

► (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. ■

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## PHYSICS

# Stop all the clocks

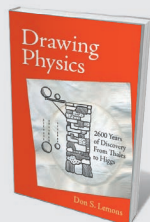
**Andrew Jaffe** probes Carlo Rovelli’s study arguing that physics deconstructs our sense of time.

**A**ccording 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.

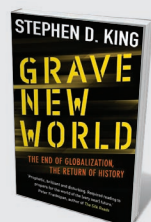
Rovelli is one of the creators and champions of loop quantum gravity theory, one of several ongoing attempts to marry quantum mechanics with general relativity. In contrast to the better-known string theory, loop quantum gravity does not attempt to be a ‘theory of everything’ out of which we can generate 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 book is split



**The Order of Time**  
CARLO ROVELLI  
Allen Lane (2018)

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.

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

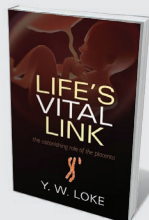
mathematician Alain Connes.

*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. ■

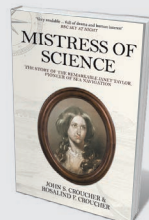
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### Life’s Vital Link: The Astonishing Role of the Placenta

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.