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PREFACE

New perspectives on reduction and emergence in physics, biology and psychology

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This volume has grown out of a conference on Reduction and Emergence held in Paris, at the Ecole Normale Supérieure, 12–15 November, 2003.

Traditionally, and until quite recently, *emergence* and *reduction* were taken to be contrary notions: a theory T_1—or more often, the phenomena described by that theory—was taken to be emergent with respect to another theory T_2 if and only if it is impossible to reduce T_1 to T_2, although T_1 and T_2 appear to describe and explain the same natural systems or phenomena. This doctrine has recently been challenged by new conceptions of emergent phenomena which allow them to be scientifically explained and even reduced. If the distinction between emergent and resultant phenomena is to be upheld, the task is then to ground emergence on a new criterion independent of reducibility. This is closely linked to the search for an account of scientific reduction that avoids conceiving it in terms of syntactic derivability, as did Nagel's classical account. It is well known since Feyerabend's, Popper's and Kuhn's work that Nagel's standards for reduction were too strong to be met by most real pairs of theories. Indeed, many if not all scientific reductions are accompanied by corrections to the reduced theory. There are now several models of such "approximate" reductions, situated somewhere between full conservation and radical elimination. To mention only a few, one important idea was to abandon the requirement of derivation of the reduced T_1 from the reducing theory T_2, to replace it by the weaker requirement of derivation from T_2 of a theory T_1* *analogous* to T_1. Structuralism, which represents relations between theories by way of the relations between their

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models, has developed its own formal means to represent such corrections. According to the model of "functional reduction", an account first developed in the philosophy of mind, reductions have two parts: an a priori part in which a higher-level concept is analysed as having a functional nature, and an empirical part in which the lower-level role-player is discovered which executes the function.

Several new concepts have been developed to account for the diversity of relations existing between the theories and explanations situated at different levels, during and after a successful reduction of some natural phenomenon: the concept of the *co-evolution* of the reduced and the reducing theories may account for the fact that a reduction establishes connections between these theories that influence both in many ways. Some reductions are accomplished by creating new "*interfield*" theories that merge elements of the theories existing before the reduction. Finally, the reducing theory may be seen to provide "*mechanisms*" executing what the reduced theory conceives of as a simple phenomenon.

The essays collected here show that the conceptual difficulty of understanding reduction and emergence is basically the same for physical, biological and cognitive phenomena. Much can be learnt for understanding the reduction and emergence of a cognitive capacity to/from its neurophysiological underpinnings by studying the reduction and emergence of the heat conduction in metal bars to/from its atomic and molecular underpinnings, and the same is true in the other direction.

Previous publications on the topic by the participants are available at http://www.institutnicod.org/reduction.htm

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