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Abstract: In this article the authors discuss the end of the debate regarding nature and nurture as separate evolutionary forces. They note that one of the most pivotal arguments regarding the relative roles of genes and environment in human nature has seemingly been resolved, but the nature/nurture debate continues to thrive. A discussion on what the authors think the debate is really about, including the ambiguity and uncertainty of various nature/nurture questions, is presented.

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The sound of distant drumming

Goodbye nature vs nurture debate

Talking about nature and nurture as separate, clear-cut forces is now seriously adrift from the complexities of developmental science, says Evelyn Fox Keller

ONE of the most striking features of the nature/nurture debate, the argument over the relative roles of genes and environment in human nature, is the frequency with which we read it has been resolved (the answer is neither nature nor nurture, but both) while at the same time we see the debate refuses to die. So what is it that evokes such contradictory claims, that persists in confounding us? Indeed, what is the debate really about?

This turns out to be far from easy to explain because different kinds of questions take refuge under its umbrella. Some express concerns that can be addressed scientifically, others may be legitimate and meaningful but perhaps not answerable, and still others make no sense. One reason for the persistence of the nature/nurture debate, then, is that these questions are knitted together by ambiguity and uncertainty into an indissoluble tangle, making it all but impossible to stay focused on a single, well-defined, meaningful question.

Another important issue is that some of that ambiguity and uncertainty comes from the language of genetics itself. For example, we may read that the debate is about sorting contributions of nature from those of nurture, and trying to estimate the relative importance, but what exactly is meant by "nature" and "nurture"? Sometimes the distinction is between what is inborn and what is acquired after birth; more often, it is between genes and environment. But not only does nurture affect prenatal development, we also need to ask what exactly is a gene, and what does it do? What do we mean by environment? Does it refer to factors beyond the organism

that affect its development, to the milieu in which the fertilised egg develops, or to everything other than the DNA sequence? Finally, there's the question of contributions. Contributions to what? This question is almost never posed, yet it is the most recalcitrant source of trouble with the nature/nurture debate. The reason is that the subject of debate depends critically on our tacit assumptions about how that question is to be completed.

A common assumption is that what is at issue is a comparison of the contributions of nature and nurture to the formation of individual traits. In his widely read book, *Nature via Nurture*, Matt Ridley argues that modern genomics has shown that, expressed that way, the nature/nurture debate invokes a meaningless opposition: "The discovery of how genes actually influence human behaviour, and how human behaviour influences genes, is about to recast the debate entirely. No longer is it nature versus nurture, but nature via nurture. Genes are designed to take their cues from nurture."

Ridley is, of course, correct. But H. Allen Orr, a population geneticist at the University of Rochester, New York, complained in *The New York Review of Books* (14 August 2003) that Ridley "seems to have the right answer to the wrong question". The right question is statistical, Orr says. "It asks about the percentage of variation in, say, IQ, that arises from inherited differences among individuals (do some parents pass on smart genes to their kids?) versus the percentage that arises from environmental differences (do some parents pass on books to their children?). [Ridley's] question is mechanistic. It asks about how genes behave within individuals. The fact that genes respond to experience is certainly interesting and important. But it's the wrong kind of fact to settle the debate."

Orr is writing from a field where virtually all efforts focus on statistics, and where most of his colleagues recognise the question of how much an individual trait owes to nature/genes and how much to nurture/environment to be unanswerable. Yet ambiguity in the language of genetics fosters slippage between the two questions, maintaining their linkage not only in the popular imagination, but also in the literature. Even Orr's colleagues have difficulty sometimes in remaining clear about the distinction between statistics and mechanism. The unfortunate effect is to obscure the basic fact that the causes of the development of a trait are not separable.

The factors involved in development are many: nucleic acids (DNA/RNA), metabolites and proteins; nuclear and cytoplasmic factors; genetics and environment. Recognition that their influence cannot be disentangled goes back a long way. In 1932, in *Nature and Nurture*, geneticist Lancelot Hogben wrote: "Genetical science has outgrown the false antithesis between heredity and environment productive of so much futile controversy in the past." And everything we have learned since has only underscored the fact that the entanglement of developmental processes is from the start immensely intricate.

The development of a fertilised egg depends on the complex orchestration of multiple events involving interactions among many kinds of elements, including not only pre-existing ones such as molecules, but also new elements, such as coding sequences formed out of such interactions, temporal sequences of events, and dynamic interactions.

Compounding this entanglement of genes and environment further, biologists now recognise that the development of phenotypic traits is guided not so much by the actual sequence of nucleotides as by patterns of gene expression. These are themselves products of an immensely complex web of interactions between environmental stimuli (both internal and external to the cell) and the structure, conformation and nucleotide sequence of the DNA molecule. To think of the causes of development as separable is, therefore, a mistake. Moreover, given that the very notion of interaction presupposes entities that are, ideally, separable, it can even be misleading to speak of development as a product of causal elements interacting with one another.

Hans Kummer, a primatologist now at the University of Leipzig, Germany, offered a useful analogy when he said that trying to determine how much of a trait is produced by nature/genes and how much by nurture/environment is as useless as asking whether the drumming we hear is made by percussionist or instrument. Neither the drumming nor the trait of an organism is composed of separable elements.

The formulation that presupposes the separability of nature and nurture can be traced to Francis Galton's 1874 book, *English Men of Science*, where he wrote: "The phrase 'nature and nurture' is a convenient jingle of words, for it separates under two distinct heads the innumerable elements of which personality is composed." Authors had written about nature and nurture long before, but never to my knowledge in terms of disjoint elements. Yet the notion took off, at least in the Anglo-Saxon world. Why? And why, given what we now know about developmental dynamics, is it so resistant to dissolution?

Galton's formulation was greatly assisted by Charles Darwin's theory of particulate inheritance. But where Darwin thought these particles ("gemmules") might sometimes allow acquired characteristics to be passed on, Galton was convinced otherwise. To him, they were unchanging--hard, like atoms--and, like many others, he thought particulate inheritance could do for biology what atomic theory had done for chemistry.

But biology, and genetics, turned out to be vastly more complicated. Not surprisingly, the language of genetics lags behind, keeping alive debates that no longer have--indeed, may never have had--meaning. My hope is that a language that better reflects contemporary science will help us out of this morass, and let us reformulate questions about nature and nurture in ways that more productively address concerns people continue to have.

Profile

This essay is based on *The Mirage of a Space Between Nature and Nurture* by Evelyn Fox Keller (Duke University Press), emeritus professor of history and philosophy of science, Massachusetts Institute of Technology. Her books include *Making Sense of Life* (Harvard University Press, 2002).

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