for analysis, most important discoveries related to the various topics have been included. As an instructor of evolutionary biology in a college that retains a quarter system, I especially welcome such a textbook. In an instructional term lasting only 10 to 11 weeks, no instructors can expect a student to read 2,700 pages of a textbook full of the subtlety and challenge involved in evolutionary biology. A gigantic volume would shake the confidence of beginners, but Hughes has wisely chosen to be concise.

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References


The Ontogeny of Information: Developmental Systems and Evolution. 2d. ed.

Pp. xxi + 273, $59.95.

Susan Oyama’s book thoroughly deserved reprinting. This is an exciting and engaging work that is still timely 15 years after its initial publication. Some of the text of the new edition is revised, and Oyama has added a new Preface and an Afterword. The new Foreword by Richard Lewontin provides a succinct
and sympathetic overview of the book and constitutes a rousing endorsement for the contemporary relevance of Oyama’s work to biology.

Oyama presents a very direct and extremely radical critique of explanatory practice in biology and psychology (her original target): stop attributing so much causal power to the information gene. Understanding her criticism does not necessarily make matters easier for practicing biologists. Her basic idea follows from this claim: “The genome as constituting rules, instructions, or a program, either in the sense of a plan or in the sense of a computer program, is so common a notion as not to seem metaphoric at all” (p. 59). Her point is that, despite this state of affairs, the information gene concept is a metaphor that has seriously misled us. So, if we import this concept from molecular and evolutionary biology into developmental biology and psychology, our explanatory practice will founder. If we acknowledge and agree with this powerful point, defended at great length throughout the book, we can still ask “What is next?” or “How should we go about our explanatory practice in biology?” The answer that Oyama and “developmental systems theorists” propose is that what is next are new kinds of biological explanation and that our practice will become much more difficult.

As Lewontin rightly points out, Oyama has at least two main critical foci. The first is the concept of the information gene, which she argues derived from a cluster of pervasive metaphors rather than being a legitimate component of an explanatory theory. The second is the set of concepts of causation invoked in biology and psychology. She proposes an alternative understanding of causation that fits with the explanatory practice that will result from abandoning the information gene concept. Her overall project is to unite developmental and evolutionary explanations into a coherent understanding of the origin of organismal traits. These traits include the morphological traits of all organisms and psychological traits of humans. Oyama’s theoretical perspective is “constructivist interactionism” (she substitutes this term for all appearances of “interactionism” in her first edition). She argues that we can only fully understand “developmental systems” from this perspective. Constructivist interactionism is the way she proposes that we understand an organism’s response to genes and its environment. Each organism is part of a developmental system whose constellation of traits, at any one stage in the organism’s life, can only be accounted for in terms of the interaction between many causal antecedents. Among these are the organism’s genetic make-up, contingencies in its current environment, features of its environment reliably shared by conspecifics across generations, and so on. Oyama rejects any explanation that accords causal priority to one or other of the causal antecedents of the organism’s traits. She rejects locutions such as the “gene for” a trait and “environmentally determined,” arguing that they are equally suspect: “Since the genome represents only a part of the entire developmental ensemble, it cannot by itself contain or cause the form that results. But then neither can its surroundings” (p. 23).
Oyama presents a convincing case that the information gene concept deployed in evolutionary and molecular biology contains vestiges of preformationism and Aristotelian notions of causation. These two points are connected. Her charge is that the idea of information as a program or set of instructions contained in the gene takes the place of the miniature complete organism in the preformationists' view. What is crucial for Oyama is that the notion of information here is of a complete prior plan for an organism's development. (She also objects to incomplete plans, for example, so-called "open programs.") What is reliably passed on from one generation to the next on the information gene view is not a complete microscopic organism but a complete set of instructions. Underlying this view, which Oyama attributes to many molecular biologists, is the notion that the information in the genome provides a plan and thus correlates with Aristotle's final and formal causes. The fact that the relevant information is in some ordinary causal sense responsible for an organism's development invokes efficient cause, and the matter, cellular material, and so on upon which the information gene acts invokes material cause. This "cognitive-causal" nexus underlying the information gene is what Oyama rejects. There are prima facie grounds for not wanting either preformationism or Aristotelian conceptions of cause to be behind our scientific explanations, but Oyama is not satisfied with leaving things this way. She goes on to propose alternative accounts of information and causation that do not succumb to these outmoded views.

Rather than the information in the genome being preformed or ready to use, Oyama argues that it must have its own ontogeny. Information that plays a role in an organism's development is not primordial; rather, it has its own developmental history. The same information also can be used to different ends in different specific situations. She summarizes these points as follows:

Controls, preferred settings, constraints, programs, rules, plans and information then, all have contingent developmental histories. The cognitive-causal models we have considered have tended to present these controls as ahistorical . . . which provided no satisfactory way of explaining either species typical development (maturation) or the manifest flexibility and multiplicity of many developmental phenomena, save the declaration that all contingencies were somehow anticipated, or at least hypothesized, by the DNA. (p. 137)

Thus while Oyama allows that the genome is one of the important causal prerequisites for the development of an organism, she argues that it is utilized during the life of the developmental system in the same way that many other resources are. The complexity of gene expression revealed by developmental molecular biologists lends some empirical support to this theoretical perspective. For example, whether an individual fruit fly is male or female is determined by a host of complex factors including proteins produced by the fly's...
mother that have not been produced by the larval fly itself. Chemicals such as hormones in a developing organism’s immediate vicinity or the surrounding temperature at certain developmental stages can also directly effect the development of adaptive traits such as the sex of the adult organism.

The perspective Oyama presents is in stark contrast to that advanced by John Maynard Smith in many recent works (see for example, the summary of his views in his *Shaping Life*). Maynard Smith (1998) defends a concept of the information gene that he claims can bring new and useful insights to the study of development. For example, he says that “progress is being made by applying the ideas and techniques of genetics to the process of development. The philosophy behind this approach is that the genes carry, in digital form, the instructions for making an organism” (p. 2). Maynard Smith and Oyama are more-or-less at the two extremes of a continuum of views about the relations between evolution and development. For Maynard Smith, developmental biologists should look to concepts from evolutionary and molecular biology to provide direction. Oyama obviously believes that this approach is doomed to failure, as the very concepts Maynard Smith is offering are formed from clusters of misleading metaphors. She maintains that developmentalists have much to offer evolutionary and molecular biologists. Since Oyama’s book was first written, biologists, psychologists, and philosophers of biology have occupied numerous points on this continuum: there is nothing close to a consensus on what the right approach to evolution and development should be. Rereading Oyama reminds us of many of the issues that need to be resolved in these debates.

A perhaps more fortuitous comparison with contemporary literature is also in order. Many have been exasperated after reading Oyama. As she points out herself, biologists say that they do not know any other way to think than the way Oyama asks them to abandon, and so what is to be done? If Sarah Hrdy’s (1999) recent work is any indication, there are scientists who believe that the evolution and development of human traits should be understood from a fully interactionist perspective. Hrdy’s account of motherhood invokes developmental biology, life history theory, and cultural and evolutionary explanations in a complex and nuanced approach that comes close to putting into practice the constructivist interactionism that Oyama endorses. Oyama says that “ultimately, I am quite sympathetic with E. O. Wilson’s desire for a biological synthesis [i.e., sociobiology]. I just think he has gone about it wrong” (pp. 165–66). In approaching sociobiology from her careful interactionist perspective, Hrdy may be realizing what Oyama had recognized in Wilson’s work.

Oyama’s critical targets also include psychologists and other social scientists. Although I have emphasized her criticism of the information gene concept, she has more general aims. She rejects all explanations that are based on the presupposition of a strong dichotomy, as such efforts result in a disproportionate attribution of causes for phenomena to one or other side of the dichotomy.
In her view, the appeal to either side of the nature/nurture dichotomy results in the most problematic explanatory approaches in the social sciences. (Here again Hrdy is an ally.) Oyama finds cultural determinism, as exemplified by some approaches in the social sciences, as exasperating as genetic determinism. Having such critical targets is consistent with her views about biology and is in keeping with her aims to advance methodological reform in her own field, but in the new edition of her book she also turns her critical attention to philosophers of mind. What is at stake here?

It would seem plausible for Oyama to respond to the host of philosophers of biology now occupying positions on the continuum I mentioned above, and she does respond to some of them. What stands out in the Afterword is her critical attack on David Chalmers and Daniel Dennett. Dennett is an easier case to deal with. His 1995 defense of somewhat orthodox Dawkinsian views about evolution is consistent with Maynard Smith’s views and hence antithetical to Oyama’s. Oyama reveals that Dennett falls foul of critical arguments she developed before he began his major work on Darwinism. For example, she argues that Dennett has implicitly accepted a much more liberal view about information than he avows: information relevant to the development of phenotypic traits is not only in the genes but potentially everywhere. Holding on to a distinction in kind between genetic information and other contributors to phenotypic outcomes is an important component of the Maynard Smith view. Oyama obviously approves of relinquishing this distinction, but she rightly does not think that Dennett can do so and remain consistent.

Chalmers presents another case entirely. Around five pages of Chalmers’s *The Conscious Mind* (1996) are dedicated to evolution. In these pages he says that evolutionary explanations can play no role in our understanding of consciousness. He believes that this conclusion follows from various complex thought experiments about imaginary creatures called zombies and swamp men. The rest of the book is dedicated to numerous other complex a priori arguments that are aimed at honing our philosophical intuitions about consciousness. Where does Oyama come in here? The connection she sees between her work and Chalmers’s book is a shared concept of information, which she defines as “a reducer of uncertainty, a difference that makes a difference” (p. 199). Her problem is that she and Chalmers draw opposite conclusions from their shared concept. Oyama believes that information is bound “inextricably to a point of view,” whereas she takes Chalmers to hold that points of view derive from information. Given their radically different methodologies, it is perhaps not surprising that Oyama and Chalmers can derive contradictory views from shared concepts. Although Oyama’s criticisms of Chalmers may be on target, he and other a priorist philosophers of mind are unlikely to heed them. Where Oyama’s insights are likely to have their biggest influence in philosophy is among philosophers of biology who are currently working on genetic infor-
Oyama has already set much of the agenda for these discussions, and the re-release of her book will ensure that another generation has access to her important arguments.

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