

they weren't observed, Einstein argued that they had independent reality, prompting his famous claim that "God does not play dice". Years later, he added a gloss: "What we call science has the sole purpose of determining what is." Suddenly, scientific realism — the idea that confirmed scientific theories roughly reflect reality — was at stake.

Quantum phenomena were phenomenally baffling to many. First was wave-particle duality, in which light can act as particles and particles such as electrons interfere like light waves. According to Bohr, a system behaves as a wave or a particle depending on context, but you cannot predict which it will do.

Second, Heisenberg showed that uncertainty, for instance about a particle's position and momentum, is hard-wired into physics. Third, Bohr argued that we could have only probabilistic knowledge of a system: in Schrödinger's thought experiment, a cat in a box is both dead and alive until it is seen. Fourth, particles can become entangled. For example, two particles might have opposite spins, no matter how far apart they are: if you measure one to be spin up, you instantly know that the other is spin down. (Einstein called this "spooky action at a distance".)

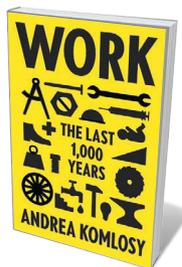
Becker explains how these observations challenge locality, causality and determinism. In the classical world of billiard balls, projectiles and apples falling from trees, they were never problems.

Sifting through the history, Becker shows how Bohr, as an anti-realist, brought to his side many rising physicists, including Heisenberg, Wolfgang Pauli and Max Born. Einstein, however, persistently argued that the Copenhagen interpretation was incomplete. He conjectured that there might be hidden variables or processes underlying quantum phenomena; or perhaps 'pilot waves', proposed by de Broglie, govern the behaviour of particles. In 1932, mathematician John von Neumann produced a proof that there could be no hidden variables in quantum mechanics. Although mathematically correct, it was revealed to be flawed decades later. But the damage had been done: the potentially viable alternatives conceived by Einstein and de Broglie remained relatively unexplored. The Copenhagen interpretation had taken hold by the 1930s, and textbooks today state that Bohr's view 'won'.

Thus, the Solvay Conference can be seen as a stand-off between two mathematically equivalent but fundamentally different paradigms: Bohr's instrumentalist view of quantum physics and Einstein's realist one. In science, a dominant paradigm determines which experiments are done, how they're interpreted and what kind of path a research programme follows.

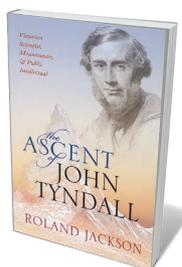
But what if a field picks the wrong paradigm? Becker shows how, in the 1950s and 1960s, a handful of physicists dusted off the ▶

Books in brief



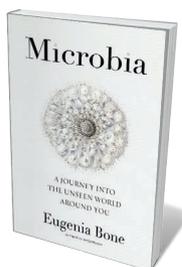
Work: The Last 1,000 Years

Andrea Komlosy, trans. Jacob K. Watson & Loren Balhorn VERSO (2018)
Employment outside the home became the globally dominant form of work only after 1900. Yet in policy and discourse, it has eclipsed older, more informal modes of production. Social historian Andrea Komlosy probes the joins between them in this sweeping chronicle, from 1250 — the dawn of globalization and urbanization — to today, when international corporations threaten labour standards. This is a book teeming with insights, from the contempt for manual labour in ancient Greece to the historical tendency for all kinds of subsistence tasks to be "housewife-ized" into unpaid domestic labour.



The Ascent of John Tyndall

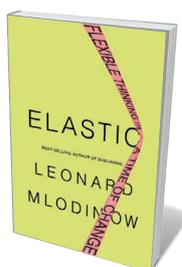
Roland Jackson OXFORD UNIVERSITY PRESS (2018)
A leading light in climate science, germ theory and magnetism, Victorian researcher John Tyndall seemed a man for all sciences. He discovered the greenhouse effect and why the sky is blue, and as a public intellectual, hobnobbed with physicists Michael Faraday and Hermann von Helmholtz, and poet Alfred Tennyson. This splendid monument of a biography by Roland Jackson tracks Tyndall's rise from rural Ireland to laboratorial glory days in Britain and Europe. The experimentalist's obscurity now, Jackson avers, may be down in part to his death in 1893: he just missed the era of relativity and the quantum.



Microbia

Eugenia Bone RODALE (2018)

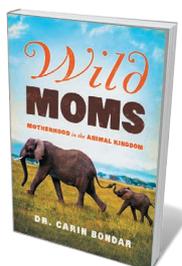
At the age of 55, journalist Eugenia Bone returned to university to take a microbiology course, reasoning that "humility is the entry point for studying nature". The microbial matrix of life came into focus. Bone's is an exquisitely observant, often amusing voyage from the origins of life to antibiotic resistance, punctuated by scientific revelations. (The compound geosmin, produced by *Streptomyces* bacteria, gives soil its sweet smell; bacteria nucleate rain; a quadrillion microbes pack part of a cow's stomach.) The devil's in the detail, Bone finds, but what enchants is the connectivity of this 'hidden' ocean.



Elastic: Flexible Thinking in a Constantly Changing World

Leonard Mlodinow PANTHEON (2018)

Physicist Leonard Mlodinow revels in the neuroscientific. Here he extends his explorations with an in-depth study of agile creative thinking in a hectic age. Among the psychological factors Mlodinow isolates are a yen for novelty, and the capacity to reconcile diverse ideas. He plunges deep into the human brain, marshalling compelling research both on brain basics and on outlier issues such as mental blocks. Perhaps most gripping is his take on the "default network" — the brain structures that govern richly creative activities such as daydreaming, the "dialogue we have with ourselves".



Wild Moms

Carin Bondar PEGASUS (2018)

Biologist and broadcaster Carin Bondar's tour of the vagaries of motherhood in the animal kingdom is a thrills-and-spills survey, from brood parasitism to cooperative breeding. The diversity of evolutionary solutions to maternity is mind-bending. We learn, for instance, how baby koalas ingest their mothers' faeces to inoculate their gut microbiomes, and that female gastric-brooding frogs vomited up their froglets. Ultimately, however, this is less a synthesized narrative than a biological litany. [Barbara Kiser](#)