GENETICS

Winding road to DNA

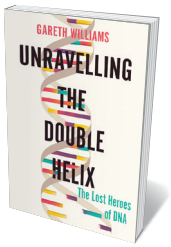
Jan Witkowski lauds an account of the half-obscured scientists whose work helped to reveal the double helix.

Long before the double helix was discovered in 1953, biochemists vied to determine the enigmatic nature of DNA. As early as 1914, chemist Walter Jones wrote (in his monograph *Nucleic Acids*) that the macromolecules "constitute what is possibly the best understood field of Physiological Chemistry". Cytologists, geneticists and even physicists, however, also co-authored the story of DNA.

In *Unravelling the Double Helix*, medical historian Gareth Williams illuminates key research in the 85 years between the discoveries of nuclein, as it was first known, and the double helix. He refreshes a familiar chronicle by ending there, rather than using it as a stepping stone to the Human Genome Project, epigenetics or gene editing. Moreover, he eschews the 'mountain top' approach — featuring individuals synonymous with major advances. Instead, he shines a light on lesser-known scientists struggling, as philosopher Bertrand Russell put it, to bring into the world "some little bit of new wisdom".

Williams starts in 1868, the beginning of a biochemistry golden age. Biologist Friedrich Miescher, working with physiologist Felix Hoppe-Seyler in Tübingen, Germany, was then developing a technique for isolating cell nuclei from the white blood cells in pus. He extracted a strange, fluffy substance from the nuclei, dubbing it nuclein. Moving to Basel in his native Switzerland, he determined its chemical formula using nuclei from salmon sperm. A decade later, cytologist Walther Flemming was studying division in salamander cells by staining them with dyes; he revealed coloured threads that he called chromatin (chromosomes). In 1882, he showed with great clarity their behaviour in the replication processes of mitosis and meiosis.

Genetics enters the picture in 1900, when abbot-scientist Gregor Mendel's research on principles of inheritance was rediscovered by botanists Hugo de Vries, Carl Correns and Erich Tschermak. Williams adds immediacy to the tale of pea plants and heredity by starting with an encounter between Mendel and C. W. Eichling, whose story was new to me. A German seller of exotic flowers, he visited Mendel in Brünn, Austria, in 1878, looking for new varieties. He later published a verbatim account of his conversation with Mendel — the only one in existence (C. W. Eichling *J. Hered.* **33**, 243–246; 1942).



Unravelling the Double Helix: The Lost Heroes of DNA
GARETH WILLIAMS
Weidenfeld & Nicolson (2019)

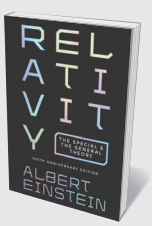
The contributions of cytology continued in the early twentieth century with the work of Walter Sutton. (Williams could also have mentioned Nettie Stevens and William Cannon.) They recognized that the distribution of chromosomes during mitosis and meiosis mirrored what was expected of Mendel's hereditary 'factors', and showed that specific chromosomes were associated with sex. The fusion of genetics and cytology came in the 1910s, when Thomas Hunt Morgan and his colleagues mapped the chromosomal locations of fruit-fly mutations.

Physicists' work in the field was at first theoretical. In 1944, Erwin Schrödinger published *What Is Life?*, which built on work by biophysicist Max Delbrück to suggest that genes were "aperiodic crystals". This influenced physicists including Francis Crick and Maurice Wilkins (see P. Ball *Nature* **560**, 548–550; 2018). But physics really entered the fray when X-ray crystallography was harnessed to study biological macromolecules.

That field was tiny in the 1920s. William Astbury, J. D. Bernal and Kathleen Lonsdale worked at the Royal Institution in London

NEW IN PAPERBACK

Highlights of this season's releases.



Relativity: The Special and the General Theory — 100th Anniversary Edition
Albert Einstein, Hanoch Gutfreund & Jürgen Renn PRINCETON UNIV. PRESS *(2019)*
First published in English in 1920, Albert Einstein's popular introduction to his world-shaking theories reveals what he dubbed his "step-motherly" approach. This authoritative centenary edition is a fitting tribute to Einstein's efforts to make his concepts accessible — in turn, helping to raise the profile of basic science and modern physics on a global scale. Insightful commentaries and excerpts from Einstein's original manuscript of the book provide context.

under physicist and Nobel laureate William Henry Bragg, studying small molecules such as tartaric acid. Moving to the University of Leeds, UK, in 1928, Astbury probed the structure of biological fibres such as hair. His colleague Florence Bell took the first X-ray diffraction photographs of DNA, leading to the "pile of pennies" model (W. T. Astbury and F. O. Bell *Nature* **141**, 747–748; 1938). Her photos, plagued by technical limitations, were fuzzy. But in 1951, Astbury's lab produced a gem, by the rarely mentioned Elwyn Beighton. Using wet DNA fibres, he took images revealing the black-cross diffraction pattern characteristic of helical molecules. They were never published, and Astbury did not follow up on them; if he had, the story of DNA might have been very different.

Many other "lost heroes" emerge in Williams's telling. Martin Henry Dawson and James Lionel Alloway made important contributions to Oswald Avery's demonstration that DNA probably made up genes. H. F. W. Taylor, C. J. Threlfall and Michael Creeth crucially participated in J. Masson Gulland's work showing that DNA solutions changed viscosity owing to the rupture of hydrogen bonds between nucleotides. All is scrupulously documented in more than 50 pages of notes.

Although there is little Williams can add to the intensely scrutinized narrative on the double helix itself, he clarifies key issues. He points out that the infamous conflict between Wilkins and chemist Rosalind Franklin arose from actions of John Randall, head of the biophysics unit at King's College London. He implied to Franklin that she would take over Wilkins' work on DNA, yet gave Wilkins the impression she would be his assistant. Wilkins conceded the DNA work to Franklin, and PhD student Raymond Gosling became her assistant. It was Gosling who, under Franklin's supervision, took the iconic X-ray diffraction 'Photograph 51'. Williams debunks the myth that Wilkins "stole" it; he clarifies how, before moving on to Birkbeck, University of London, Franklin gave her materials and data on DNA to Gosling, to pass on to Wilkins to use as he wished. It was after this that Wilkins showed Photograph 51 to James Watson, who, with Crick, used it to uncover the double helix.

There are a few errors — inevitable in a book of such scope. Williams writes, for instance, that biochemist Linus Pauling took a "surprisingly long time" to recognize that his proposed three-strand structure of DNA was wrong. In fact, at a meeting before the publication of the true, two-strand structure (J. D. Watson and F. H. C. Crick *Nature* **171**, 737–738; 1953), Pauling remarked that the discovery "may turn out to be the greatest development in the field of molecular genetics in recent years". And, on occasion, the scope is too broad. The tragic figure of Nikolai Vavilov, the great Soviet plant geneticist of the early twentieth century who perished in the Gulag, features prominently, but I am not sure how relevant his research is here. Yet pulling such figures into the limelight is partly what distinguishes Williams's book from others.

What of those others? Franklin Portugal and Jack Cohen covered much the same ground in the 1977 *A Century of DNA*, but that now seems dated. James Schwartz's *In Pursuit of the Gene* (2008) hardly touches on biochemistry, whereas Siddhartha Mukherjee's 2016 *The Gene* devotes little space to the backstory of the double helix.

Isaac Newton wrote to natural philosopher Robert Hooke that he had seen further than others only by standing on the shoulders of giants. *Unravelling the Double Helix* looks beyond giants to the many researchers, now half-forgotten, whose contributions paved the way for an icon of science. ■

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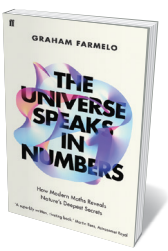
PARTICLE PHYSICS

A singing, dancing Universe

Jon Butterworth enjoys a celebration of mathematics-led theoretical physics.

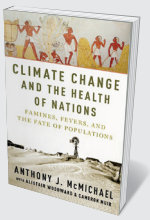
Mathematics is an immensely powerful tool for understanding the laws of the Universe. That was demonstrated dramatically, for instance, by the 2012 discovery of the Higgs boson, predicted in the 1960s. Yet an ongoing, often fervid debate over the direction of theoretical physics pivots on the relationship between physics and maths — specifically, whether maths has become too dominant.

The worry — expressed by a number of theorists and writers over several decades — is that theoretical physics has become a monoculture too focused on a small clutch of concepts and approaches. Those include string theory, overstated predictions of new discoveries, over-reliance on mathematical elegance as a guide and a general drift into what physicist and writer Jim Baggott, in *Farewell to Reality* (2013), called "fairy-tale physics", divorced from its empirical base. Notable critiques have come from theoretical physicists including Peter Woit, Lee Smolin and, more recently, Sabine Hossenfelder (see A. Ananthaswamy *Nature* **558**, 186–187; 2018). Science writer Graham Farmelo clearly intends *The Universe Speaks in Numbers* as a riposte.

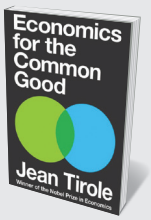


The Universe Speaks in Numbers: How Modern Maths Reveals Nature's Deepest Secrets
GRAHAM FARMELO
Faber & Faber (2019)

Farmelo takes us on a tour through the ▶



Climate Change and the Health of Nations
Anthony J. McMichael OXFORD UNIV. PRESS *(2019)*
In this posthumously published volume, epidemiologist Anthony McMichael journeys through the deep history of Earth's changing climate and its human implications — such as agricultural collapse resulting from shifts in temperature. A book with echoes for today.



Economics for the Common Good
Jean Tirole PRINCETON UNIV. PRESS *(2019)*
French economist Jean Tirole's deft study (translated by Steven Rendell) questions his discipline's role in society. Researchers, he argues, should become socially responsible, probing issues beyond the euro's stability, such as climate change and resource distribution.

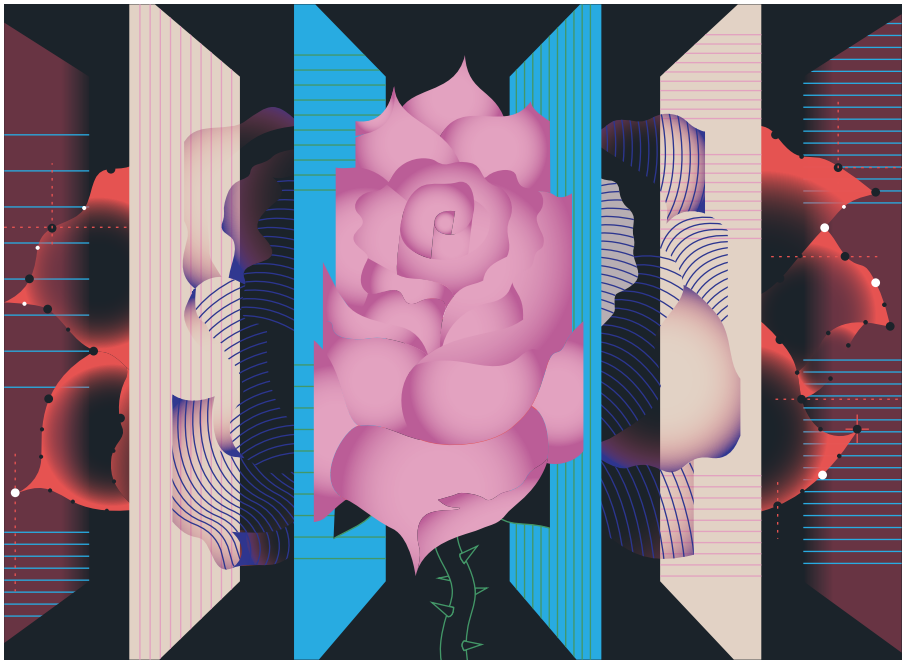
history of the field. His main protagonists are James Clerk Maxwell, Albert Einstein and Paul Dirac (subject of Farmelo's outstanding 2009 biography, *The Strangest Man*). The unification of electricity, magnetism and light in Maxwell's equations is a highlight of any good physics degree. I suspect most physicists can remember the moment when, after a few algebraic tricks with currents and voltages, the speed of light appeared, as if by magic. The Universe isn't just speaking in numbers: it's singing and dancing.

That constant value of the speed of light led to Einstein's special theory of relativity in 1905. From this, in an amazing conceptual (and mathematically abetted) leap, Einstein conjured up general relativity in 1915 (see page 306), then the curvature of space-time, and eventually the gravitational waves discovered by the Laser Interferometer Gravitational-Wave Observatory (LIGO) 100 years later. And in 1928, Dirac, demanding mathematical consistency between quantum mechanics and special relativity, gave us both an understanding of the spin of the electron — without which the periodic table of the elements makes no sense — and predicted the existence of antimatter, discovered experimentally a few years later.

These are brilliant successes of the mathematical approach, and Farmelo leads us through them adeptly, with a mixture of contemporary accounts and scientific insight. He also casts a sceptical eye on the stories the players tell about themselves — and here the tensions start to be felt. Take Einstein's warning to those who want to learn about theoretical physicists' methods: "Don't listen to their words, fix your attention on their deeds." As Farmelo recounts, this is given interesting context by studies of Einstein's notebooks, showing how he later overstated the role of mathematics, and underplayed that of physical insight, in his own breakthrough.

A PRODUCTIVE UNION

Farmelo's argument is that mathematics and physics work effectively together, to the benefit of both. Dirac and Einstein were evangelists for mathematically led physics, but their pleas were more or less ignored by their younger colleagues, such as Richard Feynman and Steven Weinberg, who were



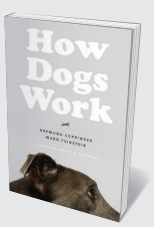
developing the standard model of particle physics. During what Farmelo calls "the long divorce" between mathematics and theoretical physics from the 1930s to the 1970s, our current understanding of fundamental physics was assembled. Dirac and Einstein were hardly involved in those developments.

That the most fruitful period in the development of particle physics coincided with its estrangement from pure mathematics could be seen as undermining Farmelo's case. However, the pace of progress probably had more to do with the rapid experimental advances of the time than with any intrinsic issue in the relationship between the two subjects.

This was a fertile patch for experimentation, and theorists were continually buffeted by new and startling results, from the appearance of the muon to the observation of structure inside the proton; these demanded explanation. Although the few mathematical physicists engaged in the field, notably Freeman Dyson, made important contributions, most physicists didn't need to go beyond well-established mathematical techniques to progress. Dyson himself (quoted by Farmelo) says that "we needed no help from mathematicians. We thought we were very smart and could do better on our own." And, as Farmelo puts it, the feeling was mutual: physicists "rarely generated ideas that were of the slightest interest to mathematical researchers". Many on both sides of the divorce were content with the situation.

MATHEMATICS AND PHYSICS WORK EFFECTIVELY TOGETHER, TO THE BENEFIT OF BOTH.

There has been a re-engagement since the 1980s. In the mainstream of particle physics, theorists and experimentalists were calculating and confirming multiple results that established the standard model as, at the very least, a remarkably precise 'effective theory'. But others, led by luminaries such as Michael Atiyah, Edward Witten and pioneers of



How Dogs Work
Raymond Coppinger & Mark Feinstein
UNIV. CHICAGO PRESS *(2019)*
Cognitive scientists Raymond Coppinger and Mark Feinstein explore the biological basis of canine behaviour and its interplay with the environment, examining everything from dogs' wildly varying morphologies to why they bark.

Listening In: Cybersecurity in an Insecure Age
Susan Landau YALE UNIV. PRESS *(2019)*
Digitization, notes mathematician Susan Landau, offers amazing potential and convenience — at the cost of privacy and a need to ramp up security. She issues both a warning to protect data, and a call to modify how much control we relinquish in our cyber-reliance.

string theory including Michael Green and John Schwarz, were probing its mathematical boundaries.

Whether the mathematical approach eventually became too dominant, taking over in terms of academic recognition and funding, is the crux of much of today's debate. Farmelo gives a lively description of the back-and-forth of contributions typical of any thriving interdisciplinary area, with physical problems stimulating mathematical breakthroughs and mathematics throwing up new insights and techniques in physics. He steers clear of discussing the infeasibly large 'string landscape' of possible physical theories to which the mathematical approach seems to have led — contrary to hopes of a unique 'theory of everything'. Instead, he concentrates on developments more directly useful and testable in physics, where some of this mathematical sophistication begins to feed back into an understanding of the standard model.

The standard model is a complex, subtle and immensely successful theoretical structure that leaves significant questions unanswered. Farmelo makes a convincing case that, in attempting to answer those questions, mathematics has a crucial role. Yet whether theoretical physics has become too enamoured of beautiful mathematics will, I suspect, remain a topic of hot debate.

The long experimental search for the Higgs was motivated by the fact that, before we accepted the existence of a quantum energy field that fills the whole Universe — part of the theory that predicted the particle — we demanded more evidence than 'it makes the maths come out right'. The need for evidence is even stronger if the argument is 'it makes the maths look beautiful'. The Universe might speak in numbers, but it uses empirical data to do so. ■

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HISTORY

England's Galileo

Georgina Ferry relishes a biography of the formidable Moon-mapping Tudor scientist Thomas Harriot.

The phrase 'publish or perish' came into use in the twentieth century to encapsulate academic pressures. It is also a lesson from the life of Thomas Harriot, who lived when there were no academic journals, and who never taught at a university.

A contemporary of William Shakespeare, Harriot was an English mathematician, astronomer and natural philosopher whose original work bears comparison with that of Johannes Kepler and Galileo Galilei. Yet, outside the enthusiastic circle of historians of early modern science who call themselves Harrioteers, his name is almost unknown: he never published his mathematical work. In *Thomas Harriot: A Life in Science*, mathematician Robyn Arianrhod sets out to explain how historians have nevertheless been able to place him, almost four centuries after his death in 1621, among the founders of modern science.

Harriot is elusive. The earliest known document concerning him lists him as a "plebeian" scholar registering to study at the University of Oxford in 1577. He never married and left no children. By 1583, he was employed by Walter Raleigh, naval commander, explorer and favourite of Queen Elizabeth I, to teach astronomy and navigation — a field he greatly improved — to sea captains. He was celebrated in his lifetime by the writer Gabriel Harvey as among the "profound mathematicians", alongside Thomas Digges and John Dee. Afterwards, he was largely forgotten.

He has a higher profile in the United States, thanks to the one work he did publish. *A Brief and True Report of the New Found Land of Virginia* is a first-person account of a 1585–86 voyage sent by Raleigh to survey what is now part of North Carolina. The party landed on Roanoke Island and surveyed it and the nearby mainland; almost all its members returned to England in June 1586. Harriot was "employed in discovering". His report, published in 1588, includes the first detailed English description of the language and customs of the Algonquian people, and of the region's natural resources and climate. Arianrhod shows that his interest in local people was far from typical: he learnt their language, admired how they interplanted beans, squashes and maize (corn), and respected their religion. Meanwhile, the military expedition leaders fatally soured relations by overreacting to perceived wrongdoing and making unreasonable demands.

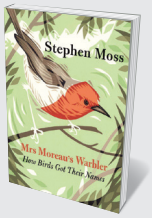
Thomas Harriot: A Life in Science
ROBYN ARIANRHOD
Oxford University Press (2019)

Previous biographers — the US authors Henry Stevens in 1900 and John Shirley in 1983 — were prompted by the *Brief and True Report*. Neither fully addressed Harriot's scientific contributions, as Arianrhod tries to do. Harriot's will mentioned a trunk full of mathematical papers. A few were circulated and partly published by friends such as the mathematician Walter Warner after his death, but what became of the collection was unknown until 1784, when it turned up in some disorder at Petworth House, home to heirs of the ninth Earl of Northumberland, Harriot's patron after Raleigh. Only since the mid-twentieth century have scholars made sense of the thousands of manuscript sheets.

What they reveal is astonishing. To mention only a portion of Harriot's work, he discovered Snell's law of refraction two decades before mathematician Willebrord Snell; formulated laws of motion and falling bodies independently of Galileo and decades before Isaac Newton; produced the first drawing of the Moon through a telescope and made important observations of sunspots, again independently of Galileo; played with binary arithmetic nearly a century before Gottfried Wilhelm Leibniz; and was the first to develop fully symbolic algebra. There are well-grounded suspicions that René Descartes saw some of Harriot's papers before publishing *The Geometry* in 1637.

Where Harriot falls down, say some ▶

Magnificent *Principia*
Colin Pask PROMETHEUS *(2019)*
Isaac Newton remains a giant of physics, as his 1687 *Principia* confirms. Maths historian Colin Pask presents an easily digestible guide to the work, enlivened with passages from Newton's life. An invitation to wonder at what some see as the greatest single scientific book ever published.



Mrs Moreau's Warbler
Stephen Moss FABER *(2019)*
Names make sense of the world; they also reveal something about us. Stephen Moss unveils the often surprising roots of avian etymology and offers insight into fierce, long-standing debates such as that over *Prunella modularis,* variously known as the dunnock and hedge sparrow.

scholars, is that he did not draw his observations into coherent theory. It's possible he just never got round to it. Harriot spent his adult life in the households of Raleigh and Northumberland. They paid him generously, and all appearances suggest that he was a friend rather than a servant. However, both were players on the volatile political scene, and malicious rumours of atheism and necromancy did the rounds. Soon after James I succeeded Elizabeth I in 1603, Raleigh was convicted of treason, and Northumberland of lesser charges when a cousin was involved in the Gunpowder Plot to murder the king. Both were imprisoned in the Tower of London; Raleigh was executed in 1618.

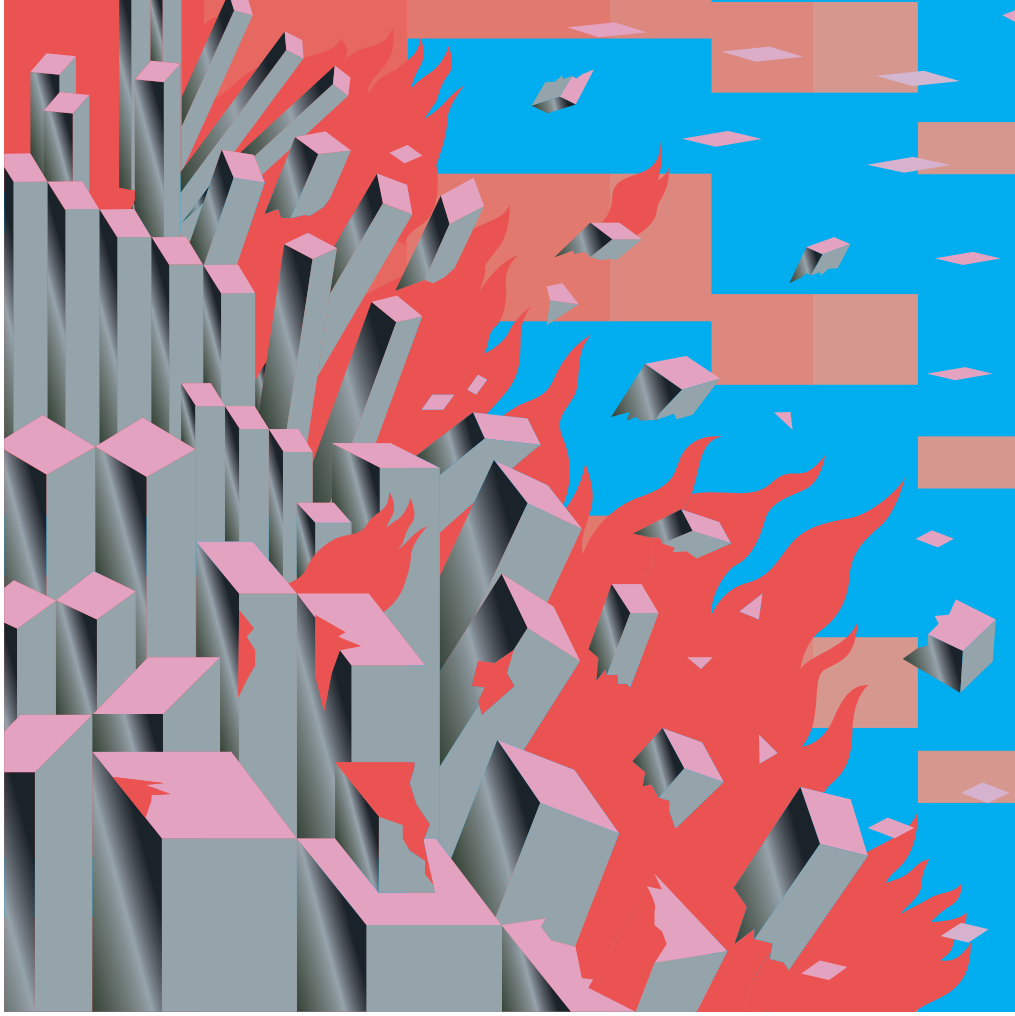
Harriot spent an anxious few weeks in prison because of his association with Northumberland; he might have felt the need to keep his head down over the years. He died aged about 60 from cancer of the nose, possibly caused by his enthusiasm for tobacco after his American adventure.

The lack of finished work makes evaluating his contribution complex. Arianrhod does not hesitate to call him a genius, and the evidence she presents is impressive. Yet she fully explores his rightful position in the pantheon only in a page-long endnote; I think this short-changes the "general reader" she seeks to enlighten. Some might find her technical passages challenging, although they are necessary to her argument. And it is irksome to see diagrams relating to Harriot's navigational work in an appendix, rather than with the text they illustrate.

Has Arianrhod, as she intended, "put a human face to scientific inquiry in the Elizabethan and Jacobean worlds"? She has revealed a scientific mind, but the face is more elusive: the one supposed portrait of Harriot is of unknown provenance and, because of a discrepancy in dates, some historians doubt it is him.

This black-clad, driven, sceptical man, "contented with a private life for the love of learning" as he wrote to his captors, still declines wholly to step into the light. ■

Georgina Ferry's *biography of Dorothy Crowfoot Hodgkin will be published in a revised edition this year.*
e-mail: georgina.ferry@gmail.com

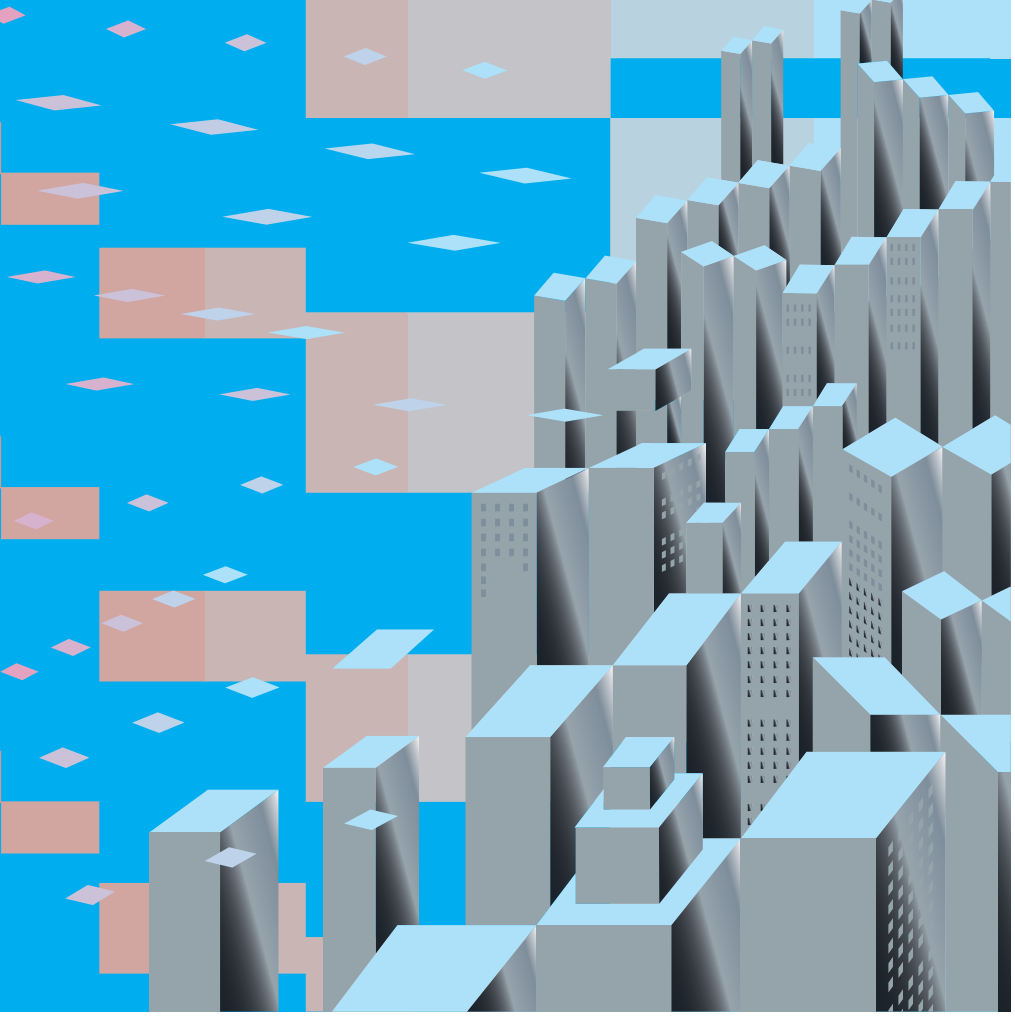


SOCIETY

How to survive an apocalypse

Richard Rhodes weighs up Jared Diamond's study of national resilience in the face of catastrophe.

The geographer Jared Diamond is the bestselling author of a number of books on the vicissitudes of civilizations. His anchoring perspective, argued across such works as *Collapse* (2005) and *The World Until Yesterday* (2012), is geographic determinism. He sees the environment as fundamentally shaping the founding, development and challenges of nations and civilizations. "History," he argued in the 1997 *Guns, Germs, and Steel*, "followed different courses for different peoples because of differences among peoples' environments, not because of biological differences among peoples themselves." His perspective has been both celebrated for clarifying historical

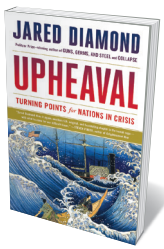


complexities and criticized as oversimplified and dated, but he has defended it vigorously.

Upheaval, then, is something of a curiosity. Diamond says that his wife, psychologist Marie Cohen, suggested the idea: compare nations in upheaval with individuals in crisis. Do nations go through similar stages of challenge, disturbance and even breakdown to emerge, if successful, selectively changed? What factors influence that failure or success?

Normally confident of his methodology, Diamond proposes this comparison with caution. He writes that he set out to investigate seven modern nations — Finland, Japan, Chile, Indonesia, Germany, Australia and the United States — because he happens to have "much personal experience" of them. He acknowledges, however, that a sample of seven is inadequate for drawing statistically significant conclusions, and so proposes a "narrative exploration" that he hopes will "stimulate quantitative testing".

Diamond's caveats limit him to an informed but speculative discussion of how his seven nations struggle, or struggled, with crises profound or wide-ranging enough to potentially destroy them. These range from climate-change impacts and advanced technology to geopolitical pressures and nuclear weaponry.



Upheaval: Turning Points for Nations in Crisis
JARED DIAMOND
Little, Brown (2019)

Thus, Finland fought the Soviet Union in 1939–40 and aligned with Germany against the common foe in 1941–44, sacrificing some 100,000 soldiers, rather than allow itself to be absorbed into the Soviet Union as Latvia, Lithuania and Estonia had been. It then found accommodation with its Eastern neighbour by treating it with respect and hewing close to its economic and foreign policies, despite the resulting dissonance. Finland is not a member of the North Atlantic Treaty Organization, for example; nor was it part of the European Union until 1995, after the Soviet Union was dissolved.

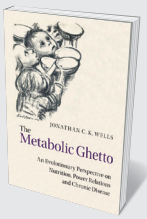
In looking at Japan, Diamond harks back to 1853, when US Navy commodore Matthew C. Perry sailed his warships into Edo Bay, demanding that the country open itself to Western trade. Japan maintained independence, in part, Diamond argues, by acquiring a Westernized facade, while maintaining its traditional values. (In one respect, this may have backfired: Japan's severe restrictions on immigration have left it struggling to sustain a labour force while the population ages and birth rates stay well below replacement levels.)

Comparisons with psychology soon fall by the wayside as Diamond explores crises in Indonesia, Chile, Germany and Australia. The model is, in any case, a poor fit.

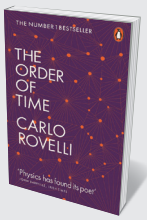
My country, the United States, is also Diamond's. I find his assessment of its challenges partly acute and partly eccentric. Diamond acknowledges the country's great natural advantages in climate, geography, population and form of government. He judges its current troubles to be consequences, predominantly, of the venality of US politicians and of a "politically uncompromising" population. He attributes this polarization mostly to the rise in digital communications. A persistent focus on screens, he argues, is producing people who "no longer experience one another as live humans".

Attributing social change one dislikes to new technology is a familiar moral panic. In my house, we call it hell-in-a-handbasket syndrome. Certainly, smartphones and their ilk expose their users to an artificial environment much more pervasively than older communication technologies did. But whether this distributed consciousness is good, bad or simply different remains to be seen, in my view.

More to the point is Diamond's identification of inequality as a serious problem in the United States. Emmanuel Todd — the French demographer who was almost alone in predicting the collapse of the Soviet Union on the basis of an unprecedented rise in infant mortality — commented more than a decade ago that he saw "the possibility in the medium term of a real Soviet-style crisis in the United States". Increasing financial



The Metabolic Ghetto
Jonathan C. K. Wells CAMBRIDGE UNIV. PRESS *(2019)*
Power relations in society affect human health. Here, child-nutrition specialist Jonathan Wells draws on fields such as biomedicine, evolutionary biology and epidemiology to illuminate the socio-economic and historical factors behind chronic conditions such as obesity.



The Order of Time
Carlo Rovelli PENGUIN *(2019)*
Physicist Carlo Rovelli elegantly dismantles our understanding of time as a flow from past to future. He argues that there is a multitude of times, and that the present is only localized. Ultimately, he says, our concept of time is as much about us as about the cosmos.

inequality, and the despair of unmet expectations that it has induced in many white Americans, is almost certainly behind the opioid crisis in small towns and rural areas. There, life expectancy is declining much as it did in the final years of the Soviet Union, where rising alcohol addiction took a grim toll.

Inequality is even more serious for African Americans, for whom neglect and mistreatment in medical care, education, housing and criminal remand have resulted in an average lifespan half a decade shorter than that of white people in the United States, although the gap is closing.

Among the biggest global problems Diamond mentions are the risk of nuclear war and the fact of climate change. Here, his answers are conventional. No one knows what to do about nuclear weapons, maintained as they are under the pretence that they deter the very disaster they are designed to produce. On climate change, Diamond recognizes the double challenge of reducing greenhouse-gas production while meeting the rising expectations of the developing world. But he fails to recognize that substituting renewable energy for fossil fuels without a major expansion of nuclear power will merely decarbonize the existing supply. Without nuclear power, the doubling of demand projected for the developing world in the next 30 years will be met mainly through coal — or, at best, natural gas, which produces fully half as much carbon dioxide as coal when it burns.

Diamond's historical analyses hold up better than do his contemporary assessments. Energy from fossil fuels supported the West's transformation from subsistence to long-term prosperity; today, it threatens to cook our goose. The nation-state system, embedded in international anarchy, has never dealt well with global threats. So far, the response has mostly been denial and timidity: tragedy of the commons indeed.

I read *Upheaval* with appreciation for its historical sweep and its generally informed speculation. If the world is going to hell in a handbasket, Diamond has not given up hope that we can change course. ■

Richard Rhodes's *latest book is* Energy: A Human History.
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MEDICINE

Sorrows of psychiatry

Alison Abbott probes a history on the fraught nexus of mental illness and biology.

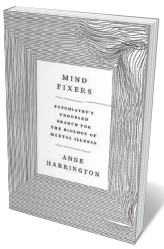
In January 1973, *Science* published an article called 'On being sane in insane places'. The author, psychologist David Rosenhan, described how he and seven other healthy people had reported themselves to a dozen psychiatric hospitals, claiming to hear voices uttering odd words such as 'thud' or 'hollow' — a symptom never reported in the clinical literature. Each person was diagnosed with either schizophrenia or manic-depressive psychosis, and admitted; once inside, they stopped the performance. They were released after an average of 19 days with diagnoses of 'schizophrenia in remission' (D. L. Rosenhan *Science* **179**, 250–258; 1973).

One research and teaching hospital, hearing about the study, declared that its own staff could never be so deceived. It challenged Rosenhan to send it pseudopatients. He agreed, but never did. Nonetheless, the hospital claimed to have identified 41 of them.

Psychiatric hospitals, it seemed, could recognize neither healthy people nor those with mental illnesses. Rosenhan's study exemplifies much of what went wrong in twentieth-century psychiatry, as biologists, psychoanalysts and sociologists struggled for supremacy. Science historian Anne Harrington takes us through the painful history of that struggle in the enthralling *Mind Fixers*, which focuses particularly on the United States.

She reveals the shameless hubris of many of the prominent battlers. She fails, however, to acknowledge promising approaches in biological psychiatry, particularly very new insights about brain circuitry as a potential target for treatment. Many neuroscientists today are very aware of past mistakes in overclaiming the power of theories and drugs. In my opinion, Harrington's omission weakens the case for her pessimistic conclusion.

She begins in mid-nineteenth-century Europe, with a new experiment to give people with psychosis rest and care, with no restraint, rather than the standard brutality and neglect of the conventional 'lunatic asylum'. It visibly failed.

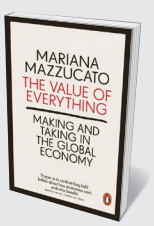


Mind Fixers: Psychiatry's Troubled Search for the Biology of Mental Illness
ANNE HARRINGTON
W. W. Norton (2019)

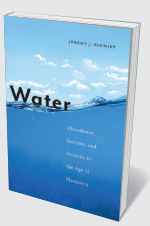
By the 1870s, asylums had become overpopulated, and gave up all pretence of being therapeutic. They began to supply post-mortem brains to any scientist wishing to investigate a possible anatomical basis for mental disorders. These turned out to be unrevealing. Harrington describes how the failure encouraged Sigmund Freud to turn away from neuroanatomy in the 1890s to develop his theory that mental disorder is rooted in biography — specifically, early-childhood sexual fantasies. These, Freud thought, needed only to be drawn out by intense psychoanalysis to achieve a cure.

At the same time, Harrington shows, the German psychiatrist Emil Kraepelin began a large-scale, systematic survey to categorize symptoms such as hallucinations or extreme moods. Without proper diagnostic criteria, he reasoned, clinical science would never make progress. In 1899, he published the sixth edition of his influential textbook *Compendium of Psychiatry*, which distinguishes disorders — particularly, psychoses such as schizophrenia and affective disorders including manic depression, now known as bipolar disorder. (Kraepelin was also interested in eugenics, like many intellectuals of the time.)

In the following decades, biologists and Freudians cut separate paths, for good or ill. Certain discoveries, such as the findings in 1897 and 1913 confirming that syphilis causes late-onset psychosis, bolstered biologists' view that mental disorders were brain-based. Some



The Value of Everything
Mariana Mazzucato PENGUIN *(2019)*
A crisis faces capitalism, argues economist Mariana Mazzucato. She reveals that we value those who extract wealth over those who create it. Noting that the debate is economic, social and political, she pinpoints the urgent need to reform how we define value in a fast-changing world.



Water
Jeremy J. Schmidt NEW YORK UNIV. PRESS *(2019)*
Humans both consume too much water and fail to benefit from it equitably. Geographer Jeremy Schmidt's multidisciplinary study shows how historical US approaches to water management have gained global reach, leading to problematic biases. **Mary Craig**