detectors to read from and write information to the vacuum of space-time? It is speculation piled upon speculation — breathless stuff.

Alexander writes that this "bizarre notion" could explain why the observed amount of dark energy in the Universe is nearly 120 orders of magnitude smaller than expected from theoretical considerations: maybe "the aliens used dark energy as a resource to run their ultimate computers in much the same way we devour oil to run our cars and jets". Why would they? To enjoy high-quality virtual reality, of course. Alexander's leaps of imagination follow the strong tradition of thought experiments in physics, but their import might be accessible only to cognoscenti.

Case studies in diversity

Along the way, Alexander wants to convince the reader that the lack of diversity in science diminishes the quality of the research accomplished, as well as being a social-justice concern. Two of his stories exemplify the issues. One is about James Gates, an African American theorist, whose work on supersymmetry (an extension to the standard model of particle physics) in the 1990s with Hitoshi Nishino got little attention. According to Alexander, similar work more than a decade later, called the ABJM theory (after the last names of the researchers who developed it: Ofer Aharony, Oren Bergman, Daniel Jafferis and Juan Maldacena), was hailed as a landmark result. Alexander challenges us to reflect on why few researchers (himself included) noticed Gates and Nishino's earlier work.

The other story is more personal. Alexander gives a harrowing account of being told by a white visiting colleague and friend that his fellow postdocs at Stanford University in California might be shunning him because "they feel that they had to work so hard to get to the top and you [Alexander] got in easily, through affirmative action". It goes without saying that they had no idea how hard Alexander had had to work, or what barriers he'd had to vault, to make it in physics, coming from a poor family growing up in the Bronx, New York City, in the 1980s.

Stung, and realizing that he had to showcase his strengths independently, Alexander began working alone in a café, without help from colleagues. Here, he honed the outside-the-box thinking that led to a paper (with his mentor Michael Peskin) providing a new theory for why there is much more matter than antimatter in the Universe (S. H. S. Alexander *et al. Phys. Rev. Lett.* **96**, 081301; 2006). His account offers powerful insight into the systemic forces that work against inclusion.

There's no doubt that physics has a diversity problem in the United States — one of the biggest in all the sciences. According to the American Institute of Physics, in 2012, Black or African Americans, who comprise about 13.4% of the US population, made up only 2.1% of physics faculty members. In 2018, members of the American Physical Society's inclusion team warned that although about one-third of university-age US citizens are African Americans, Hispanic Americans or Native Americans, less than 11% of bachelor's degrees in physics are awarded to people from these groups. The figure is just 7% for PhDs — around 60–70 students each year (see T. Hodapp and E. Brown *Nature* **557**, 629–632; 2018).

In addition to the impact of historical and structural racism on the gatekeeping of ideas, other sociological factors advantage some avenues of research over others. The community of string theorists is large and well funded and can out-compete other theories of quantum gravity, for instance — as is explored in books such as *The Trouble With Physics* (2006) by Lee Smolin. And many ideas are discarded simply because they are bad. *Fear of a Black Universe* might have been richer for a more searching look at the way these factors interact. Nevertheless, it's a timely reminder of the need to hear a wider variety of voices in physics, as in all the sciences.

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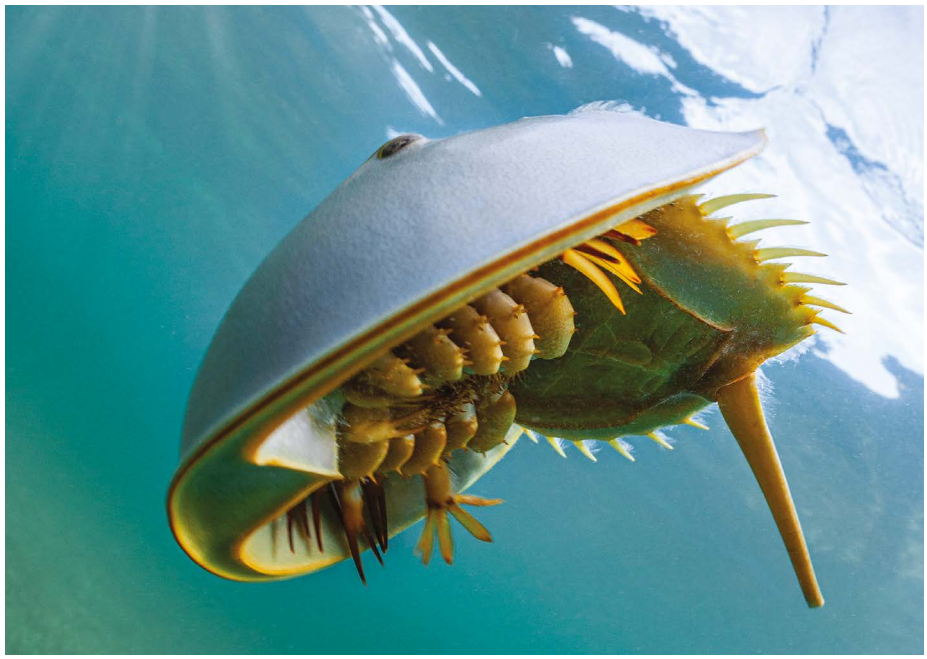

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Horseshoe crabs' blood is blue: their oxygen-transport protein is copper-based.

A meander around many circulatory systems

Of hearts, and other solutions to multicellular living. **By Henry Nicholls**

Rich in meaning and metaphor, the word 'heart' conjures up many images: a pump, courage, kindness, love, a suit in a deck of cards, a shape or the most important part of an object or matter. These days, it also brings to mind the global increase in heart attacks and cardiovascular damage that attends COVID-19. As a subject for a book, the heart is an organ with a lot going for it.

Enter zoologist Bill Schutt. His book *Pump* refuses to tie the heart off from the circulatory system, and instead uses it to explore how multicellular organisms have found various ways to solve the same fundamental challenge: satisfying the metabolic needs of cells that are beyond the reach of simple diffusion. He writes of the co-evolution of the circulatory and

respiratory systems: "They cooperate, they depend on each other, and they are basically useless by themselves."

At his best, Schutt guides us on a journey from the origin of the first contractile cells more than 500 million years ago to the emergence of vertebrates, not long afterwards. He takes in, for example, horseshoe crabs, their blood coloured blue by the presence of the copper-based oxygen-transport protein haemocyanin (equivalent to humans' iron-based haemoglobin).

We learn that insects, lacking a true heart, have a muscular dorsal vessel that bathes their tissues in blood-like haemolymph. Earthworms, too, are heartless but with a more complex arrangement of five pairs of contractile vessels. Squid and other cephalopods have three distinct hearts.

The are plenty of zoological nuggets to enjoy along the way. The tubular heart of a sea squirt, for instance, contains pacemaker-like cells that enable it to pump in one direction and then the other. Some creatures need masses of oxygen, others little, leading to more diversity. The plethodontids (a group of salamanders) have neither lungs nor gills, he explains: their relatively small oxygen requirements are met by diffusion through the skin.

Cardiac records

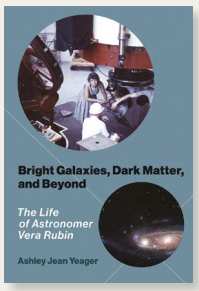
Hagfish can get by with the lowest recorded aortic pressure of any vertebrate, between 5.8 and 9.8 mm Hg. A giraffe's heart, by contrast, must generate extraordinary pressures – up to 280/180 mm Hg – to send blood up its 2-metre-long neck to its brain. Hummingbird hearts can reach an astonishing 1,260 beats per minute. Shrew hearts must work faster still, each cardiac cycle lasting just 43 milliseconds – a heart rate that must be "awful damn close" to the electrophysiological maximum.

Schutt refers to one of his own research interests, cold adaptation in bats: a physiological trick that sees the heart rate collapse from well over 500 beats per minute during flight to less than 20 beats per minute during hibernation. These metabolic extremes might help to explain why bats are a reservoir for so many viruses (A. T. Irving *et al*. *Nature* **589**, 363–370; 2021). However, *Pump* contains no reference to SARS-CoV-2 and the many ways – direct and indirect – in which this particular coronavirus seems to affect the cardiovascular system (M. Nishiga *et al*. *Nature Rev. Cardiol.* **17**, 543–558; 2020).

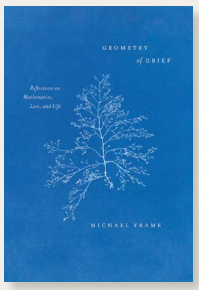
As Schutt works his way around the evolutionary tree, he is keen to stress that "there should be no bragging rights associated with the fact that some circulatory systems are quite complex while others are relatively simple. They key here is that all of them work." Rather than seeing humans as the

Books in brief

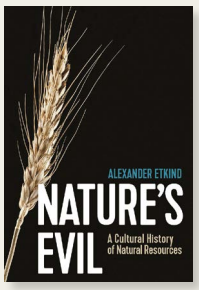
Silent Earth
Dave Goulson *Jonathan Cape* (2021)
Biologist Dave Goulson loves insects. As a child, he fed yellow-and-black caterpillars and watched them become cinnabar moths. As an adult, he showed how bumblebees avoid wasting time on a flower visited by another bee — by sniffing it for the fresh whiff of smelly feet. They also detect a decrease in the electrostatic charge on its pollen. Bees are "the intellectual giants of the insect world", he writes enchantingly, while pondering an alarming estimated 75% decline in global insect populations over half a century.



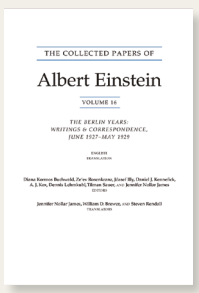
Bright Galaxies, Dark Matter, and Beyond
Ashley Jean Yeager *MIT Press* (2021)
'More matter than meets the eye' is a chapter title of this insightful biography of the pioneering astronomer Vera Rubin by science journalist Ashley Yeager, who interviewed her in later life. Best known for her observations of galactic rotation rates, which provided evidence for the existence of dark matter, Rubin also campaigned for equality in science. Her many honours did not include a Nobel prize, but a new observatory in Chile bears her name and this is the second biography of her in a year (see A. Abbott *Nature* **591**, 523–524; 2021).



Geometry of Grief
Michael Frame *Univ. Chicago Press* (2021)
This brief, intriguing personal meditation is inspired by mathematician Michael Frame's lifelong love of geometry — including 20 years' collaboration with fractal geometer Benoit Mandelbrot — and the childhood loss of his aunt, who set him on his career path. He writes: "Grief informs geometry and geometry informs grief." How so? His epiphany on first understanding any beautiful mathematical idea is always tinged with sadness, because it is unrepeatable. With quirky illustrations, he integrates the lives of his Mom and Dad.



Nature's Evil
Alexander Etkind *Polity* (2021)
In detailed chapters on grain, animal products, sugar, hemp, metals, peat, coal and oil, historian Alexander Etkind explores how nature and its commodification has shaped states and societies, as the pursuit of power and wealth has degraded people and despoiled the planet. His Eurocentric survey weaves together material, intellectual, economic, ecological and moral history to reflect on "the mess we have made of our world". To predict the outcomes of our choices, he argues, it pays to know the consequences of choices that people made in the past.



The Collected Papers of Albert Einstein, Volume 16
Eds Diana Kormos Buchwald *et al*. *Princeton Univ. Press* (2021)
Albert Einstein's collected papers began publication in 1987. The 16th of these uniquely comprehensive volumes covers 1927–29, up to Einstein's 50th birthday, when he hid from acclaim. It includes the 1927 Solvay Conference on quantum mechanics, where he sparred with Niels Bohr but scribbled a note: "Who knows who'll be laughing in a few years?" He also engaged further in politics, dubbing himself an anti-fascist, and hired assistant Helen Dukas, who preserved his letters post-mortem, creating his vast archive. **Andrew Robinson**

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A shrew's heartbeat lasts for just 43 milliseconds.

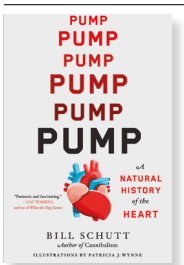
highest peak on the evolutionary landscape, as writers might have in previous centuries, he celebrates the functional equivalence of non-human circulatory systems, successful arrangements that have propelled their owners to other summits. Many of these peculiar anatomies are brought to life in beautiful line drawings by award-winning illustrator Patricia Wynne.

Conversation piece

Schutt's try-hard tone will not be for everyone. "Hey, guys, don't take this the wrong way," he writes as part of a dialogue with organisms (such as flatworms) that have no "circulatory-system junk". "We interrupt this chapter …" he announces, to suggest that anyone without a carbon monoxide detector should "go purchase one. I'll wait." Perhaps the most surprising sentence to have made the cut, despite what Schutt acknowledges as "significant and outstanding editorial input", comes after one of many digressions: "For some reason, I thought this information was worth including here."

As Schutt turns from comparative anatomy to historical interpretations of the heart, and then to more recent milestones in cardiovascular medicine, the off-piste jaunt loses its way. From the ancient Egyptian belief that the heart held a record of a person's good and bad deeds to the use of stem cells and 3D printers to build new organs, there is a lot of ground to cover. Highlights include the contributions of thirteenth-century Syrian polymath Ibn al-Nafis, along with Spanish theologian Michael Servetus and Italian anatomist Matteo Realdo Colombo in the sixteenth century, to our understanding of the true relationship between the heart and lungs. The English physician William Harvey (1578–1657) is most commonly associated with this discovery.

"Epidemiology, electrophysiology, bypass surgery and stents have transformed the diagnosis and treatment of cardiovascular disease."



Pump: A Natural History of the Heart
Bill Schutt
Algonquin (2021)

Priority shift

Other choices are puzzling. A chapter dedicated to Charles Darwin's long illness after his voyage on *The Beagle* is a case in point. Although the mystery involves the naturalist's heart and is undeniably interesting, why give this space while a landmark in cardiovascular medicine such as the invention of the heart–lung machine is barely mentioned? Schutt gives scant attention, either, to how epidemiology, electrocardiography, bypass surgery and stents have transformed the diagnosis and treatment of cardiovascular disease. All have contributed to a dramatic decline in cardiovascular mortality by around 60% over the past 50 years. As for the legacy of the damage wrought to hearts – in every sense – by the COVID-19 pandemic? That's a book that needs to be written.

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