

**The Madhouse Effect: How Climate Change Denial is Threatening Our Planet, Destroying Our Politics, and Driving Us Crazy**  
MICHAEL E. MANN  
AND TOM TOLES  
Columbia University  
Press: 2016.

and anthropogenic climate change (as well as second-hand smoke and the dangers of pesticides). We read of the television, radio and Internet ‘shock jocks’ who chase ratings by giving equal weight to scientific consensus and denier rhetoric. The power of vested interests in US politics and implications for state and federal action on climate change are made abundantly clear, with Mann an amiable, if rather despairing, guide.

He begins with an overview of the scientific method, the science of global warming and key uncertainties — such as feedback mechanisms, whereby warming can itself boost greenhouse-gas emissions and so cause even more warming. He and Toles then explore the “six stages of denial”, ranging from ‘it’s not happening’ through ‘it’s self-correcting’ to ‘geoengineering will fix it all’.

Where this book shines is in its exploration of the debate in the United States, and a veritable who’s who of denial. As the November presidential election looms, it’s useful to learn about key players’ stances. Unsurprisingly, most of the contenders for the Republican nomination when the book was finished back in July emerge as outspoken critics of climate science and international action. The party’s current candidate, Donald Trump, wants to renegotiate or leave the 2015 Paris climate agreement joined by President Barack Obama in September, and has called climate change a hoax. But Mann suggests that several candidates were influenced by cryptic political and financial forces in the fossil-fuel industry, which apparently bankroll denier activity and lobbying to protect their interests.

The authors discuss how Republican senator Jim Inhofe (Oklahoma) is waging a “war” on climate science by using hearings of the Senate environment committee that he chairs to try and debunk climate change. Mann’s writing is subjective in places — such as when discussing former Virginia attorney-general

CLIMATE SCIENCE

# Denialism deciphered

Dave Reay enjoys a wry history of US climate–science obfuscation.

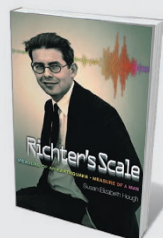
As an iconic climate-change image, the ‘hockey-stick graph’ by geophysicist Michael Mann — showing global temperature change over the past 1,000 years — is up there with the greats. Others include the Keeling curve of changing atmospheric carbon-dioxide concentrations and the ‘boiling frog’ metaphor from Al Gore’s 2006 documentary *An Inconvenient Truth*. Mann’s figure (from a seminal paper: M. E. Mann *et al. Geophys. Res. Lett.* **26**, 759–762; 1999) appears in ‘Climate Science 101’ lectures the world over; was a touchstone of the 2001 third assessment

report of the Intergovernmental Panel on Climate Change; and still elicits invective from deniers (S. Lewis *Nature* **483**, 402–403; 2012). Who better than Mann, then, to explore the history of climate-change denial, and its politics, personalities and implications?

*The Madhouse Effect* is a breezy, engaging read, interspersed with wry illustrations courtesy of cartoonist Tom Toles of *The Washington Post*. It offers many excellent insights into life on the front line battling US climate-science obfuscation. We learn about the cadre of contrarian scientists routinely rolled out to cast doubt on issues such as ozone depletion

NEW IN  
PAPERBACK

Highlights of this  
season’s releases



**Richter’s Scale: Measure of an Earthquake, Measure of a Man**

Susan Hough (Princeton Univ. Press, 2016)

Charles Richter’s eponymous, logarithmic scale of earthquake classification made him globally famous. In this illuminating biography, seismologist Susan Hough describes Richter’s accidental arrival at the Seismolab of the California Institute of Technology, and the colleagues there who resented his fame. A surprising selection of Richter’s poetry surfaces, reflecting his sentiments on married life and mortality (see Gregory Beroza’s review: *Nature* **445**, 599; 2007).

Ken Cuccinelli, an erstwhile alger of data manipulation, now an oyster farmer on an island threatened by rising sea levels. But he generally manages to avoid score-settling.

In 2009, Mann's work was caught up in the 'Climategate' scandal ([nature.com/climategate](http://nature.com/climategate)). This was the unauthorized release of more than 1,000 e-mails from the Climatic Research Unit at the University of East Anglia in Norwich, UK — many containing private correspondence, some to or from Mann. Excerpts were published by climate sceptics to smear scientists and cloud public and political judgement. Mann gives this seismic event just a couple of pages. He explains briefly how the e-mails were taken out of context and that references to a "trick" used to "hide the decline" referred simply to a trick of the trade: combining direct measurements of global temperature with proxy estimates. Given that Mann was bombarded with threats and abuse following Climategate, a fuller exploration — as in Fred Pearce's *The Climate Files* (Guardian Books, 2010) — would have been good to see.

Despite the political tensions, Mann and Toles strike a positive tone in the final section. They highlight action being taken at community, city and state levels, and the potential of the Paris agreement to avoid the most damaging effects of climate change. And they find hope in the power of individual choice to shift the most recalcitrant hangovers from our carbon-intensive history. Their key recommendations are for each of us to support renewable energy and carbon pricing, to vote for politicians who do the same and to stop equivocating on climate science.

As Mann points out, denialists are not likely to read this book. For climate researchers outside the United States, it is an eye-opening primer (despite its baffling references to baseball stars) on the vested interests with which their US colleagues must do battle. For a wider readership, it makes clear just how high the stakes are. If tackling climate change is indeed a war, then Mann and Toles have certainly earned their stripes. I salute them. ■

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## MEMOIR

# Love and uncertainty

Werner Heisenberg's wartime letters to his wife record scientific and personal privations, finds **Ann Finkbeiner**.

**W**erner Heisenberg is a conundrum. He won the 1932 Nobel Prize in Physics for creating the foundations of quantum mechanics and his uncertainty principle, which describes how it is impossible to know a particle's location and its momentum simultaneously. During the Second World War, directed by the Nazi government, he headed Germany's unsuccessful efforts to create an atomic bomb. Why didn't he succeed? Why did he try?

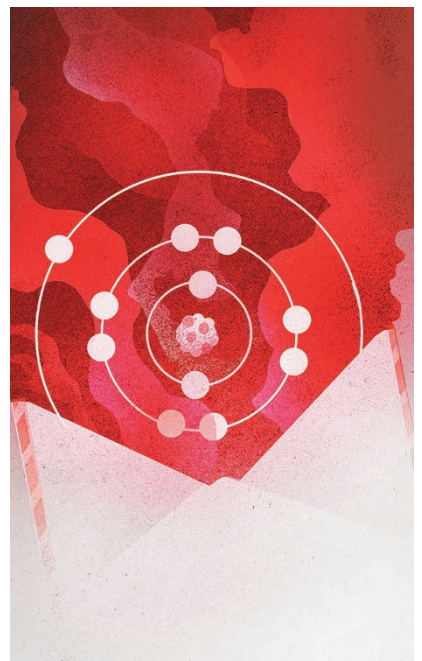
There are no unambiguous answers here, although clarifying Heisenberg's motives is one reason that his daughter, Anna Maria Hirsch-Heisenberg, gives for publishing the letters between him and her mother. What the letters do illustrate is Hirsch-Heisenberg's other reason for publishing (in German in 2011, and now in English for the first time): how a couple much in love lives through a war.

Werner begins his letters with "My dear Li". Li is Elisabeth, née Schumacher; they met in 1937 at a musical evening. The two talked — a conversation, Werner wrote, that seemed to have begun so long ago that continuing it for the rest of their lives felt natural. Two weeks later, they were engaged; four months later, they began a 40-year marriage. But Heisenberg had to travel for research and was rarely at home, thus the letters. This collection spans the tumultuous years from 1937 to 1946.

The letters, necessarily discreet about politics and the military, contain mostly the quotidian — frighteningly so, this being Germany during that war. By 1939, Werner lives in Leipzig and Li has moved to their safe country house in southern Germany. Li has had twins; she will have four more children in the next five years. The war has started. "I get caught up pondering the dark picture everybody is painting," Li writes, "how fortunate that the children ... are so



**My Dear Li: Correspondence, 1937-1946**  
WERNER HEISENBERG AND ELISABETH HEISENBERG; ED. ANNA MARIA HIRSCH-HEISENBERG, TRANSL. IRENE HEISENBERG  
Yale University Press: 2016.



unencumbered and jolly." Werner makes a long lecture trip to the United States, where he finds the audiences receptive and the students bright. He tells his US colleagues who offer him jobs that he needs to stay in Germany "so that I might also be here afterward and help"; as he writes to Li, "we are just not at home here".

Over the next few years, Werner alternates between Berlin, where "it is quite ▶



## How to Clone a Mammoth

Beth Shapiro (Princeton Univ. Press, 2016)  
Ecologist Beth Shapiro parses possible impacts of the "unextinct". Reintroducing mammoths to Siberia, for example, could restore grasslands and keep carbon trapped in the permafrost (see Henry Nicholl's review: *Nature* **521**, 30-31; 2015).



## Future Arctic: Field Notes from a World on the Edge

Edward Struzik (Island, 2016)  
Arctic journalist Edward Struzik compresses 30 years of circumpolar observation in this portrait of a thawing world. As warmer oceans induce powerful storms that hasten the ice's retreat, ecological anomalies surface, such as the grizzly bear-polar bear hybrid.

▶ striking these days how everybody becomes thinner”, and Leipzig, where newspapers carry obituaries of young people dying. “I myself am often so sad and downcast,” he writes to Li, “without you I would not quite be able to cope”. Food is scarce; Werner preserves cherries from his Berlin garden. His work, directing research on nuclear fission, “makes no sense”.

In 1945, between air raids, Werner advises Li that as the front moves closer to southern Germany, she should watch for attack planes and the children should practise throwing themselves to the ground near a wall. Li makes her own yeast and worries about getting enough flour for bread. They tell each other that they are thinner and more exhausted. “Love,” he writes, “stay well and prepare for the more difficult times.”

Near the war’s end, Heisenberg and other German nuclear scientists are arrested by the Allies. They are held for six months in England; few letters are allowed. For lack of food, Li puts two of the children into a home. She cares for Heisenberg’s dying mother and cuts their firewood. He’s released in January 1946. “I want to build a containing wall around you from all the love I have in my heart,” writes Li. The letters end that June, with the family reunited and living in Göttingen; in 1950, they have a seventh child.

Hirsch-Heisenberg writes that the letters were chosen and edited for relevance and concision. We cannot know what other filters, if any, children apply to the publication of their parents’ letters. Hirsch-Heisenberg gives no sources, but makes the case that her father’s motives for working on a German atomic bomb were to control atomic research and to convert it to peaceful uses, but that building an actual bomb was “out of the question”. Judging from these letters, Heisenberg was doing what it took to wait out the dreadful storm so that he could get on with his life with physics and Li. ■

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## THEORETICAL PHYSICS

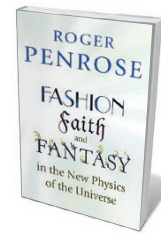
# The emperor’s new physics

**Richard Dawid** examines a critique of quantum mechanics, string theory and inflationary cosmology.

**T**he eminent theoretical physicist Roger Penrose is worried about the current path of physical research. In *Fashion, Faith, and Fantasy in the New Physics of the Universe*, he argues that the eponymous triad of trends has become overly powerful in contemporary fundamental physics. This core message is delivered in language that demands some mathematical sophistication of the reader. Penrose also discusses some of his own ideas, such as twistor theory — his take on a synthesis of quantum theory and general relativity.

Penrose claims that even well-confirmed theories, such as quantum mechanics, are ‘oversold’ with respect to their presumptive stability. Quantum physics has had an impressive record of predictive success, ranging from quantum chemistry to elementary particle physics. But it faces a deep conceptual problem. Whereas quantum mechanics has a perfect internal consistency when it describes a system that evolves without being measured, the way in which it represents measurements is not coherently embedded in that description. To Penrose, this indicates that the fundamental principles of quantum mechanics have not yet been found and will rely on the elusive full integration of gravity into quantum physics. He argues that the success of quantum mechanics tends to make physicists insensitive to the theory’s conceptual problem and generates an unjustified degree of faith in its basic principles as a solid foundation of physics.

Another source of undue trust in a theory, Penrose asserts, is the physics community’s tendency to follow fashion — that is, to



**Fashion, Faith, and Fantasy in the New Physics of the Universe**

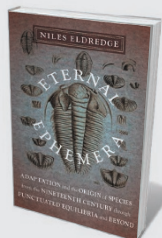
ROGER PENROSE  
Princeton University  
Press: 2016.

settle on one strategy of dealing with a problem before severely testing the theory’s empirical predictions. Penrose views string theory (a theory of quantum gravity) as the pre-eminent example.

The final trend in Penrose’s triad is fantasy — that is, a wildly speculative idea that goes far beyond what is implied by the known data. Penrose assigns that category to inflationary cosmology, which he argues is treated as an established theory despite a lack of evidence.

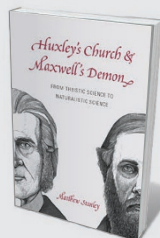
Of these three, Penrose’s discussion of quantum mechanics (‘faith’) is the most successful. On the basis of an inspired presentation of quantum mechanics, he makes a case that the theory’s enormous scientific success does not remove serious doubts about the finality of its basic principles. His discussions of fantasy and fashion, however, are problematic. He paints an exaggerated picture of their role and systematically underrates the merits of the theories he criticizes.

Fashion and fantasy are presented in separate chapters as independent influences that have become too powerful. But, as Penrose acknowledges, fantasy has always been at the root of new theories. Just think about the atomist speculations that led to the kinetic gas theory in the nineteenth century. For Penrose, the trouble arises when fantasy



## Eternal Ephemera

**Niles Eldredge** (Columbia Univ. Press, 2016)  
Palaeontologist Niles Eldredge presents an insightful history of evolutionary biology, from transmutation’s forefather, Jean-Baptiste Lamarck, comparing fossil molluscs in 1801, to the theory of punctuated equilibria, whereby rapid speciation disrupts periods of stasis.



## Huxley’s Church & Maxwell’s Demon

**Matthew Stanley** (Univ. Chicago Press, 2016)  
The context of Victorian science swung smoothly from the theistic to the naturalistic, shedding supernatural causality along the way. Matthew Stanley attributes the relative amity between Christian and atheist scientists to shared ideals such as intellectual freedom.



is given too much credit before a theory is empirically tested. This occurs, he says, when a theory becomes the subject of fashion. In this light, it is difficult to see the independent role of ‘fantasy’ in Penrose’s argument.

Inflationary cosmology is, moreover, not a good illustration of fantasy, even by Penrose’s own account. As he acknowledges, recent precision measurements of the cosmic microwave background agree with typical predictions of inflationary cosmology, so it seems difficult now to call it a mere flight of fancy. Penrose presents his important criticism that inflation generically does not explain the low initial entropy of the Universe (although explanations have been suggested in certain models; see S. M. Carroll and J. Chen. <https://arxiv.org/abs/hep-th/0410270>; 2004). But he presents the case against inflation in a way that hides the independent significance of problems that can be solved by it, such as explaining the homogeneity and flatness of the observed Universe.

There are similar issues with Penrose’s claim that fashion is the main reason for

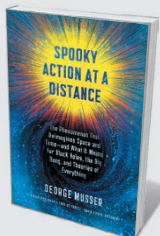
string theory’s influential position. His analysis of its problems is not up to the task of debunking proponents’ physics-based reasons for confidence. Penrose’s main complaint about string theory is that it lacks a clear specification of its number of degrees of freedom. He tries to show this in several contexts. However, he tends to omit information that could make the situation less confusing than he takes it to be. For example, he expresses unease about ‘gauge–gravity duality’, the claim that string theory is empirically equivalent to a quantum field theory in a lower-dimensional space. (If generally valid, that would mean that a string theory in three extended spatial dimensions was empirically equivalent to a quantum field theory in two spatial dimensions.) Such a claim looks startling, because one would naively expect that a three-dimensional theory has more degrees of freedom than a two-dimensional one. Penrose presents this as one of many questionable implications of string theory.

Curiously, however, he presents his case without mentioning that Gerard ’t Hooft,

who is cited in the book, provided a general understanding of the reduced number of degrees of freedom in quantum gravity without any reference to string theory, before cases of gauge–gravity duality were conjectured in the context of string theory (G. ’t Hooft. <https://arxiv.org/abs/gr-qc/9310026>; 1993). In this light, by generating examples of gauge–gravity duality, string theory does not, as Penrose maintains, make one more *prima facie* implausible claim, but opens up perspectives for a more thorough understanding of a characteristic of quantum gravity that had already been suggested.

It is always inspiring to read Penrose’s uncompromisingly independent perspective on physics. He seems more at home with developing visionary ideas than with detailed criticism of prevalent theories. Unfortunately, this book offers too few of the former and too much of the latter. ■

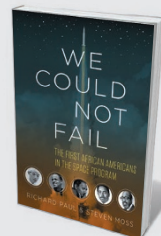
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### Spooky Action at a Distance

George Musser (*Scientific American/Farrar, Straus and Giroux*, 2016)

Bending time, space and minds, George Musser investigates nonlocality — two distant particles acting in harmony. With lessons in photon entanglement, particle teleportation and string theory, he ponders how space evolved after the Big Bang.



### We Could Not Fail: The First African Americans in the Space Program

Richard Paul and Steven Moss (*Texas Univ. Press*, 2016)

Profiling NASA’s first ten black employees, Richard Paul and Steven Moss show what the space age meant for African Americans. In 1962, NASA granted US\$181,000 to a study of the space programme’s impact on race relations.



also had a predilection for sedatives such as the opiate Eukodal (oxycodone). But the extent to which he took any of these drugs remains controversial.

Ohler has effectively written two separate books, one focusing on the military; the other on Hitler and Morell. There is a thin connecting thread attributing Hitler's military misjudgements to drugs, such as Operation Barbarossa against the Soviet Union when he overstretched German troops. Ohler's descriptions of military operations, such as the Blitzkrieg against Poland and France, are very generalized. By contrast, the treatment of Hitler as a patient is a detailed study based on Morell's diary and personal records.

Called 'Patient A' by Morell, Hitler is depicted as increasingly stooped and tremor-ridden. Ohler attributes this decline to drug dependency rather than Parkinson's disease (mooted as early as 1945 by the Nazi neurologist Max de Crinis). And Ohler goes further. He argues that drug consumption initially boosted the Reich's military success, but then undermined it as widespread addiction set in — a focus that ignores corrosive factors such as anti-Semitism, the Holocaust and the drive to secure Lebensraum (territorial living space). Ohler presents some staggering statistics on drugs supplied to individual units, but fails to provide statistics on Pervitin production, fluctuations in its supply to the military, or the extent and duration of its use. Nor is there a detailed analysis of individual soldiers to determine the impact on health. If military operations were so saturated by drugs, more evidence should be forthcoming.

Ohler draws on the same sources as other books and papers on the Nazi consumption of crystal meth and cocaine, and on Hitler's medical predilections. These include Giles Milton's *When Hitler Took Cocaine and Lenin Lost His Brain* (Picador, 2016) and the paper 'Speed in the Third Reich' (S. Snelders and T. Pieters *Soc. Hist. Med.* **24**, 686–699; 2011). Some material countering Ohler's argument is not referenced. In *Was Hitler Ill?* (Polity, 2012), Henrik Eberle and Hans-Joachim Neumann argue that Morell was a competent diagnostician, albeit compliant in prescribing. And Ohler does not draw on witness studies such as that of SS nutritionist Ernst-Günther Schenck on Hitler as a patient. Finally, Pervitin was known by the

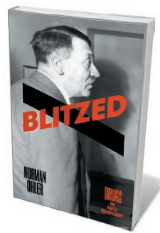
## HISTORY

# Addiction and the Reich

Paul Weindling ponders a study of drug use among the Nazi leadership and military.

Norman Ohler's *Blitzed* depicts the pervasive drug culture that allegedly developed in Germany's Third Reich. From 1933 to 1945, Adolf Hitler, many Nazi officials and a proportion of the military rank and file were — he contends — in thrall to prescription and recreational drugs. Ohler's is a vivid account; whether it convinces is less certain.

Historians now recognize that despite Nazi racial and political persecution of German scientists, Hitler's Reich offered immense opportunities to many. There was an upswing of research in pharmacology during preparation for total war, and new drugs were hailed as additions to the armoury of high-performance medicine. However, drugs were viewed paradoxically in the Reich. The Nazi ideology of fitness meant that users of opiates such as morphine were branded 'psychopathic personalities', and serious addicts could be compulsorily sterilized. Yet Nazi officials took high-performance drugs such as methamphetamine hydrochloride (crystal

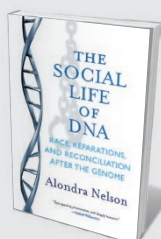


**Blitzed: Drugs in Nazi Germany**  
NORMAN OHLER  
Allen Lane: 2016.

meth) and cocaine. German military units and aviators were dosed with the patent methamphetamine-based drug Pervitin (manufactured in Germany from 1937) to improve operational efficiency. And drugs such as Pervitin and metabolic stimulants were tried out on on

students, military recruits and, eventually, in concentration camps. Questions remain, however, over precisely how the drugs were tested, prescribed, distributed and used.

Meanwhile, Hitler's façade was that of a vegetarian and non-smoker, but he became increasingly dependent on patent vitamin tonics produced from bovine thyroid glands, livers and bones. (His favoured physician, Theodor Morell, claimed exclusive rights to process these in occupied Ukraine.) Hitler



### The Social Life of DNA: Race, Reparations, and Reconciliation After the Genome

Alondra Nelson (Beacon, 2016)

Geneticist Alondra Nelson analyses the rise in DNA 'roots' testing among African Americans seeking their lost identity. Race, politics and science emerge as intertwined as the double helix itself (see Fatimah Jackson's review: *Nature* **529**, 279–280; 2016).



### Evolving Ourselves: How Unnatural Selection and Nonrandom Mutation Are Changing Life on Earth

Juan Enriquez and Steve Gullans (Current, 2016)

In this study of the evolution of evolution, Juan Enriquez and Steve Gullans ponder the potential of genome editing and synthetic life. Could pig lungs, 'humanized' by the addition of our genes, obviate human transplants?

1980s to be a crucial component of Nazi high-performance medicine.

Ohler pays more attention to the perpetrators of Nazi drug experiments than to their victims. He cites experiments with mescaline, trying to create a ‘truth’ drug, from the perspective of the Dachau doctor Kurt Plötner, for instance. My book *Victims and Survivors of Nazi Human Experiments* (Bloomsbury, 2014) draws on original findings from more than 15,000 prisoners’ narratives of coerced medical testing — including of mescaline — at Auschwitz and Dachau, but is not referenced. Nor does Ohler mention the victims of another notorious experiment. Seven British Royal Navy commandos endured experimentation with stimulants, including cocaine and amphetamines, at the Sachsenhausen concentration camp. After a forced, three-day march carrying heavy loads, five were executed in 1945. Ohler mentions only a German survivor.

But my key issue is with Ohler’s central claim that Pervitin and Eukodal induced a sense of invincibility, first enhancing operational boldness, then destroying the Nazis’ ability to engage with military collapse. He also concludes that addiction to ever-stronger doses of patent medicines clouded Hitler’s judgement on strategic issues concerning Dunkirk and Crimea. He reduces every twist and turn of the war on the German side to addiction. Yet the US and UK military used amphetamines as part of a highly successful scientific and technological war effort without apparent issues with addiction.

Ohler ends at what he dubs the “Last Exit Bunker”, with Hitler addicted to Eukodal. That title encapsulates my problem with *Blitzed*. It strings the reader along with facile phrases such as “High Hitler” and “One Reich, One Dealer”, calling the bunker-bound Führer a “super-junkie”. This is a text full of short cuts and speculation rather than a balanced synthesis of a mass of literature and sources to date, rendered readable and accessible. ■

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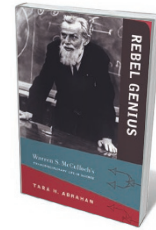
CYBERNETICS

# A mathematician of mind

**Manuel Blum** examines a biography of cybernetics pioneer Warren McCulloch and his revolutionary times.

In 1958, in my junior year at the Massachusetts Institute of Technology, Richard Schoenwald — whose tutorial on Sigmund Freud I was taking — encouraged me to meet the anti-Freud, Warren McCulloch. Where Freud had written *The Future of an Illusion* (1927), a critique of religion, McCulloch countered with *The Past of a Delusion* (1953), a reference to Freud (the title says it all). I dropped into McCulloch’s basement lab and found myself facing a tall, striking character: long beard, coarse Scottish wool suit, books piled to the ceiling. I confided that I wanted to understand how the brain works. He handed me a sheaf of his ‘Research Laboratory of Electronics’ publications. These showed how to construct neural networks of formal (model) neurons that could control for errors in those neurons. Weeks later, I stated and proved a theorem that his formal neurons could be configured to do what his networks needed. With that, I was in, mentored and inspired by McCulloch for the next six years and counting.

In *Rebel Genius*, science historian Tara Abraham offers a biography of McCulloch (1898–1969) that shines a light on the twentieth-century revolution in the mind sciences and cybernetics — the scientific study of automatic control in animals (including humans) and machines.



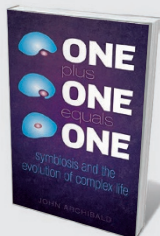
**Rebel Genius:** Warren S. McCulloch’s Transdisciplinary Life in Science  
TARA ABRAHAM  
MIT Press: 2016.

McCulloch insisted that the ‘magic’ of the brain lay in what electrical networks can do (nowadays, chemistry would count for more). He asserted that the magic would arise whether the networks were constructed from neurons, which he called software (later, meatware) or vacuum tubes, which he called hardware.

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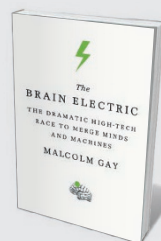
Like mathematician and computer scientist John von Neumann, McCulloch was interested in errors. Neurons, like vacuum tubes, were unreliable. The problem, he pointed out, was that neuronal thresholds, which affect what neurons compute, are constantly changing. “Thresholds fall when we drink coffee. They

rise when we drink alcohol. Yet we can still talk; we can still walk.” At least, he could. Computers were then, as now, designed to work with components that make virtually no errors. But at that time, a computer could run for only minutes before errors crept in. How the brain manages with ▶



**One Plus One Equals One**

*John Archibald* (Oxford Univ. Press, 2016)  
Exuberantly describing the greening of Earth 500 million years ago, John Archibald vivifies the origins of complex life. His microbiologist predecessors star, including Carl Woese, who first sequenced rRNA to track evolution (see Nancy Moran’s review: *Nature* **510**, 338–339; 2014).



**The Brain Electric**

*Malcolm Gay* (Farrar, Straus and Giroux, 2016)  
People enduring amputations, once subject to messy surgery, are now at the forefront of neuroprosthetics research. Malcolm Gay explains the science behind an evolving technology that binds brain impulse to exoskeletons, enabling people with paralysis to move.

▶ faulty neurons was a big question. (And as transistors drop to the size of atoms, errors again become a serious problem in computing.)

McCulloch held sway in a phenomenal period for many fields of science. His multitude of friends and colleagues included neuroscientist Jerry Lettvin, who would drop by to demonstrate one of Hermann von Helmholtz's extraordinary experiments on the eye. Artificial-intelligence pioneer Marvin Minsky showed McCulloch how to construct Venn diagrams of any number of variables (to represent neurons with many inputs). And Manuel Cerrillo convinced McCulloch that he was a genius at filter-design with a self-built hi-fi set that could separate musical instruments from the human voice in a recording.

McCulloch bubbled with ideas. In one co-written paper, 'A Logical Calculus of Ideas Immanent in Nervous Activity' (W. S. McCulloch and W. Pitts *Bull. Math. Biophys.* 5, 115–133; 1943), he argued that neurons must be capable of inhibition as well as excitation. If not, they would compute only a very small class of 'monotonic' functions. McCulloch told me that neurophysiologists of his time rejected this idea because inhibition had never been observed. His prediction — that inhibition exists in the brain — was later proved experimentally.

Abraham appraises the McCulloch I knew knowledgeable, accurately and insightfully. For example, she writes: "McCulloch's scientific life at its heart was less a philosophical project and much more about transcending disciplines, the power of science to do away with metaphysics, and the power of a neurophysiological, biological psychiatry to eliminate dualist accounts of the mind and non-biological practices in psychiatry." This is both perceptive and accurate.

There are also many aspects of McCulloch in Abraham's book that I did not know, a lot that I wanted to know and got, and a lot that I did not even know I wanted to know. For example, Abraham's account of psychologist



Clark Hull reveals Hull to be another enormously interesting individual — a proponent of behaviourism who worked in motivation and learning, and who thought that the problem of mind is solvable through scientific theory.

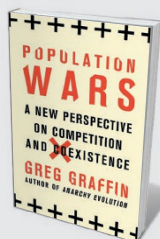
What Abraham does not capture enough of, for my taste, is the striking impression that McCulloch made on his audience — intellectually, through his astute observations, and visually, through his erudite Scottish bearing. Abraham describes a formative experience of McCulloch's: when he was "a student at Haverford College in Pennsylvania in 1917, a teacher asked him what he planned to do with his life". Her

version of the event is accurate, but misses the soul of it. What I recall McCulloch saying is that the president of Haverford, Quaker philosopher Rufus Jones, asked, "Warren, what wilt thee be?" to which McCulloch answered, "I don't know." "What wilt thee do?" "I don't know. But," McCulloch added, "I do have a question: 'What is a number that a man may know it, and a man that he may know a number?'" To which Jones rolled back his head and roared, "Thee wilt be busy for the rest of thy life!"

Not everything about McCulloch comes up roses, and Abraham is critical of certain aspects of his approach. She quotes neurophysiologist Ralph Gerard's critique on the Macy conferences on cybernetics — where McCulloch aimed to get psychologists, neurophysiologists, mathematicians and engineers talking. Gerard's words were very much a critique of McCulloch himself. He noted how the group began "in the 'as if' spirit. Everyone was delighted to express any idea that came into his mind, whether it seemed silly or certain or merely a stimulating guess that would affect someone else ... Then, rather sharply it seemed to me, we began to talk in an 'is' idiom. We were saying much the same things, but now saying them as if they were so."

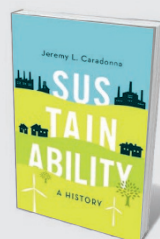
McCulloch was a polymath: a neurophysiologist who was also a physician, psychiatrist, poet, writer, architect, engineer and mathematician. His was the all-encompassing intellect that could and did bring these disparate fields together — both in the Macy meetings and in his lab. Through its discussions of McCulloch in the round, *Rebel Genius* is an excellent portrait of the man and his time, and a significant contribution to the history of science. ■

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### Population Wars: A New Perspective on Competition and Coexistence

Greg Graffin (Thomas Dunne, 2016)  
Zoologist, geologist and punk rocker Greg Graffin explores how an "us vs them" attitude has infiltrated human consciousness and driven populations to war, despite our unique power to plan our future by reflecting on the past.



### Sustainability: A History

Jeremy L. Caradonna (Oxford Univ. Press, 2016)  
Historian Jeremy Caradonna chronicles the arc of sustainability from its roots in eighteenth-century European forestry to contemporary local food and zero-waste movements, and its emphasis on balance and the long view over economic growth. [Emily Banham](#)