

▶ skin and noses — the microbiome — express their own sequences. Thanks to epigenetic controls (cellular mechanisms that affect how genes are expressed), even genetically identical organisms can display very different characteristics. I learnt that the fur of cloned cats can be a different colour from their genetic donor's. At best, we are patchworks of genomic expression, and identity isn't as straightforward as many assume. In the era of consumer genetic-sequencing services, that is cause for caution.

Ball facilitates an informed conversation about our future by inviting us into the grey zone where binary answers don't exist and complexity reigns. That ambiguity grows as he discusses the ethical and societal implications of new technologies such as CRISPR gene editing, and growing models of the brain and embryos in culture. How do we ensure equity in an era when intelligence could be decided by gene editing? How do we understand our moral obligations to an organ grown outside the human body that might experience pain, memory and emotion? In exploring innovations that blur our concept of identity, rights and death, Ball forces us to ask how and why. To investigate those questions, we must expand our ethical frameworks.

One thing rankles in a chronology of biology: the homogeneity of the protagonists. They decide how the story is told, and the cast list here is dominated by men of European descent, from Rudolf Virchow, Thomas Hunt Morgan and Francis Crick to George Church. As Ball points out, women, notably Rosalind Franklin in molecular biology and stem-cell biologist Gail Martin, are often written out of science history — as are people of colour, such as pioneering cancer researcher Jane Cooke Wright. He also recounts how the prejudices of some scientists — such as French surgeon Alexis Carrel's white-supremacist ideologies in the early twentieth century, and British biologist Julian Huxley's enthusiasm for eugenics a few decades later — influenced biological theories and practice.

Yet Ball fails to go a step further and raise what I think is the most important question: who gets to decide whether and how to grow a human? Whose ideas about identity, gender, power and mortality will shape our scientific story? And how does humanity create a system that allows diverse world views to shape the future of biomedicine? ■

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Wingspan uses egg tokens, bird cards, food dice and boards that fold like field notebooks.

EDUCATION

Game of birds

Does a beautiful avian-themed board game deliver on the biology? **Stuart West** and his team of testers think so.

Birdwatchers are list-makers, totting up species they have seen in their lifetimes, on holiday, from their office windows. Designer Elizabeth Hargrave has harnessed that impulse in her highly original board game, Wingspan, in which players compete to discover birds and attract them to wildlife reserves. But will non-birders find it exciting? To find out, I tested the game with a team of academics, graduate students, a biodiversity analyst and older children.

Each player's board features a network of reserves: forest, grassland and wetland. To attract birds (represented on cards) to one of your reserves, you need food: insects for a chimney swift (*Chaetura pelagica*), for instance, or fish for an American white pelican (*Pelecanus erythrorhynchos*). You win points (feathers) according to the species — one for a house wren (*Troglodytes aedon*), eight for a golden eagle (*Aquila chrysaetos*).

You're not, however, just attracting birds to get points. You are also effectively

Wingspan
Stonemaier Games
(2019).

building a biodiversity engine. It's a challenge, a biology lesson and nail-biting fun. There are

numerous routes to victory, from specializing in certain types of bird to amassing eggs. This is a thoughtful and strategic game with many interlocking parts.

It's also visually gorgeous — an obvious labour of love. Food is represented on the sides of chunky wooden dice that roll out of a bird box. There are dainty, pastel-hued egg tokens, and the game boards fold up like field notebooks. Each of the 170 unique cards shows a different North American species, so superbly drawn that it wouldn't look out of place in a field guide. And the cards feature key details, from what the species eats to how many eggs it lays, and a distinguishing fact — say, that the common nighthawk (*Chordeiles minor*) is crepuscular, hunting insects at dawn and dusk.

Strategy is not simple. At each turn, you can either

Ruddy duck, one of 170 species featured.



place a bird in one of your reserves or 'activate' a reserve so that, for example, the grassland triggers egg laying, and the wetland acquires new birds. Species-specific needs force difficult choices. Take habitats: the more species you have in one, the better reward you get when you activate that reserve. So, with an extra species in your woodland, activation provides two items of food. You end up wanting to do everything, but can't. You have to weigh up the costs and benefit of acquiring birds at speed, making each game a tight race.

Beyond points, birds give you powers, which flow from species' biology. Northern cardinals (*Cardinalis cardinalis*) help you to acquire fruit faster. Snowy egrets (*Egretta thula*) haul in fish. Inca doves (*Columbina inca*) lay extra eggs. Some birds even give you a bonus while another player takes a turn. For instance, the bronzed cowbird (*Molothrus aeneus*), being parasitic, gains an egg when another player does.

Each game presents a new puzzle. You can spot and exploit synergies in certain combinations. A wood duck (*Aix sponsa*) enables you to draw more bird cards; a common grackle (*Quiscalus quiscula*) can turn those cards into eggs. Bonus cards push you in different directions, for example, giving extra points to players collecting birds whose names contain a geographic location (such as the American kestrel, *Falco sparverius*), or that nest in cavities or have wingspans greater than 65 centimetres.

Too complex? No: everything in the game flows elegantly from the biology, and once that's explained by the rule book, or the how-to-play video (go.nature.com/2v3vwyq), it makes sense. Each player quickly gets lost in building up their bird empire. Even those who lost enjoyed the journey.

What makes Wingspan special is how science infuses it. You can't play without painlessly absorbing some zoology. Perhaps a bonus card nudges you to hunt for woodland species, or you focus on species that gain points through predation. Or maybe you're just pleased to get a particularly stunning species: a scissor-tailed flycatcher (*Tyrannus forficatus*) or Anna's hummingbird (*Calypte anna*).

At least one new set of cards is planned, based on a different global region. That could change the game's dynamics, as well as introducing many new species. Wingspan teaches avian biology by stealth. It might spread the word about the thrills of bird-watching — not least, the solid satisfactions of ornithological list-making. ■

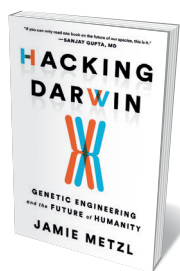
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Books in brief



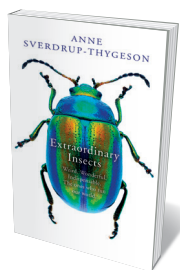
Bored, Lonely, Angry, Stupid

Luke Fernandez and Susan J. Matt HARVARD UNIVERSITY PRESS (2019)
Online immersion can distort emotion. However, technologies have been shaping US emotional culture for more than a century, argue computer scientist Luke Fernandez and historian Susan Matt in this original study. Marshalling archival sources and interviews, they trace how norms (say, around loneliness) have shifted with technological change. Broadcasting deregulation under President Ronald Reagan, for instance, made room for anger-inducing right-wing 'talk radio'. Yet, as they show, the digital world lifts even more limits, stimulating and affirming a range of negative emotions.



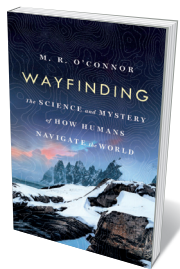
Hacking Darwin

Jamie Metzl SOURCEBOOKS (2019)
Technology futurist Jamie Metzl probes the present and potential future of genetic engineering, from personalized medicine to human-genome synthesis. Propulsive, fact-packed and engrossing, his narrative interweaves backstory, bioethics and related shifts in human behaviour with data-crunched resources such as maps tracking variations in global regulation. Metzl has a knack both for clarifying granular scientific and moral complexities, and for seeing the big picture — such as the risks of a potential international genetic "arms race" involving engineered embryos.



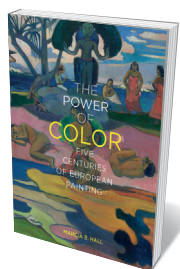
Extraordinary Insects

Anne Sverdrup-Thygeson MUDLARK (2019)
Trillions of them share the planet with us: pollinating, forming soil and decomposing the dead. Insects — from jewel beetles to stink bugs — present an embarrassment of riches, as ecologist Anne Sverdrup-Thygeson spectacularly proves. She tours their anatomy, reproduction and more, delivering a hail of facts with brio and precision — whether about the fungal gardens of leafcutter ants or the lac-bug exudations that, processed into shellac, coat violins. She reminds us, too, that despite having survived five major extinction events, insects now face compounded human-driven threats.



Wayfinding

M. R. O'Connor ST MARTIN'S (2019)
What are navigation apps doing to our innate spatial orientation? To find out, science journalist M. R. O'Connor embarked on a journey of discovery both inner and outer. She walks the labyrinth of the brain's time-and-space-mapping hippocampus. And, on the road, she meets astrophysicists, anthropologists and traditional wayfinders — such as Bill Yidumduma Harney of Australia's Wardaman culture, who steers by thousands of memorized stars. At one point, landscape historian John Stilgoe tells her: "I feel sorry for your generation. It doesn't get lost much." This hymn to topophilia offers a corrective.



The Power of Color

Marcia B. Hall YALE UNIVERSITY PRESS (2019)
Art historian Marcia Hall examines five centuries of Western painting through the lens of colour, "attempting to pull thread through the fabric" to trace material and technical innovation. Her sumptuously illustrated survey of masters including Domenico Ghirlandaio, Michelangelo Buonarroti and Johannes Vermeer ranges back and forth over the borders of art and science, from how technologies such as X-ray diffraction can unpeel paint chemistry, to how the pigment palette has gradually expanded to include clays, verdigris, lapis lazuli and industrial greens and yellows. **Barbara Kiser**