

Books & arts



A male bowerbird creates an intricate arrangement of found objects to attract a mate.

A tour of the evolution of minds

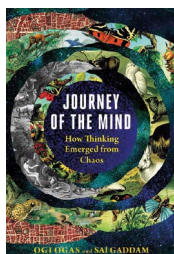
An informative guide takes in archaea, birds, primates and more – overconfidently. **By Philip Ball**

Look through a microscope at a macrophage cell pursuing, engulfing and consuming a bacterium, and it is hard not to impose a narrative: one is trying to catch the other, which is in turn trying to escape. In *Journey of the Mind*, neuroscientists Ogi Ogas and Sai Gaddam imply that this interpretation is not fanciful. They argue that minds of a sort have existed since the first archaea colonized the planet, billions of years ago.

Ogas and Gaddam's tour of the evolution of minds starts with the first cells on Earth and continues from flatworms to insects, reptiles and mammals. Along the way, biological brains amass sophisticated functions and capabilities, from navigation to memory, pattern recognition and sociality. The story

doesn't end with humans: the authors argue that civilizations represent a kind of collective super-mind, augmented with wholly artificial AI minds. The narrative is enjoyable and illuminating, but it is flawed by a failure to separate fact from speculation.

The book offers an admirable survey of how minds might comprise modules that control



**Journey of the Mind:
How Thinking Emerged
from Chaos**

Ogi Ogas and Sai
Gaddam
W. W. Norton & Company
(2022)

simple operations, which are combined to solve complex problems of survival. For instance, a bacterium can move towards food sources thanks to motor systems that switch between directional swimming and random tumbling, depending on how it senses nutrient concentrations changing in its environment. In this way, a spatial problem acquires a temporal solution – how does the situation now compare with a moment ago? – and the microbe acquires a memory of sorts.

A rat finding food in a maze breaks down a visual scene into component features of edges, foreground and so on. And there's more: the rat mind holds a complex internal representation of the world against which to compare sensory input; it is constantly checking this inner map. The authors lean here towards the 'free-energy minimization' model proposed by neuroscientist Karl Friston and others, in which organisms strive to shrink the mismatch between expectation and experience.

Ogas and Gaddam take a very broad view of mind as "a physical system that converts sensations into action". At face value, this grants a mind to thermostats and robots as much as to living entities. "A mind responds. A mind transforms. A mind acts," they write. But the same is true of many machines. What, then, distinguishes a mind? If it's sentience or awareness, the authors give a confusing picture. They say the "self-awareness" of an amoeba is "piddling" – and later seem to deny this quality to all organisms except vertebrates.

Many assertions go beyond the facts. The discussion of consciousness rests on the belief that the problem has been solved by cognitive scientist Stephen Grossberg (whom the authors thank for "guidance and support"). Since the late 1960s, Grossberg has developed the idea that consciousness arises from 'resonance' between specific modules of the brain. Ogas and Gaddam are vague about what resonance means here, beyond saying that the modules amplify and prolong each other's outputs, and they give the reader little indication of what empirical evidence exists to support the idea. Grossberg's theory is provocative and stimulating, but, couched in the abstract mathematical framework of dynamical systems theory, it remains contingent on his supposition that "all conscious states are resonant states". I'm not convinced it amounts to the revolution that the authors assert.

There are many other proposals for what consciousness is and how it arises. Better-known is global workspace theory, championed in the past three decades by Bernard Baars, Stanislas Dehaene and others.

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They present consciousness as a phenomenon of information exchange in the brain, positing that awareness simply ‘ignites’ once certain criteria in the interaction of brain circuits are satisfied. Their corollary is that this would apply to any information-processing circuits with the correct architecture. Others, including neuroscientist Anil Seth, suspect that consciousness might be supported by only certain kinds of entities – as far as we know right now, ones that are alive. Ogas and Gaddam jump the gun, in my view, when they suggest that Grossberg has all the answers.

There are other instances in which they present contentious ideas with certainty. For all of the minds they discuss, much remains open. They write that birds didn’t develop language “because they don’t have hands”, but in fact it’s still debated whether gestures helped lead to the origin of language. They state that insects have no consciousness, when there is good reason to suppose that bees, at least, have many of the mental attributes associated with consciousness, such as foresight and the ability to imagine. Even bacteria are not the simple automata portrayed here; other researchers describe bacterial behaviours in the language of cognition.

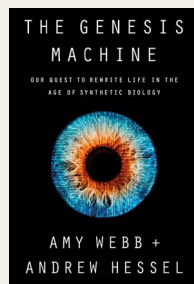
The structure of a progression from the seemingly simple minds of bacteria and amoebas to the complex ones of primates makes narrative sense, but recalls the outdated image of evolution with humans at the apex. Our minds do excel in certain respects, most obviously in developing language and complex culture – but in dexterity, vision, navigation and more, other species eclipse us. There is more than a hint that evolution is striving to a particular end in Ogas and Gaddam’s suggestion that, once early single-celled organisms acquired the ability to sense and move, “the royal road to consciousness beckoned”.

The authors deploy some unedifying metaphors to tell their tale. One is the story of the nineteenth-century US anti-slavery campaigner Frederick Douglass, offered (I think) in an attempt to illustrate the social construction of the self. And they trivialize a pivotal social moment when they compare the mind’s attentive focus to the media presentation of the murder of George Floyd in Minneapolis in 2020.

There is plenty to like in *Journey of the Mind*. It is so often informative and entertaining that it feels mean to cavil. But the book exemplifies a persistent problem in popular science, in which pet theories are presented with too much confidence and too little context. Readers deserve the full picture – less definitive and satisfying, perhaps, but ultimately more honest and illuminating.

Philip Ball is a writer based in London. His next science book is *The Book Of Minds* (Picador). e-mail: p.ball@btinternet.com

Books in brief



The Genesis Machine

Amy Webb & Andrew Hessel *PublicAffairs* (2022)

Two moving stories bracket this fascinating survey of the present and future of biotechnology. Futurist Amy Webb and synthetic biologist Andrew Hessel describe their attempts to bypass personal fertility struggles by using cutting-edge technologies. Very soon, they argue, such difficulties could be obsolete, thanks to a “genesis machine” of people, labs, computer systems, government agencies and businesses that are “creating new interpretations, as well as new forms, of life” – along with unprecedented ethical, legal and political dilemmas.

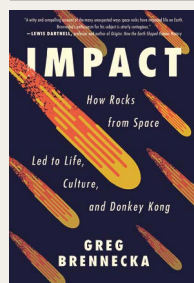
Seven Games



Seven Games

Oliver Roeder *Norton* (2022)

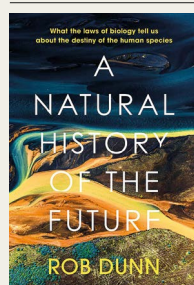
In a cautionary Aesop fable, a grasshopper asks an ant to play games on a summer day, rather than seeking food for winter. Ant refuses. Come winter, ant eats well; grasshopper goes hungry. But to journalist Oliver Roeder, the ludic grasshopper is the “diligent hero”. Roeder’s appealing biography of seven games – draughts (checkers), backgammon, chess, Go, poker, Scrabble and bridge – explores why play is both fascinating and necessary. Judging by the pandemic boom in online games, especially chess and Scrabble, many agree.



Impact

Greg Brenneka *William Morrow* (2022)

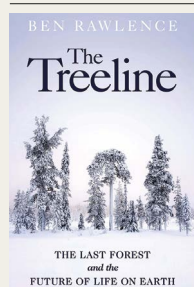
Some meteorites contain diamonds older than the Sun, along with, astonishingly, predominantly left-handed amino acids and large amounts of water – the ingredients of life on Earth. Did meteors feature in the inception of the Solar System and of life? “To study meteorites truly is about studying origins,” concludes Greg Brenneka, one of only about 100 full-time, professional meteoricists around the world. His far-ranging and entertaining study deserves to win converts, although its ‘pop’ comparisons can be off-putting.



A Natural History of the Future

Rob Dunn *Basic* (2021)

“Most depictions of the future do not even include non-human life, except on distant farms (tended by robots) or in indoor gardens,” notes ecologist Rob Dunn. This is misleading, argues his articulate study of the relationship between humans and other life. Non-human life will survive us, suggests an experiment by microbiologist Michael Baym: bacteria exposed to increasingly concentrated antibiotics evolved resistance in just 10–12 days. Microorganisms will probably dominate the post-human world, as in the beginning of life on Earth.



The Treeline

Ben Rawlence *Jonathan Cape* (2022)

The concept of a fixed treeline, beyond which trees will not grow, has become redundant because of climate change. In the boreal forest encircling the globe, “the trees are on the move” towards the North Pole, notes writer and environmental activist Ben Rawlence. Having seen this migration for himself, he writes with accuracy, beauty and urgency about six key treeline species: Scots pine in Scotland, birch in Scandinavia, larch in Siberia, spruce in Alaska, poplar in Canada and mountain ash in Greenland. **Andrew Robinson**