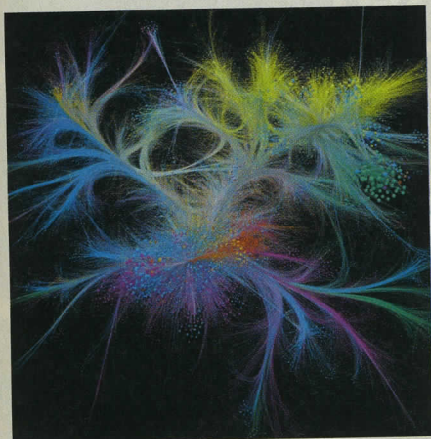


# Contents



## 150 YEARS OF NATURE

A special issue celebrating our sesquicentenary.

### Editorial

- 7 **Nature at 150: evidence in pursuit of truth**  
Transparency in science is more important than ever before

### Feature

- 22 **150 years of Nature: an analysis of the archive**  
Charting the journal's history

### Books & arts

- 25 **The evolution of scientific illustration**  
*Geoffrey Belknap*

### Comment

- 29 **Science must move with the times**  
To fulfil its social contract, research needs to advance in new ways  
*Philip Ball*
- 32 **Nature's reach: narrow work has broad impact**  
A new analysis reveals research papers' inspirations and influences  
*Alexander J. Gates, Qing Ke, Onur Varol & Albert-László Barabási*

### 10 extraordinary papers

- 35 **Highlights from 150 years of Nature**  
Key research articles from our archive, chosen by the editors

### Award

- 52 **The winners of our young-writer essay competition**  
*Yasmin Ali, Robert Schittko & Matthew Zajac*

### Insight

- 63 **Science and society**  
The research areas that could aid future health, sustainability and inclusivity

### Careers

- 239 **Careers and controversy before the First World War**  
Why women's contributions to research were downplayed
- 243 **The women who cracked the glass ceiling**  
How female scientists gained footholds from the 1920s

### World view

- 9 **Better methods can't make up for mediocre theory**  
Problems of reproducibility will fall away if we improve hypotheses  
*Paul Smaldino*

### Research highlights

- 10 High-speed battery charging / Whisky leaves its mark / Blight-resistant rice / Bat bonds / Mighty modified microscope

### News in brief

- 12 Climate funding boost / Comet contains alien water / UN summit forced to decamp / Measles erases immune 'memory'

### News in focus

- 15 Researchers race to assess health risks of wildfire smoke in California
- 16 Evacuations and power cuts disrupt science as wildfires blaze
- 17 Monkey embryos grown in a dish for longer than ever before
- 18 Largest genome study of enslaved people traces African origins
- 19 San and Khoi communities win right to share of rooibos tea profits

### Books & arts

- 27 **Books in brief**  
*Andrew Robinson*

### Correspondence

- 51 Darwin brokered others' *Nature* publications / Scientism and the abuse of science / Engage egg donors in gene-editing debate / Open-access fees cause concern

### Technology

- 247 **Containers in the cloud**  
How standardized platforms let researchers run each other's software – no installation needed

### Where I work

- 250 **Terri Adams**  
*Sarah Boon*

# Research

## 10 extraordinary papers

- 35 Genetics**  
**The structure of DNA**  
 The discovery of the DNA duplex  
*Georgina Ferry*
- 36 High-energy physics**  
**Detection of a strange particle**  
 From the observation of a neutral kaon to the standard model  
*Taku Yamana*
- 38 Neuroscience**  
**Neuronal signals thoroughly recorded**  
 An innovative technique to record the electrical activity of cells  
*Alexander D Reyes*
- 40 Materials science**  
**Birth of a class of nanomaterial**  
 How multimolecular templates launched the field of mesoporous materials  
*Ryong Ryoo*
- 41 Palaeontology**  
**Evolutionary insights from *Australopithecus***  
 A fossil reported in 1925 revolutionized ideas about the human family tree  
*Dean Falk*
- 43 Astronomy**  
**First exoplanet found around a Sun-like star**  
 Observations that opened up a new era of exoplanetary exploration  
*Eliza Kempton*
- 44 Cell biology**  
**Cell identity reprogrammed**  
 Looking back at the original cell-reprogramming experiments  
*Samantha A Morris*
- 46 Atmospheric science**  
**The discovery of the Antarctic ozone hole**  
 An unexpected finding that changed global environmental policy  
*Susan Solomon*



## ON THE COVER

**150 years of Nature.** This issue marks the 150th anniversary of *Nature* — the first issue was published on 4 November 1869. The cover image visualizes the co-citation network for the journal. More than 88,000 papers published by *Nature* since 1900 are each represented by a dot, coloured by discipline. Papers are linked if another scientific paper cites both; the dot size reflects the number of these co-citation links. The complex network reveals the relationships between papers and captures the multidisciplinary scope of the journal. The story of key papers is revealed in a video (<https://www.nature.com/articles/d41586-019-03325-6>), and a fully interactive version of this network can be explored at [go.nature.com/n150int](http://go.nature.com/n150int). Cover design: Alice Grishchenko, Mauro Martino (IBM Research), Claire Welsh. Data analysis: Alexander Gates, Qing Ke, Onur Varol, Albert-László Barabási (BarabasiLab 2019).

Pages 32 & 35

- 47 Immunology**  
**The advent and rise of monoclonal antibodies**  
 Method to make antibodies reported in 1975 transformed science and medicine  
*Klaus Rajewsky*

- 49 Materials science**  
**The nano-revolution spawned by carbon**  
 The discovery of a remarkable cage-like carbon molecule  
*Pulickel M Ajayan*

## News & views

- 57 Neurodegeneration**  
**Selective clearance of mutant huntingtin protein**  
 Compounds that enable selective autophagy of mutant Huntingtin protein  
*Huda Y Zoghbi*  
 See Article p.203
- 58 Engineering**  
**Soft microbots controlled by nanomagnets**  
 Microscopic robots that change shape in magnetic fields  
*Xuanhe Zhao & Yoonho Kim*  
 See Article p.164
- 60 Cancer genetics**  
**Genomes captured during tumour spread**  
 Comprehensive analysis of genetic changes across metastatic cancers  
*Jillian F Wise & Michael S Lawrence*  
 See Article p.210
- 61 Experimental physics**  
**Progress on the proton-radius puzzle**  
 Two independent and consistent measurements of the proton charge radius  
*Jean-Philippe Karr & Dominique Marchand*  
 See Article p.147

Continues ►

# Research

## Insight

- 63 Science and society**  
In this collection of Reviews and Perspectives, we take a snapshot of areas where science might help ease the transition to a healthy, sustainable and inclusive future.
- 64 Review**  
**Strategies for improving the sustainability of structural metals**  
*D Raabe et al.*
- 75 Review**  
**Recycling lithium-ion batteries from electric vehicles**  
*G Harper et al.*
- 87 Perspective**  
**The technological and economic prospects for CO<sub>2</sub> utilization and removal**  
*C Hepburn et al.*
- 98 Perspective**  
**Anatomy and resilience of the global production ecosystem**  
*M Nyström et al.*
- 109 Review**  
**Genetic strategies for improving crop yields**  
*J Bailey-Serres et al.*
- 119 Review**  
**Immunization: vital progress, unfinished agenda**  
*P Piot et al.*
- 130 Review**  
**A new twenty-first century science for effective epidemic response**  
*J Bedford et al.*
- 137 Perspective**  
**Sex and gender analysis improves science and engineering**  
*C Tannenbaum et al.*

## Articles

- 147 Experimental physics**  
**A small proton charge radius from an electron–proton scattering experiment**  
*W Xiong et al.*  
*See N&V p.61*
- 151 Photovoltaics**  
**Carrier-resolved photo-Hall effect**  
*O Gunawan et al.*
- 156 Condensed-matter physics**  
**High-temperature superconductivity in monolayer Bi<sub>2</sub>Sr<sub>2</sub>CaCu<sub>2</sub>O<sub>8+δ</sub>**  
*Y Yu et al.*
- 164 Engineering**  
**Nanomagnetic encoding of shape-morphing micromachines**  
*J Cui et al.*  
*See N&V p.58*
- 169 Biomedical engineering**  
**Dry double-sided tape for adhesion of wet tissues and devices**  
*H Yuk et al.*
- 175 Materials science**  
**Seeing mesoatomic distortions in soft-matter crystals of a double-gyroid block copolymer**  
*X Feng et al.*
- 180 Biogeochemistry**  
**California's methane super-emitters**  
*R M Duren et al.*
- 185 Evolution**  
**Human origins in a southern Africa palaeo-wetland and first migrations**  
*E K F Chan et al.*
- 190 Social science**  
**Quantifying the dynamics of failure across science, startups and security**  
*Y Yin, Y Wang, J A Evans & D Wang*
- 195 Neuroscience**  
**Hierarchical organization of cortical and thalamic connectivity**  
*J A Harris et al.*
- 203 Neurodegeneration**  
**Allele-selective lowering of mutant HTT protein by HTT-LC3 linker compounds**  
*Z Li et al.*  
*See N&V p.57*
- 210 Cancer genetics**  
**Pan-cancer whole-genome analyses of metastatic solid tumours**  
*P Priestley et al.*  
*See N&V p.60*
- 217 Cancer**  
**The clinical KRAS(G12C) inhibitor AMG 510 drives anti-tumour immunity**  
*J Canon et al.*
- 224 Microbiology**  
**Human gut bacteria contain acquired interbacterial defence systems**  
*B D Ross et al.*
- 229 Genetics**  
**Altered chromosomal topology drives oncogenic programs in SDH-deficient GISTs**  
*W A Flavahan et al.*
- 234 Molecular biology**  
**Structure of the Fanconi anaemia monoubiquitin ligase complex**  
*S Shakeel et al.*