

Significant Acidification in Major Chinese Croplands

J. H. Guo et al.

Intensifying agriculture in China in the past 30 years is the major contributor to soil acidification at the regional scale.
10.1126/science.1182570
>> *Food Security section p. 797*

Fixing the Legal Framework for Pharmaceutical Research

S. M. Knowles

10.1126/science.1184188

SCIENCE NOW

www.sciencenow.org

Highlights From Our Daily News Coverage

Australia, Antarctica Linked by Climate

Carbon dioxide emissions could be leading to record drought and snowfalls.

Can Thin Mountain Air Make You Slim?

High living—in the topographical sense—causes weight loss, a study suggests.

Better to React Than to Act

Legendary quantum physicist's speculations about Westerns inspire discovery about reaction speed.

SCIENCE SIGNALING

www.sciencesignaling.org

The Signal Transduction Knowledge Environment

RESEARCH ARTICLE: ARD1 Stabilization of TSC2 Suppresses Tumorigenesis Through the mTOR Signaling Pathway

H.-P. Kuo et al.

Acetylation by ARD1 of an inhibitor of mammalian target of rapamycin may inhibit cancer growth.

RESEARCH ARTICLE: SUMOylation Mediates the Nuclear Translocation and Signaling of the IGF-1 Receptor

B. Sehat et al.

Attachment of SUMO lets insulin-like growth factor receptors act as transcriptional regulators in the nucleus.

PERSPECTIVE: Glucocorticoid Receptor DNA Binding Decoy Is a Gas

M. J. Garabedian and S. K. Logan

By mimicking a DNA response element, a noncoding RNA inhibits glucocorticoid receptor activity.

SCIENCE CAREERS

www.sciencereers.org/career_magazine

Free Career Resources for Scientists

Plant Geneticist Cultivating a Future for Peanut Farming in Uganda

G. Vince

David Kalule Okello is one of Uganda's weapons in the battle against hunger.

Careers in Food Security Span Several Disciplines

C. Janes

Feeding the planet is an urgent issue that needs scientists in many different fields.

>> *Food Security section p. 797 and*
www.sciencemag.org/special/foodsecurity/

Science Careers Communities

Science Careers Staff

Join the conversation in MySciNet for scientists of diverse backgrounds or the Clinical and Translational Scientist Network at community.sciencereers.org.

SCIENCE TRANSLATIONAL MEDICINE

www.sciencetranslationalmedicine.org

Integrating Medicine and Science

PERSPECTIVE: Genetic Polymorphisms—A Cornerstone of Translational Biobehavioral Research

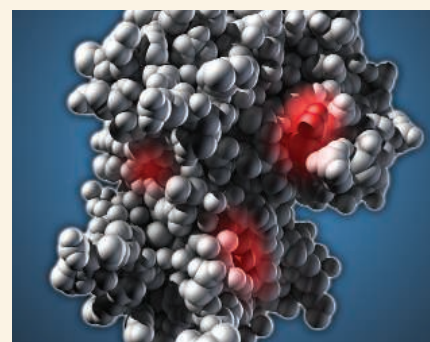
A. R. Hariri

Understanding common genetic variation can serve to explain individual behaviors.

COMMENTARY: Liberating Health Data for Clinical Research Applications

Je. J. Nadler and G. J. Downing

Electronic health record systems represent important new strategies to improve health care.



SCIENCE SIGNALING

Sites of sumoylation on the IGF-1R.

RESEARCH ARTICLE: The Origins of Sexually Transmitted HIV Among Men Who Have Sex with Men

D. M. Butler et al.

A cell-free virus in semen is the origin of sexually transmitted HIV among men who have sex with men.

RESEARCH ARTICLE: A Monoclonal Antibody Against $\alpha V\beta 3$ Integrin Inhibits Development of Atherosclerotic Lesions in Diabetic Pigs

L. A. Maile et al.

An antibody directed at the C terminal of an integrin subunit can prevent atherosclerosis in diabetic pigs.

SCIENCE PODCAST

www.sciencemag.org/multimedia/podcast

Free Weekly Show

Download the 12 February *Science* Podcast to hear about measuring food insecurity, rethinking agriculture for the 21st century, and reducing meat consumption.

>> *Food Security section p. 797 and*
www.sciencemag.org/special/foodsecurity/

SCIENCE INSIDER

blogs.sciencemag.org/scienceinsider

Science Policy News and Analysis

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 © 2010 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): \$910; Foreign postage extra: Mexico, Caribbean (surface mail) \$95; 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. **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. The identification code for *Science* is 0036-8075. *Science* is indexed in the *Reader's Guide to Periodical Literature* and in several specialized indexes.



ADVANCING SCIENCE. SERVING SOCIETY

Science

327 (5967)

Science **327** (5967), 757-887.

ARTICLE TOOLS

<http://science.sciencemag.org/content/327/5967>

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.