axes are aligned, the light is imprinted with the same curlicue polarization pattern expected from gravitational waves in the early Universe.) Yet the team decided to go ahead with the announcement, buoyed by data from a slide used for a 2013 talk by a scientist affiliated with BICEP2's chief competitor, the European Space Agency's Planck satellite.

The slide showed an unpublished dust map of unknown accuracy. Extrapolating from it, the BICEP2 team concluded that in the region of sky observed by its telescope, galactic dust would have little effect on the results. Keating writes that he objected to relying on such evidence for a high-stakes discovery, but was ultimately swayed. New data from the Planck satellite later revealed that dust had led the BICEP2 team to misread the results. Its vision, Keating feels, had been clouded not only by dust, but by 'Nobel lust' and the fear of being scooped.

Journalists embraced the BICEP2 announcement at first. It was an exhilarating story to report, and I have since debated whether its potential might have clouded my own vision. The dozen or so independent experts I contacted, who had read advance copies of a paper that the BICEP2 team would later post online, all commented positively on the work. But it's possible that for a few, confirmation bias played a part, because they were proponents of the inflation theory.

Keating suggests several remedies for Nobel fever. He argues that the physics prizes should be awarded only for serendipitous findings; an example is the evidence, discovered in 1998 by two teams of cosmologists, that the Universe was revving up its expansion instead of slowing down. If a team finds something it had set out to look for, it should not gain the Nobel, is his provocative view. Keating also asserts that Nobel prizes should be awarded to an entire team. He would eliminate the stipulation, added in 1974, that the prizes cannot be awarded posthumously. And he would allow more than one prize for the same research if a person was originally overlooked or ignored (which has, historically, often occurred to women, such as co-discoverer of radio pulsars Jocelyn Bell Burnell).

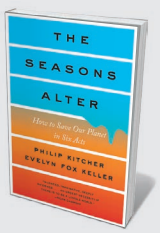
These changes, he argues, might motivate physicists to think outside the box in conducting research, and might discourage in-fighting. However, I doubt that reconfiguring the Nobels would accomplish what Keating hopes. As he himself notes, both the US and European processes for allocating funding and tenure encourage cut-throat competition. Modifying those ingrained systems would have much greater impact.

Keating notes that his own work has begun to embrace the spirit of cooperation. In 2016, the Simons Foundation, a private philanthropic foundation in New York City that supports research in maths and the basic sciences, gave the green light for him to spearhead a collaboration between his CMB team, based at UCSD, and one based at Princeton University in New Jersey. Together, they hope to dig from the dust a true signal of primordial gravitational waves in the CMB. Even if that pans out, the work would not be eligible for a Nobel under Keating's reforms; it would be science for science's sake. And maybe that's the point. ■

Ron Cowen *is a freelance science writer, focusing on physics, astronomy and the history of technology.*
e-mail: roncowen@msn.com

NEW IN PAPERBACK

Highlights of this season's releases.



The Seasons Alter: How to Save Our Planet in Six Acts
Philip Kitcher and Evelyn Fox Keller LIVERIGHT *(2018)*
"Clearly, we need to talk." Philosophers of science Philip Kitcher and Evelyn Fox Keller call for constructive discourse on climate change in their unusual exploration of this urgent, highly politicized issue. While coherently explaining the science, they use Socratic dialogue to explore differing viewpoints. As they warn, considerate, productive conversation is essential if we're not to go down in history as "the people who argued while the world burned".

NATURAL HISTORY

Of plumes and plunder

Stuart Pimm on the tragic tale of a hobbyist, a heist and a natural-history collection.

I'll never forget my first sight of a bird of paradise. On a hike in the central highlands of New Guinea one morning, I found an exquisite blue *Paradisaea rudolphi*, hanging upside down, puffing up its feathers, swaying and calling loudly. The birds' very names allude to the sixteenth-century assumption that their exotic feathers — and the lack of feet on skins that made it to Europe — showed that they were celestial beings. Founder of taxonomy Carl Linnaeus knew two species. He followed the myth, naming the greater bird-of-paradise *Paradisaea apoda* (*apoda* meaning 'without feet'). Naturalist Alfred Russel Wallace delivered the first scientific accounts of their behaviours in his 1869 book *The Malay Archipelago*. (Fellow Victorian scientist and ornithological artist John Gould named one species *Semioptera wallacii*.) And who can fail to be enthralled by David Attenborough's BBC films of their otherworldly displays?

Given all that, it's appalling that museum specimens of these birds — including a number collected by Wallace — were stolen and plucked, and their unique associated data discarded. The culprit was Edwin Rist, practitioner of an arcane art: recreating Victorian ornamental salmon-fishing flies using rare feathers. That heist lies at the core of *The Feather Thief*, in which investigative writer Kirk Wallace Johnson recounts his quest to retrieve what remained of those specimens. Johnson's book also probes how the human yen for the exotic can in some cases harm species and what we know about them.

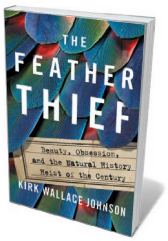
In June 2009, Rist, a 21-year-old US flautist then studying at the Royal Academy of Music in London, broke into the Natural History Museum's collection at Tring. He came away with 299 stuffed skins of brightly coloured birds, including birds of paradise, showy species of cotingids and quetzals. Rist sold some of the stolen feathers and skins, and used others for his own creations.

Johnson's interest in the story arose from his own devotion to fly fishing. He took up the sport as respite from emotionally draining work helping Iraqis who had worked with US development agency USAID to relocate to the United States. Johnson writes of his fishing reveries: "Out in the river … five hours would pass in what felt like thirty minutes." One day, his fishing guide told him about Rist and the community devoted to Victorian fly-tying.

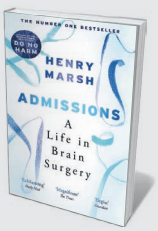
When I got to this part of the book, I needed help. My friend David Blinken is a professional fly-fishing guide on Long Island, New York (strictly catch and release). His understanding of fish natural history and behaviour is impressive, exceeded only by his ability to show even me how to catch fish. "Isn't the point of tying a fly to imitate whatever insect is on the water that day? Doesn't entomology matter?" I asked. Blinken replied: "Atlantic salmon are thinking only of reproduction and strike at gaudy objects reflexively. The flies aren't meant to resemble any insect."

I surmised that a salmon fly is so time-consuming to make that it might seem too precious to lose. Blinken said that I had guessed correctly. "Many will never get wet. Most are cherished works of art, enjoyed by a passionate group of collectors at the fringe of the fly-tying community. Attention to historical methods, style and detail are paramount."

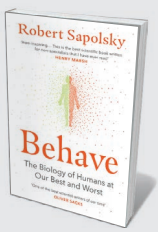
As Johnson reveals, these enthusiasts revived the craft and formed an online community in the late twentieth century. Rist was involved from his early teens, recreating classic flies as a student and then a teacher. One fly might include the 'period-specific' feathers of the golden pheasant (*Chrysolophus pictus*) from China, the red-ruffed fruitcrow (*Pyroderus scutatus*), macaws and the plum-throated cotinga (*Cotinga maynana*) from South America, along with feathers of domesticated birds, such as chickens. But many of the wild birds are rare or endangered, and supply has dwindled to sources such as Victorian feather hats or moulted plumage from zoos. Traded feathers are hugely expensive. ▶



The Feather Thief: Beauty, Obsession, and the Natural History Heist of the Century
KIRK WALLACE JOHNSON
Viking (2018)



Admissions: A Life in Brain Surgery
Henry Marsh WEIDENFELD & NICOLSON *(2018)*
In this unflinchingly honest memoir, retired neurosurgeon Henry Marsh seamlessly intertwines his life experiences and surgical career. He reflects on both what he has learned by probing the brain, and our limited knowledge of mind, from emotions to consciousness.



Behave: The Biology of Humans at Our Best and Worst
Robert Sapolsky VINTAGE *(2018)*
Neurobiologist Robert Sapolsky tackles the question of why we behave in the ways we do — whether commendably or despicably. He explores the biology of violence, and examines what it can teach us about altruism.

(My quick check online showed that pairs from three species of cotinga sell for US$25 to $45. I easily found feathers on sale from birds on the International Union for Conservation of Nature's Red List of Threatened Species.)

US thief Willie Sutton allegedly said that he robbed banks because "that's where the money is". Museums are where the feathers are. In July 2009, senior curator Mark Adams found the drawers with missing specimens; 16 months later, Rist was caught. He pleaded guilty to burglary and money-laundering. The court fined him £125,150 (US$200,000 at the time), of which he had about 10%. He also got a mere 12-month suspended sentence, owing to a diagnosis of Asperger's syndrome (an autism spectrum disorder).

Of the 299 skins stolen, police retrieved only 102 with the labels intact. More had been stripped of the essential data that such labels provide, and 106 were missing. Johnson's exhaustive sleuthing tracked down some feathers in 2016, but nothing more.

Museum specimens are a unique, contextualized archive, as Robert Prys-Jones, a scientific associate at the Natural History Museum, makes clear in the book. They hold information about where and when species lived, who collected them and perhaps why; and they can be studied for visual and genetic clues. But after interviews with individuals in the fly-tying community, Johnson feels that only some are horrified by the theft. His investigations revealed that the bulk of the birds "dissolved into the bloodstream of the feather underground", some realms of which seemed to trade in endangered species and flout the Convention on International Trade in Endangered Species of Wild Fauna and Flora. As Blinken told me, the art can become "a pursuit of perfection so intoxicating that its practitioners lose all sense of ethics".

The Feather Thief is a riveting read. It also stands, I believe, as a reminder of how an obsession with the ornaments of nature — be they feathers, bird eggs or ivory — can wreak havoc on our scientific heritage. ■

Stuart Pimm *is professor of conservation at the Nicholas School of the Environment at Duke University in Durham, North Carolina, and directs the non-profit group SavingSpecies, www.savingspecies.org. He tweets at @StuartPimm.*
e-mail: stuartpimm@me.com

PHYSICS

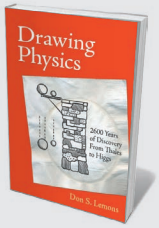
Stop all the clocks

Andrew Jaffe probes Carlo Rovelli's study arguing that physics deconstructs our sense of time.

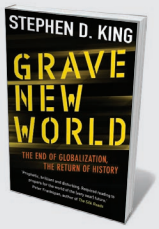
According to theoretical physicist Carlo Rovelli, time is an illusion: our naive perception of its flow doesn't correspond to physical reality. Indeed, as Rovelli argues in *The Order of Time*, much more is illusory, including Isaac Newton's picture of a universally ticking clock. Even Albert Einstein's relativistic space-time — an elastic manifold that contorts so that local times differ depending on one's relative speed or proximity to a mass — is just an effective simplification.

So what does Rovelli think is really going on? He posits that reality is just a complex network of events onto which we project sequences of past, present and future. The whole Universe obeys the laws of quantum mechanics and thermodynamics, out of which time emerges.

Rovelli is one of the creators and champions of loop quantum gravity theory, one of several ongoing attempts to marry quantum mechanics with general relativity. In contrast to the better-known string theory, loop quantum gravity does not attempt to be a 'theory of everything' out of which we can generate all of particle physics and gravitation. Nevertheless, its agenda



Drawing Physics
Don S. Lemons MIT PRESS *(2018)*
For millennia, drawings have elucidated chewy concepts in physics, providing a "pre-mathematical picture of reality". Don Lemons delves into the archive for powerful sketches representing ideas and results from Isaac Newton's colour theory to the Higgs boson.



Grave New World: The End of Globalization, the Return of History
Stephen D. King YALE UNIV. PRESS *(2018)*
Economist Stephen D. King's analysis of globalization is searing and timely, offering historical lessons on how political narratives that abandon the global agenda, such as Brexit, threaten our economic order.

of joining up these two fundamentally differing laws is incredibly ambitious.

Alongside and inspired by his work in quantum gravity, Rovelli puts forward the idea of 'physics without time'. This stems from the fact that some equations of quantum gravity (such as the Wheeler–DeWitt equation, which assigns quantum states to the Universe) can be written without any reference to time at all.

As Rovelli explains, the apparent existence of time — in our perceptions and in physical descriptions, written in the mathematical languages of Newton, Einstein and Erwin Schrödinger — comes not from knowledge, but from ignorance. 'Forward in time' is the direction in which entropy increases, and in which we gain information.

The Order of Time
CARLO ROVELLI
Allen Lane (2018)

The book is split into three parts. In the first, "The Crumbling of Time", Rovelli attempts to show how established physics theories deconstruct our common-sense ideas. Einstein showed us that time is just a fourth dimension and that there is nothing special about 'now'; even 'past' and 'future' are not always well defined. The malleability of space and time mean that two events occurring far apart might even happen in one order when viewed by one observer, and in the opposite order when viewed by another.

Rovelli gives good descriptions of the classical physics of Newton and Ludwig Boltzmann, and of modern physics through the lenses of Einstein and quantum mechanics. There are parallels with thermodynamics and Bayesian probability theory, which both rely on the concept of entropy, and might therefore be used to argue that the flow of time is a subjective feature of the Universe, not an objective part of the physical description.

OUR PERCEPTION OF TIME'S FLOW DEPENDS ENTIRELY ON OUR INABILITY TO SEE THE WORLD IN ALL ITS DETAIL.

But I quibble with the details of some of Rovelli's pronouncements. For example, it is far from certain that space-time is quantized, in the sense of space and time being packaged in minimal lengths or periods (the Planck length or time). Rather, our understanding peters out at those very small intervals for which we need both quantum mechanics and relativity to explain things.

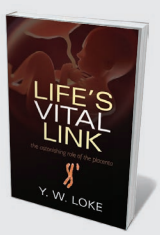
In part two, "The World without Time", Rovelli puts forward the idea that events (just a word for a given time and location at which something might happen), rather than particles or fields, are the basic constituents of the world. The task of physics is to describe the relationships between those events: as Rovelli notes, "A storm is not a thing, it's a collection of occurrences." At our level, each of those events looks like the interaction of particles at a particular position and time; but time and space themselves really only manifest out of their interactions and the web of causality between them.

In the final section, "The Sources of Time", Rovelli reconstructs how our illusions have arisen, from aspects of thermodynamics and quantum mechanics. He argues that our perception of time's flow depends entirely on our inability to see the world in all its detail. Quantum uncertainty means we cannot know the positions and speeds of all the particles in the Universe. If we could, there would be no entropy, and no unravelling of time. Rovelli originated this 'thermal time hypothesis' with French mathematician Alain Connes.

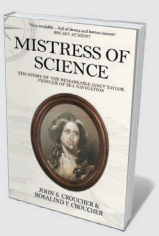
The Order of Time is a compact and elegant book. Each chapter starts with an apt ode from classical Latin poet Horace — I particularly liked "Don't attempt abstruse calculations". And the writing, translated from Italian by Erica Segre and Simon Carnell, is more stylish than that in most physics books. Rovelli ably brings in the thoughts of philosophers Martin Heidegger and Edmund Husserl, sociologist Émile Durkheim and psychologist William James, along with physicist-favourite philosophers such as Hilary Putnam and Willard Van Orman Quine. Occasionally, the writing strays into floweriness. For instance, Rovelli describes his final section as "a fiery magma of ideas, sometimes illuminating, sometimes confusing".

Ultimately, I'm not sure I buy Rovelli's ideas, about either loop quantum gravity or the thermal time hypothesis. And this book alone would not give a lay reader enough information to render judgement. *The Order of Time* does, however, raise and explore big issues that are very much alive in modern physics, and are closely related to the way in which we limited beings observe and participate in the world. ■

Andrew Jaffe *is a cosmologist and head of astrophysics at Imperial College London.*
e-mail: a.jaffe@imperial.ac.uk



Life's Vital Link: The Astonishing Role of the Placenta
Y. W. Loke OXFORD UNIV. PRESS *(2018)*
This exploration of the placenta's evolution devotedly details the 'forgotten' organ's vital role in the womb, and other complex functions. Immunologist Y. W. Loke also ponders how such findings could provide insight into his field.



Mistress of Science
John S. Croucher and Rosalind F. Croucher
AMBERLEY *(2018)*
Nineteenth-century British mathematician Janet Taylor has been overlooked by history, yet she invented navigational tools such as the mariner's calculator, founded an academy and authored textbooks. A fitting tribute to a gifted trailblazer.

PSYCHOLOGY

War and peace and summer camp

Alex Haslam appraises an account of key psychology experiments on conflict and cooperation.

A few years after the Second World War, Muzafer Sherif conducted possibly the most complex field studies ever attempted in social psychology. Sited in summer camps around the United States, they focused on conflict and cooperation within and between two groups of about a dozen 11- and 12-year-old boys. The children were never informed that they were taking part in research. In each study, Sherif and his fellow researchers spent up to three weeks disguised as counsellors and caretakers, manipulating features of the camp set-up — in particular, the structure of team competitions and challenges — to examine their impact on group relations.

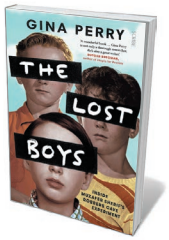
In *The Lost Boys*, Gina Perry puts these extraordinary experiments under the microscope. As in her 2013 book *Behind the Shock Machine*, which probed psychologist Stanley Milgram's 1960s research on obedience, she is unsatisfied with the half-truths lazily handed down in textbooks. Her aim is to make a distinctive contribution to the current debate about replication and reproducibility in social psychology. She goes in search of the stories behind the research, in particular reassessing Sherif's legacy through the recollections of study participants and research collaborators. The result is an enlightening read, and a ripping yarn.

All three studies featured a phase in which the two groups competed for scarce resources such as prized penknives. In other respects, their designs were quite different. In the 1949 and 1953 studies, the boys underwent a phase of making friends. They were then assigned to one of two distinct groups that cut across friendship lines.

Move Fast and Break Things
Jonathan Taplin PAN MACMILLAN *(2018)*
With Facebook, Google and Amazon monopolizing consumer culture, digital-media expert Jonathan Taplin argues that their dominance is an economic war as well as a cultural one. His solution? A "digital renaissance" returning to principles of decentralization.

Resurrecting the Shark
Susan Ewing PEGASUS *(2018)*
Helicoprion, a bizarre prehistoric shark with teeth set in a spiral whorl, swam the oceans more than 270 million years ago. It remains shrouded in mystery. Susan Ewing traces how the fossil obsessed scientists for centuries, and how new research could resolve how its teeth fit into its jaw.

In the 1954 study, at Robbers Cave State Park in Oklahoma, there was no initial friendship phase. Moreover, competition was followed by a period in which the two groups could achieve a prized outcome (such as watching a movie) only if they cooperated (say, by pooling group funds). The studies were very much of their time: the scientists selected white, Protestant boys who were deemed psychologically 'well adjusted'.



The Lost Boys: Inside Muzafer Sherif's Robbers Cave Experiments
GINA PERRY
Scribe (2018)

As Sherif and his colleagues reported in later texts — notably the 1966 book *Group Conflict and Co-operation* — their manipulations profoundly affected the boys' behaviour. In particular, as predicted by 'realistic conflict' theory, competition generally led to 'us–them' group identities: well-mannered boys were turned into aggressive, prejudiced adversaries. Significantly, at Robbers Cave, this process was then reversed with the requirement to cooperate in the study's final phase.

Sherif's research is less well known than Milgram's, or later classic studies by Solomon Asch on conformity and Philip Zimbardo on tyrannical power dynamics (B. Maher *Nature* **523**, 408–409; 2015). But what has made Sherif's legacy clearer and more enduring is the meticulous theoretical work that informed his studies' design. Sherif was no blind experimentalist. Rather, his ambitious goal was to create an empirical landscape capable of capturing the richness of 'big picture' social relations.

In many ways, this concern was a reflection of his own tumultuous life. As Perry clearly documents, that had been marked by external conflicts and inner torture. Before and after the Second World War, Sherif had moved back and forth between his native Turkey and the United States in the face of threats posed by nationalism, Nazism and McCarthyism. At various points, these pressures placed his work — sometimes his life — under threat, and led him to win and lose many friends along the way.

The Lost Boys illuminates Sherif's life and times, as well as Turkish history and how large field studies work. Sherif's own accounts of the latter give a sense that support for his theoretical hypotheses followed reasonably seamlessly from the studies' manipulations. In practice, it wasn't quite like that, as Perry's careful detective work reveals.

First, the boys responded in a range of ways to changing group relations and escalating conflict, and it is not always easy to weave these into a single account. Second, even when they were describing the same event, Sherif's co-investigators often interpreted it differently. Third, it was impossible for the investigators not to shape the boys' behaviour — not least because 'doing nothing' was itself laden with significance

WELL-MANNERED BOYS WERE TURNED INTO AGGRESSIVE, PREJUDICED ADVERSARIES.

(as when researchers refused to censure intergroup aggression, and the tacit approval led to escalation). Fourth, sometimes things simply didn't go to plan. This is seen most vividly in the 1953 study, which — to Sherif's dismay — had to be abandoned because the boys, realizing the tensions were engineered, refused to buy into group conflict.

Perry does a magnificent job of documenting these nuances. She tracks down participants, many now retired, and shares their reactions on first discovering that they had taken part in a famous study. Most were intrigued and hungry for information; some were conflicted. Perry rightly worries about the ethics of her own psychological archaeology.

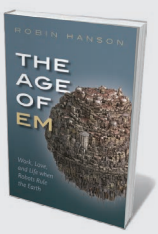
Nevertheless, her efforts to fill in the inevitable gaps in her sources are not always convincing. Sometimes she does rather too much 'imagining' to join the dots between experimenters' actions and participants' reactions. This is especially problematic in the context of her rather unforgiving commentary on similar shortcomings in accounts by Sherif and his team. Although she questions whether Sherif's data collection was merely fleshing out a preconceived script, she herself is not immune to this charge.

A bigger problem is that Perry does not put the material she excavates to better use. Had she more thoroughly surveyed contemporary social psychological research on group conflict and collaboration, she would have found important clues that fit closely with the evidence she unearths, and pave the way for significant progress in the questions that Sherif posed.

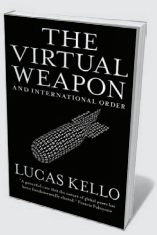
For example, in his 1976 monograph *Social Psychology and Intergroup Relations*, Michael Billig observed that Sherif's key theoretical failing was not factoring in the experimenters as the studies' third group. Michael Platow and John Hunter have pointed out that Sherif himself recognized that the effects of group membership (such as in-group affinity) preceded competition, and so seem to be as dependent on internalized group identity as on the battle for scarce resources (in ways that Henri Tajfel and John Turner would later unpack in their social identity theory). More generally, Sherif failed to appreciate how the participants and researchers would follow his own lead (in particular, in his cultivation of shared identity). As research has since clarified, this is a blind spot in many classic social psychology studies — not least those of Milgram and Zimbardo.

In *The Lost Boys*, Perry opens the door to clearer theorizing about these crucial processes of identity and influence, but she fails to walk through it. In these terms, her book leaves the reader concerned not just for the boys' lost voices, but for Sherif's. He argued passionately and compellingly for theoretical progress in social psychology. Today, when a focus on empirical replicability often drowns out the equally important requirement for strong integrative theory, we need that voice as much as we did 70 years ago. ■

Alex Haslam *is professor of psychology and Australian Laureate Fellow at the University of Queensland in Brisbane. His most recent book is* The New Psychology of Health *(with Catherine Haslam, Jolanda Jetten, Tegan Cruwys and Genvieve Dingle). e-mail: a.haslam@uq.edu.au*



The Age of Em: Work, Love, and Life when Robots Rule the Earth
Robin Hanson OXFORD UNIV. PRESS *(2018)*
Marshalling economics, physics and philosophy, Robin Hanson predicts a future run by brain emulations ("ems"), featuring era-specific issues such as "mind theft". Hanson's predictions detail a world both uncanny and eerily familiar.



The Virtual Weapon and International Order
Lucas Kello YALE UNIV. PRESS *(2018)*
The cyber revolution clearly constitutes an ever-growing challenge to international order. Lucas Kello reflects on technology's role in political revolution, and the importance of aligning international-relations studies with the unruly expansion of cyberspace.

GENETICS

Pinpointing the pain gene

Tor Wager lauds a book on the hunt for an elusive root of sensory suffering.

Two soldiers receive similar injuries in battle. One recovers in months; the other endures excruciating pain for years. Why this difference?

The question is pressing. One in five people suffers from chronic pain, affecting every aspect of their lives. Although significant gains have been made with anaesthetics and anti-inflammatory medications, the roots and relief of long-term pain are proving harder to find. Pain is also fuelling a global epidemic of opioid addiction and related deaths. In *Chasing Men on Fire*, neurologist Stephen Waxman provides a compelling portrait of scientific discovery in this area.

Waxman, who works in basic research and clinical medicine, offers an insider's account of the global search for a pain gene, beginning in 1966. He intertwines descriptions of cross-disciplinary neuroscience with portraits of scientists, and the struggles of people with conditions such as erythromelalgia, or 'man-on-fire syndrome', characterized by burning pain in hands and feet. Structurally, the book is innovative: 11 research papers are interlaced with the stories behind them. It is thus both a boon for researchers and an engrossing read for nonspecialists.

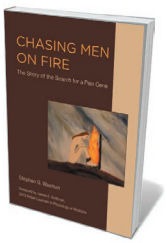
Humans love simplicity. We want the intricate systems in our brains and bodies to 'just work'. But Waxman shows that biology is complex, and genetic clues can be elusive. Detecting them relies on finding regularities across many people, which can make it seem impossible to pinpoint a key gene, and the rare mutations in it that lead to disease. As he reveals, it took considerable sifting and coordinated effort on three continents by scientists including pharmacologists, electrophysiologists, molecular biologists and geneticists before a 'master gene' for pain was isolated.

That gene, *SCN9A*, encodes the complex molecule $Na_v1.7$, a sodium channel and a basic building block of nervous-system function. When activated by electrical current (for example, from stimulation of nerve endings), sodium channels allow ions to rush into neurons, causing the cell to fire a nerve impulse. $Na_v1.7$ channels are found nearly exclusively in peripheral nociceptive neurons in the dorsal root ganglia; these nerve centres in the spinal column are the first 'relay station' in transmitting pain-related information to the brain. This makes the channels potential targets for therapies that alleviate pain without altering brain function catastrophically.

Over more than 20 years, Waxman worked with dozens of people with erythromelalgia. His team painstakingly sequenced each person's *SCN9A* gene, hunting for mutations. As he puts it, he was "navigating a large, complex sea". To understand the functional implications of the mutations, he and his team extracted adult blood cells and turned them back into stem cells. They then triggered these cells to grow into $Na_v1.7$-expressing neurons in the dorsal root ganglia, to study how each individual's unique mutation affected the cells' properties. They discovered dozens of rare pain-causing mutations. Later, they used computer models to understand how the mutations affect the sodium channels' structure, allowing them to predict whether a person would respond to a particular drug.

> ***"People are suffering, and we have the responsibility to help them if we can."***

This research has already helped some people with chronic pain by providing an explanation for its cause, and identifying drugs that are effective for some. Compounds that interact with $Na_v1.7$ channels to alleviate pain are currently in clinical trials. Understanding the mechanisms can help the rest of us: genetic variation in the channels affects susceptibility to common sources of chronic pain, such as surgery. (This does not mean that molecular mechanisms are the only important ones. Post-surgical pain can be strongly affected by emotions such as anxiety, and the complex brain circuitry underlying them.)

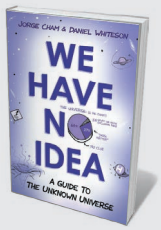


Chasing Men on Fire: The Story of the Search for a Pain Gene
STEPHEN G. WAXMAN
MIT Press (2018)

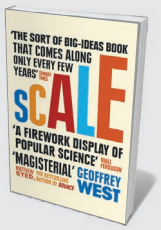
Embedded in Waxman's narrative are broader lessons. First, we need to face complexity head-on. One gene can go wrong in thousands of ways. Each of the 1,800 amino acids in *SCN9A* presumably affects how the protein it encodes folds. That, in turn, determines whether the channel opens and closes properly to transmit pain-related signals at appropriate times. The story of *SCN9A* reveals how the pursuit of basic understanding lays a crucial foundation for clinical advances once undreamt of. With the pain gene, this pursuit stretches from scientific experiments on squid by Alan Hodgkin and Andrew Huxley in the mid-twentieth century to the reconstruction of ion channels' crystal structures by Waxman's group, and beyond.

Waxman's story is also deeply human. It pivots on cross-border, cross-disciplinary scientific collaboration in service of the greater good. It demonstrates a pursuit of scientific understanding that keeps sight of the big picture: that people are suffering, and we have the responsibility to help them if we can. Finally, it conveys the spirit of how science at its best is accomplished — with urgency, passion, inventiveness and collaboration. In Waxman's words: "Let's just do it." ■

Tor Wager *is a professor of psychology, neuroscience and cognitive science at the University of Colorado Boulder, and director of the Cognitive and Affective Neuroscience Lab. e-mail: tor.wager@colorado.edu*



We Have No Idea: A Guide to the Unknown Universe
Jorge Cham and Daniel Whiteson RIVERHEAD *(2018)*
This cheerily conversational exploration of grey areas and conundrums, from the composition of the cosmos to the elements, is peppered with cartoons. Jorge Cham and Daniel Whiteson are upbeat guides to universal ignorance.



Scale
Geoffrey West WEIDENFELD & NICOLSON *(2018)*
In this "grand unified theory of sustainability", physicist Geoffrey West explores underlying laws that link society and nature, called scaling theory. Insights (into city size and walking speed, for instance) abound. (See P. Ball *Nature* **545**, 154–155; 2017.) Mary Craig