Book Review

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Cycles of Contingency: Developmental Systems and Evolution. Susan Oyama, Paul E. Griffiths, & Russell D. Gray (Eds.). (2000, MIT Press). $50.00, 377 pages.

Science cannot proceed without simplifying assumptions. Scientists look for explanations that will apply to more than just one instance and for this reason they need to simplify, to attempt to look for connecting essences in the explanation of otherwise diverse phenomena. When one simplification fails to provide the necessary answers alternative abstractions and metaphors may come to the rescue. They are, after all, the common currency of science. So, why should anyone raise an alarm against them?

The successful metaphor of today can easily become the dogma of the coming generation. An attractive explanatory strategy makes practitioners search for problems to which it will fit and concentrate less and less on the anomalies. A metaphor can construct its own niche of scientific practice that validates it and establishes it more firmly in the mind of the enquirer. When this happens a critical attitude is most needed.

The same critical attitude is not just desirable but can often be crucial when scientific ideas spill over into adjacent human activities, such as policy making. Here scientific principles do not necessarily apply and politics will often take control. The measure of a good scientific explanation, and its reward in terms of funding, may be how well it fits the political, ideological, or commercial Zeitgeist. Finding a correlation between IQ and race, even while ignoring blatant differences in socioeconomic biases in the test groups, may well fit certain strategies in educational policy. Classifying a disease as innate may easily retard investment into cures other than gene therapy. To say that science has an ethical role to play in these circumstances is something that should not need to be repeated.

If explanatory success is the measure of good science, what is the measure of sound scientific criticism? Above all, it should be pragmatic. It should help unblock impasses, wake up a community from its dogmatic slumber and bring anomalies out of the blind spot. It should also be fair and never facile, as all metaphors are inaccurate. Any other motivation will diminish the impact of criticism and can easily transform it into commentary—the idle spinning in the void of argument and counterargument without the necessary pragmatic friction to make someone design a new experiment, build a new model, or propose a new hypothesis.

Nowhere is serious scientific criticism more needed than when dealing with extremely complex and politically hot issues such as the generation of intelligent adaptive behavior or the genesis and evolution of biological forms and traits. At the same time, nowhere is it easier to move from criticism to commentary. Both these domains of research have been dominated by related simplifying metaphors. A computationalist approach to the generation of cognitive behavior parallels in more ways than one a

genocentric perspective on development and evolution. Both rely on broad metaphors of program and data and both have been successful up to a certain point.

Developmental systems theory (DST) is a recent umbrella label for a series of critical attitudes to the prevailing genocentric views of development and evolution in biology. This 24-chapter collection presents a series of essays by scientists and philosophers on DST exploring possible systematizations, clarifications, and extensions of its central tenets, some of its historical roots, as well as connections and resonances with other disciplines such as anthropology and sociology.

DST extends the critical discourse championed by Richard Lewontin since the 1970s on the dialectics of gene, organism, and environment and how developmental and evolutionary processes should be better understood through the causal interpenetration of levels that are often taken as separate and explanatorily asymmetrical. These ideas, of course, have had other defenders in the past. James H. Woodger questioned in 1929 the opposition between organisms and environment and even suggested that the concept of inheritance might not be as solid as it appeared. Based on his research on nerve growth and the development of coordinated behavior since the mid 1920s, Paul Weiss offered a hierarchical systems view of development that challenged reductionist priority of one level, for instance the level of genetic regulation, upon the others. Although these precursors are not mentioned in the book, the first part is dedicated to "influences" on DST. This section includes a reproduction of Lewontin's 1983 influential article "Gene, organism and environment" accompanied by a new introduction by the author. It also reproduces Daniel Lehrman's 1953 critique of Lorenz's theory of instinct, which is introduced by a very valuable piece by Timothy Johnston providing important contextual information on the concept of innate behavior.

As implied in the historical section, the influences on DST are varied in origin—they include critical views from fields such as embryology, ethology, developmental psychology, ecology, and evolution. Is there a coherent point of view that can provide heuristics for research, or at least a general theoretical perspective across this wide range of disciplines? In their introductory essay the editors attempt to articulate what DST is all about, acknowledging internal tensions in emphasis and usage of terms amongst its supporters. DST aims to dissolve explanatory frameworks built upon dichotomies such as gene/environment, nature/nurture, and replicator/vehicle. Explaining developmental processes forces us to take account of multiple causes and interactants. DST goes further than to say, for instance, "surely the environment is relevant too" because such an attitude would simply perpetuate a separation between causal factors. The theory argues for the context sensitivity and contingency of the role of one single element on reliable aspects of the state of the others. For example, gene transcription is crucially dependent on the elaborate mechanisms of DNA edition and repair already present in the living cell—without them, the process loses its reliability and stability, the key conditions that lead many biologists to think of DNA as the single source of developmental constancy.

As a consequence of this shift of attention, DST points to extended systems of inheritance whereby the source of transmittable variation includes, besides the genotype, maternal effects on fetal as well as on behavioral development, socially learned behavior patterns, and cultural and symbolic artifacts. The best metaphor for understanding such multiply influenced processes, DST supporters argue, is less one of developmental programs and more one of construction and distributed control where no single factor plays a privileged directional or representational role. The consequence of the reliable cospecification between organism and environment that allows the reappearance of similarities and the inheritance of variation from one generation to the next is that evolution is also best understood as a constructive process where codetermined entities change together.

Whether the effect is premeditated or not, the allocation into sections of the different contributions in the book is belied by the rich interconnectivity between the chapters—the conversations flow across the editorial boundaries in a process that could well serve as a metaphor for the ideas that DST defends. The metaphor can be stretched a bit, and it is possible to say that the book suffers from some problems similar to those identified by critics of DST. If developmental processes are such a complex web of distributed, mutually influencing, contingent and dynamic factors, then what sort of scientific explanation will researchers be able to handle productively? If simplifying assumptions can be criticized as perpetuating dichotomous thinking, then what is the alternative way to manage the daunting complexity of developmental processes? DST, critics say, does not provide an answer to this. It does not offer scientists a set of alternative heuristics for research, because it cannot, or it will not, separate causal factors into essential and nonessential. The chapters in this book suffer from a parallel failing—some of them are very relevant to scientific research, others are interesting but spread into adjacent disciplines, and a few seem to offer very little more than clever armchair mindgames. But because most of the contributions are very well written, provide excellent information, and generally speaking are interesting to read, discrimination in this case also is difficult.

The "so-what?" theme is discussed in Lewontin's introduction to his 1983 essay. The empirical connection, he argues, is essential: "The biological philosopher only interprets the world; the point, however, is to change it" (p. 55). Some chapters provide varied examples of empirical work that support the ideas of DST and, more importantly, suggest (to some extent) possible research directions where a DST frame of mind could indeed make a concrete difference. The examples range from gene transcription to behavioral development and ecological and cultural inheritance—these include essays by Eva Neumann-Held, Lenny Moss, Frederik Nijhout, Eva Jablonka, and Patrick Bateson, and an essay by Kevin Laland, John Odling-Smee, and Marcus Feldman on niche construction. Still, what remains unclear for the skeptic is whether the supporting empirical evidence cannot be accommodated within more traditional views, perhaps with the aid of some minor changes of emphasis, rather than within a whole new framework.

Peter Godfrey-Smith asks what other roles DST could possibly occupy. It can be a source of critical views on current research practice and discourse, as already suggested. But DST need not be restricted to this role or deemed futile if it is not very good at it. DST can also be a post-empirical "philosophy of nature": a commentary on scientific research, but not bound by its constraints. The use of such a role would be, for instance, the correct translation and clarification of scientific language to the general public and policy makers (e.g., the careful discrimination between technical and metaphorical usage of scientific terms).

Some chapters, but perhaps not their authors, seem to accept this distinction implicitly because their empirically fruitful connections are rather tenuous while their concern with terminological clarification is central. Evelyn Fox Keller analyzes the development of the genetic program metaphor. Kim Sterenly criticises DST for the misuse of the term inheritance and discusses the conditions he feels that inheritance systems should meet. Susan Oyama dwells on the problem of choosing the right words when the most appropriate ones—like system, interaction, and construction—carry undesired baggage. These and other essays similar in style seem to be, and indeed are, part of ongoing conversations. They concentrate highly on responding to previous commentary on the original critical stance of DST. As commentary, they can, and surely will, go on for some time but it is not clear that the world will change because of that.

Many of the problems of DST seem to boil down to two fundamental questions. The first is about the nature of causation in complex processes. How can we avoid conflating functional and causal discourse as if they were the same in kind when terms

such as gene and DNA are used in both? How can causal spread be reconciled with the aims of understanding and describing the origin of regularities? How can we hope for useful methods of control and safe manipulation when the very idea of cause may even be inapplicable? This issue is very much recognized as fundamental by some developmental systems theorists and it is clearly a philosophical minefield.

The other fundamental issue, itself not unrelated to how we understand causation, is whether there is a privileged level of description that may serve to anchor the complex web of interacting processes both above and below it. DST's opposition to geno-centrism, combined with its dialectical sophistication, has pushed it to advocate, in principle, equal footing for organismic, suborganismic and extra-organismic factors in development. Although it is clear that such a stance is at least logically consistent, and possibly empirically revealing, it is possible that it is missing something fundamental about the nature of living systems: these systems are alive. Not their genes, not their niches, but themselves as organisms. There is currently little room in DST that will allow this distinction, and no inkling of what would happen if it were made. Keller comes very close to a discussion of this problem when she questions whether some system boundaries are indeed more equal than others, in particular the cell boundary or the skin of the organism. Unfortunately, she does not develop this theme further.

If there were something that privileges the level of the organism—its metabolism, its self-bounded nature, its body, its autopoiesis, and so forth—would it be possible to recast other levels as constrained by these organismic properties? Other theorists have already explored this possibility (e.g., Maturana and Varela, Helmut Plessner, and Hans Jonas) and it may indeed be fruitful for DST to explore moves in similar directions.

Another theme that is little explored in the book but that many authors allude to is that of the use of models aimed at capturing, at least partly, the complexity of developmental and evolutionary processes. It is here that disciplines such as artificial life may be of some help. Mathematical modeling is limited by issues of tractability and can only approach complex processes in a crude, but often useful, manner. Computer modeling techniques such as individual-based simulations allow for the relaxation of many assumptions and can be used to expand the scope of traditional modeling to include, for instance, complex frequency-dependent effects such as niche modification by evolving populations. Many artificial life models have already addressed, in more or less disciplined ways, such issues. What are their possible contributions to DST? Such models can address a specific question to test the plausibility of a hypothesis and they can also be more abstract, attempting in thought-experimental fashion to recast the importance of certain ideas from peripheral to central roles.

In 1987 Hinton and Nowlan produced a very simple, but powerful, computer model showing the Baldwin effect in action. This theoretical possibility in evolution—whereby phenotypic plasticity may lead to evolutionary acceleration and, if costly, to genetic assimilation of developmentally acquired traits—had been known for 90 years but was always suspected of Lamarckism and never quite taken as a serious factor in evolution. Suddenly it gained notoriety and respect and many biologists produced further models and attempted to use the idea in evolutionary scenarios. A simple abstract model went much further in convincing scientists than decades of theoretical argumentation. Many evolutionary simulation models have already addressed some of the ideas defended by DST, but the next Hinton and Nowlan model may still be there to be formulated, programmed, debugged, run, and analyzed. No doubt, one key requirement for its success will be a clear understanding of the central ideas of DST and their implications. This book, as well as the primary literature, is from this perspective essential reading for the interested, ambitious modeler. Hopefully it will take less than 90 years.