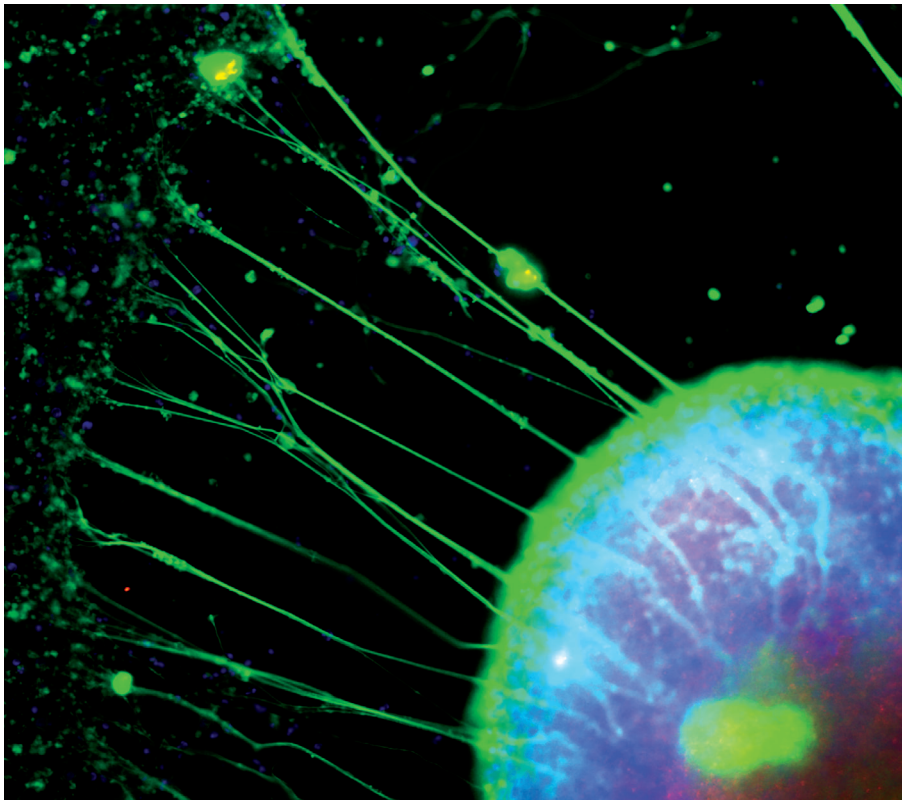


CHRISTOPHER LOVEJOY/CHARLIE ARBER/SELINA WRAY, UNIVERSITY COLLEGE LONDON

Neurons grown from the reprogrammed skin cells of science writer Philip Ball.

BIOETHICS

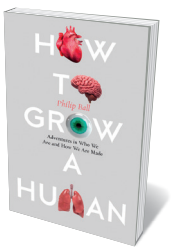
Dished brains and designed babies

Natalie Kofler is engrossed by a book that examines what cutting-edge biotechnology means for our sense of self.

Walking down Fifth Avenue in New York City recently, I was amused by some billboard wordplay. Below a picture of two pairs of jeans, crumpled on a carpeted floor, were the words: "Before you drop your jeans, be sure to check your genes."

My twin passions are genetics and equity. Yet I didn't fully appreciate the advert's flippant and heteronormative assumptions about identity, reproduction and future generations until I read the latest book from prolific science writer (and former *Nature* editor) Philip Ball, *How to Grow a Human*. The book should probably come with a warning: you might never look at the life sciences in quite the same way again.

Ostensibly, *How to Grow a Human* examines how scientific advances from genomics to assisted reproduction influence human identity. Ball starts by introducing us to his "mini-brain"; a collection of signalling neurons grown from his own reprogrammed skin cells by researchers at University College London. His observation of "part of himself" in a Petri dish begins a journey that spans centuries, giving context to a not-so-distant future in which organs are grown to order and gene editing steers human evolution. Faced with technologies that cheat death and circumvent reproduction, Ball forces us to reassess what being human actually means.



How to Grow a Human: Adventures in Who We Are and How We Are Made
PHILIP BALL
William Collins (2019)

The book's main thrust, however, is that the concept of pure, objective science is a farce. Ball reminds us that scientific progress does not occur in a vacuum: questions, results and conclusions are shaped by their cultural milieu. Patriarchal biases of the seventeenth century steered early theories of human reproduction; histories of colonialism continue to influence descriptions of infectious disease, among many other aspects of life. This goes for the scientists who create the stories, the language that gives context to their research and the public that must find ways to accommodate advances into an evolving world view. Perception of science is inexorably linked to culture. It always has been — with implications for both.

Ball starts by retelling the story of human biology chronologically, beginning in the mid-seventeenth century, when English natural philosopher Robert Hooke coined the term 'cell'. He continues to the emergence of molecular biology in the 1950s, and concludes in the twenty-first century, with breakthroughs such as Japanese cell biologist Shinya Yamanaka's discovery of factors that can make any cell a stem cell, along with more recent advances, such as cancer immunotherapies.

Ball introduces us to prominent scientists and the political, economic and social forces that influenced their work. For instance, zoologist Theodor Schwann's exposure to German Romantic philosophies of universality probably inspired him to extend cell theory from plants to animals. Yamanaka was motivated to circumvent regulatory restrictions on the use of stem cells from human embryos.

Next, Ball leads us around the science-fiction-like forefront of emerging technologies, where human organs for transplantation are grown in pigs, and parents use gene editing to customize their offspring. He points out how chimaeric organisms disrupt our ideas about the "natural order", evoking images of Frankenstein. And he shows how terms such as "test-tube baby" and "designer baby" are laced with cultural and religious judgements about how conception should proceed.

This is a deeply engaging crash course. Ball's description of cellular organelles and their functions, in particular, is an impressive feat. And his sense of wonder at biological processes is palpable: passages on the intricacies of cell plasticity had me (with my doctorate in molecular biology) exclaiming, "That is incredible!"

This awe evokes some much-needed humility. It is a book that requires us to reflect on our biases and preconceived ideas.

Ball pushes back, for instance, against the familiar narrative that genes are the 'blueprint' of life. We are much more than this, he argues. Our bodies are made up of multiple genomes; for example, genetic material is often exchanged between mother and fetus during pregnancy. And the trillions of microorganisms lodging in our guts, ▶

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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KIM EUKER

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.

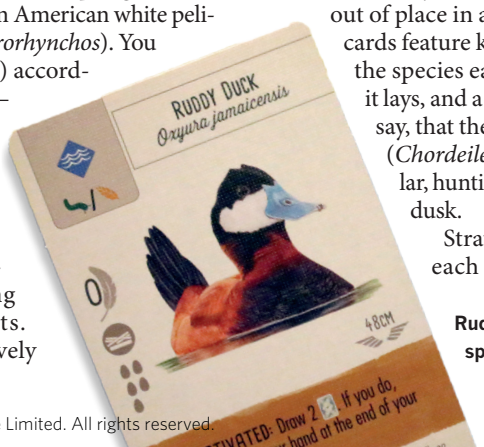
Each player's board features a network of reserves: forest, grassland and wetland. To attract birds (represented on cards) to one of your reserves, you need food: insects for a chimney swift (*Chaetura pelagica*), for instance, or fish for an American white pelican (*Pelecanus erythrorhynchos*). You 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 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.

Wingspan
Stonemaier Games (2019).

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



KIM EUKER

Ruddy duck, one of 170 species featured.