

Book Review

The Molecular Genetic Footprints of Evolution¹

A review of Sean B. Carroll, *The Making of the Fittest: DNA and the Ultimate Forensic Record of Evolution*. W.W. Norton: New York, 2006, 301pp, US\$16.95, ISBN-13 978-0393330519 (paperback)

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Sean B. Carroll, professor of molecular biology and genetics at the University of Wisconsin-Madison, injects three decades of research and experience into *The Making of the Fittest: DNA and the Ultimate Forensic Record of Evolution*. Carroll does not assume the same scientific experience of his readers as he deftly explains evolution by natural selection from a molecular genetics perspective. For most readers, especially those familiar with the principles of natural selection, Carroll's book will not provide novel insights, but he does a fine job reviewing Darwinian selection with clarity and accessibility.

The book is divided into two major sections. The first consists of a broad review of primarily molecular genetic empirical evidence consistent with evolution by natural selection, whereas the second summarizes social and religious responses to Darwin's theory. In the first section, Carroll documents the fact of evolution by natural selection, given heritable variation, differential reproduction, and the vast expanse of time available for selection to operate. Carroll briefly reviews empirical evidence for several apparent adaptations, highlighting these cases as examples of the primary product of evolution by natural selection.

Carroll begins his empirical defense of evolution by natural selection by demonstrating its computational feasibility. This section may be old-hat for readers well-versed in evolutionary theory, but it has value for those who are either skeptical about or not aware of the tremendous impact that the understanding of evolution has had upon the life sciences. Carroll's main goal here appears to be to convince the reader that not only does evolution by natural selection occur, but also that in some species it may occur more rapidly than one might expect. To make this last point accessible for a general audience, Carroll reviews the now-famous studies tracking the color adaptation of peppered moths. As England and the United States began to industrialize in the 19th century, air pollution levels increased dramatically. Between 1848 and 1896, 98% of the peppered moth

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population evolved a dark, melanic coloration. With the onset of clean-air laws in the last half of the 20th century, the melanic coloration has virtually disappeared, now comprising just 10% of the peppered moth population.

Noting that there are several misconceptions about the nature and occurrence of genetic mutations, Carroll next addresses the role of mutations. Two of the most common misconceptions are that all mutations are destructive, and that chance mutations cannot play a role in the ordered complexity of living organisms. Carroll quickly dismisses both as exemplar “arguments from incredulity” (*sensu* Dawkins). Humans experience a mutation rate of roughly 175 mutations per individual. These generally occur at inactive genetic sites, do not alter genetic function, are compensated for by duplicated genes, or interact with other genes in a tolerable fashion. To address the second misconception, Carroll explains that over a vast period of time, natural selection operates on chance mutations to build incrementally and gradually every adaptation of every living organism.

After reviewing how evolution by natural selection is computationally feasible and empirically substantiated, Carroll references the archaea and bacteria kingdoms to discuss the origins of life. Carroll reviews investigations of genetic code which reveal that several pieces of DNA code are shared by archaeans and eukaryotes. This provided a significant clue to the origin of eukaryotes. As geneticists further investigated the three kingdoms—archaea, bacteria, and eukaryote—they found that archaean and eukaryotic genomes were closely related to bacteria. Further research indicated that eukaryotes derive from a combination of bacteria and archaea. The fusion of bacteria and archaea results in a ring which then leads to the eukaryotic branch. Carroll concludes that the popular depiction of the tree of life is not quite accurate: “The resulting base of the tree of life is then not a trunk, but a ring from which our tree ascends and branches” (p. 88).

In the first three chapters, Carroll asks and answers two fundamental questions: “How possible is it that evolution by natural selection has occurred?” and “What is the origin of complex organisms?” For much of the remainder of the book, Carroll discusses the products of natural selection, notably adaptation, with much of this discussion focusing on the molecular genetics of color vision.

The great ape family is marked by trichromatic vision, which replaced reliance on olfactory senses to identify mates, dangers, and food sources. To illuminate this point, Carroll contrasts the visual and olfactory abilities of humans and other, smaller mammals. Small mammals, such as mice, have about 160 functional V1r receptors for olfaction whereas humans have just five such receptors. It is estimated that half of all human olfactory receptor genes are “fossilized,” meaning that they remain in the genome, but their function has been abandoned. Research has identified that mammals other than members of the great ape family have dichromatic vision, which is composed of a single MWS (medium wavelength of light)/LWS (long wavelength of light) opsin. Humans and other great apes have two separate opsins for MWS and LWS. This example encourages the reader to appreciate how organisms can evolve different solutions to similar adaptive problems.

After providing the reader with overwhelming data supporting the fact of evolution by natural selection, Carroll discusses a few of the arguments in apparent opposition to the theory. Although he relates interesting examples from the political and pseudoscientific spheres, such as the banning of the discussion of evolution and genetics in the former Soviet Union, the ones he relates are extreme and infrequent. In our view, the greatest

apparent opponent to evolution by natural selection comes by way of religious ideology. One-third of American adults do not “believe” in the theory of evolution by natural selection; furthermore, a greater percentage of adults in Japan and 32 European nations accept evolution by natural selection than do Americans (Miller, Scott, and Okamoto, 2006). An important contributing factor to American disbelief or denial of evolution by natural selection is religious fundamentalism and biblical literalism (Miller et al., 2006).

Carroll claims that religion and science can co-exist without opposition. He also claims that a large percentage of scientists adhere to mainstream religious beliefs. In our view, the principles of science not only directly oppose faith and superstition, but also are used to generate rational, evidence-based answers for phenomena that were once thought to be miracles. With regard to the religious beliefs of scientists, Larsen and Witham (1998) report the results of a survey in which they asked 517 members of the National Academy of Science about belief in a personal god. A paltry 7% of the surveyed members reported belief in a personal god, whereas over 90% rejected or doubted the existence of a personal god. When Larsen and Witham considered the beliefs of scientists by their field of expertise, a mere 5% of biologists reported belief in a personal god. More recently, Graffin and Provine (2007) invited 271 evolutionary scientists to share their views concerning religion and other topics. Of the 149 responses received, less than 5% reported theistic beliefs. Carroll’s two claims are inaccurate and misleading.

Overall, *The Making of the Fittest* is a potential useful addition to an evolutionary psychologist’s bookshelf. It provides a wealth of biological and especially molecular genetic information that most psychologists may not otherwise encounter, but with which they should be familiar. It also is likely to be useful for students, possibly serving as a supplementary tool for those struggling to understand evolution by natural selection. Although we have severe disagreements with Carroll’s philosophical claims about the interface of science and religion, this is otherwise a fine book that is written in a clear and engaging voice.

References

- Graffin, G.W., and Provine, W.B., (2007). Evolution, religion and free will: The most eminent evolutionary scientists have surprising views on how religion relates to evolution. *American Scientist*, 95, 294-297.
- Larson, E.J., and Witham, L. (1998). Leading scientists still reject god. *Nature*, 394, 313.
- Miller, J.D., Scott, E.C., and Okamoto, S. (2006). Public acceptance of evolution. *Science*, 313, 765-766.