

includes not just one correct answer, but all other possibilities.

In a medical experiment, the null hypothesis might be that a new drug has no effect. But the hypothesis will come packaged in a statistical model that assumes that there is zero systematic error. This is not necessarily true: errors can arise even in a randomized, blinded study, for example if some participants work out which treatment group they have been assigned to. This can lead to rejection of the null hypothesis even when the new drug has no effect — as can other complexities, such as unmodelled measurement error.

To say that  $P = 0.05$  should lead to acceptance of the alternative hypothesis is tempting — a few million scientists do it every year. But it is wrong, and has led to replication crises in many areas of the social, behavioural and biological sciences.

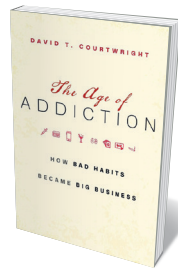
Statistics — to paraphrase Homer Simpson's thoughts on alcohol — is the cause of, and solution to, all of science's problems. Many difficulties have been associated with the misuse of statistics to make inappropriately strong claims from noisy data, but I don't think that the solution is to abandon formal statistics. Variation and uncertainty are inherent in modern science. Rather, we need to go deeper in our statistical modelling. For example, in polling, we accept that we cannot get clean randomized or representative sampling, so we gather the data necessary to adjust our sample to match the population.

As I recall the baseball analyst Bill James writing somewhere, the alternative to good statistics is not no statistics: it's bad statistics. We must design our surveys, our clinical trials and our meteorological studies with an eye to eliminating potential biases, and we must adjust the resulting data to make up the biases that remain. If we do not, people can take the numbers that are available and draw all sorts of misleading conclusions. One thing I like about Stewart's book is that he faces some of these challenges directly.

In a sense, the answer to Stewart's question, "Do dice play god?", is yes. Probability is an unreasonably effective mathematical model for uncertainty in so many areas of life. I believe that a key future development in the science of uncertainty will be tools to ensure that the adjustments we need to make to data are more transparent and easily understood. And we will develop this understanding, in part, through mathematical and historical examples of the sort discussed in this stimulating book. ■

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## Books in brief



### The Age of Addiction

David T. Courtwright BELKNAP (2019)

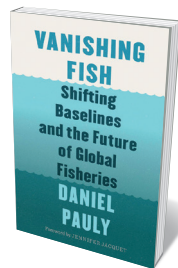
Opioids, processed foods, social-media apps: we navigate an addictive environment rife with products that target neural pathways involved in emotion and appetite. In this incisive medical history, David Courtwright traces the evolution of "limbic capitalism" from prehistory. Meshing psychology, culture, socio-economics and urbanization, it's a story deeply entangled in slavery, corruption and profiteering. Although reform has proved complex, Courtwright posits a solution: an alliance of progressives and traditionalists aimed at combating excess through policy, taxation and public education.



### Cosmological Koans

Anthony Aguirre W. W. NORTON (2019)

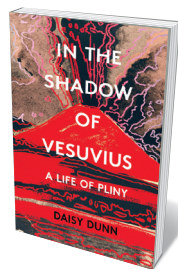
Cosmologist Anthony Aguirre explores the nature of the physical Universe through an intriguing medium — the koan, that paradoxical riddle of Zen Buddhist teaching. Aguirre uses the approach playfully, to explore the "strange hinterland" between the realities of cosmic structure and our individual perception of them. But whereas his discussions of time, space, motion, forces and the quantum are eloquent, the addition of a second framing device — a fictional journey from Enlightenment Italy to China — often obscures rather than clarifies these chewy cosmological concepts and theories.



### Vanishing Fish

Daniel Pauly GREYSTONE (2019)

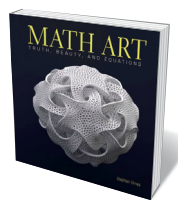
In 1995, marine biologist Daniel Pauly coined the term 'shifting baselines' to describe perceptions of environmental degradation: what is viewed as pristine today would strike our ancestors as damaged. In these trenchant essays, Pauly trains that lens on fisheries, revealing a global 'aquacalypse'. A "toxic triad" of under-reported catches, overfishing and deflected blame drives the crisis, he argues, complicated by issues such as the fishmeal industry, which absorbs a quarter of the global catch. If current subsidies were redirected to sustainable ends, he avers, the worst outcomes might be avoided.



### In the Shadow of Vesuvius

Daisy Dunn WILLIAM COLLINS (2019)

On 24 August in AD 79, the Roman aristocrat Pliny the Younger witnessed a "cloud, both strange and enormous in appearance" above the Bay of Naples. The eruption of Vesuvius engulfed cities, including Pompeii, and killed his uncle, the renowned admiral and natural historian Pliny the Elder. Daisy Dunn's nuanced biography breathes new life into the younger Pliny, revealing his uncle's scientific and philosophical influence on his own evolution into poet, magistrate, senator, curator of drains and prolific letter writer. An evocative portrait of Renaissance men before the Renaissance.



### Math Art

Stephen Ornes STERLING (2019)

The elusive elegance of mathematics might seem inaccessible to those who don't speak the language — but some artists brilliantly bridge the gap. And in this visually sumptuous, intellectually compelling study, science writer Stephen Ornes has tapped that community for a virtual maths-art gallery. Here are *Self-Similar Surface* by Robert Fathauer, a ruffled homage to rotational and mirror symmetry; Anita Chowdry's sculptural 'steampunk' harmonograph, *Iron Genie*; the glowing fractal 'portrait' *Buddhabrot* by Melinda Green — and much more. Mathematics made manifest, and beautifully. [Barbara Kiser](#)