



Carl Woese discovered the ‘third domain’ of life — the Archaea.

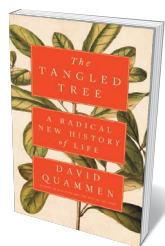
EVOLUTION

Scaling life’s tree

John Archibald praises a compelling guide to 3 billion years of life — and its molecular historians.

In *The Tangled Tree*, celebrated science writer David Quammen tells perhaps the grandest tale in biology: how scientists used gene sequencing to elucidate the evolutionary relationships between living beings. Charles Darwin called it the ‘great Tree of Life’. But as Quammen reveals, at the molecular level, life’s history is more accurately depicted as a network, a tangled web through which organisms have been exchanging genes for more than 3 billion years. This perspective is indeed radical, and he presents the science — and the scientists involved — with patience, candour and flair.

Centre stage in Quammen’s narrative is Carl Woese (1928–2012), the US microbiologist best known as the discoverer of the Archaea (Archaeobacteria) — the ‘third domain’ of life. Inspired by the visionary musings of Francis Crick, Linus Pauling and



The Tangled Tree: A Radical New History of Life
DAVID QUAMMEN
Simon & Schuster
(2018)

Emile Zuckerkandl, Woese committed himself to molecular phylogenetics at a time when this powerful approach to the study of evolution was in its infancy. During the 1960s and 1970s, the Woese Laboratory at the University of Illinois at Urbana-Champaign developed and refined techniques for deriving sequence information from molecules of ribosomal RNA (core components of the cell’s protein-synthesizing factory, the ribosome). Sequences were painstakingly obtained from diverse

microbes and used as molecular yardsticks to infer how the organisms were related to one another and to animals and plants. Through the following two decades, as molecular sequencing got easier and cheaper, Woese’s ‘three-domains’ tree — comprising archaea, bacteria and the nucleus-containing eukaryotes — served as the definitive road map for the field of comparative genomics. In many ways, it still does.

But life is complicated, and so are the scientists who study it. In his breezy, conversational style, Quammen shepherds us up and down life’s vast timeline, and across 150-plus years of exciting, often controversial discoveries. He handles the complexities with humour and clarity (he’s right: some ribosomes do look like rubber ducks). We learn about the seeds of “tree thinking” in biology, before and after Darwin’s 1859 *On the Origin of Species*. We learn of a time when a natural classification of microorganisms was considered impossible (they were deemed morphologically too simple, physiologically too variable). We learn how molecular sequencing helped test and eventually prove the endosymbiont hypothesis for the origin of mitochondria and chloroplasts; these eukaryotic organelles are now known to have evolved from once free-living bacteria.

And we learn that although molecular phylogenetics provided the means with which to build a universal tree of life that includes microbes, it also provided the data that ultimately led us to question the precise nature of the tree. From the late 1990s onwards, with dozens and eventually thousands of complete genome sequences in hand, biologists began to realize that the horizontal exchange of genes between distantly related organisms is an important evolutionary force. (Quammen also reminds us that, as early as 1963, medical microbiologist Tsutomu Watanabe and colleagues provided evidence for horizontal gene transfer as a mediator of antibiotic resistance in bacteria.) Because genes have “moved sideways”, not all genes in a given genome share the same history. Current evidence suggests that this is also true for at least some macroorganisms (such as plants). The tree of life is tangled, some branches hopelessly so.

At times, this master storyteller’s book reads like a travelogue. It brims with revelations from dozens of interviews with key players in their native habitats: the late Lynn Margulis, US champion of endosymbiotic theory; former Woese Lab members George Fox, Mitchell Sogin and Linda Bonen; and the environmental-DNA-sequencing legend and three-domains defender Norman Pace. Here too are “the four horsemen” of the gene-transfer apocalypse: William Martin, Jeffrey Lawrence, Peter Gogarten and Ford Doolittle.

Some of the stories are laugh-out-loud

funny. In one, Woese's collaborator Charles Vossbrinck — an “openhearted bear of a man” — picked up a tipsy, pontificating Woese at a barbecue and threw him into the bushes. (Their friendship survived.) Other tales are shockingly intimate. Woese's last months and weeks with pancreatic cancer, as revealed by those closest to him, make for painful, albeit illuminating reading. I was surprised, for instance, to learn that Woese believed in a deity.

The Tangled Tree traces the full arc of Woese's life and career. We see the fiercely determined young scientist struggling to collect the data that he intuited would be important, and the brooding, combative mid-career professor fighting to have his beloved archaea and three-domains tree accepted by the scientific community. Finally, there is the jaded, curmudgeonly

legend wracked by a Darwin complex. None of the accolades showered on Woese seemed to matter (he and many others clearly felt he deserved a Nobel prize, but he never got one). Around 2010, Woese and Canadian science historian Jan Sapp began to collaborate on a book tentatively entitled *Beyond God and Darwin*. The project never moved beyond Sapp's draft introduction, on which Woese wrote: “Jan, you accord Darwin so much more substance than the bastard deserves.”

Above all, Quammen reminds us that science is an imperfect, highly social activity. It happens in labs — but also in hallways and airports, over pizza or coffee. And as with any other human endeavour, egos and reputations play a huge part. Friendships are forged, broken and mended over perceived or actual slights in the literature or at conferences. The actual data matter less often than we would like to admit.

To what extent is the tree metaphor still ‘useful’? On this thorny question, Quammen is clear: among practising scientists, opinions differ greatly. Horizontal gene transfer is here to stay — it's now a question of how, how much, how important and between which organisms. And it is here that our twenty-first-century science connects back to the centuries-old struggle to classify and make sense of the world around us. At root, science and philosophy are interwoven in ways that many of us fail to realize, a fact to which Quammen is wisely alert. ■

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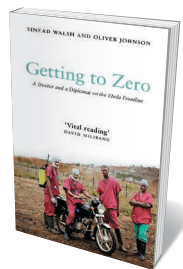
Books in brief



The Scientific Journal

Alex Csiszar UNIV. CHICAGO PRESS (2018)

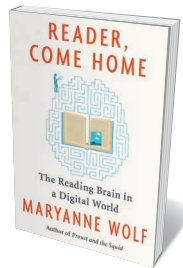
Journals form the canon of scientific knowledge. But how, asks historian Alex Csiszar, did it come to bear “so much epistemic weight”? Focusing mainly on France and Britain during the turbulent nineteenth century, he unpicks the knotted roots of journals from the Royal Society's *Philosophical Transactions* to *Annales des sciences naturelles*, and touches on the role of luminaries such as *Nature*'s first editor, Norman Lockyer. Amid fresh convulsions in scholarly publishing, much here resonates — not least, how commercial interests have shaped science communication almost from the start.



Getting to Zero

Sinéad Walsh and Oliver Johnson ZED (2018)

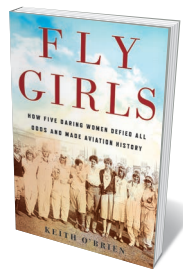
In 2014, as West Africa's Ebola crisis exploded, 28-year-old physician Oliver Johnson was co-running the isolation unit in Sierra Leone's main hospital; Sinéad Walsh was Irish ambassador to the country and head of Irish Aid. Their in-depth memoir enshrines distinct perspectives on the front line of a fraught epidemic, to offer a nuanced analysis: we see both the Herculean efforts on the ground, and the humanitarian response, warts and all (see also P. Piot *Nature* **537**, 484–485; 2016). Among the lessons learnt, the need to respect local ‘citizen medics’ and collaborate with governments is pure gold.



Reader, Come Home

Maryanne Wolf HARPER (2018)

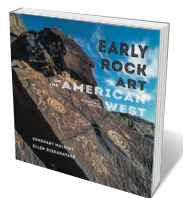
This rich study by cognitive scientist Maryanne Wolf tackles an urgent question: how do digital devices affect the reading brain? Wolf explores the “cognitive strata below the surface of words”, the demotivation of children saturated in on-screen stimulation, and the power of ‘deep reading’ and challenging texts in building nous and ethical responses such as empathy. She advocates “biliteracy” — teaching children first to read physical books (reinforcing the brain's reading circuit through concrete experience), then to code and use screens effectively. An antidote for today's critical-thinking deficit.



Fly Girls

Keith O'Brien HOUGHTON MIFFLIN HARCOURT (2018)

Shredded wings, broken propellers, stalled engines: in the 1920s, aviation was insanely risky. Undeterred, a select cadre of women embraced US aeroplane racing. In this engrossing mix of group biography and technology history, Keith O'Brien follows the lives of five: Amelia Earhart, Florence Klingensmith, Ruth Elder, Ruth Nichols and Louise Thaden. Earhart became a celebrity before disappearing over the Pacific Ocean; others found their prowess no match for sexism. The brilliant record-breaker Nichols, for instance, never flew professionally after the Second World War, and killed herself in 1960.



Early Rock Art of the American West

Ekkehart Malotki and Ellen Dissanayake UNIV. WASHINGTON PRESS (2018)

The ancient geometric petroglyphs and pictographs of the American West — pecked into or painted on boulders and canyon walls — are beautiful enigmas. In this fascinating volume, linguist Ekkehart Malotki and scholar Ellen Dissanayake parse images created up to 15,000 years ago by Palaeoamericans from Arizona to Idaho, speculating about their origins and functions. Alongside Malotki's stunning photographs of some 200 examples, the authors recontextualize the relics as products of ritualistic activity (‘artification’) rather than symbolic artworks. [Barbara Kiser](#)