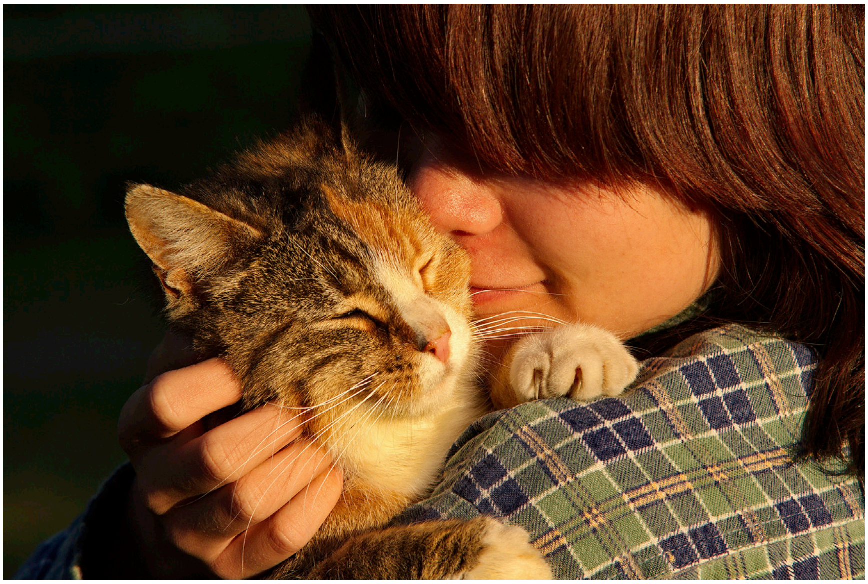

Pet: Although millions of cats are now kept as companions more than as mouse hunters, they have remained similar to their wild ancestors in many ways — much more than dogs. (Photo: JensEnemark/Pixabay.)

In a recent analysis of ancient DNA of guinea pig remains from South America and the Caribbean, Edana Lord from the University of Otago at Dunedin, New Zealand, and colleagues found that the guinea pigs imported into the Caribbean Islands before 600 CE, and after 1500 to Europe and the rest of the world, all descend from a population kept in the Andean region of Peru (Sci. Rep. (2020) *10*, 8901). The animals were initially captured and kept for food but were then also used in religious ceremonies. A different species of *Cavia* was domesticated in Colombia but didn't spread further. The conquest of the Americas brought guinea pigs to Europe as exotic and expensive pets. From the 18th century, they also became the proverbial laboratory animal for medical research.

Some species have a story of domestication that turns out to be a myth as soon as science gets to have a closer look. Thus, European rabbits (*Oryctolagus cuniculus*) were allegedly domesticated by monks in 600 CE after an edict from Pope Gregory declared that it was acceptable to eat foetal rabbits, known as laurices, during Lent. Trying to use this widely cited time point to test a dating method, archaeologists Evan Irving-Pease and Greger Larson at the University of Oxford, UK, discovered that there was no truth to the story. Instead, they now believe that the transition of rabbits from wildlife to pets was a drawn-out gradual process ranging from hunting to keeping the food alive, to breeding rabbits and eventually keeping them as pets (Trends Ecol. Evol. (2018) *33*, 149–152).

Since the first human settlements, we have been creating new urban environments and novel ecological niches for a wide range of species, from bed bugs to pigeons. The field of urban ecology is still in its infancy and still has much to explore, especially as the urbanisation of the planet continues at dramatic speed (Curr. Biol. (2018) *28*, R635–R638).

Beyond the simplistic (and not necessarily true) stories about how we tamed this species or domesticated that one, there are much more interesting processes to be discovered. With our activities we changed the ecological fabric around us, destroyed many habitats, but also created new ones. The story of how cats and mice moved in with us is part of a much bigger picture of how we redefine our natural environment and create our own ecosystem.

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Q & A

Andrew Berry

Born in London, Andrew Berry received an undergraduate degree in Zoology from Oxford. He moved to the US in 1986 to do his graduate work at Princeton with Marty Kreitman on ways of detecting positive selection — adaptation — in Drosophila *DNA sequences. He did a postdoc with Dick Lewontin at Harvard and is still there, as a lecturer in Organismic and Evolutionary Biology. In history of science, he has a particular interest in Alfred Russel Wallace, the co-discoverer with Darwin of the theory of evolution by natural selection. He has edited an anthology of Wallace's writings (*Infinite Tropics*, 2002) and the Penguin Classics edition of Wallace's* The Malay Archipelago *(2014). Also in a historical vein, he worked with James Watson to mark the 50th anniversary of the discovery of the double helix. The result was a series of media projects — online materials, a TV series, and a trade book,* DNA *(2003; new edition with Kevin Davies, 2017) — that laid out the key scientific ideas, outlined their development, and explored their social and political significance.*

What turned you on to biology in the first place? Inertia. I always worry when an undergraduate asks me this question hoping for an inspiring tale featuring some kind of I-have-to-be-a-scientist epiphany because I can provide none. It's fair to say that both nature and nurture conspired to point me in the direction of academic biology. And my career choices have generally as a result been default ones. Both my parents were geneticists — my father, R.J. 'Sam' Berry, was at University College, London, and my mother, Caroline Berry, at Guy's Hospital, London — meaning that I was raised in a thoroughly biological milieu. Our family holidays were trips to my father's field sites where the offspring were put to work as field assistants. And the subliminal you're-destined-for-biology message was amplified by my formal education. I went to

Shrewsbury School, whose most famous alumnus is Charles Darwin. Now it's true that Darwin wasn't exactly enthusiastic about the school, writing that "nothing could have been worse for the development of [his] mind", but his ghost nevertheless hovered benignly and encouragingly over my education. The biology department's African grey parrot — another prominent feature of my school career — was called Fitzroy, in honor of the captain of the *Beagle*.

What is your favourite experiment? One that I've done? A study from 1991 with Jim Ajioka and Marty Kreitman on adaptive evolution on the *Drosophila* fourth chromosome (Genetics (1991) *129*, 1111–1117). I think that this was the first convincing demonstration of a 'selective sweep', and it also introduced the term itself, which has since become a standard part of the lexicon of evolutionary genetics. The fourth chromosome is tiny — it's long been known as the 'dot' chromosome — and apparently does not undergo recombination. Jim, who was then a postdoc at Washington University, St. Louis, suggested that this would be the ideal place to look for evidence of positive selection because the entire chromosome would be subject to hitchhiking. In a sequencing study of a single fourth chromosome locus, we found a complete dearth of variation within species coupled with normal levels of divergence between species, suggesting that the standing crop of variation had been swept away as a by-product of the fixation of a favourable mutation. This general approach — looking for genome regions with low levels of polymorphism — has since become central in attempts to understand patterns of selection across genomes. I thought that the story would end there, but I was wrong. A follow-up paper out of Manyuan Long's lab (Science (2002) *295*, 134–137) demonstrated that our original single-locus study was too limited. It turns out that the fourth chromosome does in fact very rarely recombine, resulting in chromosomal segments that have very different histories. Again, the fly fourth chromosome was instrumental in establishing what has since become commonplace: that different pieces of genomes have their own distinct evolutionary histories.

Okay, but what is actually your favourite experiment? Ah, you mean one not done by me? Easy: Mathieson *et al.*'s 'Genome-wide patterns of selection in 230 ancient Eurasians' (Nature (2015) *528*, 499–503). Iain Mathieson, then in David Reich's lab, applied ancient DNA genomics to the detection of adaptive evolution in human genomes. The logic is exquisitely simple. Positive selection changes allele frequencies in a deterministic way over time (as opposed to the stochastic effect of drift), so it should be possible with a series of samples through time to identify loci under selection on the basis of their allele frequency trajectories. This is the joy of ancient DNA: it truly is a genetic time machine. By sampling European populations starting around 8,500 years ago, Mathieson *et al.* showed clear evidence of selection at several loci. The idea of comparing allele frequencies before, during, and after selection is far from new, but the scale of this study's application of ancient DNA data in doing this is what makes it a game changer. For the past century or so, population geneticists have worked to develop tools to infer past processes from current patterns of genetic variation. The fourth chromosome studies are just one example of this kind of study. The past is a black box, and it's for us to reconstruct what happened from the single snapshot that we have of the black box's output: namely today's patterns of variation. Now, assuming we have access to appropriate ancient DNA samples (a big ask I admit), the black box becomes transparent: we can add the previously missing time dimension to our analysis of population genetics.

You have a teaching position, though you sound pretty enthusiastic about research. Why did you give it up? It's complicated. In a nutshell, I realised that I could contribute more in the classroom than in the lab. I see teaching as a huge privilege: I get to stand up (well, these days, sit down in a Zoom session) in

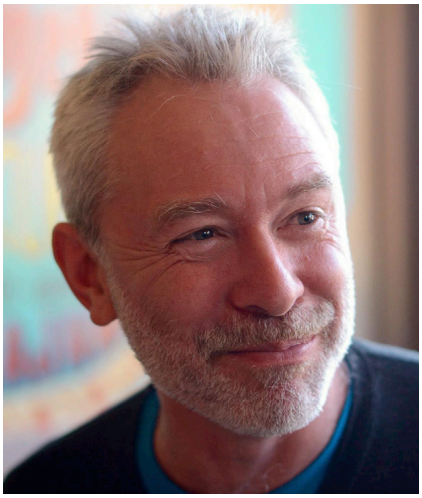

Photo credit: Shori Hijikata.

front of motivated, smart students and explain to them the things that I think are important. And, in my case, there was a major element of right time, right place to it as well. In the life sciences, in particular, the traditional model of a research/teaching university is beginning to creak. That old model of a faculty member with a small research group connecting in the classroom with undergraduates — the next generation of scientists — has worked superbly well. But today's equivalent of that faculty member runs a lab with 30 people in it, and it may well be a multi-million-dollar operation. They used to attend their one 'trade' meeting a year, but now in today's globalized scientific community successful PIs are forever giving keynote addresses in San Diego or Cape Town or Singapore. And yet there are still only 24 hours in the day. Something has to give, and often it's the teaching piece. Let's face it, most academic scientists are in science because they want to do science, not because they want to teach. There's a need, therefore, for dedicated science teachers to work alongside regular research faculty. That's what I do.

I love my job. I'm embedded in the scientific community — it's my responsibility to ensure that I'm on top of current developments so that what I teach is completely up to date — but I'm spared the constant publish-or-perish and/or funding anxieties of PIs. And I get to work closely with undergraduates, many of them remarkable people.

Where did the history of science piece originate? Teaching. It's an old standby from the science teachers' playbook: you can enliven and humanise an otherwise dusty and dry exposition of scientific ideas by bringing in stories about the people who gave us these ideas. I bet that virtually everyone who teaches evolutionary ideas about adaptive radiation brings up a vision of a young Charles Darwin rushing around the Galápagos Islands in pursuit of finch specimens. Initially then, for me the history of science was just a way to add colour to a lecture or a piece of writing, but over time it has become much more significant to me than that. It's a great way, for example, to give students a sense of how science is actually done. Too often a textbook account makes the scientific process seem more vectored and coherent than it really is, and that same account can make scientists seem almost superhumanly smart. Let's go back to Darwin in the Galápagos. We have the popular vision of a 'eureka!' moment as he encountered for the first time the different bill morphologies of the finches. In fact, he screwed up completely: he failed to note from which islands his finches were collected, and he only started to understand the birds' significance when the London ornithologist John Gould ran his experienced eye over them. Science is a messy, non-linear business and is often collaborative. A student who hears the 'eureka!' version of the Darwin story is likely to be intimidated — "I couldn't have done that. I'm no Darwin". On the other hand, hearing that Darwin too made mistakes and needed help is positively encouraging.

You teach courses that explicitly combine science and history of science. How does that work? Yes, I take a group of students every summer to the UK (well, except sadly this summer, 2020) for a program that jointly explores the science and the history of evolutionary biology. I also teach a condensed version of this on campus with Janet Browne, the Darwin scholar and biographer. I think that this is a great way to learn science: by getting a robust sense of how previous generations grappled with conceptual obstacles, students get a much better understanding of an idea than if it's simply asserted *ex cathedra*. Take the age of the Earth, a key problem in the development of evolutionary thinking. That the planet is ancient is not intuitively obvious, but any student who steps through the relevant history of science — Ussher's 4004 BC estimate, Buffon's study of the cooling rates of iron balls, Hutton's uniformitarianism, Lord Kelvin's objections to Darwin's time frame, modern isotopic analysis — emerges with a solid, well-informed appreciation of why current ideas are, well, current. This approach also allows students to understand that scientific discovery is very much an ongoing process: science is not a matter of discovering 'truth' and then moving on to the next problem. Too often students embrace our current understanding as definitively true. I love dismantling these ideas. In the past, plenty of very smart people embraced ideas that, today, are demonstrably false. Kelvin, for example, was wrong about the age of the planet because he didn't know about radioactive processes. And it wasn't only the Victorians who made mistakes. During the first half of the 20th century virtually all scientifically informed speculation on the identity of the hereditary molecule insisted that it would be protein, not nucleic acid. You surely wouldn't encode the baroque complexity of life with a four-letter nucleotide alphabet rather than a 20-letter amino acid one? In addition, learning science alongside its history shows students that, despite the protestations of plenty of scientists, science is a political enterprise. Eugenics eventually came to represent the hijacking of science for political purposes, but plenty of scientists aided and abetted that process.

You have an Alfred Russel Wallace fixation. Where did that originate? In 2000, the *London Review of Books* approached me about writing an essay on Wallace. At that stage I knew no more about him than most biologists know: I was dimly aware of a biogeographical boundary somewhere in Southeast Asia named after him, but mostly he was just the 'other guy' in the Darwin story. Writing the piece forced me to read Wallace — or to start reading Wallace, since he's written over 20 books and has more than 1,000 publications, so there is a lot to take on board — and I believe it's impossible not to fall in love with him once you've done so. For a start, there's the whole underdog thing. Why does Darwin get all the credit when in fact Wallace was the co-author of the theory of natural selection? Then there's Wallace's story: he grew up poor, dreaming of a career in science, and spent four years collecting natural history specimens in the Amazon, only for his ship to catch fire on the way home. He was rescued after 10 days adrift in a small boat in the middle of the Atlantic. You cannot but root for him! And these adventures are irresistible because he is such a marvellous writer. His description of eating durian fruit applies to his prose as well: "the more you eat of it the less you feel inclined to stop". His writings address a huge range of topics, scientific and non-scientific, and they're unfailingly compassionate and (usually) ahead of their time. For example, he insisted that, "to allow one child to be born a millionaire and another a pauper is a crime".

But perhaps the most compelling reason for being interested in Wallace relates back to the nature of the scientific process. Too often — yes, I certainly am guilty — we teach history of science as a series of 'Great Man' stories, when in fact scientific discovery is distilled from a complex matrix of social, political, and technological factors combined, yes, with individual insight. That both Wallace and Darwin came up with the same relatively simple idea more or less simultaneously is a beautiful illustration of this point: the discovery is not so much about Darwin or about Wallace but rather about the milieu in which they lived and did their thinking.

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