

## **Evelyn Fox Keller: *The Mirage of a Space Between Nature and Nurture***

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### **1 Introduction**

For well over 100 years, some scientists have been interested in disentangling how nature and nurture affect the development of people's characteristics. After all, some characteristics appear uninfluenced by the contexts in which development occurs, whereas others appear very much affected by developmental environments. To choose two obvious examples, skin color appears to be little affected by a child's nurturing environment—children born to black Kenyan adults, for example, grow up to have dark skin like their parents even if they are raised by adoptive white parents in Denmark—and language appears to be little affected by a child's natural biological inheritance—those same children learn to speak the perfect Danish of their adoptive parents, knowing nothing of their biological parents' Swahili. As a result, it seemed reasonable to Charles Darwin's cousin Francis Galton to attempt to develop a way to measure the relative influences of nature and nurture on human traits. Efforts building on Galton's studies in this domain have continued to the present day.

More recent theorists have recognized that Galton mischaracterized the origins of our traits; because nature and nurture in fact always interact during development, both factors are always influential. Although skepticism about this fact remains high when the traits in question are thought to be "biological"—for example, many people seem confident that traits like skin and eye color are genetically determined and therefore uninfluenced by nurture—psychological traits (e.g., behaviors, intelligence, and temperament) are generally understood to be influenced by both genetic and environmental factors. Consequently, the nature/nurture debate is considered by many to have been resolved. Why, then, might a new book on this old debate be of value?

In *The Mirage of a Space Between Nature and Nurture*, Evelyn Fox Keller explains why this debate is ongoing in spite of repeated claims that it has been resolved. She uses several sorts of evidence to demonstrate that even molecular biologists, behavior geneticists, and philosophers of science sometime appear confused about these issues. But the general

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public remains confused as well; traits like hair color and height are widely thought to be caused by the actions of our genes alone, but it is now clear that such beliefs reveal a mistaken understanding of how traits actually develop. Genetic and non-genetic factors really do interact to produce *all* of our traits, whether they are biological traits like eye color and brain structure or psychological traits like schizophrenia, shyness, or alcoholism.

Likewise, many people continue to believe that it is possible to measure the extent to which a trait is genetic, but this idea, too, is mistaken. In fact, no one can measure the importance of a factor known to be *necessary* to produce an outcome. How important is it to have gasoline in your automobile if you want to be sure it will run? It is necessary! How important is it to have functioning spark plugs in your car's engine if you want to be sure it will run? It is necessary! Which is *more* important to the functioning of your car, spark plugs or gasoline? The question makes no sense, because both are absolutely necessary. Similarly, it makes no sense to ask if nature or nurture is more important in the development of a trait, because both play essential roles. The persistent belief that it is possible to conclude that some traits are *more* genetically determined than others illustrates why the world still needs a book like Fox Keller's.

Of course, this topic has been considered in detail before, including by Lewontin (1974), Block (1995), and myself (Moore 2001, 2006), among others. In fact, Fox Keller cites many other writers who have offered trenchant critiques of some of the issues underlying this debate; hers covers much of the same ground, and, frankly, in a way that would not be quite as accessible to readers completely unfamiliar with these issues. What makes this book a helpful addition to this literature is its focus on the *reasons why* critiques like these have been so unsuccessful at changing how people think about the nature/nurture debate. In particular, Fox Keller is concerned with the question of how and why, in the history of science, nature came to be seen as separable from nurture. People living before Galton's time did not think of these two as independent factors, let alone as potentially oppositional *alternative* contributors to development; as Fox Keller asks, "how did the separation on which opposition is predicated—the *and* on which a *versus* depends—come to be so taken for granted?" (p. 10). Her argument ultimately focuses on the semantic confusion that has arisen as a result of the fact that the word "heritable" means two different things.

Among the strengths of the book is its concise format and tight focus. Fox Keller recognizes that her subject invites discursions into topics like eugenics and how economic and political forces influence scientific pursuits, but in her text she wisely sticks close to her central question about the inseparability of nature and nurture. Her first chapter provides the historical background necessary to understand her subsequent arguments, and her final (4th) chapter offers her visions of a reasonable path forward. In between are two chapters that present the heart of her arguments, the first—Chapter 2—on the distinction between traits and trait differences, and the second—Chapter 3—on the distinction between individual organisms and populations. At a mere 84 pages (not including notes, bibliography, and index), the book is a quick read and so undoubtedly useful in graduate-level courses.

## 2 Chapter One

In this chapter, Fox Keller traces the historical roots of "the tendency to think of nature and nurture as separable and hence as comparable, as forces to which relative strength can be assigned, as suggesting opposability and, accordingly, as inviting debate" (pp. 15–16). Her

discussion of these issues is thought-provoking, fresh, and important. Nonetheless, the text would likely be somewhat challenging for readers with less experience thinking about these matters. There are ideas here that will be difficult for some readers to assimilate, in part because the separability of nature and nurture seems so intuitively reasonable to our modern minds, and in part because Fox Keller is comfortable using words—such as “disjunction,” “polysemy,” and “elide”—that, while precisely right in the current context, will still be unfamiliar to many. Although it would be good for all of us if Fox Keller’s message could reach a large audience, this book is somewhat less accessible than it might have been.

Fox Keller’s historical analysis leads her to conclude that our modern understanding of nature and nurture as separate and oppositional has its roots in a novel understanding of heredity first evident in Darwin’s writings. For Darwin, she claims, heredity came to refer “to the transmission of something biological, of some substance that resided *inside* the body” (p. 21, my emphasis). Subsequently, the word “innate” came to be associated with heredity and the word “acquired” came to be associated with the environment (i.e., that which is external to the body). This internal/external dichotomy allowed nurture to be disjoined from nature. From here, it was a relatively small step for Galton to begin thinking about empirical methods that could be employed to measure the relative contributions of nature and nurture to the development of human characteristics. His chief innovation for this purpose, the study of twins, is still in use by quantitative behavioral geneticists to this day.

### 3 Chapter Two

The goal of twin studies is to measure the extent to which a trait is heritable in a population. In Chapters 2 and 3, Fox Keller systematically explores the conceptual problems that arose when the common word “heritable” was given a new technical definition in 1936, one that is quite different from its traditional definition. Although “heritable” traditionally meant “capable of being passed from one generation to the next,” the same word is now used in the quantitative behavioral genetics literature to describe traits that vary across a population in a way that can be statistically accounted for by genetic variation in the population. And although Galton clearly hoped this technically defined type of heritability would reflect our intuitions about the traditional type of heritability, this chapter explains why technical heritability measurements do not, in fact, tell us how inheritable our traits are.

Following Galton, quantitative behavioral geneticists spent the twentieth century asking statistical questions about genetic and environmental contributions to our differences, and *not* asking causal questions about genetic and environmental contributions to the “processes that make us what we are” (p. 32). If these two types of questions—one a question about trait differences, the other a question about processes that *build* traits—do not strike you as particularly distinguishable, you are not alone; this distinction is typically difficult to grasp. After all, if I tell you I have discovered a gene present in all blue-eyed people and absent in all brown-eyed people, you might think I have identified the gene that *causes* blue eyes. But this is not correct. In fact, the distinction Fox Keller considers here is an extremely important one, and the two types of questions are actually very different from one another.

One question asks “can we account for the *difference* between blue-eyed and brown-eyed people by considering this gene alone?” Given the hypothetical situation I just

described, the answer to this statistical question could very well be “yes.” But having identified a gene that distinguishes blue- from brown-eyed people, have we *not* identified the gene that causes blue eyes? The answer here must be “no,” because it is quite possible that blue eyes actually develop only in the presence of several genes, one of which is our newly discovered gene, but the rest of which are common to both blue- and brown-eyed people. Of course, there is a sense in which the new gene can be thought of as the gene for blue eyes—because in this hypothetical story, this gene appears necessary for the development of blue eyes—but there is another sense in which it ought not be thought of as the gene for blue eyes, because it is not *sufficient* to produce that trait; people with blue eyes all have several genes that together build blue eyes. (For more information on the polygenic determination of iris color in human beings, a reasonable place to start would be Sturm and Frudakis 2004.)

So, finding a genetic difference that accounts for a trait difference across multiple people does not tell us what causes the trait in any individual. In particular, it does not tell us how important any genetic contributions to the development of the trait might be (other than that there is at least one genetic contributor that has *some* influence, however small or indirect it might be). This is why a trait that is consistently found to be highly heritable (in the technical, statistical sense) is no more caused by genetic factors than is a trait consistently found to be hardly heritable at all. Using examples similar to those introduced by Block (1995), Fox Keller draws a clear and accurate conclusion: “we cannot predict the technical heritability of a trait even when it is known to be genetic, and we cannot predict whether a trait is genetic even when it has been shown to have high heritability” (p. 62). This is because technical heritability tells us only about *differences* in traits across a population, not about the causes of those traits. As Fox Keller puts it, “technical heritability neither depends on, nor implies anything about, the mechanisms of transmission (inheritance) from parent to offspring” (p. 61).

This distinction between the meanings of “heritability” is so important—and has been the cause of so much confusion—that Fox Keller’s treatment of it is a valuable addition to the literature on this topic. In particular, she does an excellent job of finding quotations—for example, from Sober, to Sesardic, to Wikipedia, and to Pinker—that illustrate the rampant conceptual confusion that still surrounds this issue. She writes that “slipping” from cause-of-trait talk to cause-of-difference talk “has become so routine [...] as to go unnoticed, even to the point of having become part of much conventional reasoning about genetics” (p. 41). Some parts of Chapters 2 and 3 re-cite previously raised criticisms, or merely identify instances in which writers have ignored the crucial distinctions critics have warned us not to ignore. However, there is value in being explicit about the kinds of problems we should *expect* to arise when a single word is used to mean two different things, and when writers are neither explicit about which meaning they intend nor write in a way that allows contextual disambiguation. Ultimately, there can be little doubt that the existence of widespread confusion is interesting and worthy of analysis. As Fox Keller posits, the fact that many critiques have failed to end the dichotomous nature/nurture debate is likely a reflection of the fact that our words have perpetuated—and perhaps even encouraged—misinterpretations of what exactly we are discussing at any given moment. Put bluntly, “when... words... have multiple meanings... it is not only easy to mean two—or even three—things at once, it may be unavoidable” (p. 71).

When Fox Keller considers modern medical genetics in Chapter 2, she demonstrates how resolution of philosophical issues like these can sometimes have very real effects in our day-to-day world. She writes “the notion of a gene ‘causing’ a disease (or even of a particular [DNA] sequence ‘causing’ a disease) has exactly the same status as the notion of

a gene ‘causing’ a phenotypic difference” (p. 47). That is to say, genes ought not be understood to cause diseases. Instead, the presence of a single mutation could theoretically be shown to be correlated with the presence of particular symptoms without those symptoms being caused directly by that mutation (in the same way that a single gene might distinguish brown-eyed from blue-eyed people, even though we know that eye color is not caused by any single gene). In fact, even in the exceedingly rare cases in which single mutations *have* been implicated in diseases, what has turned out to matter when we try to treat or prevent the disease is not the mutated gene, but that gene’s effects-in-development. To date, successful treatments of most of these types of diseases have depended on understanding (via direct biochemical analysis) what is occurring in an affected body metabolically, not on understanding what genetic difference distinguishes afflicted from unaffected people. In speaking of one such disease—PKU—Fox Keller writes:

There is no way in which the genetics of difference alone could have produced [our current understanding of PKU]... What was required for [...] therapeutic intervention was a biochemical analysis of the metabolic pathway that had gone astray. That analysis *might* have begun with the identification of a particular gene, but if it had, what would have been required is an understanding of the gene’s downstream effects, of the particular role actually played in development by the [mutated] gene... (p. 49)

I found Fox Keller’s Chapter 2 to be clear and illuminating, but it is definitely abstract in places and assumes some familiarity with molecular biology; given how important her points are, it is unfortunate that some of this text would be rather challenging for anyone who has not already thought about the fundamental differences between what causes traits and what causes trait differences.

#### 4 Chapter Three

Fox Keller’s next chapter focuses on the fact that technical heritability measurements tell us about populations, not about individuals. This issue is intimately related to the trait *differences* versus trait *causes* issue, because studies of the differences between people necessarily involve the study of *multiple* people.

One reason “heritability” has retained both of its meanings (even among scientists who recognize the need for linguistic precision) has been because in specific contexts, the meanings dovetail nicely. For example, the dual meanings of heritability are non-problematic for farmers—even as they are extremely misleading for the rest of us—because farmers are always concerned with populations, not individuals; as Fox Keller notes, “Unlike academic biologists, farmers are seldom concerned about how an individual plant or animal acquired a superior attribute” (p. 59). Nonetheless, because scientists in several disciplines use this word to refer to different things, the problem remains with us. Molecular biologists typically use “heritable” colloquially (i.e., to describe traits that are transmissible *to individuals* across generations), and consequently, as Fox Keller points out, “even if behavioral or quantitative geneticists were scrupulously careful to avoid [...] ambiguity, never sliding into the colloquial sense of heritable” (p. 67), the multiple meanings of this word would remain a problem for most readers of these literatures.

In the end, my position is much like that of Fox Keller, who writes “I’m not exactly sure how to parse the term [heritability] in a strictly populational sense” (p. 68). In fact, I am on record as believing that technical heritability is, at best, of questionable utility (Moore 2006). To her credit, Fox Keller considers the possibility that there might be useful applications of technical heritability measurements, but ultimately she appears to find their

utility as questionable as I do. As valuable as it might be for scientists to have at their disposal a tool for measuring what Darwin referred to as the “strength of the hereditary tendency,” we currently have no such tool, and the heritability statistic—although it *seems* to assess something like this force—does not fit the bill. Presently, it remains unclear how to interpret what is meant when quantitative behavior geneticists write that a trait is heritable; when Fox Keller considers what it might mean to say “a trait is statistically heritable,” she concludes “not much” (p. 68).

## 5 Chapter Four

Having identified a significant problem, Fox Keller concludes by reformulating the questions she believes people want answers to when they ask about “nature and nurture.” I am not confident that this approach will succeed in putting an end to this old debate, but I do believe Fox Keller’s suggestions lead readers to a safe pathway out of the nature/nurture labyrinth.

Specifically, Fox Keller sees in the nature/nurture debate three distinct questions:

1. When people ask about nature/nurture, what they really want to know is if particular traits become relatively fixed (i.e., no longer plastic) at some point in development.
2. When people ask about nature/nurture, what they really want to know about is the extent to which our genes dictate who we are.
3. When people ask about nature/nurture, what they really want to know is *what makes us what we are?*

Fox Keller is almost certainly correct about her first question; when people talk of nature/nurture, the real question often appears to be a general one about trait malleability at various ages. However, when reformulated as a question about plasticity, the problematic dichotomy between nature and nurture can be dispensed with, allowing the reformulated question to actually be answered scientifically.

Her second question derives from the fact that the classical gene concept has lost much of its usefulness as molecular biologists have discovered what actually takes place inside our cells. Therefore, it behooves us to recast our questions about genes into questions about DNA more generally. This approach opens the door to understanding the importance of non-coding DNA—which is not technically genetic but which is nonetheless transmitted faithfully across generations—as well as the importance of epigenetic marks and various non-nuclear biological factors now known to be transmitted from parents to offspring. A change from gene-talk to DNA-talk would reflect our increasing understanding that phenotypic development is significantly more complex than we thought it was in the latter half of the twentieth century, back when genes were considered able to “code for” certain phenotypes. In Fox Keller’s words, the findings of molecular biologists “invite us to try to understand how traits are formed by focusing not on the putative causal powers of such conceptual entities as genes, or even on the concrete and incontrovertibly real sequences of the DNA we inherit, but on the interactive dynamics of the extraordinarily resourceful molecular systems that evolution has bequeathed to us” (p. 78).

In advocating this shift in focus, Fox Keller is appropriately careful not to deny the important roles that DNA plays in development. She acknowledges that mutations can have discrete and significant effects, that errors in protein-coding sequences of DNA can be recognized as difference-makers in several disease states, and that under normal

circumstances, DNA is an extraordinarily important developmental resource for cells (even if it can no longer fairly be considered to be a “master molecule”). Nonetheless, she says:

DNA has turned out to be a far more interesting molecule, providing a far richer reservoir of potential applications, than anyone had imagined. It cannot be divided into fixed, prescribed units called genes, nor can it animate the cell, but it does constitute an astonishingly fertile resource both for the construction of the many kinds of actors that do animate the cell, and for the systems of regulation the cell employs for its maintenance and reproduction. (p. 79)

Consideration of her third question initially leads Fox Keller to a more controversial claim, namely that the boundary between evolution and development “more recently... has blurred significantly” (pp. 81–82). Although I do not believe a blurring of the distinction between these processes could be substantiated, I nonetheless find Fox Keller’s conclusions here to be sound; just because nature and nurture cannot be separated from one another does not prevent us from studying the varying components that contribute to development (e.g., genes, proteins, diet, cultural norms, etc.). Nor does it prevent us from studying how these components interact. Thus, even though I am confident it will remain helpful to distinguish between development and evolution, Fox Keller is surely correct that questions about *how* inheritance occurs are more important than questions about *whether or not* particular developmental factors are hereditary. In some ways, *all* human behavioral traits are heritable, so what should concern us are the mechanisms by which developmental factors can be transmitted across generations, not *which* factors are “hereditary.” As Fox Keller points out, this approach is likely to yield manipulations that actually have the potential to influence human development in positive ways.

## 6 Giving Development Its Due

The conclusion of *The Mirage of a Space Between Nature and Nurture* reconsiders how to address the question of what makes some of us different from others. Here, I think Fox Keller’s story becomes a bit muddled. Initially, she cites Tabery’s (2007, 2008) conclusions that although studies of heritability are useful for farmers and breeders, they are not similarly useful for understanding human characteristics (because scientists cannot exercise control over the ranges of relevant environmental variables to which human research subjects are exposed). However, rather than explicitly concluding that heritability estimates are therefore of little value to those of us interested in human traits, Fox Keller begins a discussion about how and why political motivations drive people to ask questions like ‘*why is Lisa shyer than Amy?*’

Clearly, political motivations can drive people’s questions, and the fact that people’s values differ means—as Fox Keller observes—that “scientific data will not be of much use” in some cases (p. 84). But rather than leaving readers with this rather disheartening conclusion, it seems to me that Fox Keller missed an opportunity to more explicitly extol the value of studying the *development* of human traits. After all, if we study the *development* of shyness in children like Amy and the *development* of shyness in children like Lisa, we will wind up with an understanding of why Amy and Lisa differ, but more importantly, we will wind up with an understanding of how we can influence development so as to make the Amys of the world more shy or the Lisas of the world less shy (should concerned and appropriate parties ever deem intercession to be warranted in either case). Unlike studies of heritability, developmental analysis of trait origins *can* help us “maximize the development of individual human potential” (p. 84), a commitment that Fox

Keller asserts all her readers share. As she notes on her penultimate page, “how we choose to distribute [our] resources depends on our social and political values,” but until we understand how a trait in question develops in an individual, politics can safely remain on the sidelines. Political issues undoubtedly influence our research questions, but they ought not influence debates about established facts, and because we now understand that technical heritability estimates do not help us understand the origins of individuals’ traits—because there is in fact no space between nature and nurture—the decision to study development instead of attempting to measure genetic “influences” on trait variation in populations need not be influenced by political positions.

In spite of not having an explicit disavowal of studies of heritability in human populations, it is clear by the end of the book that Fox Keller is a strong advocate of the developmental approach to studying the origins of human characteristics. In her final paragraph she writes “let us ask not how much of any given difference between groups is due to genetics and how much to environment, but rather how malleable individual human development is, and at what developmental age” (and, I would add, let us ask which developmental resources are involved in the development of which characteristics, and how they work together to accomplish what they do). Fox Keller is almost certainly right when she suggests that asking these latter questions will lead to genuinely helpful advances in human beings’ understandings of themselves.

For its careful analysis of the *causes* of the confusion that continues to keep the nature/nurture debate alive long after it has become clear that the questions motivating the debate have been ill-formed, Fox Keller’s book can be highly recommended for classroom teachers or teacher educators. Although the book itself would be difficult for many students, Fox Keller’s message is an extremely important one, one that educators really should understand before discussing the nature/nurture debate with their classes.

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