

speculates that these protocells could evolve. Thus, each new biological innovation begets a new functional niche fostering yet more innovation. You cannot predict what will exist, he argues, because the function of everything biology generates will depend on what came before, and what other things exist now, with an ever-expanding set of what is possible next.

Because of this, Kauffman provocatively concludes, there is no mathematical law that could describe the evolving diversity and abundance of life in the biosphere. He writes: “we do not know the relevant variables prior to their emergence in evolution.” At best, he

**“The function of everything biology generates will depend on what came before.”**

distribution of extinctions. Life’s emergence might rest on the foundations of physics, “but it is not derivable from them,” Kauffman argues.

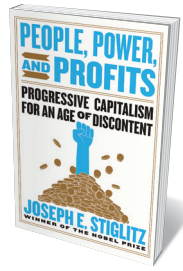
If biology cannot be reduced to physics, however, is it “beyond physics”, as Kauffman claims? This is an interesting time to work on life’s origins: there is intensive debate in the field about whether current physics is adequate, or whether new principles are necessary. Will a deep understanding of life ultimately come from comprehending how form and function arise from flows of information? Will life be understood only as a planetary-scale process, fundamentally linked to exoplanet sciences? Or will merging theory and experiment lead to new approaches to creating artificial life? Those approaches are being developed as an international effort, which coalesced in the 2015 conference Re-Conceptualizing the Origins of Life, drawing researchers from institutions including the Santa Fe Institute in New Mexico, the Earth-Life Science Institute at the Tokyo Institute of Technology and Arizona State University in Tempe.

#### WITHIN, NOT BEYOND

I agree with Kauffman that life cannot be explained by our current laws of physics, but dispute his argument that the explanation is ‘beyond’ physics. The distinction might be semantic, but it is important.

Physics has already grown far beyond simply describing aspects of reality, such as the very big (astronomy, cosmology), the very small (quantum systems, particle physics) or the human-sized (mechanics, as studied by Galileo Galilei and Isaac Newton). Interesting work is emerging from the study of complexity in areas such as economics, electronics, climate physics, the science of societies and non-equilibrium thermodynamics. ▶

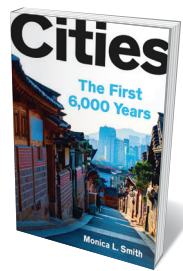
## Books in brief



#### People, Power, and Profits

Joseph E. Stiglitz W. W. NORTON (2019)

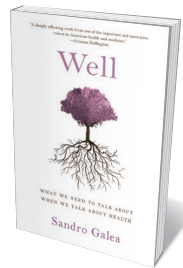
The US economy is in thrall to corporate monopoly, inequality and slow growth — so argues Nobel-prizewinning economist Joseph Stiglitz in this powerful, grounded analysis. Excoriating supply-side “voodoo economics”, Stiglitz proposes a progressive agenda echoing those of presidents Theodore and Franklin Delano Roosevelt. This aims to build shared prosperity by managing globalization, supporting basic research and reforming taxation and the judiciary. A country’s might, he reminds us, lies in scientific advance, education, the rule of law — and the “countervailing power” of the voting booth.



#### Cities: The First 6,000 Years

Monica L. Smith VIKING (2019)

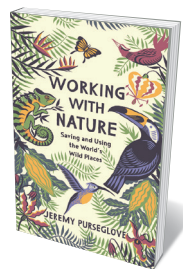
Seedbeds of civilization and economic nodes, cities have thrummed with enterprise and wallowed in waste from the start, some 6,000 years ago. Archaeologist Monica Smith examines the evolution of urbanization through the lens of her field, showing the remarkable persistence of material and social norms — takeaway shops, upward mobility, crime and more. From digs such as Tell Brak in Syria and India’s Sisupalgarh, Smith’s journey explores methodologies and advances including magnetic gradiometry, but is at heart a revelation of the drive and creative flux of the metropolis over time.



#### Well

Sandro Galea OXFORD UNIVERSITY PRESS (2019)

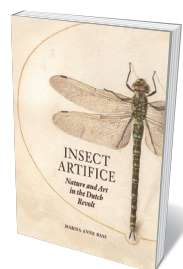
US citizens top world spending on health, yet have shorter ‘healthspans’ than people in other rich countries. Why? Cogently and often movingly, epidemiologist Sandro Galea argues that an obsession with drugs, doctors and insurance obscures the fact that the roots of sickness and health are life circumstances: money, status, education, environment and a range of other socio-economic issues. With the richest 1% living for up to 15 years longer than the poorest 1%, investment in public goods such as education, universal health coverage and environmental regulation is ever more urgent.



#### Working With Nature

Jeremy Purseglove PROFILE (2019)

As a ‘broker for nature conservation’, Jeremy Purseglove has worked with developers in China, Ghana, Papua New Guinea, Tajikistan and beyond to ensure that engineering projects do not encroach on biodiversity. His compelling account, glinting with highlights from a nomadic life, is packed with case studies — whether successes such as integrated rice and fish cultivation in Bangladesh, or more sobering stories such as the agricultural enclosure sweeping Africa and the ongoing struggle to rejuvenate Central Asia’s Aral Sea. A trove of experiential insight into on-the-ground sustainability.



#### Insect Artifice

Marisa Anne Bass PRINCETON UNIVERSITY PRESS (2019)

One of the most arresting natural-history works of the sixteenth century is a compendium of known animals depicted in exquisite miniature paintings. *Four Elements*, by Dutch merchant and artist Joris Hoefnagel, is a “stunning and eccentric assemblage” of knowledge, notes art historian Marisa Anne Bass. Her study beds the manuscripts in early-modern empiricism, and beautifully complements the plates — a jewel box of exquisitely rendered sunfish, chameleons, bees, an Indian elephant and more. [Barbara Kiser](#)