

old. And we discover how candidate drugs, labelled with ^{14}C at specific parts of the molecule, can be followed through phases of the body's metabolism to test the drugs' safety and efficacy. There is so much more. Marra explains, for instance, how, shortly after ^{14}C was discovered, dissolved CO_2 in seawater was used to track the movement of currents in the deep ocean, revealing connections around the planet considered unfathomable before.

Carbon-14 may be the star, but scientists, institutions and happenstance have valuable supporting roles. Take Libby, winner of the 1960 Nobel Prize in Chemistry for his work developing radiocarbon dating. At one point, his team waded into the sewers of Baltimore, Maryland, collecting methane produced from human waste to demonstrate unequivocally that it contained considerably more ^{14}C than did archaeological samples and a precisely dated piece of redwood heartwood.

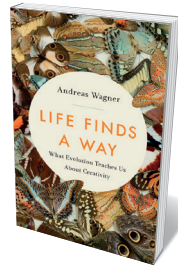
Marra also reveals, in vivid detail, the difficulties faced by early researchers in acquiring precious samples of plankton, which opened up a new perspective on ocean productivity and, ultimately, carbon sequestration. His own experience in this area illuminates the researchers' pioneering spirit in the face of wild conditions, cramped spaces and sometimes surly ships' captains. The technological limitations were progressively overcome by dogged perseverance and a belief that the work would help them to understand the oceans' potential for incorporating inorganic carbon into organic compounds — still the focus of fierce investigation.

Mysteries remain in the Earth sciences, such as the effectiveness of the carbon cycle and the ramifications of human activity, including our seemingly insatiable hunger for fossil fuels. Importantly, Marra shows how ^{14}C can be used to tease out processes across a range of timescales. He explains why the Southern Ocean is the 'gatekeeper' to the planet's ocean circulation, and how abrupt changes in the formation of deep water and the position of the overlying wind belts can drive dramatic shifts in the carbon cycle. Soberingly, a doubling of atmospheric levels of ^{14}C — arising from mid-twentieth-century nuclear-bomb testing — is preserved as a spike in annually formed natural archives, including tree rings. That marker could be chosen to delineate the start of a new geological epoch: the Anthropocene.

Hot Carbon offers a timely perspective on how mind-bogglingly connected our planet is — and how ^{14}C will continue to be important in helping us to understand what lies ahead. ■

Chris Turney is professor of climate change and Earth science, and director of the Chronos ^{14}C Carbon-Cycle Facility, at the University of New South Wales in Sydney, Australia. His website is christurney.com e-mail: c.turney@unsw.edu.au

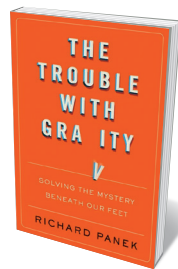
Books in brief



Life Finds a Way

Andreas Wagner BASIC (2019)

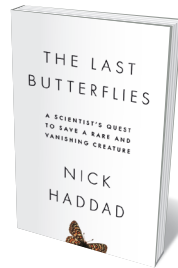
From gut microbes to elephants, the embodiments of evolution are marvels of innovation. So writes biologist Andreas Wagner, whose eloquent study finds the “augmented” view of Darwinian evolution echoed in the ‘landscape thinking’ of human creativity — the mental exploration of possibility. Wagner meshes research into areas such as genetic drift with theories on aspects of the creative process (such as serendipity) seen in luminaries from radioimmunoassay inventor Rosalyn Yalow to artist Pablo Picasso, and shows how such a mindset can solve real-world problems.



The Trouble with Gravity

Richard Panek HOUGHTON MIFFLIN HARCOURT (2019)

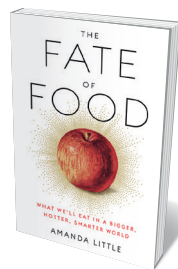
Gravity is, scientifically speaking, an enigma. We know that it is a weak force with infinite reach, pulling all matter to form bodies from black holes to galaxies — but that is what it does, not what it is. Science writer Richard Panek follows the evolution of gravitational theories through time, from Aristotle (arguably the first to question why things fall on Earth but heavenly bodies stay aloft) through the momentous discoveries of Galileo Galilei, Isaac Newton and Albert Einstein. He also touches on insights from the likes of poet Dante Alighieri and philosopher-physicist Ernst Mach.



The Last Butterflies

Nick Haddad PRINCETON UNIVERSITY PRESS (2019)

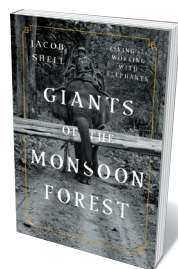
Terrestrial ecologist Nick Haddad studies the beleaguered denizens of liminal lands: the world's rarest butterflies. Far from niche research, he argues, findings on species and subspecies such as the St Francis' satyr (*Neonympha mitchellii francisci*) and crystal skipper (*Atrytonopsis quinteri*) offer a valuable lens on the biodiversity crisis. Yet Haddad does not just gather data on habitat loss and other drivers of decline — although he does that with crystalline acuity. He emphasizes that measures such as restoring ecological systems can protect populations of these fragile “ambassadors of nature”, against the odds.



The Fate of Food

Amanda Little HARMONY (2019)

As Earth's human population tips towards 8 billion, is our food system up to it? In this tour of the brave new world of adaptive production, environmental journalist Amanda Little encounters robot weeders, aquaponics innovators, permaculture farmers, toilet-to-tap water recyclers and other players in the field — both high-tech innovators and eco-traditionalists. That balanced viewpoint extends to broader discussions of debates over genetically modified crops in Kenya and cultured meat production in the United States. Witty, nimble and timely, this is a gem of crack reporting.



Giants of the Monsoon Forest

Jacob Shell W. W. NORTON (2019)

In this thought-provoking study, geographer Jacob Shell probes an unusual interspecies alliance: the relationship between people and the working elephants of Indonesia, Myanmar and India. Never selectively bred, the night-roaming pachyderms are essentially wild, yet engage in cognitively demanding tasks such as rescue work during floods. Examining everything from the muscular miracle of the beast's proboscis to the species' wartime work, Shell also charts the threats facing Asian elephants, and the dearth of local voices in relevant policymaking. [Barbara Kiser](#)