THE METAPHYSICS OF SCIENCE

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THE METAPHYSICS OF SCIENCE

An Account of Modern Science in Terms of Principles, Laws and Theories

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“Perhaps the greatest theoretical success of the book is its convincing arguments for the importance of metaphysical considerations to science. On the PTL model, Dilworth shows why metaphysics plays, or should play, a central role in understanding modern science. If one accepts the notion that there are non-empirically testable (in the standard sense) principles on which all of science is based, one is also forced to admit metaphysics. ... Dilworth does a convincing job of walking the fine line between the strong foundationalist and strong coherentist positions, carving out, in the process, an interesting place for metaphysics in science.”

Dialogue

“The book would make a suitable addition to the shelves of any philosophy department or science faculty library. It is thoughtful, original and many will find it provocative.”

Australasian Journal of Philosophy

“Dilworth does not content himself with a mere philosophical analysis of the phenomenon of modern science, but tries to draw a lesson from this analysis applicable to the actual practice of science. Whereas in its beginnings modern science was a paradigm of open-mindedness, it is now in danger of becoming an ideology, due to its refusal to reflect on its own principles. *The Metaphysics of Science* performs the much-needed function of opening the door to such reflection – both for professional philosophers and scientist themselves.”

Epistemologia

“The book is clearly written and well structured. [It provides] an interesting general introduction to the philosophy of science from quite a different perspective than is usually offered – a perspective which is decidedly Kantian in flavour.”

Philosophy

“The main message of *The Metaphysics of Science* is that science is based on metaphysical principles. [Dilworth] expresses this in an apposite way such that scientific concepts are ‘principle-laden,’ where the principles intended are those of the uniformity of nature, the continuous existence of substance, and causality. Around this he builds a model of scientific explanation, based on the three concepts, principles-theories-laws, and shows its applicability in a number of areas of science."

Sven Ove Hansson, *University of Stockholm*

"Dilworth's book is [an] interesting Whewellian 'top-down' account of the aims, methods and structure of science. An outgrowth of *Scientific Progress*, this monograph is a very well written and insightful account of science as an enterprise which imposes certain (intelligible) principles on more specific theories."

Matti Sintonen, *University of Tampere*

"These two works [*Scientific Progress* and *The Metaphysics of Science*], the latter growing out of the former, are a sustained and comprehensive account of the methodology of science in the light of the theories which have dominated twentieth-century thinking. Dilworth argues that all the competing accounts are flawed, and substitutes his own, applying it in detail to concrete examples from both the natural and social sciences. ...

"Both [books] have much to recommend them. They are written with great fluency, and their combined historical survey is immensely valuable. They also contain a wealth of critical comment which ... is important and suggestive, providing a stimulus for further debate. Together they make a significant contribution to the philosophy of science, and will be found useful to both students and professionals alike."

Ratio

CONTENTS

APPENDICES

PREFACE TO THE FIRST EDITION

The roots of this work lie in my earlier book, *Scientific Progress*, which first appeared in 1981. One of its topics, the distinction between scientific laws and theories, is there treated with reference to the same distinction as drawn by N. R. Campbell in his *Physics: The Elements*. Shortly after completing *Scientific Progress*, I read Rom Harré's *The Principles of Scientific Thinking*, in which the concept of theory is even more clearly delineated than in Campbell, being directly connected to the notion of a *model* – as it was in my book. In subsequent considerations regarding science, Harré's work thus became my main source of inspiration with regard to theories, while Campbell's remained my main source with respect to empirical laws.

Around the same time I also read William Whewell's *Philosophy of the Inductive Sciences*. In this work, Whewell depicts *principles* as playing a central role in the formation of science, and conceives of them in much the same way as Kant conceives of fundamental synthetic a priori judgements. The idea that science should have principles as a basic element immediately made sense to me, and from that time I have thought of science in terms of laws, theories and principles.

Two questions then presented themselves, namely precisely how laws and theories are related to principles, and what the fundamental or core principles of modern science actually are. Though an answer to these questions had already been put forward by Whewell, his conception was in a particular respect too rigid, and furthermore lacked a certain clarity and simplicity. It has been mainly through attempts to overcome these shortcomings that the present work has taken form. Here, modern science is conceived as an enterprise centred on three particular principles in such a way that it includes as integral aspects both empirical laws and abstract theories.

After already having become clear as to the basic structure of this work, I read F. S. C. Northrop's *Science and First Principles*, in which Greek scientific-philosophical thought is conceived as consisting of three main streams, with modern science being a development of one of them in particular. Northrop's historical view not only fit well with my philosophical conception, but was also in keeping with my own thoughts on these matters.

So the present work has been influenced mainly by Whewell, Campbell and Harré, and from one point of view may be seen as a synthesis of certain of their central ideas in such a way as is in keeping with the historical account of Northrop; from another point of view it may be seen as a development of Chapter 10 and Appendices I and IV of the latest edition of *Scientific Progress*. It is a work, like *Scientific Progress*, fundamentally antithetical to the logico-linguistic tradition of twentieth-century analytic philosophy, and moreover one which constitutes an instance of the application of a metaphysical approach in the philosophy of science.

A number of people have helped me with comments on earlier publications and on the present text at various of its stages, and to all of them I extend my thanks. They include Evandro Agazzi, John Blackmore, Robert S. Cohen, Yves Gingras, Rom Harré and Peter Manicas. Peter Söderbaum and Stig Wandén have commented on Chapter 6, as has Roger Pyddoke, with whom I have previously worked on the topic of that chapter. Comments on Chapter 7 have been afforded by Paul Dumouchel and Jaap van Brakel. I would also like to thank James Crompton, Ingvar Johansson and Giovanni Sommaruga for comments on the whole of the book in manuscript. Very special thanks are due to Louk Fleischhacker, who has discussed the subject of the book with me in detail, and has been a source of encouragement throughout its preparation. Financial support for research has been provided by the Swedish Council for Research in the Humanities and Social Sciences.

STOCKHOLM
May 1995 C. D.

PREFACE TO THE SECOND EDITION

Apart from typographical improvements, the addition of the odd footnote, and the emendation of a small part of the text, this edition has been supplemented with three appendices. The first of these provides justification for claims made at the end of Chapter 10 regarding the future of humankind. In this appendix, a theory of human development is presented based on what is termed *the vicious circle principle*. According to the theory, the key difference between the development of humans and other animals lies in our ability to generate new technology. This ability has meant that on many occasions we have been able to solve problems of need by technological means, which has led to a growth in the human population, which in turn has brought us back to a situation of need, which we often once again succeed in overcoming through technological innovation. The vicious aspect of the circle consists in its leading to a dead end when either resources no longer exist that are amenable to technological innovation, or the waste the ever-increasing use of technology gives rise to makes further development impossible.

The second appendix is an analysis of particular enterprises which we intuitively take to be non-scientific against the background of the principles of modern science as they are presented in this book. This analysis should perform either or both of two tasks, namely that of indicating the extent to which the various subjects treated are or are not scientific, and/or that of supporting the approach of the present work by showing how its handling of this question is in keeping with our intuitions.

The third appendix is a comprehensive and detailed reply to criticisms made of this book and of later editions of my other major work in the philosophy of science, *Scientific Progress*. In it I show that my critics have been unable to move beyond an essentially logicalempiricist conception of science – to which alternative conceptions are provided in both books – which has prevented them from properly appreciating the views being advanced in either of them.

I would like to thank Jan Faye for comments on Appendix II, and Louk Fleishhacker for comments on all three appendices.

STOCKHOLM
August 2005 C. D.

INTRODUCTION

This book, in its attempt to depict the metaphysics of science, has a form which differs in a number of ways from that of most other contributions to the philosophy of science. Part of this difference is already implied in the book's title, for few modern writers would want to say that science has any metaphysics at all. What does it mean to say that science has a metaphysics?

Metaphysics itself may be thought of as having two main aspects which, following Kant, we shall call the transcen*dent* and the transcenden*tal*. Both of these notions are important for the message of the present work. The transcendental, as it is to be understood here, may be seen as consisting of a person's most fundamental convictions or beliefs about the nature of reality. These are beliefs – such as, for example, belief in the existence of God – which affect the whole of a person's conception of reality, and which, psychologically speaking, are the most difficult to give up. Furthermore, they are beliefs of which a person may not be conscious. In distinction from Kant's view, however, we do not take the transcendental to be independent of experience; rather, while the beliefs that compose it are not just generalisations of experience, they are nevertheless arrived at through some combination of experience and thought. What is important however is that once arrived at, they constitute the very preconditions for the way one afterwards experiences the world. And, as follows from this, the transcendental need not take a predetermined form, as it did for Kant. As conceived by him, the very constitution of humans was such that they experience nature in terms of, for example, cause and effect. Here, the transcendental is open to reform – in terms of our example, though one's belief in God may be deep, it may come to be given up.

As regards science then, the transcendental may be seen as concerning the most fundamental beliefs scientists as a group have regarding the nature of reality, as these beliefs are manifest in their scientific endeavours. Or, moving from psychology to epistemology, we should say that the transcendental for science consists of the most fundamental *presuppositions* of science. In being transcendental with respect to science they cannot have been arrived at through the pursuit of science, but must be, in a definite sense, pre-scientific, or metascientific. And, as in the example given above, they can be revised or abandoned in favour of alternatives. Thus the idea that science has transcendental presuppositions does not conflict with the idea that science is a dynamic, evolving enterprise, but rather directs the philosopher's attention to analysing the dynamics and evolution of science in terms of changes in its presuppositions. These changes may be more or less drastic, which can lead us to say that changes in science, or scientific revolutions, are more or less total. And at the end of the day we may still find that certain basic presuppositions – or core *principles* – have continued to function as regulative ideas for science throughout its history, and furthermore that this transcendental heart of science is what makes science what it is and not another thing. It is just this transcendental aspect of science, and how it affects the enterprise of science as a whole, that is focussed on in the present work.

The other aspect of metaphysics is the transcendent, which, broadly speaking, is that which lies beyond the limit of some generally accessible realm, whether it be, for example, experience, knowledge, understanding, language, or thought. Of immediate relevance for the study of science is the idea of something's lying beyond the limit of knowledge, where knowledge is understood as empirical knowledge. It is largely with regard to the issue of whether science should be restricted in its investigations to what can be empirically known, or whether it should also delve into the transcendent realm of theoretical entities, that the long-standing battle in the philosophy of science between empiricists and realists has been waged (whereas the issue concerning the transcenden*tal* may be seen as the focal point of the debate between empiricists and rationalists). Our difference from Kant with regard to the transcendent, apart from his not considering its possible application as limiting realms other than that of empirical knowledge, is that what is transcendent at one point in time need not remain so – what is at one time hypothetical may become factual. So we have more of a pragmatic view of the transcendent than does Kant, at least as regards its application to science. And further, on our notion there are *levels* of transcendence, such that, for example, physical atoms may be viewed as transcendent with respect to particular empirical laws concerning gases, while quarks and leptons may be considered transcendent with respect to physical atoms. It may here be noted that, properly understood, the realist is not necessarily advocating that one can have knowledge of any particular transcendent realm, but that it is through theorising about the nature of such a realm and its relation to the non-transcendent or empirical that the latter can be made intelligible. This issue is the topic of the first chapter of the book, and constitutes a theme throughout the work which is rounded off in the penultimate chapter.

So what is here meant by saying that science has a metaphysics is that it has a transcendental aspect, the question of whether it also has or ought to have a transcendent aspect being one investigated in the book against the background of the presupposition that the transcendental aspect has the particular form specified in Chapter 2.

A second way in which this book differs from most other contributions to the philosophy of science is in its emphasis on 'paradigm-thinking.' There are various ways in which the relation between the transcendental and science may be conceived, and the way in which it is conceived here is perhaps novel. During the nineteenth century it was common among philosophers and scientists to think in terms of the principles of science, but for them the principles were to constitute the *basis* of science, whereas here principles are to constitute the *core* of science – a distinction to which we shall return directly. Furthermore, for most thinkers at that time, and even today, science was conceived of as a monolithic enterprise providing the one and only sure route to truth. Here, on the other hand, as is in keeping with the view that the transcendental can take different forms, science is conceived as one particular epistemological activity which may be compared with others. Moreover, what is intended by *science* in the present work is restricted to what is normally considered *modern* science, i.e. science since the time of Galileo and the Scientific Revolution. Thus modern science can be compared with other ostensible means of gaining knowledge or understanding of reality – such as Aristotelian science, or magic – such a comparison to be made first in terms of similarities and differences in their core principles.

What is meant by saying that particular principles constitute the core rather than the basis of science is that they are not general self-evident truths from which particular empirical truths can be formally deduced, but are rather ideal conceptions of reality which guide scientists' investigation of actual reality. From this perspective, what makes a particular activity scientific is not that the reality it uncovers meets the ideal, but that its deviation from the ideal is always something to be accounted for. In this way transcendental principles constitute *paradigms* in much the same sense as this term is intended by Kuhn (and Wittgenstein), it being understood however that they are conceptual and ontological rather than concrete and methodological in nature. Thus, as distinct from Kuhn's view, principles constitute a paradigm for modern science in that they are mental constructs depicting, in broad outline, an ideal reality, rather than being instances of scientific practice embodying an ideal method. Similarly to Kuhn's view, on the other hand, an enterprise focussed on a particular ontological paradigm can go through a number of historical phases. On the present account, the paradigm of modern science as a whole had its golden period during the nineteenth century – a period that has been termed 'the age of science' – while during the twentieth century greater difficulty has been experienced in the attempt to assimilate the results of scientific enquiry to its transcendental ideal, particularly in its core discipline of physics.

Speaking of the 'core discipline of physics' brings us to another sense in which transcendental principles constitute the ontological paradigm of modern science. Thus, just as science had an historical period during which the reality it revealed was most similar to the ideal depicted in the principles, so too can we say that various scientific disciplines lie closer or further from the transcendental core of science depending on how similar the reality they uncover is to the reality of the principles. Due to the nature of the principles of science on the one hand, and reality on the other, the greatest success in applying the principles has been had in physics and chemistry, while biology lies further from the core, and the social sciences further still.

Another way that paradigm-thinking enters the present work is in the claim that this sort of thinking actually occurs in science. Thus on the present view both scientific theories and the expressions of empirical laws constitute in science itself intellectual paradigms intended to capture the *essence* of particular aspects of reality; and these essences are not necessary or sufficient conditions that reality must meet in order for the relevant laws or theories to be applicable, but *idealised* states of affairs which as a matter of fact might never have real correlates. One area in which this paradigm-thinking is particularly clearly manifest is in the treatment of natural kinds in biology (as examined in Chapter 7), where difference of natural kind is not an all-or-nothing affair. In this context, paradigm-thinking involves the taking of certain real things or intellectual constructs as each constituting the ideal of a particular type, such that individual entities are seen as gravitating more or less to one paradigm or another depending on their characteristics; in this way such an entity may thus be considered to be of some particular type, or perhaps to constitute a borderline case between types.

The use of paradigm-thinking in the present work does not stop there however, but lies in the background throughout. Thus, when in the book we speak of the function of theories as being to provide causal explanations of laws, we mean that this is their *paradigmatic* function, which does not exclude their being used, for example, to provide information about a deeper-lying reality as such; or when we say that the aim of the empirical aspect of science is the discovery of empirical laws, we mean this is its *paradigmatic* aim, and do not intend to deny that the empirical aspect of science may also involve e.g. the determination of the existence of particular entities. The conception of science presented here is, it is hoped, a coherent whole in which various concepts occupy particular nodal points, thereby making it also a system. In this system these concepts, the most important of which are principles, laws and theories, function at these nodes as conceptual paradigms.

So the notions of principles, laws and theories constitute the nodal or paradigm concepts in terms of which the present account of science is conducted. This account, in broad outline, runs as follows. Modern science, as presented in Chapter 2, is a particular epistemological enterprise which consists in the application of, and thereby obtains its nature from, particular *fundamental metaphysical principles*. In order to find clear application to reality, these fundamental principles are refined in various ways, giving rise to different groupings of what may be termed *refined principles*, each grouping defining a different science or scientific discipline. Where the fundamental principles are normally implicit in the doing of science, the refined principles are explicit.

The assumption that reality has the basic nature depicted by the implicit fundamental principles leads to its being investigated according to a particular method – the experimental method – resulting in the discovery of *empirical laws* (the topic of Chapter 3). There is no guarantee however that the laws discovered by employing this method will be in keeping with the fundamental principles as a whole, nor, more particularly, with the refined principles of the science or scientific discipline in question. In order to show that and how they are so, one or more depictions of the reality being investigated is advanced, depictions each of which is more detailed than that provided by the refined principles.

Such depictions are of hypothetical realities which on the one hand naturally give rise to the empirical laws that are of interest, while at the same time are constrained by limits set by the refined principles. This constraint consists in the depicted realities' not transgressing the refined principles, as well as in the depictions' employing only concepts taken from them. Such ontological depictions are *theories* which, if they achieve their aim, may be said to have scientifically *explained* the laws in question by showing them to be but an empirical manifestation of the principles underlying the science in question (the topic of Chapter 4). In this way, where empirical laws provide scientific *knowledge*, theories, by linking the laws to the principles, provide scientific *understanding.*

This, then, is the central message of this book. Following its presentation in Chapters 2 to 4, it is employed in various ways. First, in Chapter 5, it provides the structure for a model of scientific explanation. This model is the Principle-Theory-Law (PTL) model, which involves a further development of the law/theory distinction in introducing notions of the *nominal* vs. the *real* aspects of the domain of a theory. While it is intended that this model capture the essence of explanation in modern science, it is possible that it also has application outside this realm. In any case, it is applied in Chapter 6 to a case study taken from modern microeconomics, where it appears to fit rather well. There, according to the core ideas of the book, the key difference between mainstream economics and the natural sciences, apart from their subject-matter, lies in their having different conceptions of causality.

Against the background of one of the fundamental principles of science presented in Chapter 2, the distinction between the nominal and the real developed in the PTL model is presented in Chapter 7 as the key to understanding the modern-scientific conception of natural kinds. There it is suggested that for modern science natural kinds are to be conceived of as having both nominal and real essences, where a real essence can be a nominal essence relative to some even deeper-lying real essence. This notion of difference of level, mentioned above with regard to the transcendent, stems from the relativisation of the law/theory distinction; it is also a key aspect of the discussion of probability in Chapter 8. In that discussion, for which another fundamental principle is central, the distinction is made between nominal and real probability determinations, where nominal probability is based on empirical samples while real probability is based on ontological theories.

In Chapter 9, as mentioned, the realist/empiricist discussion is brought to a close; and the distinctions between epistemology and ontology, and between knowledge and understanding, are discussed. In the final chapter, Chapter 10, the modern-scientific worldview is compared with other historical worldviews, and the question is raised whether for both epistemological and pragmatic reasons it may be time to change to some fundamentally different epistemology, whether or not the name "science" be applied to it.

As is clear from the above, this work is one in the philosophy of science as distinct from epistemology. We are here focusing on the nature of modern science, and not on how best to obtain knowledge of reality in some wider context. Though basic epistemological issues are broached in Chapter 3, this is done only with the aim of determining the fundamental conception of knowledge acquisition of modern science. This marks a third difference between this work and most other contributions to the philosophy of science. In them it is implicitly assumed that modern science constitutes the best way of obtaining knowledge about reality, the question being what is the best way to conduct science. In other words there is an implicit faith that humankind has been constantly moving forward along the one road to Truth, that road being Science, without consideration being given to the thought that modern science might appear just as wrongheaded in the future as alternative forms of science do now. The interest of the present volume, on the other hand, is primarily in clarifying the nature of science, though questions as to its value are taken up in the final chapter.

As is implied in that chapter, that the nature of modern science be clarified is becoming a pressing need in an age where science, while helping provide most people in industrialised nations with a high standard of living, has at the same time been an essential factor in the development of nuclear and chemical weapons, and a contributing factor to the spread of pollutants threatening future human life on earth. In spite of these trends, science shows signs of becoming the first world-wide religion. The scientific enterprise is in serious need of demystification.

The present work is intended to reveal the nature of modern science as an intellectual enterprise. If successful, it should thereby explain such central aspects of modern science as the way in which the Scientific Revolution of the seventeenth century actually was a revolution with respect to preceding epistemological approaches. Similarly, it should explain both why the nineteenth century may be considered the golden age of science, as well as why physics and chemistry lie at the core of the enterprise while the social sciences continue to struggle to obtain scientific status. It should also afford a means of demarcating science from non-science (in terms of paradigms), and explain the nature of scientific revolutions, whether major or minor. Furthermore, the present work should clarify the nature of the foundational problems in physics today, as well as the nature of such activities as scientific explanation and classification.

We begin our excursion into the metaphysics of science by examining the historical debate regarding the role of the transcendent in science, as manifest in the empiricism/realism issue in the philosophy of science.