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Collaborative explanation and biological mechanisms

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ABSTRACT

This paper motivates and outlines a new account of scientific explanation, which I term 'collaborative explanation.' My approach is pluralist: I do not claim that all scientific explanations are collaborative, but only that some important scientific explanations are—notably those of complex organic processes like development. Collaborative explanation is closely related to what philosophers of biology term 'mechanistic explanation' (e.g., Machamer et al., Craver, 2007). I begin with minimal conditions for mechanisms: complexity, causality, and multilevel structure. Different accounts of mechanistic explanation interpret and prioritize these conditions in different ways. This framework reveals two distinct varieties of mechanistic explanation: causal and constitutive. The two have heretofore been conflated, with philosophical discussion focusing on the former. This paper addresses the imbalance, using a case study of modeling practices in Systems Biology to reveals key features of constitutive mechanistic explanation. I then propose an analysis of this variety of mechanistic explanation, in terms of collaborative concepts, and sketch the outlines of a general theory of collaborative explanation. I conclude with some reflections on the connection between this variety of explanation and social aspects of scientific practice.

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1. Introduction

Mechanistic explanation is an increasingly important topic in philosophy of science, implicated in recent debates about modeling, causality, explanation and scientific practice. This paper draws on emerging interdisciplinary practices in biology to motivate a new account of mechanistic explanation, along the way clarifying several strands of debate. The clarification is warranted, because (I will argue) the prevailing account of mechanisms and mechanistic explanation is ambiguous, lumping together at least two distinct ideas. Disambiguation reveals conceptual space for a new variety of mechanistic explanation, which I term 'collaborative explanation.' The first part of this paper offers a general framework for distinguishing the different aspects of mechanisms and, correspondingly, different varieties of mechanistic explanation. The second part makes a start on analyzing one of these varieties, heretofore neglected due to conflation with causal mechanistic explanation.

I begin by setting out the prevailing view of mechanisms and mechanistic explanation. Several influential definitions of the former have been proposed[1]:

> Mechanisms are entities and activities organized such that they are productive of regular changes from start or set-up to finish or termination conditions (Machamer, Darden & Craver, 2000, 3).

> A mechanism underlying a behavior is a complex system which produces that behavior by the interaction of a number of parts according to direct causal laws (Glennan, 1996, 52).

> A mechanism is a structure performing a function in virtue of its component parts, component operations, and their

[1] See also: Bechtel and Richardson (2010), Glennan, 2002, Woodward, 2002, Craver, 2007. Other uses of term 'mechanism' are beyond the scope of this paper (see Nicholson, 2012 for discussion of these different, though interrelated, meanings).

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organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena (Bechtel & Abrahamson, 2005, 423).

These and other definitions characterize a mechanism as a complex causal system of multiple components that together produce some overall phenomenon. A further claim is that mechanistic explanations describe mechanisms, succeeding insofar as they accurately represent how a mechanism's components are organized to produce the phenomenon of interest, which is thereby explained (Bechtel 2011; Craver, 2007; Kaplan & Craver, 2011). These two claims comprise what I will refer to as the prevailing view of mechanisms and mechanistic explanation (the prevailing view, for short).

The prevailing view contrasts sharply with the classic covering law view of explanation, which states that to scientifically explain an event/regularity is to demonstrate that that event/regularity is an expected consequence of a (more) general law and initial conditions. Although the original D-N theory has been roundly criticized, the idea that explanation consists in subsuming diverse phenomena under a single general law remains prevalent (e.g., Kitcher, 1981; Strevens 2008; Woodward, 2003). But biological practice offers strikingly little support for the covering law view. Laws in the traditional sense (exceptionless universal generalizations of wide scope) are conspicuously absent from models of protein synthesis, cell respiration, long-term potentiation, and many other biological phenomena. Yet these detailed descriptions are widely seen by practitioners of molecular, cellular and developmental biology, immunology, virology, neuroscience, and other fields, as having explanatory value. Covering laws thus appear peripheral to many fields of biology and medicine.[2] This situation motivates the 'New Mechanist' alternative to the covering law view.[3]

As the above definitions indicate, New Mechanist accounts emphasize the causal aspect of mechanisms: productive continuity, causal laws, production of and responsibility for phenomena. This emphasis is understandable, as concepts of cause and of mechanism are deeply entwined both historically and in the philosophical literature. Yet the definitions also attest that mechanisms are not *only* or *simply* causal. Other concepts are implicated as well: diversity, complexity, part-whole hierarchy, and orchestrated functioning. Furthermore, if one takes scientific practice as the starting point, then association of mechanisms with causality is not self-evident. A major goal in molecular and cell biology (among other fields) is to explain the behavior of a cell, tissue, or organism in terms of *underlying* molecular mechanisms. In such cases, relations between different levels of biological organization seem to take precedence over causal dependencies. Indeed, philosophical commitments about causal mechanisms may present an obstacle to accounts of explanation in fields like neuroscience, immunology and developmental biology, which did not exist in their present form when classic theories of scientific explanation and causality were first proposed. In engaging these explanations, it is advisable to relax the assumption that mechanistic explanations are causal by

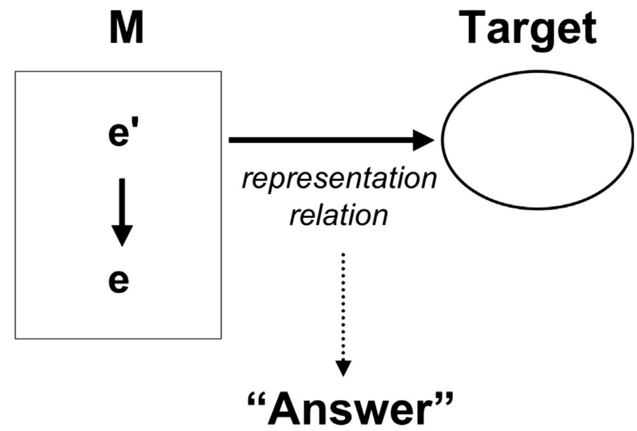

Fig. 1. Schematic of structure and role of explanatory models in science.

definition, and explore other alternatives. The next section proposes a framework for such exploration.

My argument proceeds as follows. I use a stock New Mechanist example to identify three necessary conditions for an object to count as a mechanism (Section 2). This minimal characterization of mechanisms provides a general framework for comparing different accounts currently on offer, and makes explicit some subtle contrasts among them. I develop these contrasts to distinguish two types of mechanistic explanation: causal and constitutive (Section 3). While the causal variety is well-characterized, its constitutive counterpart is not. One reason for this is that different aspects of mechanisms and mechanistic explanation have not been clearly distinguished, while the availability of new causal theories encourages conflation of mechanistic with causal explanation. I use a case study from recent Systems Biology to begin addressing this gap (Section 4). This case illustrates several distinctive features of constitutive mechanistic explanation, which furnish the starting point for a more general positive account (Section 5). The core concept of this new account is *jointness*, analogous to the social action theory concept distinguishing collective from individual activity. Explication of constitutive mechanistic explanation in terms of jointness yields a new account of explanation, which makes central the concept of collaboration. I conclude by indicating several areas for future work to develop this account (Section 6).

The main claim I wish to defend is that we should conceptualize *some* explanations of biological phenomena (namely, those that describe underlying mechanisms) in terms of components working together—collaborating, in a non-intentional sense. This thesis goes against the currently prevailing view that mechanistic explanations are causal, and that characterizing them philosophically requires only a theory of causal relations and how we discover them. I do not dispute that causal relations are represented in most if not all mechanistic explanations. What I reject is the idea that representation of causal relations is *all there is* to all mechanistic explanations.

Concerning explanation, I assume the following:

(i) An explanation is a kind of model (representation), the purpose of which is to answer a question. The answer involves some relation between the model and a target that is the object of scientific inquiry.[4]
(ii) An explanatory model consists of an explanans, explanandum, and a relation between them (Fig. 1).

[2] The 'peripherality thesis' is due to Schaffner (1993). However, see Weber (2005) for a dissenting view. Mitchell (2003) and Lange (2000) defend pragmatic accounts of laws in some biological fields (notably ecology and evolution). My focus here is on areas of biology in which mechanistic explanations are much more prevalent than even such 'relaxed' laws.

[3] New Mechanists include William Bechtel, Carl Craver, and Lindley Darden. The qualifier 'New' distinguishes accounts of mechanisms in current life science from concepts of mechanism dating back to the 17th century and the inception of modern science. See Nicholson (2012) for a defense of historical continuity and multiplicity in the concept of biological mechanism.

[4] Note that this contrasts with the ontic view of explanation (Salmon, 1984).