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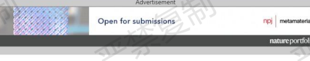
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Controlled chaos

Probing and disentangling the dynamics of many interacting quantum elements, such as those in complex molecules, poses a formidable challenge. In such strongly interacting systems, information scrambles so quickly that isolating the contribution of any single element is nearly impossible. One way to try to overcome this takes inspiration from chaos theory, in which the flap of a butterfly's wing can cause a tornado. In a similar way, a small disturbance is introduced into the quantum system, which, once unwanted signals have been filtered out, allows localized measurements to track the propagation of the wider disturbance created over time. This approach can provide rich, system-wide information about interactions between the individual elements but it is also extremely fragile and challenging to measure. In this week's issue, — show all

Cover image: SayoStudio for Google Quantum AI.

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What makes PhD students happy? Good supervision

Supervisors who invest in positive mentoring relationships with their PhD candidates also reap the benefits for their own research.

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The TrumpRx website won't slash drug prices – but this will

Tighter price regulation would deliver fewer new drugs but improve global health.

Beth Woods

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Wastewater treatment produces surprising amounts of greenhouse gases

Emissions from the process could balloon unless efforts are made to mitigate them.

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Andean peoples hunted and gathered long after they embraced farming

Remote-sensing data reveal hunting corrals that were used well into the eighteenth century.

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European bats capture migrating birds and eat them on the wing

Recordings of chewing sounds combined with altitude data bear evidence of a gruesome night-time feast.

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Gigantic black holes did not have starring role in early cosmic transition

Stars in young galaxies must have been responsible for stripping most intergalactic gas of its electrons.

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News in Focus

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Mysterious cosmic 'dots' are baffling astronomers. What are they?

A consensus is emerging that the dots, sometimes called rubies, are an entirely new type of object in the Universe.

Jenna Ahart

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Global health is in crisis – who will step in to fix it?

The United States and Europe have cut billions of dollars in health aid. Can anyone fill the gap?

Fred Schwaller

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Economics Nobel prize won by researchers who showed how science boosts growth

Joel Mokyr, Philippe Aghion and Peter Howitt share economics prize for work that underlines the importance of investing in research and development.

Philip Ball

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First proposed blood test for chronic fatigue syndrome: what scientists think

A blood test has achieved 96% accuracy in diagnosing the condition in a small study of individuals. What does the test detect, and is it a biomarker of the condition?

David Adam

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More than 30% of this century's science Nobel prizewinners immigrated: see their journeys

The most common destination for eventual Nobel laureates in physics, chemistry and medicine since 2000 is the United States, *Nature* has found.

Jenna Ahart

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AI bots wrote and reviewed all papers at this conference

Event will assess how reviews by models compare with those written by humans.

Elizabeth Gibney

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Universities are embracing AI: will students get smarter or stop thinking?

Millions of students arriving at campuses are now using artificial intelligence. Worries abound.

Helen Pearson

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How to spot fake scientists and stop them from publishing papers

Journals are considering doing identity checks to expose fake authors — but there are downsides.

Miryam Naddaf

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Speeding up diagnosis for high-risk patients
New PCR tests will be able to rapidly detect antibiotic-resistant strains of bacteria and accelerate diagnosis for immunocompromised patients.

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Why we still don't understand the Universe – even after a century of dispute

Despite huge breakthroughs, astronomers still can't agree on what the cosmos is made of, much less how it came to be. A fresh account delves into the reasons.

Helge Kragh

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Mark Norell obituary: palaeontologist who showed that dinosaurs still walk among us – as birds

Through fieldwork and innovative research, he transformed how scientists and the public perceive the prehistoric world.

Michael J. Novacek

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Alternatives to animal testing are the future – it's time that journals, funders and scientists embrace them

Biomedical research techniques that don't involve the use of animals are gaining momentum, but those using innovative approaches still face resistance from some quarters.

Todd J. Herron, Anke Brüning-Richardson ... Joseph C. Wu

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Why simply ending animal testing isn't the answer in biomedical research

Animal models provide insights that alternative approaches can't. A heated debate about which method is better is distracting researchers from doing good science.

K. C. Kent Lloyd

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Brazil must beef up its COP30 scheme to preserve tropical forests

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Genetics can give evolving societies a leg up

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Are these the happiest PhD students in the world?

Brazil, Australia and Italy have the highest satisfaction scores in *Nature*'s global 2025 PhD survey — but are these nations really the best places to do a doctorate?

Linda Nordling

Series: The global PhD landscape 2025

Where I Work

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Cold plunge: how I gained hands-on experience in marine biology

Matthew Kim learnt how to conduct research while studying in a small Canadian town for a semester.

Nikki Forrester

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Clues to why the weight-loss condition cachexia arises when cancer occurs

Analyses of RNA expression reveal molecules underpinning the cancer-associated process of skeletal-muscle wasting, a condition called cachexia.

Kerstin Haase & Mariam Jamal-Hanjani

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Copper-free chips generate robust 'combs' of multicoloured light

A stable 'frequency comb' of photons with discrete colours has been generated on a microscale chip by removing copper contaminants from the circuit.

Mher Ghulinyan & Martino Bernard

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Boosting immune cells to combat cancer using CRISPR engineering and large-scale *in vivo* testing

Immune cells can target cancer in the clinic. The ability to test a gene-editing technology in mice on a large scale should improve such immunotherapies.

Michael Hudecek

Collection: Cancer at Nature Portfolio

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Is there a 'smoking gun' test for quantum gravity?

Quantum-entanglement experiments have been proposed as a way to test whether gravity is quantum, but getting definitive proof might be harder than previously thought.

Zachary Weller-Davies

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How a tick-borne virus enters human cells

Tick-borne encephalitis virus can infect the nervous system and cause life-threatening illness. Finding the cellular gateway it uses could transform prevention and treatment.

Yaw Shin Ooi

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Classical theories of gravity produce entanglement

By applying the full framework of quantum field theory, it is shown that local classical theories of gravity can transmit quantum information and, thus, generate entanglement through physical, local processes.

Joseph Aziz & Richard Howl

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Joint neutrino oscillation analysis from the T2K and NOvA experiments

The joint analysis of datasets from NOvA and T2K, the two currently operating long-baseline neutrino oscillation experiments, provides new constraints related to neutrino masses and fundamental symmetries.

S. Abubakar, M. A. Acero ... S. Zsoldos

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Observation of constructive interference at the edge of quantum ergodicity

Experimental measurements of high-order out-of-time-order correlators on a superconducting quantum processor show that these correlators remain highly sensitive to the quantum many-body dynamics in quantum computers at long timescales.

Dmitry A. Abanin, Rajeev Acharya ... Nicholas Zobrist

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Optimization by decoded quantum interferometry

Decoded quantum interferometry is a quantum algorithm that uses the quantum Fourier transform to reduce optimization problems to decoding problems.

Stephen P. Jordan, Noah Shutty ... Ryan Babbush

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A metallic *p*-wave magnet with commensurate spin helix

A metallic *p*-wave magnet with commensurate spin helix and anisotropic electronic properties is experimentally realized and shows a giant anomalous Hall effect when distorted by a tiny spontaneous magnetization.

Rinsuke Yamada, Max T. Birch ... Max Hirschberger

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Article
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Deterministic soliton microcombs in Cu-free photonic integrated circuits

Copper-impurity-free Si_3N_4 photonic integrated circuits reduce thermal absorption and enable robust, deterministic soliton generation.

Xinru Ji, Xurong Li ... Tobias J. Kippenberg

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Cryogenic X-ray photoelectron spectroscopy for battery interfaces

Cryogenic X-ray photoelectron spectroscopy, combined with immediate plunge freezing, can be used to probe the pristine solid electrolyte interphase in lithium metal batteries.

Sanzeeda Baig Shuchi, Giulio D'Acunto ... Stacey F. Bent

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Modern sea-level rise breaks 4,000-year stability in southeastern China

Spatiotemporal hierarchical modelling of geological sea-level proxies and tide gauge data suggest that the modern global mean sea-level rise rate since 1900 has exceeded any century over at least the past four millennia, breaking the long-term stability observed in southeastern China.

Yucheng Lin, Robert E. Kopp ... Yaze Zhang

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In situ light-field imaging of octopus locomotion reveals simplified control

Using an advanced imaging system called EyeRIS, locomotion in deep-sea octopuses could be studied, revealing simplified crawling patterns that could inspire the design of robots.

Kakani Katija, Christine L. Huffard ... Alana D. Sherman

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A compressed hierarchy for visual form processing in the tree shrew

Tree shrews show a primate-like hierarchical organization in their visual pathway and object decoding accuracy, along with strongly face-selective cells, demonstrating how core computational principles of visual form processing found in primates are conserved yet compressed.

Frank F. Lanfranchi, Joseph Wekselblatt ... Doris Y. Tsao

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Rate and noise in human amygdala drive increased exploration in aversive learning

Human exploration is driven by two distinct neural mechanisms, a valence-independent rate signal and a valence-dependent global noise signal.

Tamar Reitich-Stolero, Kristoffer C. Aberg ... Rony Paz

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Human gastroids to model regional patterning in early stomach development

Neural tissue is a key signalling centre for fundic–antral patterning in development of gastric organoids featuring asymmetric PDX1 patterning.

Xia Li, Feng Lin ... Yue Shao

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Therapeutic genetic restoration through allogeneic brain microglia replacement

Brain-restricted allogeneic transplantation of myeloid progenitors enables microglia replacement without the need for genetic engineering or systemic cytotoxic preconditioning.

Marius Marc-Daniel Mader, Alexa Scavetti ... Marius Wernig

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Microglia–neuron crosstalk through Hex–GM2–MGL2 maintains brain homeostasis

A mode of bidirectional microglia–neuron crosstalk through Hex–GM2–MGL2 and centred around GM2 ganglioside turnover is essential for homeostatic regulation of central nervous system membrane components.

Maximilian Frosch, Takashi Shimizu ... Marco Prinz

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Microbial iron oxide respiration coupled to sulfide oxidation

Genomic and biochemical analyses of prokaryotic sulfur metabolism identify diverse microorganisms with the capacity to oxidize sulfide using iron(III).

Song-Can Chen, Xiao-Min Li ... Alexander Loy

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Dynamic fibroblast–immune interactions shape recovery after brain injury

Spatial transcriptomic studies and lineage tracing reveal that, after brain injury, transient profibrotic fibroblasts develop from existing brain fibroblasts, infiltrate lesions, regulate the local immune response and lead to beneficial scar tissue formation.

Nathan A. Ewing-Crystal, Nicholas M. Mroz ... Ari B. Molofsky

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LRP8 is a receptor for tick-borne encephalitis virus

LRP8, an apolipoprotein E and reelin receptor with high expression in the brain, is a receptor for tick-borne encephalitis virus.

Eva Mittler, Alexandra L. Tse ... Sara Gredmark-Russ

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In vivo CRISPR screens identify modifiers of CAR T cell function in myeloma

In vivo loss-of-function CRISPR screens were performed to identify genes influencing CAR T cell persistence and function in human multiple myeloma, highlighting *CDKN1B* as a promising target.

Nelson H. Knudsen, Giulia Escobar ... Marcela V. Maus

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Systematic discovery of CRISPR-boosted CAR T cell immunotherapies

CELLFIE, a CRISPR platform for optimizing cell-based immunotherapies, identifies gene knockouts that enhance CAR T cell efficacy using in vitro and in vivo screens.

Paul Datlinger, Eugenia V. Pankevich ... Christoph Bock

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Molecular subtypes of human skeletal muscle in cancer cachexia

Unbiased clustering analysis of the skeletal muscle RNAome in patients with cancer identifies two molecular subtypes, one of which distinguishes individuals with cachexia and indicates potential target pathways for future research.

Bhumi J. Bhatt, Sunita Ghosh ... Sambasivarao Damaraju

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CRISPR activation for *SCN2A*-related neurodevelopmental disorders

Using *SCN2A* haploinsufficiency as a proof-of-concept, upregulation of the existing functional gene copy through CRISPR activation was able to rescue neurological-associated phenotypes in *Scn2a* haploinsufficient mice and human neurons.

Serena Tamura, Andrew D. Nelson ... Kevin J. Bender

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DNA2 enables growth by restricting recombination-restarted replication

DNA2 suppresses recombination-restarted replication and checkpoint activation at stalled forks, and its loss triggers recombination-dependent synthesis, checkpoint signalling and cell-cycle exit, highlighting its essential role in proliferation and growth failure in primordial dwarfism.

Jessica J. R. Hudson, Rowin Appanah ... Ulrich Rass

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Multiple overlapping binding sites determine transcription factor occupancy

A new method enables comprehensive screening and identification of low-affinity DNA binding sites for transcription factors, and reveals that nucleotides flanking high-affinity binding sites create overlapping low-affinity binding sites that modulate transcription factor binding in vivo.

Shubham Khetan, Brent S. Carroll & Martha L. Bulyk

Matters Arising

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Uncertain climate effects of anthropogenic reactive nitrogen

Øivind Hodnebrog, Caroline Jouan ... Gunnar Myhre

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Reply to: Uncertain climate effects of anthropogenic reactive nitrogen

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Chiraag D. Kapadia, Nicholas Williams ... Jyoti Nangalia

Author Correction
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Author Correction: Mechanism of BRCA1–BARD1 function in DNA end resection and DNA protection

Ilaria Ceppi, Maria Rosaria Dello Stritto ... Petr Cejka

Author Correction
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Author Correction: Selenium-alloyed tellurium oxide for amorphous p-channel transistors

Ao Liu, Yong-Sung Kim ... Yong-Young Noh

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Publisher Correction: Multimodal cell maps as a foundation for structural and functional genomics

Leah V. Schaffer, Mengzhou Hu ... Trey Ideker

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Publisher Correction: Functional synapses between neurons and small cell lung cancer

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Advanced tools are giving researchers unprecedented insight into the human immune system.

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