Editorial Commentary

Introduction to the collection 'How We Develop—Developmental Systems and the Emergence of Complex Behaviors'

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In his classic essay, 'Seven Wonders,' the physician and essayist Lewis Thomas wrote that childhood was one of life's great mysteries. Why, he pondered, did evolution not allow us to skip childhood altogether, 'to jump catlike from our juvenile to our adult [and] productive stage of life?' It is indeed extraordinary how long it takes for humans to develop into mature, capable adults.

How does individual development work? The question of how a tiny clump of cells slowly becomes a person with a particular physique, intellect, personality, and emotional reservoir has long challenged scientists and non-scientists alike. For centuries, this question has been posed in terms of nature versus nurture—trying to determine what portion of development is dictated by inborn, innate forces such as our genes versus the portion that is shaped by experience. In recent decades, new evidence has radically updated our understanding of genes and how they relate to the processes of individual development. Furthermore, a new 'systems' view of research in such domains as fetal development, neuroplasticity, the functional organization of the brain, and cognition suggests that the old debates about nature and nurture should be thrown out in favor of something new—a unified 'developmental systems' perspective.

The new understanding starts with a new conception of the gene. Out of Gregor Mendel's 19th-century pea-plant experiments came a century-long popular and scientific belief that genes were effectively blueprints with elaborate predesigned instructions for all traits—eye color, thumb size, mathematical aptitude, musical sensitivity, and so on. Over the last several decades, the orthodox Mendelian view has been thoroughly upgraded into a more sophisticated understanding of how traits actually *emerge*. Genes are not like automatons, reciting the same lines in exactly the same way regardless of changing circumstances. Instead, they are more like jazz musicians, interacting with their surroundings from moment to moment in complex and often surprising ways.

Beyond this more dynamic view of gene action, the developmental systems perspective provides a broad framework for thinking about individual development at multiple levels (molecular, neural, and behavioral) and timescales. As outlined by Oyama et al.,[1] individual development should be viewed as the reliable reconstruction of the animal within each generation, incorporating influences that arise from continual interactions among many genetic and non-genetic factors. As development

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cascades through time, both the individual animal and its local environment change dynamically, in concert with one another. Crucial to this systems perspective is the notion of control without a controller: No specific entity—genetic or otherwise—*controls* the process. Instead, development is emergent, like a flock of birds in which each individual bird, following simple rules and without instruction from a leader, contributes to the organized behavior of the group.[2]

Further, the systems framework for individual development extrapolates over evolutionary time. Rather than imagining individuals as being 'shaped' by their environments, the animal and its environment evolve together as a codependent system. Out of this coevolutionary process has emerged the full range of animal behaviors—from those that are unique to an individual to those that are typical of a species, genus, family, and so on.

The developmental systems view also informs how we think about the brain. Some researchers insist that the brain is a modular system, hardwired for specialized abilities. But recent findings have revealed tremendous plasticity, particularly early in development. At the extreme, plasticity can take hold, restoring complex cognitive functions even when infants experience substantial brain damage due to stroke or other health complications. Simply put, none of us is hardwired or preprogrammed. Each of us develops.

This collection of essays—*How We Develop—Developmental Systems and the Emergence of Complex Behaviors*—provides a broad, accessible, and contemporary overview of the developmental systems perspective, spanning molecular and cultural levels, milliseconds and millennia, development and evolution. The themes explored here should be of interest to scientists and students, as well as parents, teachers, and policy makers who wish to understand and foster the development of individual children.

This collection provides a tour of the forces that shape typical and atypical individual development of brains, bodies, and behavior. The essays reflect emerging views of development derived from both empirical and theoretical perspectives, highlighting exciting new findings with scientific, social, and policy implications. The collection is not designed to be comprehensive. Rather, our aim is to introduce the reader to the diverse and complementary ways in which a developmental systems perspective enriches our understanding and inspires new directions for answering the biggest questions about how we come to be the way we are.

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