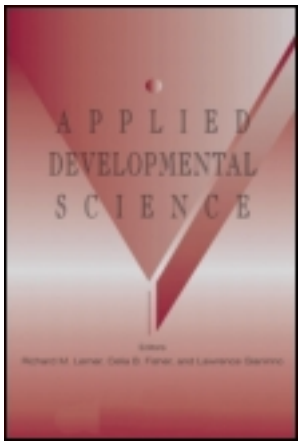

Applied Developmental Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hads20

Evolution, Epigenetics, and Application in Developmental Science

Richard M. Lerner [a] & Celia B. Fisher [a]
[a] Editors

Published online: 25 Oct 2013.

To cite this article: Richard M. Lerner & Celia B. Fisher (2013) Evolution, Epigenetics, and Application in Developmental Science, Applied Developmental Science, 17:4, 169-173, DOI: 10.1080/10888691.2013.848677

To link to this article: http://dx.doi.org/10.1080/10888691.2013.848677

APPLIED DEVELOPMENTAL SCIENCE, *17*(4), 169–173, 2013

ISSN: 1088-8691 print/1532-480X online
DOI: 10.1080/10888691.2013.848677

Routledge
Taylor & Francis Group

EDITORIAL

Evolution, Epigenetics, and Application in Developmental Science

Richard M. Lerner and Celia B. Fisher
Editors

Contemporary scientific advances in human biology have profound implications for applying developmental science. Increasingly over the last 10 to 15 years, innovative and historically important theoretical and empirical advances in evolutionary biology and in the study of genetic processes have changed the understanding of human phylogeny and ontogeny. These advances in knowledge have significant implications for human health and welfare. These advances rest to no small degree on the links among a revised, multidimensional understanding of human evolution (Gissis & Jablonka, 2011; Ho, 2010; Jablonka & Lamb, 2005); epigenetic processes that constitute alterations in the functional impacts of genes across both the life span and generations (Harper, 2005; Meaney, 2010; Roth, 2012); and human behavior, development, and culture (Harper, 2005; Jablonka & Lamb, 2005; Slavich & Cole, 2013).

The purpose of this editorial is to describe these links and to explain how developmental science and the study of its applications are integral to expanding understanding of evolutionary and genetic processes and applying this understanding to programs and policies enhancing human life (Fisher, Busch-Rossnagel, Jopp, & Brown, 2012).

THE CONTEMPORARY LANDSCAPE OF DEVELOPMENTAL SCIENCE

Developmental science seeks to describe, explain, and optimize intraindividual changes and interindividual differences in intraindividual changes across the life span (Lerner, 2012; Baltes, Reese, & Nesselroade, 1977). Contemporary developmental scientists approach these three objectives differently than in the past (Lerner, 2012). Whether studying infancy, childhood, adolescence, or the adult and aging portions of the life span, current scholarship in human development attempts to explain how mutually influential relations between individuals and their contexts (i.e., bidirectional, reciprocal, synergistic, or fused relations; e.g., Fischer & Bidell, 2006; Mascalo & Fischer, 2010; Overton, 2013; Tobach & Greenberg, 1984) provide the basis for individual behavior and development.

Today, then, developmental scientists focus on systematic and successive alterations in the course of these relations, and focus on the integration of multiple attributes of the individual (e.g., physiological, cognitive, emotional, motivational, and behavioral characteristics) and multiple levels of the ecology of human development, ranging from the biological level through the sociocultural and historical levels, including the designed and natural environments (Bronfenbrenner & Morris, 2006; Lerner, 2002, 2006). Accordingly, in contemporary developmental science the cutting-edge of theory and research aimed at elucidating these relations between individuals and contexts is framed by relational developmental systems theories, models best articulated by Willis F. Overton (e.g., 2006, 2013; Overton & Müller, 2012). In such models, change at any level of organization within the integrated developmental system is fused with, or embodied by, changes at all other levels of the system; history, temporality, is part of this integrated system, thus infusing change, and the potential for systematic change (for plasticity), within and across all levels of the relational developmental system (Overton, 2013).

Relational developmental systems theories focus on the "rules," that is, the processes, that govern exchanges between individuals and their contexts. Brandtstädter (1998) terms these relations "developmental regulations," and notes that, when developmental regulations involve mutually beneficial individual ← → context relations, they constitute *adaptive* developmental regulations. The possibility of adaptive developmental relations between individuals and their contexts, and the potential plasticity

Address correspondence to Richard M. Lerner, Tufts University, Institute for Applied Research in Youth Development, 301 Lincoln Filene, Medford, MA 02155. E-mail: richard.lerner@tufts.edu

of human development, are distinctive features of this approach to human development.

The emphasis on how the individual acts on the context, to contribute to the relatively plastic relations with it, fosters an interest in individual agency (or on intentional self-regulation; Geldhof, Little, & Colombo, 2010; Gestsdóttir & Lerner, 2008; McClelland, Ponitz, Messersmith, & Tominey, 2010)—on individuals as producers of their own development (Lerner, 1982; Lerner & Busch-Rossnagel, 1981). This focus is best instantiated by person-centered (as compared to variable-centered) approaches to the study of human development and thus, as well, to individual difference (diversity) oriented research. Relational developmental systems theories, and the relational metamodels within which such theories are embedded (Overton, 2013), have led developmental scientists within this perspective to draw on research from multiple disciplines. To better understand the integrated changes across the multiple levels of organization within the ecology of human development, evolutionary biology and human genetics are increasingly prominent cases in point.

EVOLUTION, EPIGENETICS, AND HUMAN DEVELOPMENT

Contemporary scholarship regarding the character of evolution reflects the concept of embodied change within the developmental system. For instance, Bateson and Gluckman (2011) observe that "gene expression is profoundly influenced by factors external to the cell nucleus in which reside the molecules making up the genes: the deoxyribonucleic acid (DNA). A willingness to move between different levels of analysis has become essential for an understanding of development and evolution" (p. 5). Similarly, Keller (2010) explains that:

> Not only is it a mistake to think of development in terms of separable causes, but it is also a mistake to think of development of traits as a product of causal elements interacting with one another. Indeed, the notion of interaction presupposes the existence of entities that are at least ideally separable—i.e., it presupposes an a priori space between component entities—and this is precisely what the character of developmental dynamics precludes. Everything we know about the processes of inheritance and development teaches us that the entanglement of developmental processes is not only immensely intricate, but it is there from the start. From its very beginning, development depends on the complex orchestration of multiple courses of action that involve interactions among many different kinds of elements—including not only preexisting elements (e.g., molecules) but also new elements (e.g., coding sequences) that are formed out of such interactions, temporal sequences of events, dynamical interactions, etc. (pp. 6–7)

Moreover, Pigliucci and Müller (2010), in presenting what they term an "Extended Synthesis" of evolution, note that:

> Far from denying the importance of genes in organismal evolution, the extended theory gives less overall weight to genetic variation as a generative force. Rather, [there is a] view of "genes as followers" in the evolutionary process, ensuring the routinization of developmental interactions, the faithfulness of their inheritance, and the progressive fixation of phenotypic traits that were initially mobilized through plastic responses of adaptive developmental systems to changing environmental conditions. In this way, evolution progresses through the capture of emergent interactions into genetic-epigenetic circuits, which are passed to and elaborated on in subsequent generations. (p. 14)

In turn, West-Eberhard (2003) argues that "the universal environmental responsiveness of organisms, alongside genes, influences individual development and organic evolution, and this realization compels us to reexamine the major themes of evolutionary biology in a new light" (p. vii). Linking the presence of plasticity across development with evolution, she makes three major points:

> First, environmental induction is a major initiator of adaptive evolutionary change. The origin and evolution of adaptive novelty do not await mutation; on the contrary, genes are followers not leaders, in evolution. Second, evolutionary novelties result from the reorganization of preexisting phenotypes and the incorporation of environmental elements. Novel traits are not de novo constructions that depend on a series of genetic mutations. Third, phenotypic plasticity can facilitate evolution by the immediate accommodation and exaggeration of change. It should no longer be regarded as a source of noise in a system governed by genes, or as a "merely environmental" phenomenon without evolutionary importance. (West-Eberhard, 2003, p. 20)

Crystallizing the embodiment of variables from all levels of organization within developmental systems that create epigenetic change across generations, Jablonka and Lamb (2005) summarize evidence demonstrating that evolution involves four interrelated dimensions:

> Molecular biology has shown that many of the old assumptions about the genetic system, which is the basis of present-day neo-Darwinian theory, are incorrect. It has also shown that cells can transmit information to daughter cells through non-DNA (epigenetic) inheritance. This means that all organisms have at least two systems of heredity. In addition, many animals transmit information to others by behavioral means, which gives them a third hereditary system. And we humans have a fourth, because symbol-based inheritance, particularly language, plays a substantial role in our evolution. It is therefore quite wrong to think about heredity and

> evolution solely in terms of the genetic system. Epigenetic, behavioral, and symbolic inheritance also provide variation on which natural selection can act. (p. 1)

Accordingly, in a book discussing the transformations of Lamarckian theory that have arisen in relation to the increasingly more active focus on epigenetic processes in the study of both evolution and development, Gissis and Jablonka (2011) note that "*Plasticity*—the capacity of organisms to change in response to varying conditions—is … a large topic, but, just as Lamarck anticipated, an understanding of plasticity is now recognized as being fundamental to an understanding of evolution" (p. xiii). In turn, and underscoring the links between plasticity of embodied relations among an organism and the multiple biological through ecological levels of its ecology and epigenetic change, they go on to note that:

> Experimental work now shows that, contrary to the dogmatic assertions of many mid-twentieth-century biologists that it could not occur, even a form of "inheritance of acquired characteristics" does occur and might even be said to be ubiquitous. In particular, new variations induced by stress are sometimes inherited. The molecular mechanisms that underlie such inheritance—the epigenetic inheritance systems—are now partially understood, and … the existence of various types of [such] soft inheritance affects how we see adaptive evolution and speciation. It also has implications for human health. (Gissis & Jablonka, 2011, p. xiii)

The epigenetic process to which Gissis and Jablonka (2011) refer involves heritable changes in genome activity (i.e., changes that are transmittable across generations) that are caused by modifications of DNA or of core histones (the structures around which DNA is wrapped within the cell nucleus) through chemical processes such as methylation or acetylation (Misteli, 2013, pp. 2010–2011). Simply, as Harper (2005) has explained, epigenetics involves "the transmission to offspring of parental phenotypic responses to environmental challenges, even when the young do not experience the challenges themselves" (p. 340).

Moreover, Slavich and Cole (2013) point to the growing research regarding human social genomics, a field that documents "changes in the expression of literally hundreds of genes … as a function of the physical and social environments we inhabit" (p. 331). In addition, Slavich and Cole point to findings with both animals and humans that indicate that social influences promote alterations in methylation process and in core histones and, quite provocatively for those interested in the application of developmental science, they note that "psychological interventions can reverse stress-induced genomewide transcriptional processes" (p. 342). They indicate that the "biological self" that is instantiated over the course of ontogeny "depends on the social conditions we experience over the life course" and point out that "these effects are often more strongly tied to people's subjective perceptions of their surrounding social environment (e.g., feeling lonely) then to 'objective' features of these environments (e.g., being single)" (Slavich & Cole, 2013, p. 331). They interpret available evidence as suggesting that there is a:

> possibility that certain positive states of mind may be associated with differences in gene expression, which in turn may shape a person's risk for a variety of psychiatric and physical disorders. Such states may include optimism, tranquility, affection, gratitude, admiration, mindfulness, social connectedness, and compassion." (Slavich & Cole, 2013, p. 342)

Many of the positive states that they point to have been found to be attributes of adolescents showing features of positive youth development, for instance, connection, caring, and hope (Lerner et al., 2012).

In short, there is now a plethora of evidence in support of the epigenetic character of evolution and ontogeny, of the multiple, integrated dimensions of evolution, and of the role of the organism's own agency and of culture in creating change within and across generations. The embodiment of the individual and of his or her plastic developmental biological, psychological, and behavioral processes within the relational developmental system provides a basis for epigenetics across generations and, especially given the evidence for human social genomics, provides great opportunities for developmental scientists, in collaboration with biologists interested in human epigenetics, to promote positive human development.

APPLYING DEVELOPMENTAL SCIENCE

Current research in evolutionary biology, epigenetics, and developmental science has profound implications for the application of developmental science. We see this burgeoning scholarship as affording optimism that future research may produce new, and actionable, information about how we can promote changes that enhance the probability of more positive development among all individuals across the life course and across generations. The research involved in the study of human social genomics (Slavich & Cole, 2013) is an excellent case in point.

Accordingly, based on current evidence regarding embodiment and plasticity in both phylogenetic and ontogenetic processes, we believe that relational developmental systems theory-predicated research can provide increasingly more nuanced information about the mutually influential relations among individual and ecological

processes that constitute the fundamental change processes of human development. If so, then applications of developmental science may successfully promote more positive, healthier developmental trajectories among all individuals.

Our belief and hope is that such work will generate evidence-based actions promoting social justice across the life spans of the diverse people of our world (Fisher et al., 2012; Lerner & Overton, 2008). The integrated scientific agenda that we believe is legitimated by the contemporary research in evolutionary biology, epigenetics (including human social genomics), and developmental science suggests that scholars should be able to undertake programmatic research specifying *what* characteristics, of *what* individuals, should be integrated with *what* features of the ecology of human development, at *what* points across ontogeny, to produce *what* instances of (more optimal) changes in behavior and development. The research directed at answering these "what" questions will enhance the likelihood that science will have a better understanding of how to promote positive trajectories among diverse individuals. Then, applied developmental scientists may design programs or contribute to the formulation of social policies enabling a more socially just world to be created for individuals across the global community.

Our hope is that such scholarship will more often characterize developmental science in the future. As such, we hope to include reports of such integrative, innovative, and important research within future issues of this journal.

REFERENCES

Baltes, P. B., Reese, H. W., & Nesselroade, J. R. (1977). *Life-span developmental psychology: Introduction to research methods*. Monterey, CA: Brooks/Cole.

Bateson, P., & Gluckman, P. (2011). *Plasticity, development and evolution*. Cambridge, UK: Cambridge University Press.

Brandtstädter, J. (1998). Action perspectives on human development. In R. M. Lerner (Ed.); W. Damon & R. M. Lerner (Editors-in-Chief), *Theoretical models of human development* (5th ed.). *The Handbook of child psychology* (Vol. 1, pp. 807–863). New York, NY: Wiley.

Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. In R. M. Lerner (Ed.); W. Damon, & R. M. Lerner (Editors-in-Chief), *Theoretical models of human development* (6th ed.). *Handbook of child psychology* (Vol. 1, pp. 793–828). Hoboken, NJ: Wiley.

Fischer, K. W., & Bidell, T. R. (2006). Dynamic development of action and thought. In R. M. Lerner (Ed.); W. Damon & R. M. Lerner (Editors-in-Chief), *Theoretical models of human development* (6th ed.). *Handbook of child psychology* (Vol. 1, pp. 313–399). Hoboken, NJ: Wiley.

Fisher, C. B., Busch-Rossnagel, N. B., Jopp, D. S., & Brown, J. L. (2012). Applied developmental science, social justice and socio-political well-being. *Applied Developmental Science*, *16*, 54–64.

Geldhof, G. J., Little, T. D., & Colombo, J. (2010). Self-regulation across the life span. In M. E. Lamb & A. M. Freund (Eds); R. M. Lerner (Editor-in-Chief), *Social and Emotional Development*: Vol. 2., *Handbook of life-span development* (pp. 116–157). Hoboken, NJ: Wiley.

Gestsdóttir, G., & Lerner, R. M. (2008). Positive development in adolescence: the development and role of intentional self regulation. *Human Development*, *51*, 202–224.

Gissis, S. B., & Jablonka, E. (2011). Preface. In S. B. Gissis & E. Jablonka (Eds.), *Transformations of Lamarckism: From subtle fluids to molecular biology* (pp. xi–xiv). Cambridge, MA: The MIT Press.

Harper, L. V. (2005). Epigenetic inheritance and the intergenerational transfer of experience. *Psychological Bulletin*, *131*, 340–360.

Ho, M. W. (2010). Development and evolution revisited. In K. E. Hood, C. T. Halpern, G. Greenberg, & R. M. Lerner (Eds.), *Handbook of developmental systems, behavior and genetics* (pp. 61–109). Malden, MA: Wiley Blackwell.

Jablonka, E., & Lamb, M. (2005). *Evolution in four dimensions: Genetic, epigenetic, behavioral, and symbolic variation in the history of life*. Cambridge, MA: MIT Press.

Keller, E. F. (2010). *The mirage of a space between nature and nurture*. Durham, NC: Duke University Press.

Lerner, J. V., Bowers, E. P., Minor, K., Boyd, M. J., Mueller, M. K., Schmid, K. L., ... Lerner, R. M. (2012). Positive youth development: processes, philosophies, and programs. In R. M. Lerner (Ed.); I. B. Weiner (Editor-in-Chief), *Handbook of psychology* (2nd ed.). *Developmental psychology* (Vol. 6, pp. 365–392). Hoboken, NJ: Wiley.

Lerner, R. M. (1982). Children and adolescents as producers of their own development. *Developmental Review*, *2*, 342–370.

Lerner, R. M. (2002). *Concepts and theories of human development* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum.

Lerner, R. M. (2006). Developmental science, developmental systems, and contemporary theories of human development. In R. M. Lerner (Ed.); W. Damon & R. M. Lerner (Editors-in-Chief). *Theoretical models of human development* (6th ed.). *The Handbook of child psychology* (Vol. 1, pp. 1–17). Hoboken, NJ: Wiley.

Lerner, R. M. (2012). Essay review: Developmental science: Past, present, and future. *International Journal of Developmental Science*, *6*, 29–36.

Lerner, R. M., & Busch-Rossnagel, N. A. (Eds.), (1981). *Individuals as producers of their development: A life-span perspective*. New York: Academic Press.

Lerner, R. M., & Overton, W. F. (2008). Exemplifying the integrations of the relational developmental system: synthesizing theory, research, and application to promote positive development and social justice. *Journal of Adolescent Research*, *23*(3), 245–255.

Mascalo, M. F., & Fischer, K. W. (2010). The dynamic development of thinking, feeling, and acting over the life span. In W. R. Overton (Ed.); R. M. Lerner (Editor-in-Chief), *Cognition, biology, and methods across the life span: Vol. 1, Handbook of life-span development* (pp. 149–194). Hoboken, NJ: Wiley.

McClelland, M. M., Ponitz, C. C., Messersmith, E. E., & Tominey, S. (2010). Self-regulation: The integration of cognition and emotion. In W. R. Overton (Ed.); R. M. Lerner (Editor-in-Chief), *Cognition, biology, and methods across the life span: Vol. 1, Handbook of life-span development* (pp. 509–553). Hoboken, NJ: Wiley.

Meaney, M. (2010). Epigenetics and the biological definition of gene x environment interactions. *Child Development*, *81*(1), 41–79.

Misteli, T. (2013). The cell biology of genomes: Bringing the double helix to life. *Cell*, *152*, 1209–1212.

Overton, W. F. (2006). Developmental psychology: Philosophy, concepts, methodology. In R. M. Lerner (Ed.); W. Damon & R. M. Lerner (Editors-in-chief). *Handbook of child psychology* (6th ed.). *Theoretical models of human development* (Vol. 1, pp. 18–88). Hoboken, NJ: John Wiley & Sons.

Overton, W. F. (2013). A new paradigm for developmental science: Relationism and Relational-Developmental Systems. *Applied Developmental Science*, *17*, 94–107.

Overton, W. F., & Müller, U. (2012). Development across the life span: Philosophy, concepts, theory. In R. M. Lerner, M. A. Easterbrooks, & J. Mistry (Eds.); I. B. Weiner (Editor-in-Chief). *Handbook of psychology: Developmental psychology* (Vol. 6, pp. 19–58). New York, NY: Wiley.

Pigliucci, M., & Mueller, G. B. (2010). Elements of an extended evolutionary synthesis. In M. Pigliucci (Ed.), *Evolution – the extended synthesis* (pp. 3–17). Cambridge, MA: MIT Press.

Roth, T. L. (2012). Epigenetics of neurobiology and behavior during development and adulthood. *Developmental Psychobiology*, *54*, 590–597.

Slavich, G. M., & Cole, S. W. (2013). The emerging field of human social genomics. *Clinical Psychological Science*, *1*, 331–348.

Tobach, E., & Greenberg, G. (1984). The significance of T. C. Schneirla's contribution to the concept of levels of integration. In G. Greenberg & E. Tobach (Eds.), *Behavioral evolution and integrative levels* (pp. 1–7). Hillsdale, NJ: Lawrence Erlbaum.

West-Eberhard, M. J. (2003). *Developmental plasticity and evolution*. New York, NY: Oxford University Press.