



The Milky Way lights up the night sky above the Navajo trail in Bryce Canyon, Utah.

ENVIRONMENTAL SCIENCE

Hymn to fading stars

An exploration of humanity's compulsion to banish darkness is highly enlightening, finds **Tim Radford**.

Here is a paradox: the brilliance of the Enlightenment happened by candlepower. Clarity of vision came courtesy of the dark. The enigmatic night sky must have gleamed everywhere as the giants of the post-Copernican revolution stumbled home from their learned societies. In Birmingham in the English Midlands in the late eighteenth century, Matthew Boulton, James Watt, Erasmus Darwin, Joseph Priestley and Benjamin Franklin met by the full Moon, calling themselves the Lunar Society. The astonishing adventure of science has now almost eliminated true darkness. And for that huge and growing portion of humanity living in cities, it has bleached the night sky of all but a handful of stars.

As Paul Bogard shows in his hymn to vanished darkness, *The End of Night*, this electric overdose comes at a high cost. It may be linked to sleep disorders, changes in migratory behaviour in birds and insects, stress and exhaustion in shift workers, and

even obesity.

Bogard's book is a literary journey — in the space of a few pages, we walk with Virginia Woolf, Charles Dickens and Rétif de la Bretonne. It is also a pilgrimage to our capitals of light. We visit London, with its 1,600 surviving gas lamps; Paris, where 110,000 4.5-watt bulbs illuminate just one courtyard in the Louvre Museum; and Broadway's 'Great White Way' in New York. Bogard hunts true darkness, too: places far from security lights, where nights are so clear and dark that the stars begin to reveal subtle gem-like colours, and the Milky Way emerges as a sight of depth and structure. He goes beyond the broad



The End of Night: Searching for Natural Darkness in an Age of Artificial Light
PAUL BOGARD
Little, Brown: 2013

splashes of electric brilliance now smeared across continents, seeking places where darkness is conserved and sponsored by bodies such as the International Dark Sky Association in Tucson, Arizona, and the Night Sky Team of the US National Park Service. Bogard dines in Mantua, Italy, with one of the makers of the first world atlas of artificial night sky brightness (see P. Cinzano *et al. Mon. Not. R. Astron. Soc.* **328**, 689–707; 2001). He sets off with amateur astronomers in darkest England and the United States. In Las Vegas, Nevada, where the brightest beam on Earth lights up the sky from the apex of the Luxor casino, he still — just — glimpses Rigel and Betelgeuse in the Orion constellation, and Sirius. He talks to researchers and engineers on two continents about the urban compulsion for brightness. Any evidence that ever brighter security lights equal ever greater security is dismissed as dubious: glare creates shadows in which predators can hide. Bogard and his interlocutors also conclude that we may in

WALLY PACHOLKA/ASTROPICS.COM

any case be surrendering to an ancient fear of the dark. The European Union alone, he reports, is estimated to waste €1.7 billion (US\$2.2 billion) a year on needless outdoor lighting.

Bogard visits New York's Museum of Modern Art to contemplate the testimony of Vincent van Gogh's 1889 painting *The Starry Night* and, as a counterweight, Giacomo Balla's 1909 *Street Light* ("Let's kill the moonlight!") was a rallying cry for Italian Futurists). Bogard explores the biology of vision, the capacity of eyes to adjust to ever lower levels of light and the concept of 'seeing' — the odd term stargazers use to record the atmospheric turbulence that makes stars twinkle. He tries to experience the darkness celebrated by Henry David Thoreau at Walden Pond in Concord, Massachusetts, but is stymied by the glow now emanating from the town.

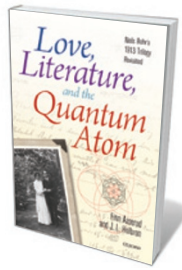
Bogard becomes a midnight sensualist. He goes into Death Valley in California and Nevada, and, training binoculars on the night sky, suddenly feels "as though I'm falling. I have to pull away to find my balance in the dark. The ground on which I'm standing, the cloth of stars above. The great nebula in Orion's belt, the Pleiades, Jupiter so bright and clear it makes me laugh." He visits the Mont-Mégantic Starry Sky Reserve in Quebec Province, Canada, where local communities have turned darkness into astrotourism. (Sadly, the sky is occluded by fog.)

He also considers the victims of 'white nights': prisoners locked in an eternal glare, shift workers trapped in a cycle of sleeplessness, and what you might call electric roadkill. In North America, some 500 species migrate by night and the catalogues of death by electrocution have been enough to trigger a Fatal Light Awareness Programme (FLAP). He cites the murderous night when 50,000 birds followed a beam of light from a Georgia airport straight into the ground and the night when 1,500 migrating grebes in Utah were confused by lights reflected from clouds "and crashed into parking lots they mistook for ponds".

This is a rich book with a rewarding appendix of notes. The straining for descriptive effect occasionally obtrudes; Bogard teaches creative non-fiction to university students, so he will know Samuel Johnson's advice about striking out the fine writing. The book's ambitious scope also necessarily dictates a sacrifice of depth. But these are small things. The big thing is that, as you read it, you too will want to reclaim the night and perhaps rediscover the heavens of the Enlightenment. ■

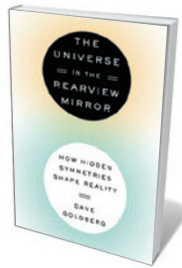
Tim Radford is the author of *The Address Book: Our Place in the Scheme of Things*. He was science editor of *The Guardian* until 2005.
e-mail: radford.tim@gmail.com

Books in brief



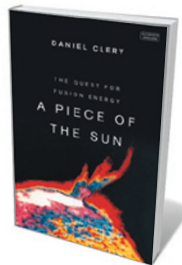
Love, Literature, and the Quantum Atom: Niels Bohr's 1913 Trilogy Revisited

Finn Aaserud and John L. Heilbron OXFORD UNIVERSITY PRESS (2013)
Science historian John Heilbron analyses the cultural underpinnings of physicist Niels Bohr's creativity. Bohr's immersion in works by Søren Kierkegaard and other greats of literature and philosophy fed the wellsprings of his quantum atom theory, argues Heilbron (see *Nature* **498**, 27–30; 2013). This is a unique contribution to the fanfare around the centenary of Bohr's theory: it incorporates archivist Finn Aaserud's assemblage of previously unpublished letters between Bohr and his family, and a reprint of Bohr's 'Trilogy' of papers.



The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality

Dave Goldberg DUTTON (2013)
Who knew symmetry could be so brilliantly entertaining? Physicist Dave Goldberg slings the reader straight in at the deep end of this big physics concept, but with enough masterly wit to keep you afloat. If you've ever longed to know the nitty-gritty on antimatter; puzzled over the exclusion principle; woken up in a cold sweat wondering why you are not a "sentient cloud of helium"; gritted your teeth over the cosmological principle; or been terrified by the beasts of the 'particle zoo', this is for you.



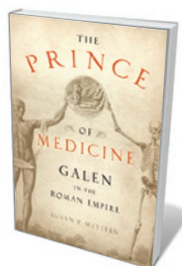
A Piece of the Sun: The Quest for Fusion Energy

Daniel Clery DUCKWORTH (2013)
"Fusion seems too good to be true," notes Daniel Clery. But for researchers in this field, making the 'perfect' energy source a reality is central to a power-hungry age. Clery chronicles the march of fusion projects and innovative physicists from the 1940s on. From Peter Thonemann's work on the Zero Energy Thermonuclear Assembly to Lyman Spitzer, Lev Artsimovich and later stars, we enter a prodigious realm of pinch plasmas, stellarators and tokamaks. Despite big hopes and machines to match, harnessing "a piece of the Sun" still faces economic and scientific hurdles, Clery shows.



The Attacking Ocean: The Past, Present and Future of Rising Sea Levels

Brian Fagan BLOOMSBURY (2013)
In his wide-ranging study of rising sea levels from the end of the last Ice Age to today, Brian Fagan traces the impact on humanity. The scattered groups that faced early thaws adapted by moving to higher ground. But the growth of populations, industrialization and coastal cities since 1860 has now left hundreds of millions at risk from the sea's climate-driven climb. Hurricane Sandy, Fagan reminds, underlines the need for adaptation strategies and coastal defences from the United States to Bangladesh.



The Prince of Medicine: Galen in the Roman Empire

Susan P. Mattern OXFORD UNIVERSITY PRESS (2013)
He was a Greek medic who patched up Roman gladiators — and the emperor Marcus Aurelius. The shadowy figure of Galen, whose treatises dominated Western medicine for centuries, here bursts into life. Susan Mattern shows that he used wine on wounds — although ignorant of its bactericidal properties — and contributed to anatomy (dissecting live Barbary macaques) and pharmacology. He was also arrogant, but Mattern argues that his clinical excellence in a plague-ridden era far outshone his flaws. [Barbara Kiser](#)