(Jonathan Cape, 2012) goes for close day-to-day observation, in poems "written at the hive wearing a veil and gloves" that express a wonderfully detailed and subtle appreciation of honeybee life:

> How bees touch and re-align their touch.
> Light migration;
> noise of a body in continual repair

This is one vital function of art in our lives: it restores our sense of wonder, and so increases our respect for other life forms. Yet writers and artists can also actively contribute new knowledge. One example of this is the work of visual artist Amy Shelton, whose engagement with bees and beekeeping over a number of years led her to set up the *Honeyscribe* project in 2011.

In ancient Egypt, 'honeyscribes' recorded the productivity of the hives. Shelton goes further, charting in multimedia artworks threats to honeybee health and reflections on the species' behaviour. Her project, she writes, "emphasizes communication, diversity and collaboration" in our shared environment. "The beehive reflects the flora, the temperature and the pesticides present in the environment within which it is situated, amalgamating these things into one vastly complicated self-regulating organism" (see www.amyshelton.co.uk/art_works).

I was fortunate to collaborate with Shelton on the artist's book *Melissographia*, which sets a series of poems drawing on Maeterlinck's study alongside embossed, hand-painted pollen maps. These, as Shelton puts it, reference "a selection of seasonal pollen loads collected by the honeybee from single plant species" and "tiny botanical samples of flowers collected over the apiarist's calendar year, which are important to sustaining the health of the honeybee".

Besides making her own extraordinary, often moving pieces, Shelton aims to foster a dialogue on bees between apiarists, scientists, writers and artists, children and the public by means of art, workshops and events. Hopefully, through this and other projects, we will continue to create less-mechanistic stories about *A. mellifera*. In so doing, we will evolve better practices in our dealings with a creature that is essential to our agriculture and our culture. ■ SEE NEWS & VIEWS P.38

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RIA NOVOSTI/SPL

The 40,000-year-old 'Lyuba' is one of the best-preserved woolly mammoths ever found.

DE-EXTINCTION

A behemoth revived

Henry Nicholls examines a clear appraisal of what it would really take to resurrect extinct species.

A hazard of studying an extinct charismatic species such as the woolly mammoth is that you spend a lot of time answering the same question: "Is it possible to clone it?" For evolutionary molecular biologist Beth Shapiro, who has a long-standing interest in both ancient DNA and mammoths, the solution was to write a book.

In *How to Clone a Mammoth*, Shapiro has an alluringly simple goal: "to provide a road-map for de-extinction" in a single volume "that separates science from science fiction". She begins by considering which species might be targeted for de-extinction, anticipating many of the difficulties to come. The poor preservation of dodo remains, for instance, means that any DNA fragments recovered are unlikely to give a clear idea of its genome. The moa, a giant flightless bird from New Zealand, is probably out on the basis that its closest living relative (the tinamou) is not close enough to assist in assembling its DNA. Steller's sea cow (*Hydrodamalis gigas*) has no living surrogate that could accommodate a cloned fetus, and the natural habitat of the Yangzte River dolphin (*Lipotes vexillifer*; widely thought to be extinct) is currently too polluted to receive the cetaceans.

Shapiro contends that the focus on individual species is misguided. "De-extinction has a place in our scientific future, but not as an antidote to extinctions that have already occurred," she writes. Engineering extinct traits into living organisms, however, could help those organisms to adapt to environmental shifts, and could re-establish ecological interactions that disappear when a species goes extinct. In Shapiro's view, this is the real value of de-extinction technology. Yet the little that we currently understand about the operation of bygone genes means that her argument is necessarily vague on detail.

How to Clone a Mammoth: The Science of De-Extinction
BETH SHAPIRO
Princeton Univ. Press: 2015.

Targeting the woolly mammoth (*Mammuthus primigenius*), a keystone species of the steppe-tundra during the last glacial period (from roughly 110,000 to around 12,000 years ago), Shapiro begins the journey towards de-extinction, and hunts for a well-preserved specimen. One bizarre expedition to Siberia ends with the juxtaposition of armed nomadic reindeer herders and a French couple with a cooler box filled with cheese. But

cells and DNA degrade rapidly after death, so it is unlikely that anyone will ever discover an intact mammoth nucleus that will allow the species to be rebooted with the cloning technique of somatic-cell nuclear transfer.

Breeding the mammoth back into existence through carefully arranged elephant backcrosses is also a non-starter, Shapiro shows. Elephants are tropical beasts with none of the adaptations to low temperatures that would need to be concentrated through artificial selection. The only realistic route, she concludes, is to engineer mammoth-like traits into an elephant stem cell. As sci-fi as this sounds, she predicts that mammoth revivalists will have achieved it within a few years.

Several hurdles remain, and Shapiro presents these clearly and entertainingly as a brilliant thought experiment at the boundaries of biological plausibility. The engineered stem cell would need to be cloned, the cloned embryo transferred to a surrogate or artificial uterus, mammoth-like elephants reared in sufficient numbers in captivity, a suitable habitat made available, and the public convinced of the benefits of releasing these genetically modified organisms. The beasts would then need to be set free.

Given the astronomical odds against pulling off all these steps in succession, it is remarkable to discover that a respected scientist such as Shapiro is actively involved in projects to bring the woolly mammoth and passenger pigeon (*Ectopistes migratorius*) back from the dead. The idea of enriching biological diversity by engineering long-lost genetic innovations into extant species is certainly worth considering and not so very different from how we already engineer crops. Unfortunately, the ecological argument for mammoth de-extinction is distinctly woolly, based more on the appeal of rewilding than on clear experimental evidence of the role of large herbivores on the Arctic tundra.

In the case of the passenger pigeon, the argument in favour of de-extinction is thinner still, and involves some seriously bird-brained ideas, such as the proposal to paint thousands of homing pigeons to look like passenger pigeons so that they can train up the resurrected birds for release.

Shapiro acknowledges that there are probably better cases for de-extinction, though she does not explore any in detail. This is a shame. The mammoth and passenger pigeon might be the perfect species to illustrate the fraught, often contradictory logic of de-extinction, but it is in simpler, more tractable settings, where there are fewer mammoth leaps of faith, that de-extinction might become the "powerful new tool" for conservation that Shapiro predicts. ■

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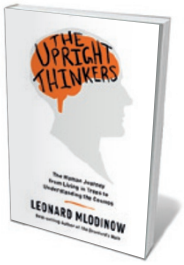
Books in brief

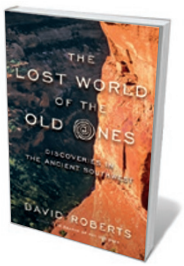


The Upright Thinkers: The Human Journey from Living in Trees to Understanding the Cosmos
Leonard Mlodinow PANTHEON *(2015)*
Like Yuval Noah Harari's *Sapiens* (Harvill Secker, 2014; see *Nature* **512,** 369; 2014), this is an audacious encapsulation of our species' trek from savannah to city. But physicist Leonard Mlodinow dwells less on our aggression than on our curiosity. As he traces the human brain's evolution over millions of years, the birth of science over hundreds, and the modern physics revolution over tens, a tale of hope and glory emerges, from the "leap in existential consciousness" at the Neolithic site of Göbekli Tepe in Turkey to twentieth-century atomic epiphanies.

The Weather Experiment: The Pioneers who Sought to see the Future
Peter Moore CHATTO AND WINDUS *(2015)*
Prepare for turbulence in this history of Britain's seminal contribution to weather forecasting. Peter Moore reveals how the lack of early warning exacerbated the impact of events such as the Great Storm of 1703 — which blew cattle over hedges and spun windmills so fast that they burst into flames. The nineteenth-century arrival of Francis Beaufort (who quantified wind) and chemist Luke Howard (who classified clouds) was a turning point. But the star was 'Darwin's captain' Robert FitzRoy, who founded the UK forecasting system, but killed himself before he saw his vision realized.

Misbehaving: The Making of Behavioural Economics
Richard H. Thaler ALLEN LANE *(2015)*
In *Nudge* (Yale University Press, 2008), co-authored with Cass Sunstein, behavioural-economics pioneer Richard Thaler revealed how human irrationality shapes markets. Here he relates the evolution of those ideas by way of eureka moments and buzzy collaborations. Puzzling over behaviours that failed to fit established economic models, he became galvanized by the work of psychologists Daniel Kahneman and Amos Tversky on heuristics and biases. As Thaler's story of research into self-control and other neglected topics unfolds, his tussles with traditional economists inject plenty of zing.

The Narrow Edge: A Tiny Bird, an Ancient Crab, and an Epic Journey
Deborah Cramer YALE UNIVERSITY PRESS *(2015)*
The red knot (*Calidris canutus rufa*) is a migratory marathoner. The sandpiper flies nearly 30,000 kilometres per year, from Tierra del Fuego to the Arctic and back, stopping on the US East Coast to feast on horseshoe-crab eggs — but on the wing for up to 6,000 kilometres at a time. With the bird's food sources and habitats now threatened, writer Deborah Cramer travels with some of the dedicated researchers working along its flyway. An eloquent interweaving of history, field practice and keen personal observation.



The Lost World of the Old Ones: Discoveries in the Ancient Southwest
David Roberts W. W. NORTON *(2015)*
An enigmatic civilization — the Ancestral Puebloans, or Old Ones — once flourished in Arizona, Colorado, New Mexico and Utah. When its peoples disappeared in AD 1300, they left behind stunning rock art and dwellings sited like swallows' nests on sheer canyon walls. David Roberts braids his own daredevil discoveries of remote sites into the stories of Southwestern archaeologists and ranchers who are as gripped by this lost culture of "genius climbers" as he is. **Barbara Kiser**