Origins: The scientific story of creation
JIM BAGGOTT
Oxford University Press: 2015.

Dark Matter and the Dinosaurs: The Astounding Interconnectedness of the Universe
LISA RANDALL
Ecco: 2015.

COSMOLOGY

A story of cosmic proportions

Michael S. Turner weighs up two distinctive popular books on the evolution of the Universe.

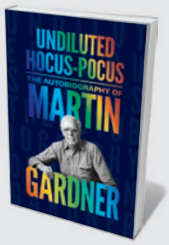
Jim Baggott's *Origins* and Lisa Randall's *Dark Matter and the Dinosaurs* recount the greatest story ever told: the evolution of the Universe since the Big Bang. This rich cross-disciplinary tale reminds us that astronomy, physics, chemistry, geoscience, biology and neuroscience are interconnected. The books cover the same ground in very different styles. Baggott, a chemist turned science writer, takes the reader on a linear, 13.8-billion-year journey. His textbook-like treatment abounds with excellent visuals, from charts to lithographs. At its best, *Origins* reminds me of Richard Holmes's marvellous *The Age of Wonder* (HarperCollins, 2008).

Randall, a particle physicist and cosmologist, makes the epic trip more succinct and conversational, interspersing her passions, perspectives and creative analogies. Describing how astronomers 'see' dark matter, she uses the analogy of knowing that a celebrity is near because of disrupted traffic and crowds of phone-wielding people. Her strong opinions — even ones I question, such as suggesting that "transparent matter" might be a better name than dark matter — liven the narrative.

The story begins with the Big Bang. What it is — the origin of matter, energy, space and time as Einstein's general theory of relativity has it, the emergence of space and time as string theory might posit, or the outcome of a previous cycle of cosmic evolution — remains to be determined. Inflation follows: a burst of expansion that smooths and flattens the Universe and stretches quantum fluctuations to astrophysical size, to become the seeds for all structure in the Universe. The details have yet to be revealed. But evidence for inflation is growing, particularly in measurements of tiny variations in the temperature of the cosmic microwave background radiation.

This 'quark soup' phase lasts a microsecond, followed by nucleosynthesis and the formation of the lightest elements at 3 minutes. Atoms form at 380,000 years. Then gravity amplifies lumpiness in the distribution of matter to become galaxies, clusters of galaxies and superclusters, with the first stars and galaxies emerging at around 500 million years. The Sun forms some 9 billion years later.

Now the narratives turn to 'local' events: Solar System formation, Earth's cooling, the emergence of oceans — and, 3.5 billion years ago, the first life forms. Important questions remain. Where did organic material originate? How did the transition from inorganic to organic occur? What was the last universal common ancestor, which Charles Darwin described as the primordial form from which all living things on Earth descend? From here, the pace quickens: multicellular organisms, atmospheric oxygenation around 2.5 billion years ago, sex as a mechanism for gene exchange, the emergence of primates shortly after the dinosaurs' demise and,



Undiluted Hocus-Pocus
Martin Gardner (Princeton Univ. Press, 2015)
Zealously debunking science fads and declaring his bafflement at the human brain, maths writer Martin Gardner was on fine form in this posthumous memoir. As it reveals, his *Scientific American* column was just a piece of his life's puzzle (see David Singmaster's review: *Nature* **501,** 314–315; 2013).

Junk DNA
Nessa Carey (Icon, 2015)
If only 2% of human DNA is technically 'useful' in coding for proteins, what is the other 98% for? Geneticist Nessa Carey uses Jackson Pollock paintings and baseball bats to explain how 'junk' DNA keeps the body functioning (see Nathaniel Comfort's review: *Nature* **520,** 615–616; 2015).

some 200,000 years ago, *Homo sapiens*.

Baggott ends at consciousness, that frontier of interdisciplinarity. But he fails to ask whether intelligent life is a convergent property of evolution. Given that evolution involves dominating local resources, the Universe may teem with 'dumb' life, while intelligent life remains exceedingly rare.

Earth's prehistory was marked by five major extinctions, identified in 1982 by palaeontologists David Raup and John Sepkoski. The Cretaceous–Palaeogene extinction 66 million years ago, which killed the dinosaurs, is the best known. Physicist Luis Alvarez and his geologist son Walter proposed that the cause was an asteroid impact, an idea met with scepticism until the mid-1990s, after a crater fitting the bill was identified in Mexico. Such an impact can alter conditions on Earth for tens of years, through a global dust cloud, firestorms and other after-effects: species ill-suited to such dramatic change go extinct.

Raup and Sepkoski also put forth evidence that extinction events occur roughly every 30 million years. This is now generally accepted, but there is no agreed mechanism. Randall and her collaborator Matt Reece offer a hypothesis. They posit that there are two kinds of dark matter: the ordinary one, whose gravity binds galaxies and galaxy clusters, and a 'social' form that also interacts with its own kind. The social dark matter forms a thin disk of material in our Galaxy whose gravity can shake things loose in the outer depths of the Solar System when it crosses the Galactic disk, every 30 million years or so. Randall admits that the idea is a long shot, although testable. This aspect of *Dark Matter and the Dinosaurs* conveys the excitement and uncertainty of cutting-edge, big-idea research.

In a chapter called 'The cosmic imperative', Baggott implies that the evolution of life is an inevitable consequence of chemistry, despite our not knowing precisely how it occurred. This reminded me of physicist Murray Gell-Mann's dictum "Everything not forbidden is compulsory" (borrowed from novelist T. H. White), which describes the importance of symmetry principles in particle physics: they set the basic rules, but not the detailed outcomes. A rich set of rules (think chess) can lead to complex and interesting outcomes. I would take this further: the Universe is governed by physical laws that permit a rich set of behaviours, resulting in its inevitable evolution from vacuum energy to quark soup, nuclei and atoms, all the way to the emergence of life and self-awareness. But that does not explain where space, time and the laws came from, or why there is something rather than nothing.

I have quibbles with Baggott's book. He gives a dated picture of inflation (tying it to symmetry breaking), gets the temperature of the cosmic microwave background wrong (it is 2.7255 kelvin) and calls the lumpiness that led to the formation of cosmic structures anisotropy, rather than inhomogeneity. But these gaffes do not interfere with the larger narrative and are a by-product of his sweeping scope and detailed description.

The longing to understand our place in the cosmos is universal. Baggott and Randall lay out how much of the story we understand, and how interconnected it all is. They remind us that big questions remain in this most wonderful scientific adventure. ■

Michael S. Turner *is professor of astronomy and astrophysics, and of physics at the University of Chicago, Illinois, and director of the Kavli Institute for Cosmological Physics.*
e-mail: mturner@kicp.uchicago.edu

NEUROSCIENCE

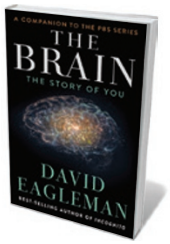
The mechanics of mind

Daniel Bor enjoys a sophisticated study of how the meat in our skulls generates the self.

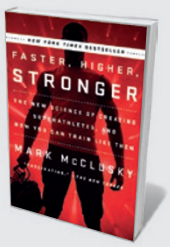
In my bolder moments, I consider neuroscience to be one of the most fundamental scientific fields. The brain is, after all, the location of our experiences and identities, and our main tool for understanding every facet of the Universe. *The Brain* by neuroscientist David Eagleman ambitiously promotes this view. Built around a series of fundamental questions, such as "what is reality?", it calls on a wide range of classic and recent findings, including innovative experiments by Eagleman himself, to demonstrate how brain science is optimally placed to answer those questions.

Eagleman begins by arguing that the brain determines who we are, and how we change. He illustrates just how dramatic such changes can be through the case of Charles Whitman, who in the 1960s switched from mild-mannered bank clerk to violent murderer because of a small tumour pressing on his amygdala, an area of the brain linked to aggression and fear.

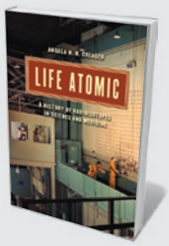
Although the brain's development has a disproportionate role in human identity, with synaptic pruning in infancy a key shaping factor, our brains remain plastic throughout our lives. Eagleman demonstrates this with the well-known example of London taxi drivers found to have enlarged hippocampi — key to memory consolidation — after memorizing thousands of the capital's streets. Memory is the bedrock of our identities, but Eagleman highlights how the past is very much a reconstruction bordering on mythology. A case in point is the relative ease with which false memories can be implanted. The emerging picture is far removed from one ▶



The Brain: The Story of You
DAVID EAGLEMAN
Pantheon: 2015.



Faster, Higher, Stronger
Mark McClusky (Plume, 2015)
From the primitive "bag-and-valve" apparatus used to measure runner's oxygen intake in the 1920s to today's Silicon Valley performance labs, Mark McClusky shows how sports science has helped humans to push their physical limits, and why we keep striving to beat the best.



Life Atomic: A History of Radioisotopes in Science and Medicine
Angela N. H. Creager (Univ. Chicago Press, 2015)
Radioisotope by-products of atomic energy are vital to molecular biology. Historian Angela Creager archives atoms, from carbon-14 and its role in studying photosynthesis to slow-decaying iron-59, which traces nutrients metabolizing in the body.