"known power". Was Teller driven, and corrupted, by the quest for power? Goodchild suggests that he was.

Despite such a tantalizing but generally underdeveloped theme, the book only rarely probes beneath the surface of Teller's political and personal life. It frequently relies too heavily on interviews to illuminate much earlier events and ignores many archival materials and some relevant secondary literature. There are also numerous errors (I spotted more than 50) in discussing events and quoting materials, describing people's careers and spelling names, and citing titles and authors.

Vigorously scrubbed and with full sourcing, including explicit reliance on other scholarship, this readable biography would deserve the significant audience it may well gain among those who want an inviting survey of Teller's life. It tells a story of Teller's personal and policy battles, with notable defeats and memorable victories. ■

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Gentle biases

Biased Embryos and Evolution
by Wallace Arthur
Cambridge University Press: 2004. 248 pp. £50, $85 (hbk); £18.95, $32 (pbk)

Armand M. Leroi

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A question of size: can biases in mutation rate alter the direction of evolution in different animals?

This book is an introduction to the principles of 'evo-devo' — evolutionary developmental biology. It is written with exemplary clarity and charm, and is clearly intended for the general reader or undergraduate. Beginning with a balanced account of the various strands of modern evolutionary thought, it goes on to outline the fossil history of animals, fruitfly developmental genetics, phenotypic plasticity, phylogenies and the various ways in which genes and ontogenies can change over evolutionary time.

So far, so conventional, even boring. But make no mistake. The author is Wallace Arthur and, as with all his books, there is a whiff of sulphur about this one. It comes on page 13 when he discusses orthogenesis, the notion that lineages have an intrinsic drive to evolve in particular directions. "Orthogeneticists were seen by many as mystics," Arthur writes. "But, even though I have no time for mysticism, I have to admit some sympathy for their cause."

These are brave words. Orthogenesis has been a cause without mainstream sympathizers for at least 60 years. The reason for this is that no one has provided a mechanism by which it might work. Most biologists believe that the evolutionary direction of lineages is largely determined by natural selection; a minority make great play of contingency (the non-selective effects of meteor strikes and the like). So what is going on? Has Arthur discovered a new principle of evolution?

Not really, no. The fuel in his orthogenetic engine is 'mutation bias'. Mutation produces novel phenotypes, but it does not produce all novel phenotypes in equal frequency in a given population. For example, mutations that cause an animal to become smaller than normal might be more common than those that cause it to become larger. This bias is the result of the way body size is specified in development — a bias that might influence the direction that evolution takes, causing small animals to evolve more often than large ones.

To epitomize Arthur's position, there is "a bias in the production of variant phenotypes or a limitation on phenotypic variability caused by the structure, character, composition or dynamics of the developmental system". The quote isn't from his book, it is from John Maynard Smith's famous position paper (*Q. Rev. Biol.* **60,** 265–287; 1985) defining what most of us call 'developmental constraints' — it's just that Arthur doesn't like the term. Many, perhaps most, evolutionary biologists accept that developmental constraints exist. If they aren't a major topic of study — and they should be — it is because distributions of mutational effects are very hard to measure.

Mutation bias is not enough to produce orthogenesis, however. If there is a single fitness optimum, or if the population is sufficiently large to ensure that all possible mutations are always present, then the direction of evolution will be dictated by natural selection alone. But if the landscape is rugged and population sizes small, the particular peak climbed by a population could depend on what mutations happen to be available. This is not orthogenesis of old — which posited a force independent of, or even capable of opposing, natural selection — but a reassignment of influence over evolutionary trajectories from natural selection to the kind of genetic variation available for it to work on.

If 'mutation bias' turns out to be a new term for an old idea, the same seems to be true for another unusual term: 'internal selection'. This is the idea that as one part of an organism evolves, it exerts selective pressure on other parts to change as well. Suppose a mutation increasing the length of an animal becomes fixed in a population. This might cause the subsequent fixation of another mutation that increases the animal's width, so restoring an original, harmonious, proportion. Arthur makes great play of this, but I think the interaction at the heart of this process is well known to population geneticists as 'fitness epistasis' and has often been experimentally demonstrated.

Evolutionary biologists will not be convinced by Arthur's arguments, for they are quite free of both data and maths. But some formal theory (for example, L. Y. Yampolsky and A. Stoltzfus *Evol. Dev.* **3,** 73–83; 2001) does underpin his claims, and it should force us to consider the relative influence of mutation and natural selection on evolution more carefully than we might have done. But this book is ultimately meant for general readers. They will find it a gentle and engaging account of how modern developmental genetics is beginning to affect the neodarwinian agenda. ■

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