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Book Review

What Genes Can't Do by Lenny Moss. A Bradford Book. The MIT Press, Cambridge, MA. 2003.

Reviewed by Michael Bradie

In the late 1950's and early 1960's, at the dawn of the computer age, there was great excitement among some researchers about the prospects of being able to use fast and powerful computers to model and understand human intelligence. Some hard line defenders of what came to be known as the 'strong program' in AI brashly predicted that within a few years machines would be built that not only simulated human intelligence but were, in fact, really intelligent. The idea, simply put, was that thinking and intelligence, in general, was merely a matter of symbol manipulation. The difference between a desk top calculator and a machine capable of understanding and appreciating a Shakespearean play or a Wagnerian opera was merely a matter of degree. The programs and manipulations involved in the latter activities were merely more sophisticated and complicated extensions of the former. This was a reductionist program with a vengeance. As the years passed and it became clear that constructing an artificially intelligent machine was going to be more difficult than some had initially thought, some critics began to reassess some of the explicit and implicit philosophical assumptions of the 'strong program.' One of the earliest critiques was by Hubert Dreyfus in his 1972 book *What Computers Can't Do: a critique of artificial reason*. Dreyfus rejected the view that thinking could be *realized* (as opposed to *simulated*) by computations and he rejected the reductionistic view that general purpose understanding can be modeled by rules and algorithms. It was time to try something new.

Lenny Moss's new book, *What Genes Can't Do*, is consciously modeled on Dreyfus's critique. Like Dreyfus, Moss's target is a strong reductionist program that sees genes as the "master molecules" that will enable us to explain and understand everything of interest in the living world. In its place, Moss hopes "to provide a platform upon which new naturalistic lines of thought can interweave biological and sociocultural threads at a very fundamental level." (xiii) His approach is to challenge the guiding and, on Moss's account, misleading metaphors of the contemporary discussion of the role of genes in organismic development: 'gene as blueprint,' 'genetic determinism,' and

'environmentalism.' The result is a complex and provocative historical, philosophical and scientific analysis of the rhetorical and metaphorical structure of contemporary genetics and developmental biology.

This is a challenging book both in its demands on the reader and its critique of the contemporary 'gene-centric' view of life. The basic idea is this. Long before we knew anything about the physical basis of heredity, factors or genes were identified in terms of their functional or phenotypic effects. The discovery of the molecular foundation of inheritance – the structure of DNA – invites an easy identification of genes as functional units with stretches of DNA. However, the fit is uneasy at best and disastrous at worst. The linguistic metaphors of 'coding' and 'information' conspire to obfuscate the conceptual gaps between two distinct concepts of 'gene' - gene-P and gene-D. The result is the promotion of a 'gene-centric' view of biological processes that is empirically suspect and heuristically at a dead end. Moss foresees the development of biology in the 21st century as guided by a rejection of the predominant view of the 20th century that genetic explanations of life processes are fundamental. In its place, he sees the development of a more nuanced approach that takes into account the contingencies of the environments within which DNA operates. The day of the 'master molecule' approach is coming to an end.

Genes are the focal units of evolutionary theory and developmental biology. But, what exactly are they? In the first chapter, "Genesis of the gene," Moss traces the emergence of the modern conception of the gene back to the 18th century debate between preformationists and epigeneticists. This is not an easy read. Moss's treatment presupposes a good deal of understanding of embryology and genetics and a willingness to take much of the historical development on faith. The historical development involves a shift from embryological models of character development to phylogenetic models of character development.

The idea of gene as 'blueprint' deploys an information metaphor that Moss argues conflates two distinct concepts of "gene." One, which he traces back to a preformationist lineage and labels "gene-P", is a predictor of phenotypic characters. For example, one talks of genes for blue eyes or brown eyes. But, Moss argues, the gene-P for blue eyes is the *absence* of the gene-P for brown eyes. The second concept of 'gene', which Moss labels "gene-D", stands for genes understood as developmental factors and are identified with molecular sequences. They are the elements of what he calls "the new epigenetics." (52)

In Chapter 2, "The Rhetoric of Life and the Life of Rhetoric," Moss develops the differences between the two gene concepts he has identified. P-genes have an instrumental utility for predicting outcomes without any understanding of the physical, chemical or biological processes involved (p. 51). Gene-D's, on the other hand, can be identified with DNA segments but have no clear relationship to phenotypic characters (p. 52). They constitute the core elements of what Moss calls 'the new epigenetics': gene-D + developmental context + environmental milieu --> phenotype.

Gene-P's are useful for predicting susceptibility to disease, for example, but the biochemistry is missing. The biochemistry of Gene-D's is known but they are not useful predictors of phenotypic traits.

The following chart diagrams their relationship:

	Discrete Sequents	Causally Privileged
Gene-D	Yes	No
Gene-P	No	Yes

The appeal to textual metaphors of 'coding' and 'information', Moss argues, leads to a conflation of these two different ideas into a "gene" as understood as being identified with a discrete DNA sequence (a gene-D property) *and* a causally privileged role in predicting and explaining phenotypic expressions (a gene-P property) (p. 52).

Moss traces the misleading implications of the 'information' or 'coding' metaphors for genes back to the influence of Schrödinger's *What is Life?* and the notion of a 'hereditary code-script' that has come to be understood as both 'architect's plan' and 'builder's craft' (p. 56). Moss argues that Schrödinger's concept is intelligible only within a framework of thermodynamical and physical assumptions that may or may not characterize the conditions under which biological development takes place. To the extent that these conditions are not satisfied, the application of the 'code script' metaphor to organic development is not warranted (p. 62).

Moss is not arguing for the possibility of a metaphor free biology. Rather his point is that we must be careful to remember the contexts in which the metaphors arise and be cautious in our appeal to them when they are used in other contexts.

Chapter 3, "A Critique of Pure (Genetic) Information," is concerned to establish that "Neither DNA nor any other aperiodic crystal constitutes a unique repository of heritable stability in the cell; in addition, the chemistry of the solid state does not constitute either a unique or even an ontologically or causally privileged basis for explaining the existence and continuity of order in the living world" (p. 76)

The central thesis is that "[t]he standard rationale for speaking of genes in the conflationary style – as the "information," "blueprint," "Program," "Instructions," and so forth for building an organism – is that DNA provides the template for synthesizing proteins and that proteins, as enzymes, regulate all of the chemical reactions of the cell. For this rationale to hold up it must be the case that either (1) spatial arrangements of enzymes in the cell are of no great consequence or (2) that spatial arrangement is somehow prefigured by the one-dimensional array of nucleic acids in the genes" (p. 94). Moss argues that both claims are false. They are, he argues, overly reductionistic. Moss discusses the approach by Stuart Kaufmann and his associates that attempts to model biological processes in terms of non-equilibrium dynamical systems but he worries that the fit between the models and the biology of cell processes is not yet secure. In the end, he leans towards the Developmental Systems Theory (or DST) approach favored by Susan Oyama, Paul Griffiths and Russell Gray. They argue that "ontogeny is best viewed as contingent cycles of interaction amongst a heterogeneous set of developmental resources, no one of which 'controls' or 'programs' the process. The resources range from DNA to cellular and organismic structure and to social and ecological interactions. Many of these resources, both inside and outside the organism, can be reliably reconstructed down evolutionary lineages. Evolution is change in these developmental cycles. The changes in gene frequency often used to define evolution are but one aspect of the richer complex of stabilities and changes captured by the developmental systems approach "(Oyama, Griffiths & Gray 2001; quoted in Moss, p. 115).

Chapter 4, "Dialectics of Disorder: Normalization and Pathology as Process," is a historical analysis of the evolution of our understanding of cancer. Moss distinguishes three key periods: [1] The ancient Greeks held a 'humor' theory of disease. Disease is viewed as the result of an imbalance of systematic elements – the humors. [2] The second period arose in the late 18th century as a corollary to the development of "modern cell theory, histology and embryology. [3] The third period commences with the advent at the beginning of the 20th century of the modern genetic viewpoint.

The moral is the same: current research strategies focus too narrowly on the genetic factors and ignore the contextual, intercellular, biochemical and sociological factors that contribute to the onset of the disease.

This is an important and interesting book. Moss challenges the empirical adequacy, the theoretical utility and the philosophical respectability of the current gene-centered approach in developmental biology. His critique is an invi-

tation to construct a better understanding that promises to have important implications not only for the future direction of scientific research but also for the wider socio-political discussion of issues connected with health, disease and development.

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