Preface

This book is the result of a decade-long collaboration that began in 2007 with the opening of the Centre for Complexity Sciences at the University of Bristol (an EPSRC-funded doctoral training centre). Teaching at this centre brought us together, and we began discussing the different phenomena and measures of complexity science and the ideas associated with it. We realised the need for a thorough analysis which would answer questions such as 'Is complexity a truly new phenomenon or merely a new label?'; 'Can the different conceptions of complexity of physicists, biologists, social scientists and others be brought into a single framework, or do they address different and unrelated phenomena?'; 'Are measures of complexity meaningful for a phenomenon this multi-faceted?'; and 'Why are information theory and network theory so prominent in complexity science?'. We strongly believed that, whatever the answers to these questions are, it would be beneficial to define precisely the terms of the debate, the phenomena they describe, and the relations between these phenomena. Lack of clarity in these respects is detrimental to science, and confused foundations are sometimes highly problematic. We came to the conclusion that the field of complexity sciences has harboured a lot of confusion, perhaps because it is rather young and includes so many different branches. Our first work on this problem led to Ladyman, Lambert, and Wiesner (2013), upon which this book builds.

This book is written for students and academics interested in complexity science and the nature of complexity and for other scientific practitioners in related areas, as well as for scientifically informed general readers. We have striven for conceptual and linguistic clarity and precision throughout and have sought to make our ideas and reasoning as simple as possible, while always being scientifically accurate. We explain both the foundations of complexity and the mathematical and computational tools currently being used by complexity scientists.

The first chapter provides an overall introduction to the subject and a brief account of its history and that of related fields. This chapter is very widely

accessible and contains much that will be familiar to complexity scientists, though even they will find it worthwhile to read how we formulate the ideas and issues. We have found that sense can be made of most of what has been written by complexity scientists about complexity and that most of what is claimed is for good reason. However, sense and reason can be obscured by the words used to express them. We hope some of what we say in this book seems obvious in hindsight because it formulates clearly and exactly what many people already know. For example, the 'truisms' of complexity science are unlikely to be disputed by any expert in complexity science, though they have never been stated this clearly and explicitly before.

The second chapter reviews typical examples of complex systems and shows how diverse they are and the wide range of features that they display, as well as some of their commonalities. This chapter is also largely very widely accessible, though some parts presuppose some knowledge of physical science. Again we think that experts will find much of what we say uncontroversial, though some will dispute that all the examples we discuss are genuine examples of complex systems. Our method in the rest of the book is to answer the questions raised briefly above and more fully in the first chapter by using the examples we discuss in the second chapter as data for our conceptual analysis.

Chapter 3 and Chapter 4 are the core of our account of the foundations of complexity. In the former we compose a list of features of complex systems, and in the latter we relate this to the measures used by scientists in the field. Some of the material in Chapter 4 requires knowledge of mathematics as we explain many mathematical and computational tools and their role in studying complexity and refer to the relevant scientific literature. The final chapter argues for our own view of the consequences of the analysis of the preceding chapters for the notion of a complex system and the phenomena of complexity, as well as for the status of complexity science as a discipline. Parts of this chapter rely on the discussions of the previous chapters, but we summarise their conclusions so that the reader who did not follow all the details can still follow our reasoning. We do not engage much directly with the extensive philosophical literature on emergence and reduction as that would require a book unto itself. Philosophers have defined many versions of both ideas, and we have adopted the most simple taxonomy as explained in the text.

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