science' troika of scientists to the present, more industrial type organization needed for such a large project.

At the conclusion of the book, Collins worries that his close relationship with the participants might have biased his account and remarks that his emphasis (some might say overemphasis) on the work of outsiders such as Weber was an attempt to maintain his distance. I believe he has succeeded admirably. Although I disagree with some of his conclusions, he has given us so much detail that readers can decide for themselves.

This book will be of interest to scientists, and to philosophers, historians, and sociologists of science. The science is clearly explained, and the book is engagingly written. It would make a fine Christmas present for a friend who doesn't have a background in physics. It would, however, have to be placed under a large Christmas tree.

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Jason Robert, ***Embryology, Epigenesis, and Evolution: Taking Development Seriously***. Cambridge: Cambridge University Press (2004), 174 pp., $60.00 (cloth).

In the last few decades, the fields of genetics and molecular biology have been of substantial importance for the philosophy of biology. The same does not quite hold for developmental biology, despite some philosophical discussions of development. Jason Robert's recent book *Embryology, Epigenesis, and Evolution* addresses precisely the explanation and our picture of organismal development, reflecting a growing philosophical interest in development and its connection to evolution. Robert's central message is that development is more than the switching on and off of genes at the right time and that a complete explanation of development has to appeal to many other developmental resources apart from genes.

What Robert finds wanting is what has come to be called the 'interactionist consensus'—the idea that not only genes, but also other factors are necessary to produce an adult organism. Even though nowadays everyone subscribes to the consensus and acknowledges that genetic and nongenetic factors have to interact in development, a gene-centered picture of development and the organism is still widespread—both among scientists and philosophers. One expression of this is the usage of the notions such as 'genetic information' or 'genetic programs'. Robert argues that these ideas are metaphors without explanatory value. In particular, they promote a distorted picture about the role of genes in development. The idea of genetic information portrays genes as being autonomous and context-insensitive agents, while other material factors are viewed as

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merely supportive. Robert argues convincingly that the facts of molecular and developmental biology do not support the view that genes have a causal primacy compared to other factors. Despite philosophical attempts to define a notion of genetic information (e.g., using teleosemantics), information thus construed is not only present in the genes, so that the notion of *genetic* information is still misguided. Robert does not reject the very idea of developmental information; instead, he emphasizes that information and developmental potential does not exclusively reside in the genes. Developmental information emerges and changes by the interaction of various material resources during ontogeny.

Not only does Robert reject the idea that genes have a causal or ontological primacy. The standard interactionist consensus has also often been combined with the assumption that the study of genes is sufficient to account for development. Robert's central task is to challenge this widespread epistemic idea about the explanation of organismal development. Reductionist research practice is justified in studying the causal agency of genes against a relatively constant background of other factors, for pragmatic and heuristic reasons. However, Robert argues that this approach does not warrant the conclusion that development is to be explained solely in terms of the activation and action of genes. It is usually granted that developmental and phenotypic differences are explained in terms of differences in gene activation, while certain cellular, developmental, and environmental background factors are held constant and thus neither studied and explained nor viewed as causally relevant. But sometimes it is argued that these nongenetic factors held constant can be explained in just the same fashion as being due to differential gene activity. Robert points out that such an assumption simply begs the question against an account that views other cellular and developmental factors as essential ingredients of developmental explanations that cannot be reduced to gene action. Proponents of a gene-centered heuristic often acknowledge that other factors apart from genes may in fact be relevant, but go on in their practical work and theorizing as if this were not the case. Against this approach, Robert proposes a different research heuristic that that makes use of simplifications such as holding causal factors constant, while not drawing unwarranted conclusions such as the idea that the constant factors are explanatorily unimportant.

Two of his chapters develop Robert's alternative account of the nature of development and its explanation. He rejects what he calls a 'genes-plus' account of developmental interaction, i.e., the idea that genes are the primary developmental resource, while other factors serve as environmental triggers of gene activation. Robert urges an alternative view of development—labeled 'constitutive epigenesis'—that views it as being due to the mutual influence of specific molecular, cellular, developmental,

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and environmental factors. Not every material factor within and outside of an organism is relevant for a particular developmental explanation, but insofar as one is really after explaining organismal development, an explanation has to involve genetic and as several types of nongenetic resources. Against the standard picture of development obtained from the study of model organisms in laboratories, Robert points to several examples and biological studies that show that not only genes and cells, but also organisms, have to be viewed as being part of a particular context that is relevant for understanding development and the emergence of biological form. Overall, Robert succeeds in supporting his account with concrete examples and some strands in recent biological research that themselves make use of an epigenetic, non-gene-centered interpretation of development. Among other things, he can rely on multidisciplinary studies of development that use knowledge and explanations from different traditional biological fields to bear on particular questions, suggesting the relevance of different causal factors for a complete understanding of development. Nowadays, multidisciplinary investigations are of increasing importance for new approaches such as evolutionary developmental biology.

Robert connects the topic of development with the question of evolution in his chapter on evolutionary developmental biology (evo-devo). Evo-devo as an independent biological field is quite recent and attempts to synthesize evolutionary and developmental biology, as these fields were without hardly any influence on each other during most parts of the twentieth century. Robert discusses the approach, goals, and aspirations of evo-devo research, in particular the assumption that while traditional neo-Darwinian evolutionary biology relied for the most part on the methods of population genetics, the new developmental approach to evolution will, in fact, transform our picture of the evolutionary process. The philosopher of biology, Kim Sterelny (2000), has recently argued that neo-Darwinism can be changed easily to integrate developmental ideas. Robert, however, offers reasons why evo-devo, in fact, makes use or works towards concepts and explanations that are beyond the framework of traditional neo-Darwinism. Despite this important discussion, given that evolutionary developmental biology attracted philosophical attention only very recently, I feel that Robert should have laid out and discussed this interesting new field in more detail.

Robert's final chapter gives a brief defense of developmental systems theory (DST), a strongly non-gene-centered approach to life used in particular by some psychobiologists. DST views the developmental system as the unit of evolution, emphasizing the variety and contextual nature of developmental resources and the existence of nongenetic modes of inheritance. Robert views a strong difference between evo-devo and DST,

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in that DST goes much further in strongly contextualizing the function of genes. Despite these differences from mainstream biology, Robert still argues that DST has some valid insights to offer, in particular with regard to the interpretation of experimental results, as some evo-devo biologists may be still prone to drawing illicit inferences about the nature of development due to reductionist research heuristics. My impression is that while DST and evo-devo are in fact institutionally distinct enterprises, Robert is too fast in construing an intellectual enterprise such as evo-devo as a sort of Kuhnian paradigm with a narrow and clearly delimited theoretical hard core, being a theoretical approach clearly distinct from other paradigms. Evo-devo biologists sometimes strongly vary in their precise views about development and evolution. On the one hand, some practitioners of evo-devo make use of a strongly epigenetic picture of development that is very similar to that of DST. On the other hand, as DST emphasizes evolution by natural selection to a degree that is absent from some evo-devo biologists, DST is in some respects closer to traditional neo-Darwinism than the approach of some evo-devoists. In any case, the relation between DST and evo-devo is not obvious and would justify a more extended discussion than Robert offers.

Overall, Robert's argument against a gene-centered understanding of development is substantiated by several biological examples and many references to the biological literature, including very recent research. However, at a few points in his discussion, the biological background could have been explained in more detail for those readers who are largely unaware of the details of molecular and developmental biology. Given the widespread existence of problematic views about the role of genes in development within the philosophical community as a whole, some more explanation of certain biological facts—in addition to Robert's justification based on references to the biological literature—might have helped to convince some potential addressees of his discussion. In sum, Jason Robert makes a convincing case for the idea that 'Taking Development Seriously' requires explaining development with reference to the interaction of different types of entities such as molecules, cells, and environmental features—instead of assuming that development can be explained by genes and their activation only.

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