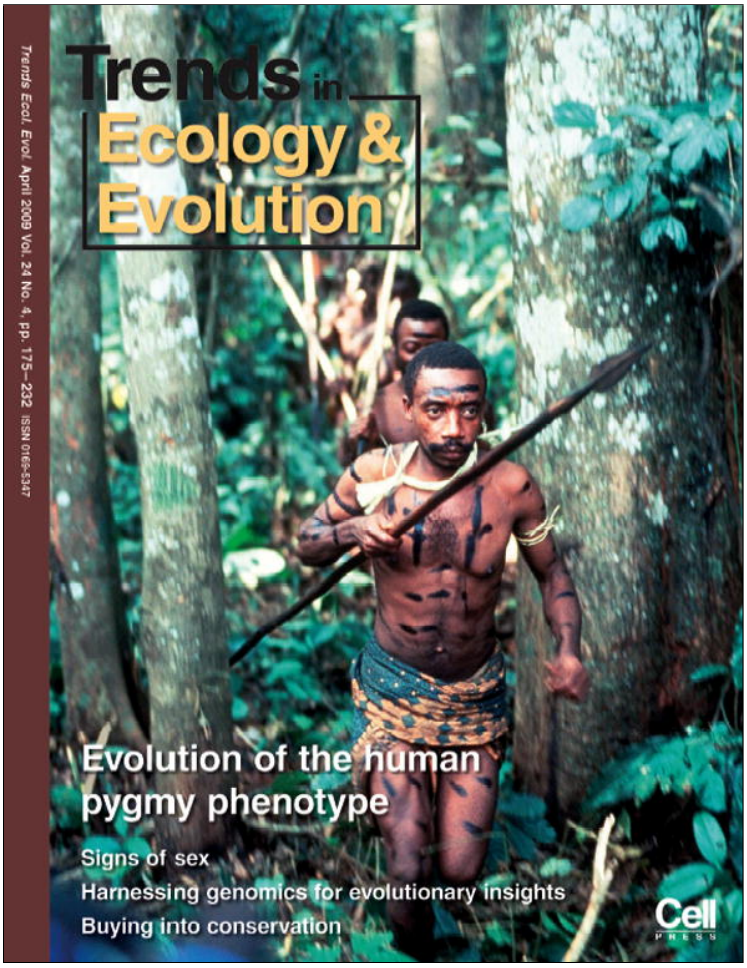
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Trends in Ecology & Evolution
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species represents evidence of its hybrid nature. *G. lamblia* certainly obtained a proportion of its genes via HGT. However, it has previously been suggested that incongruence among published *G. lamblia* phylogenies might be the result of model misspecification [7]. Interestingly, model misspecification will also inflate estimates of horizontally transferred genes [1]; but Arnold does not consider model misspecification as a possible alternative explanation in the case of *G. lamblia*.

In conclusion, I do think *Reticulate Evolution and Humans* is a book worth reading, although I feel that I should warn the reader that Arnold's view of reticulate evolution might, ultimately, be overenthusiastic, as some of the examples in his book still represent open questions (see above), and might be falsified as more data become available and better-performing phylogenetic methods and models are developed.

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Book Review

Big ideas in science

Big Questions in Ecology and Evolution by Thomas N. Sherratt and David M. Wilkinson, Oxford University Press, 2009, £55.00/£27.50 hbk/pbk (366 pages) ISBN 978-0-19-954860-6/978-0-19-954861-3

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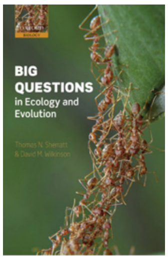

I often stump my students when I ask them 'from where do hypotheses come?' I then quote Richard Feynman [1]: 'The principle of science, the definition, almost, is the following: *The test of all knowledge is experiment*. Experiment is the *sole judge* of scientific "truth"' and note that Feynman goes on to write 'But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is imagination to create from these hints the great generalizations – to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we made the right guess.'

Sherratt and Wilkinson have written a book that will help everyone better understand where scientific ideas come from and how observation and imagination interact to create the questions on which science is based. Their book is inspired by one of a similar title by Paul Colinvaux [2] and they have honored the spirit of his book, while bringing in their own material and writing style.

Fittingly, the first page (in the chapter 'Why Do We Age?') of the book shows four pictures of Charles Darwin (at ages 35, 40, 45 and 71). In this chapter, the authors introduce the major evolutionary theories of aging as well as describe important empirical evidence and conceptual ideas such as heritability. They emphasize the importance of asking 'why' (ultimate factors) as well as 'how' (proximate factors [3]) questions and conclude, 'If you want the bottom line, the jury is still out. . .. Ageing is not all about genes.' This is a theme throughout the book: when we are at the cutting edge of science, things are blurry, regardless of the field.

The second chapter asks 'Why Sex?' After explaining the twofold cost of sex, Sherratt and Wilkinson emphasize that the question is how is sex ('a riddle, wrapped in a mystery, inside an enigma,' to quote Churchill) maintained. Once again, they emphasize that, at the edge of knowledge, there is no shortage of theories, and they do a fine job making both the explanations and difficulties clear.

Next, they turn to cooperation, another one of the great unsolved problems of both biology and the social sciences, according to Robert May in his last presidential address to the Royal Society. This chapter is followed by one on why there exist (and what exactly are) species, with an emphasis again on how species manage to persist and remain distinct. They note that Darwin, writing in *On the Origin of Species*, commented that no single definition of species satisfies everyone, yet everyone seems to know what they are at some level (much like quality [4]). They discuss one of my favorite examples of putative sympatric speciation, that of the apple maggot fly *Rhagoletis pomonella*, and then conclude the chapter by noting that the question 'why are there species' has been almost entirely neglected.

The scale then moves up to populations, ecosystems and the biosphere. The authors deal with the extraordinary diversity of tropical regions, but once again emphasize the

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lack of hard and fast rules (e.g. tropical deserts; comparison of tropical marine and terrestrial environments) and that in the tropics 'ecology meets evolution,' so that they conclude that the correct approach to understanding tropical diversity must give emphasis to both evolutionary and ecological processes. Rather than giving the following chapter the boring title 'Population Dynamics,' it is called 'Is Nature Chaotic?'; two pages into it they introduce the logistic map, one of the beautiful equations of science [5], and show how its bifurcations lead to chaos. Here I think that they missed an opportunity for emphasizing the importance of looking at things in the right way: even when a time series of population size, say $N(t)$, is chaotic, the phase plot of $N(t+1)$ versus $N(t)$ is not, and showing that would have been good. This is a fun chapter, because of the references to Lorenz's butterfly effect and Jeff Goldblum in *Jurassic Park*. It concludes with the idea that the best question to ask is, 'Under what circumstances will natural systems be chaotic?'

The next two chapters ask the connected questions 'Why Is the World Green?' and 'Why Is the Sea Blue?' Answering the first leads into food webs and top-down and bottom-up control, but of course it is rarely that only one factor operates. Answering this question leads to others, such as 'Why is the soil brown?' The blueness of the sea, compared to the greenness of the terrestrial environment, leads Sherratt and Wilkinson to discuss the lack of marine flowering plants, scarcity of nutrients in the ocean (particularly the role of iron in plankton blooms) and Redfield ratios. In concluding the answer about the blueness of the sea, they emphasize the importance of plankton (i.e. biology) in determining the chemistry of the ocean.

The book concludes nicely with a focus on the human–biosphere interaction, asking 'When Did We Start to Change Things?' and 'How Will the Biosphere End?' After discussing the arguments about humans in the Americas during the Pleistocene, the authors turn to other places (e.g. Australia), then ultimately to the entire planet and provide 1784 as the date for the start of human-induced global change (i.e. the invention of the steam engine). One lesson to learn is that there are few places untouched by the human footprint and, I extrapolate, we might be better off trying to improve all local environments rather than thinking of 'wilderness' as an isolated place that we go to [6,7]. So, how will it all end? As you might imagine, the answer from Sherratt and Wilkinson is more or less, we really do not know and that there is much thinking and learning still to be done.

To prepare this review, I reread Colinvaux [2] and also *The Problems of Biology* by John Maynard Smith [8]. In the preface to the latter, John writes, 'I have tried, then, to present what seem to me the fundamental ideas of biology, and some of the major unsolved problems.' Sherratt and Wilkinson have written a book that belongs with those of Colinvaux and Maynard Smith. Buy it for yourself and three or four for friends and relatives. It will help our entire field.

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