

► distributed quantum-computing technology.

Sophia, now an intern at a foundation created after Dodge's death, launches the brain simulation. That, in turn, gives birth to a new digital universe that expands in ways no one could have predicted.

As its god, Dodge recreates himself out of the nothingness of the digital void before building a virtual cosmos (as a video-game designer, he knows the ropes). Others join him as they die and are scanned, leaving "Meatspace" (the world of the living) behind. There are twists and turns, and many mythic tales and conflicts are re-enacted.

Much of the focus remains on Meatspace and the challenges faced by those left behind to maintain and understand the workings of the digital heaven they've created. This is one of the most interesting aspects of *Fall*. Their tools for seeing into it are imperfect, monitoring the communication between the various sub-processes distributed across a network of computing platforms (yes, Heaven is in the Cloud). Ultimately, they become obsessed with Dodge's constructed reality and it becomes a kind of *Truman Show*, where you can join the cast if you're rich enough to be scanned and are willing to die.

Fall is a doorstop. At almost 900 pages, Stephenson takes his time in laying out the story. It's a mash-up of fantasy and sci-fi, with some flavour of J. R. R. Tolkien and William Gibson, and the author is not afraid to go off on tangents that don't advance his tale.

Yet I got the impression that Stephenson, who has moonlighted for tech start-ups such as Blue Origin in Kent, Washington, and the Florida-based Magic Leap, doesn't really care what we think. Writing is an act of exploration and creation, a journey to a new world. That someone will later read what was written is arguably irrelevant; the dead in *Fall*, after all, live out their second lives in the digital realm unconcerned about observers, having left that inferior world behind.

Like Dodge, Stephenson is creating a new universe from scratch, fighting battles and wrestling with big ideas. Those of us in Meatspace can only sit mutely by and watch the spectacle in wonder. ■

Paul McEuen is a physicist at Cornell University in Ithaca, New York, and director of the Kavli Institute at Cornell for Nanoscale Science. His novel *Spiral* won debut of the year from the International Thriller Writers Association. He's hard at work on his next novel, *The Long Echo*. e-mail: plm23@cornell.edu



Kelp, a type of brown alga, growing off the coast of California.

PHYCOLOGY

A brief history of slime

Christopher Howe delights in a new book on the planet's most powerful organisms — algae.

It rankles when I hear a distinguished molecular biologist declare that this gene or that 'is conserved throughout eukaryotes, from yeast to humans'. Yeast and humans (plus nematodes, zebrafish and many other organisms) are not representative of all eukaryotes, which have nuclei and membrane-bound organelles in their cells. They belong to one rather restricted evolutionary group, the Opisthokonta (see S. M. Adl *et al.* *J. Eukaryot. Microbiol.* **66**, 4–119; 2019), and account for a tiny fraction of global biomass (see Y. M. Bar-On *et al.* *Proc. Natl Acad. Sci. USA* **115**, 6506–6511; 2018).

So it is a real pleasure to see *Slime* (sold as *Bloom* in some territories), a book devoted to algae: the often-neglected eukaryotes and prokaryotes (organisms without nuclei or discrete organelles) that are of immense biological importance, yet only distantly related to yeast and humans.

Science writer Ruth Kassinger, who specializes in botany, covers the entire range of algae. They include blue-green algae (the oxygen-producing, photosynthetic cyanobacteria), red and green algae (close relatives of land

plants), and distantly related groups such as diatoms, coccolithophores (responsible for chalk deposits such as the White Cliffs of Dover), dinoflagellates and kelp. Kassinger rightly describes algae as "the most powerful organisms on the planet" — not least for the amount of carbon dioxide they 'fix', or turn into organic matter. She sets out to educate us on their importance and compelling interest.

Slime has four parts. One concerns evolution, including how algae determined the growth of Earth's atmosphere. The second is on algae as food. The third covers cultivation for uses from sports shoes to fuel. And the last looks at human impacts, from coral bleaching to eutrophication, and how algae might redress the effects. There is also a fascinating appendix of recipes using algae. (I'm eagerly awaiting delivery of 'Irish moss', the red alga *Chondrus crispus*, to make blancmange.)

The smallest algae are single-celled prokaryotes less than a micrometre across, such as the oceanic *Prochlorococcus*, a major player in CO₂ fixation. Others range from unicellular eukaryotes to multicellular seaweeds many metres long. They grow in environments from polar snow to hot springs.

Some have lost the ability to photosynthesize and now live as parasites. The most notorious is *Plasmodium*, arguably the most dangerous alga in the world, which retains a remnant, non-photosynthetic chloroplast and is the cause of malaria.

In spite of having studied algae for more than 30 years, I learnt much from *Slime*. I



Slime: How Algae Created Us, Plague Us, and Just Might Save Us
RUTH KASSINGER
Houghton Mifflin Harcourt (2019)

DOUGLAS KLUG/GETTY

knew of the distinguished British phycologist Kathleen Drew-Baker, who 70 years ago discovered the life cycle of *Porphyra*, an alga used to make the dietary staple nori in Japan. But I didn't know that her work solved the mystery of why the nori harvest frequently failed in the years after the Second World War (all to do with typhoons and exploding mines); nor that there is a monument to her in Japan, where prayers are said every year on her birthday to honour her memory.

And I hadn't really thought about who gave nineteenth-century microbiologist Robert Koch the idea of using agar, derived from a red alga, as a growth medium for bacteria. (Attempts to use gelatine failed because it melted at the temperatures needed for cultures.) It turns out to have been Angelina Fannie Hesse, lab assistant to, and wife of, Koch's collaborator Walther Hesse. A recipe from friends in Asia for agar-based jams and jellies that didn't melt in hot summers inspired her to suggest agar to solidify growth media. As Kassinger says, it seems unfair that Koch's assistant Julius Petri is famous the world over for his eponymous dish, but that Fannie Hesse is rarely remembered for its contents.

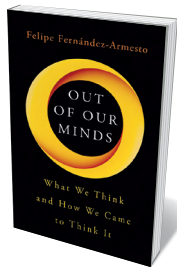
Slime is far from being a collection of interesting historical anecdotes, however. Contemporary topics are also covered, in a clear and balanced way. These include the (over) excitement associated with algal biofuels, the looming disaster that is coral bleaching (when coral cells turn white after losing their symbiotic dinoflagellate algae, probably because of rising temperatures), and attempts to preserve corals by growing them in nurseries.

I was distracted by the frequent description of the features of the people Kassinger met (“tall, slender, and white-haired”; “with a round bald head and a linebacker’s physique”; or even like a saxophonist in a jazz club). And she tends to focus on US-based entrepreneurs, despite the wealth of work elsewhere. But these are small quibbles set against what the book achieves in communicating the beauty (there are some very attractive drawings), interest and importance of algae.

Some years ago, a friend who was president of the British Phycological Society — phycology being the study of algae — declared his goal to raise the profile of algae, so that anyone searching for the society’s name online was not asked ‘Did you mean British Psychological Society?’. Kassinger’s compelling book should help hugely. There is something for everyone, from committed phycologists to people who hitherto (but hopefully no longer) regarded algae as an inconvenience or worse. Blanket weed may never seem the same again. ■

Christopher Howe is professor of plant and microbial biochemistry in the Department of Biochemistry at the University of Cambridge, UK.
e-mail: ch26@cam.ac.uk

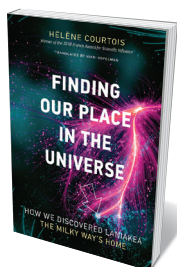
Books in brief



Out of Our Minds

Felipe Fernandez-Armesto ONEWORLD (2019)

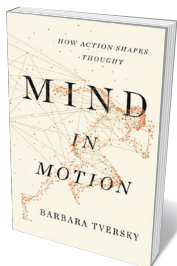
“The history of ideas is patched with crazy paving,” writes historian Felipe Fernandez-Armesto in this big, bold homage to the human imagination in all its warped and fiercely inspired glory. Beginning with cognitive science, his global survey sweeps through leaps of thought from prehistory to today — a journey from unification to uncertainty, lit by minds such as China’s fourth-century-BC master of paradox Hui Shi and paradigm-smashing mathematician Henri Poincaré. Today, Fernandez-Armesto argues, the trend is shifting as our homogenized ‘global culture’ threatens the very exchanges that spark heroic ideas.



Finding Our Place in the Universe

Hélène Courtois (transl. Nikki Kopelman) MIT PRESS (2019)

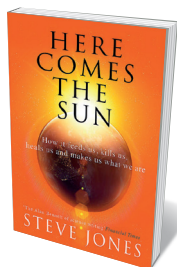
On 3 September 2014, Earth got a new ‘cosmic address’. Laniakea (Hawaiian for ‘immense heaven’) is a gargantuan supercluster folding in more than one million galaxies along with our own. This English-language edition of the award-winning primer by astrophysicist Hélène Courtois, a member of the team that described Laniakea, interweaves cosmographical challenges with backstory (and groundbreakers such as Vera Rubin) and engaging glimpses of Courtois’ own career. She nods, too, to post-Laniakea finds such as the cosmic velocity web. A luminous behind-the-scenes record of a two-decade astrophysical feat.



Mind in Motion

Barbara Tversky BASIC (2019)

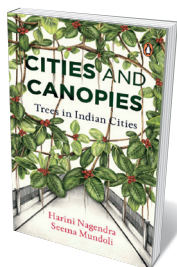
Is thinking language-based and ‘all in the head’, or do our physical actions shape it? Cognitive psychologist Barbara Tversky makes a clear case for the latter in this fascinating, many-faceted, research-based study. Moving from the ‘world in the mind’ to the ‘mind in the world’, Tversky explores myriad aspects of embodied cognition and spatial thinking: how we experience the ‘bubble around us’, express thought through gesture, perceive ideas as concrete realities in the mind’s eye and represent aspects of the world (space, time, causality) through objects as varied as sundials and diagrams.



Here Comes the Sun

Steve Jones LITTLE, BROWN (2019)

With wry wit and real clarity, geneticist Steve Jones examines the Sun and our relationship to it. It’s a nimble narrative, from the physics of the “hydrogen bomb in the sky” to its impact on the biosphere, water cycle, food chain, human health and climate change. Jones braids in gripping storylines — on conditions linked to lack of sunlight (such as the bone disease rickets) and the interplay between night, day and sleep — and many throwaway gems, from primates urinating on themselves to stay cool, to the boiling-porridge turbulence of convection on the solar surface.



Cities and Canopies

Harini Nagendra and Seema Mundoli PENGUIN INDIA (2019)

Urban ecologists Harini Nagendra and Seema Mundoli turn tour guides to the sentinels of India’s cities — the street, park and garden trees thronging Bengaluru, Chennai and Mumbai. Meshing science with cultural history, they explore species such as the majestic ‘shaggy-headed’ banyan (*Ficus benghalensis*) and golden-blossomed amaltas (*Cassia fistula*), and delve into arboreal eco-services such as passive cooling and carbon sequestration. With thousands of trees being felled in New Delhi, this is a key reminder of what the urban canopy does for the environment and for us. [Barbara Kiser](#)