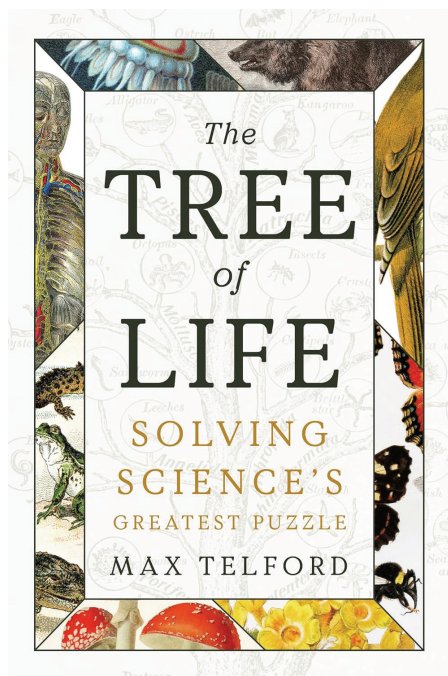


BOOK REVIEWS

KIRSTIN J. MILKS & FRANK BROWN CLOUD, DEPARTMENT EDITORS

The Tree of Life: Solving Science's Greatest Puzzle. By Max Telford. 2025. New York: W. W. Norton. (ISBN 978-1-324-06542-5). Hardcover. 274 pp., plus notes and index. \$29.99. Audiobook and e-book also available.



If you have ever wondered, “Why are we humans more closely related to a coelacanth than to a goldfish?” then this is the book for you. The answer is in the story of the history and diversity of life on Earth that we can sketch out in the “tree of life.”

Unlike simple classification, phylogenetic trees show us the hypotheses about the how and why living organisms have the features they do. They are the graphic organizers of evolutionary biology, helping us to visualize Darwin’s concept of descent with modification. In *The Tree of Life*, Max Telford provides a comprehensive look at the science behind these trees in a

succinct and accessible text. He shows us how researchers use trees as the framework for understanding and investigating important events and patterns in the emergence of new branches in the tree, as well as for understanding those branches that were discontinued.

But Telford also shows us how the tree is predictive, not simply descriptive. Early in the book, he likens the tree of life to the periodic table of the elements (p. 48). Both of these obviously organize what we know about the qualities and relationships of their constituents, but they also have the ability for us to predict the qualities and characteristics of the things we do not know—yet. Their very structures give us strong hints about what characteristics the missing elements are likely to possess.

Two of the most outstanding parts of this book are its ability to use the tree to tell the story of life on Earth and its demonstration of how to use all the diverse tools of evolutionary science to enhance the tree and test our hypotheses. Modern trees built using genomic, proteomic, developmental, morphologic, and palaeontologic data may seem to produce versions of the tree of life with small differences between them, but Telford helps readers to understand how even these differences can be used to give us a better idea of how new forms arose in the course of evolution, and how they help us to construct more accurate trees.

The pinnacle of this process is in Telford’s account of how we use the evidence from all fields of evolutionary science to understand and predict the features possessed by the last universal common ancestor (LUCA) of all organisms living on Earth today. He also reminds us that LUCA was probably *not* the very first form of life on Earth, but represents the foundational node of a tree that contains all the branches of life that we can study today (Archaea, bacteria, plants, animals, fungi).

This discussion reminds us that evolutionary science is *not* about the *origin* of life, but about how life on Earth diversified into what Darwin called “endless forms most beautiful.” Telford shows the data that scientists use to test the hypotheses (a) that all members of these major branches *can* be traced back to LUCA, and (b) that we can reconstruct the nature of unknown ancestral organisms with as-yet undiscovered intermediate features that help us to understand the evolutionary pathways along the branches of the tree.

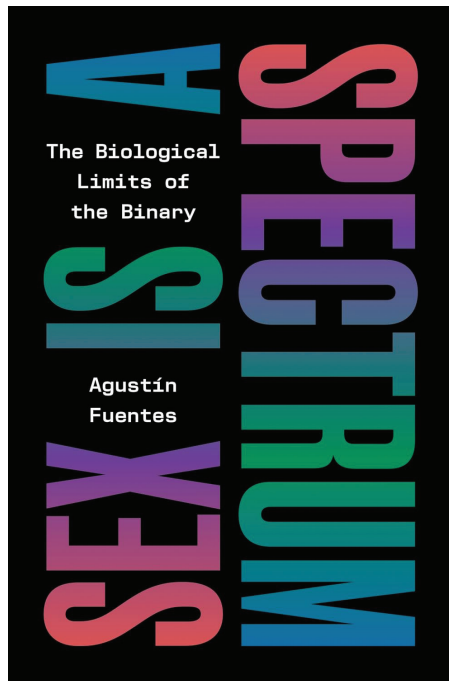
As a way of putting all these evolutionary relationships into perspective, Telford does take a close look at the biologic history that led up to a late-coming relatively minor species of African ape that we have presumptuously named *Homo sapiens sapiens*. Though a minor chapter in the history of life on Earth, this exposition is one of the best examples I have seen in showing how humans are an inseparable part of the tree of life that includes all the other forms of life on the planet.

This is a book you want on your shelf and in your library. It is full of examples that show how data from many disciplines are applied to the problem of the history and diversity of life on Earth and to test hypotheses about the relationships among life forms that have inhabited the planet. Most of the discussion is accessible to readers with a basic understanding of modern biology, but there is also enough information in the book that biology teachers could help bridge gaps for their students (and their parents) who have questions about where we come from.



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Sex Is a Spectrum: The Biological Limits of the Binary. By Agustín Fuentes. 2025. Princeton University Press. (ISBN 978-0691249414). Paperback. 150 pp.~\$16.95.



Introductory biology textbooks often describe meiosis in the chapter directly after mitosis. These processes do look very similar: DNA is copied, chromosomes condense, then genetic material is pulled toward opposite poles of a cell. This parallel presentation can obscure the inherent strangeness of sexual reproduction. An individual organism has a genome that has been sufficiently well-suited to the environment that this organism reached reproductive age ... and yet now that genome is going to be intentionally scrambled in an error-prone, mutagenic process? And paired slapdash with the genome of another organism, who might have used very different strategies for survival?

From the perspective of any one individual offspring, sexual reproduction is a raw deal. Each individual produced by sexual reproduction is less likely to receive a genome that is well-suited to the nearby environment than if the offspring had instead been cloned from a parent. However, sexual reproduction has been and continues to be a tremendously successful strategy for populations to endure. Sexual reproduction creates diversity—both introducing new mutations, and combining mutations inherited from different lineages into new unique genomes—and diversity has been essential

for populations to avoid extinction on our ever-changing planet.

Because the *function* of sex is to create diversity, there is a strong expectation that we would also see diversity in the mechanisms of sex, both between populations and within them. This is true whether we are considering the divergence of insect populations, in which reproductive organs often show the earliest and most dramatic morphological changes between new species, or the range of courtship displays seen in a single species of club-winged manakin.

When discussing insects or birds, most people with a rudimentary understanding of evolution would be unlikely to contest these general ideas. But this topic can feel so much more contentious when we consider our own minds and bodies. Sexual reproduction is deeply entwined with our identities. Who we are or aren't attracted to, how we do or don't want to be seen by those around us—these topics can feel fraught from very early on in childhood to throughout our lives.

In *Sex Is a Spectrum*, Agustín Fuentes focuses on the social ramifications of the diversity in our fellow humans' brains and bodies. This diversity is both inevitable and expected, given that ours is a sexually reproducing species, and the *function* of sex is to create diversity.

But that diversity is at times easy to overlook because there are a set of phenotypical correlates that have proven sufficiently successful over evolutionary time that the majority of humans can be classified as either male or female. Many of these differences are rooted in our genetics, although it's important to recognize that genes operate only within the context of environments. At the most trivial, it's obvious that a particular DNA sequence suspended in an aqueous solution in a test tube cannot give rise to any traits, but even within the context of a full developing human being, a whole cascade of chemical signals, environmental cues, and interpersonal relationships contribute to the expression of any given trait, whether that trait is something as genetically "simple" as skin color (affected by dozens of genes and the environment) or as complex as aggression (affected by thousands of genes and the environment).

And so the range of statements that people often make about sexual categories will be true of fewer and fewer people as we move farther from "simple" genetic causality. Males produce smaller gametes than females? True by definition. But if we were instead to argue that males have larger

external genitalia than females? Often, but not always. Males have higher levels of testosterone than females? This is true less often. Males are more likely to be attracted to women than females? True even less. Males are better at math than females? Setting aside the question of what it means to be good at math, the statistical distributions of mathematical ability will mostly overlap, and these statistical differences may result primarily from the environment.

Fuentes considers body shapes, hormone levels, personality traits, and more, carefully explaining the research showing both diversity within assigned sex categories, the overlap between sexes, and the range of phenotypes among people who are likely to feel excluded from a binary categorization of people as male or female. After all, the phenotypes of people living in the world today *were created by sex*, and sex creates diversity.

Throughout, Fuentes focuses on the social consequences of our understanding (or misunderstanding) of both sexual reproduction in particular, and of human diversity in general. In this book, Fuentes seeks to show how often a reflexive binary thinking about humans is flawed, *and* to show the real-world harms caused by such thinking.

There is also an excellent chapter on sports—please note that, although I am a volunteer assistant coach for my local high school's running teams, I don't have strong opinions about professional athletics. Many people do, though, and these big feelings about fairness in sports often spill over into people's understanding of sexual diversity in general.

Fuentes writes the following:

This focus on sports events, athlete's bodies, and testosterone is interesting and matters for the athletes and the sporting world. But it is a poor venue to examine, and think about, variation in sex biology in humans. Only a minuscule percentage of humans have the pattern of biological variation that confers bodily capacity, skillset, and opportunity to be elite athletes or even athletes in amateur and school competitive contexts ... elite athletes make up 0.0012 percent of living humans globally and 0.003 percent of people in the United States. Using one thousandth of one percent of humans, who are mostly at the extreme ends of the human range for many biological factors and with a lifetime [of] training related to their sports, as the key group to understand human-wide patterns

of sex biology is misleading and faulty science.

In terms of recommendations, I'd like to point out that Fuentes focuses more on the social implications of sexual diversity. If you'd prefer something that focuses on the underlying biology—the particular signaling cascades of transcription factors that give rise to sexual differences—I'd instead

suggest Richard Prum's *Performance All the Way Down* [link to previous ABT review: <https://online.ucpress.edu/abt/article-abstract/86/1/45/199002/Performance-All-the-Way-Down>]. That said, *Sex Is a Spectrum* is a charming, approachable treatment of a contentious topic that likely feels very important in the lives of the young people whom you work with.



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