

# CONTENTS

26 February 2015 / Vol 518 / Issue No 7540

## THIS WEEK

### EDITORIALS

#### 455 STEM CELLS

**When right beats might**  
Italy looks to move on from stem-cell mess

#### 456 AUTHORSHIP

**No strings**  
Hidden financial ties undermine platform of climate-change sceptic

#### 456 NEUROSCIENCE

**A sore thing**  
Technologies to measure pain objectively must be regulated



### WORLD VIEW

#### 457 Focus on political Islamic groups to boost science

*Dyna Rochmyaningsih*  
A societal approach is needed for the Muslim world to benefit from science

### RESEARCH HIGHLIGHTS

#### 458 SELECTIONS FROM THE SCIENTIFIC LITERATURE

DNA gels give tissues shape / Bluebirds at odds / Volcanic sulfur on the rise / Outreach needs to demolish ivory towers / Coral growth on hold / Asian climate pushed plague into Europe / Nectar chemicals benefit bee colonies

### SEVEN DAYS

#### 460 THE NEWS IN BRIEF

Cash boost for neglected diseases / IPCC chief resigns / India's PhD students protest over pay-rise delays / Rapid test for Ebola / Report warns of future New York floods

## CAREERS

#### 565 ENVIRONMENTAL TECHNOLOGY

**Green light**  
Energy-sustainable buildings are popping up everywhere — and that means opportunities for scientists who want to build them

## NEWS IN FOCUS



**463 EPIDEMIOLOGY**  
Britain launches huge children's study

**464 URBAN SCIENCE**  
Fears that trains will derail research at London's Francis Crick Institute

#### 465 ARTIFICIAL INTELLIGENCE

Computer achieves human-level performance in video games

#### 466 NEUROSCIENCE

Scientists seek to define sport-induced brain disorder

#### 468 SPACE

An illustrated guide to two dwarf-planet missions

## FEATURES



### PLANETARY SCIENCE

## The Pluto siblings

Dwarf-planet veterans Leslie and Eliot Young prepare for mission rendezvous **PAGE 470**

#### 474 NEUROSCIENCE IN COURT

**The painful truth**  
Brain scans that identify pain signals aim for the courtroom

## INNOVATIONS IN

#### S1 The microbiome

A special report on the myriad microbes that call the human gut home. Turn to page 484.

## COMMENT



### EPIDEMIOLOGY

## Open up outbreaks

*Nathan L Yozwiak, Stephen F Schaffner & Pardis C Sabeti*

Guidelines are needed for speedy and responsible data sharing **PAGE 477**

## BOOKS & ARTS

#### 480 BIG DATA

**The revolution is digitized**  
*Charles Seife*

#### 481 BOOKS IN BRIEF

#### 482 ENVIRONMENTAL SCIENCE

**Dryland epiphany**  
*Andrew Robinson*

## CORRESPONDENCE

**483** Big data in medicine / Antibody validation / Redistribution of China's pollution / Biochar pros and cons

## OBITUARY

**484 Robert A. Berner (1935–2015)**  
*Don Canfield*



## FUTURES

**568 BFF's first adventure**  
*Vernor Vinge*



# CONTENTS

26 February 2015 / Vol 518 / Issue No 7540

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## RESEARCH

### NEW ONLINE

485 Papers published this week at [nature.com](http://nature.com)

### NEWS & VIEWS

#### 486 ARTIFICIAL INTELLIGENCE

##### Learning to see and act

An artificial-intelligence system masters 49 classic computer games  
*Bernhard Schölkopf* [SEE LETTER P.529](#)

#### 487 BIODIVERSITY

##### The benefits of traditional knowledge

An ethnobotanical study of two isolated ethnic groups in the Balkans  
*Manuel Pardo-de-Santayana*  
& *Manuel J Macía*

#### 488 STEM CELLS

##### Chasing blood

Tracing the stem cells involved in steady-state haematopoiesis  
*Sidhartha Goyal* & *Peter W Zandstra*  
[SEE LETTER P.542](#)

#### 490 COSMOLOGY

##### A giant in the young Universe

A supermassive black hole from about 900 million years after the Big Bang  
*Bram Venemans* [SEE LETTER P.512](#)

#### 491 QUANTUM PHYSICS

##### Teleportation for two

Simultaneous transfer of a photon's spin and orbital angular momenta  
*Wolfgang Tittel* [SEE LETTER P.516](#)

#### 492 MOLECULAR BIOLOGY

##### RNA modification does a regulatory two-step

A mechanism by which the m<sup>6</sup>A RNA modification regulates gene expression  
*Dominik Theler* & *Frédéric H-T Allain*  
[SEE LETTER P.560](#)

### ARTICLES

495 **CANCER GENOMICS** Whole genomes redefine the mutational landscape of pancreatic cancer  
*N Waddell et al.*

502 **MOLECULAR BIOLOGY** Lagging-strand replication shapes the mutational landscape of the genome  
*M A M Reijns et al.*

507 **IMMUNOLOGY** Crystal structure of the V(D)J recombinase RAG1–RAG2  
*M-S Kim, M Lapkouski, W Yang*  
& *M Gellert*



ON THE COVER

## Learning curve

Imagined attacks from retro-styled sprites are deflected by a deep Q-network agent controlled game-paddle seen from the agent's perspective. Google's DeepMind team has developed an artificial agent — or deep Q-network — that learns to play 49 classic Atari 'arcade' games directly from sensory experience, achieving scores equal to the best human players. [PAGES 486 & 529](#)

### LETTERS

512 **COSMOLOGY** An ultraluminous quasar with a twelve-billion solar-mass black hole at redshift 6.30  
*X-B Wu et al.* [SEE N&V P.490](#)

516 **QUANTUM PHYSICS** Quantum teleportation of multiple degrees of freedom of a single photon  
*X-L Wang et al.* [SEE N&V P.491](#)

520 **MATERIALS SCIENCE** Dynamically reconfigurable complex emulsions via tunable interfacial tensions  
*L D Zarzar et al.*

525 **PLANETARY SCIENCE** An extremely high-altitude plume seen at Mars' morning terminator  
*A Sánchez-Lavega et al.*

529 **ARTIFICIAL INTELLIGENCE** Human-level control through deep

#### reinforcement learning

*V Mnih et al.* [SEE N&V P.486](#)

534 **EVOLUTION** Evolution of the new vertebrate head by co-option of an ancient chordate skeletal tissue  
*D Jandzik et al.*

538 **CULTURAL EVOLUTION** Experimentally induced innovations lead to persistent culture via conformity in wild birds  
*L M Aplin et al.*

542 **STEM CELLS** Fundamental properties of unperturbed haematopoiesis from stem cells *in vivo*  
*K Busch et al.* [SEE N&V P.488](#)

547 **DEVELOPMENTAL BIOLOGY** Tissue-resident macrophages originate from yolk-sac-derived erythro-myeloid progenitors  
*E G Perdiguer et al.*

552 **CANCER** Role of *TP53* mutations in the origin and evolution of therapy-related acute myeloid leukaemia  
*T N Wong et al.*

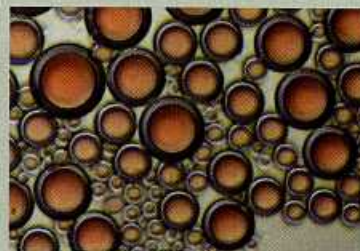
556 **GENE REGULATION** Enhancer–core-promoter specificity separates developmental and housekeeping gene regulation  
*M A Zabidi et al.*

560 **STRUCTURAL BIOLOGY** N<sup>6</sup>-methyladenosine-dependent RNA structural switches regulate RNA–protein interactions  
*N Liu et al.* [SEE N&V P.492](#)

### MATERIALS SCIENCE

## Smart solution

Multi-phase complex emulsions with droplet morphology tuned for practical applications. [PAGE 520](#)



MAX CANT / GOOGLE DEEPMIND