mechanics, the world unfolds through a combination of two basic ingredients. One is a smooth, fully deterministic wave function: a mathematical expression that conveys information about a particle in the form of numerous possibilities for its location and characteristics. The second is something that realizes one of those possibilities and eliminates all the others. Opinions differ about how that happens, but it might be caused by observation of the wave function or by the wave function encountering some part of the classical world.

Many physicists accept this picture at face value in a conceptual kludge known as the Copenhagen interpretation, authored by Niels Bohr and Werner Heisenberg in the 1920s. But the Copenhagen approach is difficult to swallow for several reasons. Among them is the fact that the wave function is unobservable, the predictions are probabilistic and what makes the function collapse is mysterious.

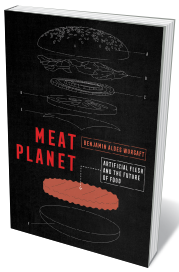
"Carroll argues that the many-worlds theory is the most straightforward approach to understanding quantum mechanics."

What are we to make of that collapsing wave? The equations work, but what the wave function 'is' is the key source of contention in interpreting quantum mechanics. Carroll outlines several alternatives to the Copenhagen interpretation, along with their advantages and disadvantages.

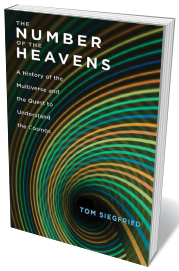
One option, the 'hidden variables' approach championed by Albert Einstein and David Bohm, among others, basically states that the wave function is just a temporary fix and that physicists will eventually replace it. Another tack, named quantum Bayesianism, or QBism, by Christopher Fuchs, regards the wave function as essentially subjective. Thus it is merely a guide to what we should believe about the outcome of measurements, rather than a name for a real feature of the subatomic world. Late in his life, Heisenberg proposed that we have to change our notion of reality itself. Reaching back to a concept developed by Aristotle — 'potency', as in an acorn's potential to become an oak tree, given the right context — he suggested that the wave function represents an "intermediate" level of reality.

Carroll argues that the many-worlds theory is the most straightforward approach to understanding quantum mechanics. It accepts the reality of the wave function. In fact, it says that there is one wave function, and only one, for the entire Universe. Further, it states that when an event happens in our world, the other possibilities contained in the wave function do not go away. Instead, new worlds are created, in which each possibility is a reality. The theory's sheer simplicity and logic within the conceptual ▶

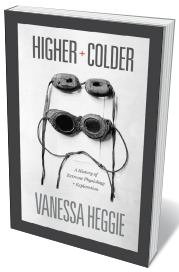
Books in brief



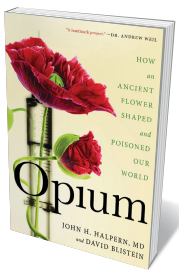
Meat Planet
Benjamin Aldes Wurgaft UNIVERSITY OF CALIFORNIA PRESS *(2019)*
In 2013, physiologist Mark Post wowed world media with a lab-grown burger, cultured from bovine muscle cells at a cost of nearly US$300,000. Yet that brave new food is still a fledgling biotechnology. Historian Benjamin Wurgaft explores this "small, strange world" in a thoughtful study mixing science reportage with philosophical meditations. He interviews Post, visits hotspots such as 'cellular agriculture' institute New Harvest in New York City, and even muses over the cultivation of human cells for consumption. *In vitro* meat, he shows, opens horizons as much moral as environmental.



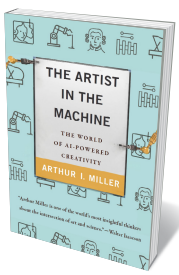
The Number of the Heavens
Tom Siegfried HARVARD UNIVERSITY PRESS *(2019)*
The philosopher Aristotle saw the idea of multiple worlds as illogical. In 1277, Étienne Tempier, bishop of Paris, countered by insisting that God could create any number of them. In this sparkling history, science journalist Tom Siegfried follows manifestations of the multiverse, from Renaissance scholar Nicholas of Cusa's worlds "without number" to the "different heavens" theorized by René Descartes, the discovery of galaxies, inflationary cosmology and a pick-and-mix of multiverses, be they 'quilted' or holographic. Whether you find the concept liberating or scientifically absurd, this is a mind-bending journey.



Higher and Colder
Vanessa Heggie UNIVERSITY OF CHICAGO PRESS *(2019)*
The North Pole, South Pole and 'third pole', Mount Everest, were prime twentieth-century expeditionary challenges. To physiologists such as Nello Pace and Kåre Rohdal, they were also labs for probing the physical impacts of extreme cold and altitude. But their scientific record, as medical historian Vanessa Heggie reveals in this insightful study, is overwhelmingly Eurocentric. The fieldwork sparked technological advances, but was tainted by racist 'science' and practice, from taking anthropometric measurements of Arctic peoples to erasing Nepalese Sherpas' contributions from papers.



Opium
John Halpern and David Blistein HACHETTE *(2019)*
Opium has been entwined with society for millennia. Here, psychiatrist John Halpern and writer David Blistein trace its path from Mesopotamia through ancient Egypt, Greece and Persia, finally reaching Britain and the United States by the nineteenth century. Both countries then fomented opium wars with China. By the twentieth century, US "drug hysteria and race-based enforcement" was rife, setting the stage for unwinnable drug wars. Now, the US opioid crisis is killing tens of thousands a year. It is time, the authors argue, to treat addiction as a curable illness — and learn the lessons of history.



The Artist in the Machine
Arthur I. Miller MIT PRESS *(2019)*
Can artificial intelligence (AI) attain the intellectual prowess of, say, astrophysicist Subrahmanyan Chandrasekhar? Arthur Miller probes that knotty question. Identifying seven hallmarks of creativity, he explores today's AI innovation landscape. Phillip Isola's app Pix2Pix 'translates' one image to another; Rebecca Fiebrink's Wekinator lets users make music with gestures; composer Eduardo Miranda plays duets with a slime-mould biocomputer. There are AI-scripted films, musicals, poetry — and, in Miller's view, many reasons to be cheerful about computational creativity, now and in the near future. **Barbara Kiser**