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Title: Introduction

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Introduction

Special Issue on Developmental System Theory (DST)

Developmental Systems Theory or DST is presented by its proponents as a challenging approach in biology aiming at transforming how biology is done from both a theoretical and an experimental point of view (see, in particular, Oyama 2000 [1985] and Oyama, Griffiths and Gray 2001). Even though some may have the impression that the enthusiasm surrounding DST has slightly faded in the very recent years, some of the key concepts, ideas and visions of DST have in fact pervaded biology and philosophy of biology. It seems crucial to us both to establish which of these ideas are truly specific to DST, and to sift through them in order to determine which ones resist the criticisms they have raised, or may raise (e.g., Sterelny 2000; Griesemer 2000; Sterelny, Dickinson and Smith 1996; Kitcher 2001; Keller 2005; Waters 2007).

Although DST can be considered as the continuation of an old tradition in biology, illustrated in particular by Lehrman, Gottlieb, or Lewontin (see Griffiths and Gray 1994: 278), in contemporary thinking it is undoubtedly grounded in (Oyama 2000 [1985]). The main goal of DST proponents, most notably Susan Oyama, Russell D. Gray and Paul Griffiths, is to reframe both developmental and evolutionary biology. They try to dismiss the conceptual confusions that are on the way to such a new refoundation. According to them, these confusions originate mainly in the causal privilege that is commonly given to genes to explain heredity, development, and evolution (Oyama 2000 [1985]).

DST proponents reject the claim that one could explain heredity by resorting exclusively to gene transmission and refer for that matter to phenomena of intracellular epigenetic heredity, to niche construction, and to vertical transmission of symbionts. As for development, insisting on the complexity and non-additivity of causal interactions, they argue in favor of the causal parity thesis, according to which it is impossible to name a single factor that would supervise or determine these processes. Consequently, they criticize the notion of a genetic program, which imply the genes' causal primacy; according to them, every component playing a causal role in development and reoccurring at each generation must be conceived of as inherited. The set of all processes taking part in the developmental construction constitutes a 'Developmental System' or DS. According to DST proponents, a DS is the main unit of evolution. Owing to this new synthesis between development and evolution, DST aims at broadening the scope of evolutionary explanations.

This special issue is composed of three papers, which all try to evaluate DST's claim to provide a unifying and fruitful framework for biology, and to assess its fundamental concepts and the internal coherence of this approach. Anouk Barberousse's aim in her paper is to scrutinize the elements DST proponents present as explanatory in the new theoretical framework they put forward. She points out the role of the construction metaphor in the explanation of development and signals some of its weaknesses. Correlatively, she shows that the relative explanatory failure of DST, as compared with its competitors, may be accounted for by the choice DST proponents have made to rely on self-organization as an *explanandum* of reproduction and development.

In her paper on DST's concept of inheritance, Francesca Merlin shows the limits of DST's idea that any resource necessary for development is to be considered as a form of inheritance. She argues that DST does not provide any evidence of the fact that the evolutionary causal power is neither localized in any privileged factor, nor in many different channels of inheritance, but is diffused in the entire developmental system. She finally suggests that DST's interactionist approach, which refuses the multiple channels model of inheritance and denies any causal differentiation between developmental resources, does not provide any advantage from an experimental point of view.

Thomas Pradeu raises the question of DST's explanatory goal. He shows that there are two very different definitions of the 'developmental system' in DST, so much so that one cannot consider DST as a unified theory of evolution and development. One of these definitions is about the developing organism per se, while the other is dependent upon DST's views on evolution. He thus proposes that DST be a theory about development, not of evolution and development, since it does not provide a well-articulated new perspective on evolution.

At the ISHPSSB meeting in Exeter in July 2007, Marie-Claude Lorne had organized a session about DST, untitled "DST and the Unification of Biology". Merlin, Pradeu and Barberousse were the other speakers in this session. At that time, Marie-Claude was a post-doc. One year later she became Associate Professor at the University of Brest. She tragically died in September 2008 by committing suicide (see Pradeu 2009).

The session organized by Marie-Claude was the result of one year of collaborative work at IHPST (Institut d'Histoire et de Philosophie

des Sciences et des Techniques), Paris. We met twice a month to discuss the major DST papers. If Marie-Claude had been still alive, she would surely have finished in time and submitted the paper she was writing on DST's parity thesis, as the other three of us did. That is why we would like to dedicate this series of papers on DST to the memory of our dear and greatly missed friend Marie-Claude.

The paper Marie-Claude presented at the ISHPSSB meeting of in Exeter was untitled "Positional Information and Parity Thesis". Here is a cursory reconstruction of the argument she opposed to the application of the parity thesis, grounded on an analysis of the notion of information.

She first recalled DST proponents' criticism of the idea that genes play a privileged causal role in development and evolution. In particular, DST proponents have fought against the claim that genes have a greater importance than other factors causally involved in development because they are the only carriers of information. They have opposed to this view the "parity thesis", according to which no analysis of the notion of information has the potential to isolate genes as the privileged cause of development, because any analysis applying to genes equally applies to other, non-genetic causes of development. Second, Marie-Claude questioned the scope and the validity of the parity thesis by means of a further analysis of the notion of information. She remarked that an important assumption of the parity thesis is that the informational discourse in biology is based on a unique conception of information. She discussed this assumption in order to defy the parity thesis. Her aim was not to propose a new, unique concept of information in biology. More modestly, she wanted to show

that, if DNA sequences (genes) carry information in a different sense than other molecular factors like proteins do, i.e. if both cases are not instantiations of the same notion of information, the parity thesis is false.

In her demonstration, Marie-Claude did not start from the usual definitions of information, but from two biological mechanisms that are usually described in terms of information, protein synthesis and cellular differentiation, in order to identify which of their properties substantiate an informational discourse and which notion of information they respectively call up. She thus reversed DST proponents' line of argument. She showed that the mechanism of protein synthesis and the mechanism of cellular differentiation are at the basis of two different concepts of information. On the one hand, the mechanism of protein synthesis substantiates the notion of genetic information according to which informational transfer needs the existence of a template (the DNA sequence with respect to the ARN sequence) and of a code (the relation between a group of three nucleotides and an amino acid). On the other hand, the mechanism of cellular differentiation substantiates the notion of positional information where the informational transfer is based on the existence of a concentration gradient and of a threshold (the differentiation of a cell can be due to the fact that the concentration in proteins has reached some threshold). What Marie-Claude showed is that DNA sequences (genes) can no more be said to carry positional information than proteins. More precisely, she claimed that, if one admits that the informational discourse in biology is based on the causal relations and mechanisms it refers to, the structural and functional differences between the mechanism of

protein synthesis and the mechanism of cellular differentiation justify that they call for two different meanings of information. On this basis, she concluded that DST's parity thesis is in trouble because one of its starting assumptions is defied: the same concept of information, the genetic or the positional one, cannot be applied to both cases, i.e. to DNA sequences (genes) and to proteins. In other words, Marie-Claude argued that DST proponents have not shown that the primacy of genes in terms of their informational role cannot be sustained. Nevertheless, she admitted that it still remained to be explained in what sense genetic information in terms of template and code could possibly ground the privileged role of genes.

We hope this series of papers will show that DST is enormously useful for every person willing to investigate current key biological concepts (heredity, development, epigenetics, information), and yet does not fulfill its whole agenda.

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References

Godfrey-Smith P (2000) Explanatory Symmetries, Preformation, and Developmental Systems Theory. Proceedings of PSA 67(3): S322-S331.

Griesemer J (2000) Development, Culture and the Units of Inheritance. Proceedings of PSA 67(3): S348-368.

Griffiths P, Gray R (1994) Developmental systems and evolutionary explanation. Journal of Philosophy 91: 277-304.

Keller EF (2005) DDS: Dynamics of Developmental Systems. Biology and Philosophy 20: 409-416.

Kitcher P (2001) Battling the Undead: How (and How Not) to Resist Genetic Determinism'. In: Thinking About Evolution. Historical, Philosophical, and Political Perspectives (Singh RS, Krimbas CB, Paul DB, Beatty J, eds.), volume two, 396-414. Cambridge: Cambridge University Press.

Oyama S (2000) The Ontogeny of Information. Durham, N.C.: Duke University Press (1st ed. 1985).

Oyama S, Griffiths P, Gray R, eds (2001) Cycles of Contingency. Cambridge, MA: MIT Press.

Pradeu T (2009) Obituary: Marie-Claude Lorne (1969-2008). Biology and Philosophy 24(3): 281-282.

Sterelny K (2000) Development, Evolution and Adaptation. Proceedings of PSA 67(3): S369-387.

Sterelny K, Smith KC, Dickinson M (1996) The Extended Replicator. Biology and Philosophy 11(3): 377-403.

Waters K (2007) Causes that make a difference. The Journal of Philosophy, CIV(11): 551-579.