on the diseases is not yet operational. Such a website would be a great help to all, but would admittedly be the cause of an enormous amount of work. Overall, this book more than meets its goals in providing a variety of answers to questions that all of us ask at one time or another about our health and the health of our families with regard to the diseases that are most likely to affect us.

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Diversity-generating mechanisms and evolution

Darwin in the Genome: Molecular strategies in biological evolution. (2003). Lynn H. Caporale. McGraw-Hill. x + 245 pp. $24.95. ISBN: 0-07-137822-7

Reviewed by
Adam S. Wilkins
Editorial Office, BioEssays
10/11 Tredgold Lane
Napier Street
Cambridge
CB1 1HN, UK

The best popular science books do more than simply present a complex scientific subject in clear, informative and interesting ways to the general reader. They also offer a new thesis or perspective, one that will engage the interest of specialists in the subject as well as non-experts. That thesis may endure and become part of the wisdom of the field or ultimately it may be invalidated or substantially modified. But if it succeeds in provoking discussion about a critical idea, the book's impact and usefulness will go considerably beyond that of the average good trade book. Richard Dawkins *The Selfish Gene* is an exemplar of this kind of popular science book.

Similarly, Lynn Caporale's short but informative and well-written book, *Darwin in the Genome*, is in the category of the ambitious popular science book. Dr Caporale tackles head on one of the central tenets of Neodarwinian evolutionary theory: the idea that evolutionary change is dependent on comparatively rare, randomly generated mutations. In the classic Neodarwinian view, not only is the rate of evolution dependent on the size of the pools of genetic variation but that rate is bound to be slow initially, as new beneficial mutations only rarely appear. In the author's view, this thesis is incorrect. She marshals, and discusses in clear fashion, the abundant evidence that evolution has selected for diversity-generating mechanisms in a wide range of organisms. These mechanisms ensure the rapid generation of new variants and, consequently, the rapid formation of pools of potentially useful genetic variation upon which selection can draw, thereby accelerating the evolutionary process well beyond what could be achieved by the classic Neodarwinian substrate of rare, randomly generated mutations.

That argument is laid out in a total of 20 short but informative and well-paced chapters. The first two chapters set the stage by presenting the basic Darwinian ideas of evolution and the fundamental facts about DNA structure and mutation. The evidence for a large and fascinating set of diversity-generating mechanisms in many different organisms, ranging from viruses to man, is then laid out in the following 17 chapters, with the final chapter providing a summing up within the larger perspective of the history of living things on Earth.

Altogether, the diversity-generating mechanisms (a general term that, incidentally, is not used by the author) comprise an impressive, and fascinating, list of phenomena. They include the mutagenic hot-spots in the toxin genes of cone snails, repeat-induced mutational events in a variety of organisms from bacteria to man, the vertebrate immune system (a diversity-generator par excellence) and a host of other mechanisms that pathogens employ to break through the defence mechanisms of their hosts. It is a highly informative survey of the plethora of mechanisms that organisms employ to boost genetic variation. Perhaps most significantly, there can be no doubt that most of the examples discussed, with the key exceptions of the repeat-generating mechanism in triplet-expansion diseases and the generation of genetic variations in cancer, have been selected by evolution. These processes accelerate the generation of new genetic variants and, in so doing, convey a selective advantage on the organisms that possess them.

The key question raised by this material is whether these mechanisms are all special (exceptional) in some sense. Do they truly challenge the general Neodarwinian precept that Dr Caporale questions? To put it slightly differently: has there been selection for diversity-generating mechanisms in the mutations that contribute primarily to organismal evolution, namely morphological (developmental) evolution, the source of the huge diversity of living forms?

The author clearly thinks that it does though she rejects the notion that evolution has "foresight" (to create the "right" sort of mutations) and she recognises that accelerated mutation rates have biological costs. Yet, in my opinion, the implicit extrapolation that she makes, from the cases of diversity-generation she reviews to evolution in general, is flawed. Most of the examples described by the author fall into the category of biological "arms races," whether in the cone snail example,

the malarial parasite, the pathogenic retroviruses, or the vertebrate adaptive immune system. Each of these cases involves accelerated variation-generation in one or a small set of genes and the selective value of such systems for their respective organisms is clear. The few examples where arms races are not involved, however, raise the question of whether the property of variant-generation has been actively selected as such or whether it is a concomitant of the system which has not been selected against. The bacterial SOS system, for instance, is an example. It is clearly an efficient diversity generator whose inherent "sloppiness" in DNA repair creates new variants in the face of physical environmental diversity. This diversity-generating machine may have been selected directly for this property but it may equally be a secondary by-product of a successfully selected rescue system, a feature that has not been selected against. It is hard to know and it is even hard to decide how one could experimentally distinguish between the two possibilities.

In contrast to the biological arms race systems, it is not clear how for morphological evolution (the kind that is responsible for the astonishing diversity of life forms), a population would "know" which genes should experience accelerated mutation in order to have selective advantage for some future evolutionary path. The alternative to such directed "adaptive mutation" would be a general boosting of mutation rates, to maximize the creation of favourable variants. This would be similar to the bacterial SOS system but would operate normally, not just under certain specific stress- or damage-inducing conditions. Yet, much evidence from prokaryotes indicates that mutations, in general, do have a cost and that the rates are kept low by selective factors (see Sniegowski et al. (2000). *BioEssays*, 22: 1057–1066). Prokaryotic mutator strains (those with elevated mutation rates) exist but do not predominate in normal bacterial populations. This cost of mutations is acknowledged in, at least, two places by the author but in passing, as if not a major caveat. The issue of cost of mutations, however, constitutes a serious objection to the validity of her argument when extended to *all* of evolution, particularly to the processes of evolution that have shaped the full diversity of living things on Earth.

In short, I was not convinced by the thesis that evolution has selected, in general, for relatively high diversity-generating mechanisms. Nevertheless, I enjoyed this book, learned things from it, and found myself forced to evaluate basic premises — which is always a useful exercise. The book is well-written, the subject is important, and it holds the reader's attention, right through to the Acknowledgements section at the end, which serves as a sort of autobiographical epilogue. (In fact, it is one of the few acknowledgement sections that I have found interesting and moving.) Despite my doubts expressed above about the generality of the author's key idea, the phenomenon of selected diversity-generating mechanisms is an important one, which has only been explored extensively in the past two decades (apart from the vertebrate immune system). Furthermore, despite the problems with extrapolating of their significance to evolution in general, the question of selection for "evolvability" remains a live one in evolutionary biology, and debate about it can only be healthy for the field as a whole. In short, I recommend this book highly, both for biologists and for non-biologist readers who are seeking a fresh look at one of the fundamental issues in the evolution of living things.

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