

already emboldened members of the media. (YouTube offers a recent striking conversation between the Today Show's Matt Lauer and a tenacious Nancy Snyderman, the show's medical analyst.) Perhaps now we can use this momentum, as Offit fiercely argues, to shift the energy and resources from the autism-vaccination debate to the need for more research about causes and the development of effective treatments and support for individuals with ASDs and their families.

References and Notes

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NEUROSCIENCE

The Emerging Nature of Nurture

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Our minds prefer to deal in dichotomies. We like to see the world as black or white, if only to sharpen issues that demand a decision. The opposite ways in which we frame the world are the stuff of pop psychology as well as of deep dialectics. Thus, Joan Stiles starts *The Fundamentals of Brain Development* by explaining how developmental psychologists have viewed cognitive development as shaped by either nature or nurture. As the subtitle, *Integrating Nature and Nurture*, indicates, she aims to bridge this divide. At the outset, she courageously asserts that an understanding of brain development is critical for her project—courageously, because she is a cognitive scientist (at the University of California, San Diego), not an expert in developmental neuroscience. She ends up taking readers through a surprisingly detailed exposition of brain development and constructing a scholarly synthesis that will inform not only developmental psychology but even all of neuroscience and cognitive science.

Halfway through the book, I was wondering whom it was written for. The preface suggests the book is intended for students of cognitive development, and indeed they will

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find it highly informative. But the heart of the book is really an extended review of the recent literature on brain development. Stiles starts with the gastrulation and neurulation stages of embryogenesis and continues through the formation of the neural tube; patterning of the neural axis; production, migration, and differentiation of neurons; formation of cortical connections; and shaping of cortical circuits by experience and electrical activity. Stiles precedes this material with a description of the gene—what it is and is not and how our ideas about gene regulation and expression are evolving rapidly. Indeed, still-newer findings (on epigenetics and RNA regulation, for example) render even more complex the nature of the gene and even richer the ways in which extrinsic influences shape gene function. The author weaves her description of brain development as a process of progressive commitment of neural elements into a masterful synthesis of innateness, inheritance, development, and plasticity. I learned a great deal from the book, and I suspect other practicing neuroscientists will, too.

Stiles correctly points out that among developmental neuroscientists the debate between nature and nurture has become outmoded. We now know that there is no such thing as a gene that acts in isolation and that every gene needs an environment—whether the environment is the presence of molecules made by other genes, signals generated internally within the developing nervous system, or electrical activity transduced from the external world. Thus, the discussion within the field has moved from nature versus nurture to the integration of nature and nurture and even beyond, to the nature of nurture—which kinds of environmental influences can affect gene expression at specific time points of development.

The nature of such environmental influences is a focus of much current research. At the earliest stages of brain development, the mere presence of certain molecules or signals may be sufficient: permissive influences likely suffice to shape gene and protein expression and thus influence brain development. Later on, the influence of the environment may be instructive, so that the specific pattern of signals or of electrical activity shapes brain networks and function.

This is where I suspect the divide that Stiles tries to bridge will likely persist. Nativists will argue that the real issue is not whether an environment is required for

brain development but what exactly is required. Indeed, we need to resolve the specific role of learning in development. When and under what conditions is the exact timing of spikes (as postulated by “spike timing dependent plasticity”) used by the developing brain? Perhaps the earliest stages of brain development simply require the presence of external signals, and only later, as the neural machinery develops, is the pattern or structure of external information important.

Another dilemma arises from the nature of biological investigation itself. The search for mechanisms of brain development has been illuminated by selective manipulations that alter development. But the changes imposed by such a manipulation may not recapitulate the process of normal development. In the visual cortex, for example, it now appears that the

pattern of projections from the two eyes is set up by the targeted early ingrowth of axons from the visual thalamus. Manipulating development by altering activity in one eye alters the pattern of projections, such that the deprived eye occupies less territory while the nondeprived eye occupies more. This plasticity, however, is a response of the system to altering the balance of activity, not a process that is necessarily used during development to settle cortical territories. Thus, the processes of plasticity, although available during development, may not be identical to the processes of development per se.

At places, the book is not an easy read. It abounds in sentences such as: “Interestingly, the introduction of Fgf8 into posterior regions where it is not normally expressed creates anomalously placed regions that express anterior identity.” This is the language of developmental neurobiologists. But it is a mark of the level of engagement that Stiles brings and the way she leads readers into the material that we find such conclusions arising naturally in a discussion of cortical patterning (the way in which the developing cerebral cortex gets divided into its constituent areas).

The dichotomies of biology—nature and nurture, constancy and variation, limits and potential—while useful as artifice, are in fact inseparable from one another. As Stiles's comprehensive overview reminds us, nowhere is this more evident than in human brain development. Fundamentally derived through natural selection, the genes of brain development are impressively environment- and experience-dependent.

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by Joan Stiles

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