Divine Action & Modern Science

Nicholas Saunders

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DIVINE ACTION AND MODERN SCIENCE

Divine Action and Modern Science considers the relationship between the natural sciences and the concept of God acting in the world. Nicholas Saunders examines the Biblical motivations for asserting a continuing notion of divine action and identifies several different theological approaches to the problem. He considers their theoretical relationships with the laws of nature, indeterminism and probabilistic causation. His book then embarks on a radical critique of current attempts to reconcile special divine action with quantum theory, chaos theory and quantum chaos. As well as considering the implications of these problems for common interpretations of divine action, Saunders also surveys and codifies the many different theological, philosophical and scientific responses to divine action. The conclusion reached is that we are still far from a satisfactory account of how God might act in a manner that is consonant with modern science despite the copious recent scholarship in this area.

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To my wife and my mother, with all my love

Contents

Preface

> The Methods of Divine Wisdom are Infinite and Unsearchable, and we must not expect fully to comprehend all the Secrets and Mysteries of God's Government, but something we may know of this, enough to teach us to reverence God, and to trust in him, and to vindicate his Providence from the Cavils of Ignorance and Infidelity; which is as much as is useful for us to know.
>
> (Sherlock 1694, 50–1)

There are of course limits to what we as human beings can say about God's activity in the world. The point was not lost on William Sherlock, a seventeenth-century Dean of St Paul's Cathedral in London, with his assertion that we could not hope to discern all of God's mysteries and secrets. We can never aspire to have a comprehensive understanding of the manner in which God acts in the world, but equally this should not push us to the opposite extreme of asserting that God's transcendent relationship with creation simply precludes any meaningful discussion of his action whatsoever. Theologians need to tread a careful middle way between claiming on the one hand that God is limited to those things human beings know and understand, and on the other that we have no relevant knowledge about divine action at all. This difficulty becomes particularly acute given the remarkable advances that the sciences have made in both explaining and predicting natural processes. Where Sherlock was concerned to vindicate divine providence from the 'Cavils of Ignorance and Infidelity', essentially to refine his understanding of God's action on the basis of what *he* knew about the nature of creation, many contemporary scientist-theologians have adopted a similar strategy with the aim of developing an understanding of divine action which is sensitive to modern scientific developments.

It must be made clear from the outset that the argument which follows rejects any rigid and immutable categorisation between those explanations offered by science and theology. It is, however, quite wrong to

assert naïvely that science and theology are methodologically identical or address identical levels of explanation and questions. There has been much recent debate on the nature of this relationship and I shall not attempt to deal with it in any detail here. On a very simplistic level a difference between the two disciplines arises because it is impossible to perform theological 'experiments' in anything like the manner of the natural sciences. The assertion runs deeper than this, however, because it also arises as a result of the vastly different evaluative processes used by theologians and scientists to decide what is a successful theory or doctrine. This fact is clear from even a cursory examination of the tests, checks and motivations under which a scientific theory is accepted by the scientific community at large and these are quite different from those that lead to theological doctrine becoming widely accepted. Nevertheless it remains the case that *both* theology and science make overlapping truth claims about the same reality, namely the nature of God's creation, and thus it is critical that our theological doctrine, claims and understanding must be examined against the wider criteria of coherence with what we know from science, and similarly that what we know scientifically should be considered in the light of, and tested for coherence with, our current theological understanding. This latter assertion, namely that particular scientific theories may be critiqued, and possibly even rejected, on *theological grounds* may sound like undue theological optimism, however there are a number of occasions in the recent history of science when this may have been exactly what took place. One example was the widespread acceptance of big-bang cosmological models over the steady state model. Some scholars have suggested that the acceptance of the big-bang account was in no small part due to the fact that the idea of a big-bang genesis of the universe appeared on initial reflection to be so germane to the concept of a creator God bringing the universe into existence *ex nihilo.* Another interesting area in which theology may have something to teach science concerns the infamous measurement problem in quantum mechanics (see chapter 6 below). Given the various competing philosophical approaches to quantum measurement it may be that several of these are open to reconsideration, and even rejection, on the basis of their *theological* implications. I have argued in chapter 6 that this is possible given detailed considerations of the theological implications of the so-called 'many worlds' approach.

Throughout the pages that follow the emphasis is nevertheless primarily on considering theological assertions in the light of coherence with our modern understanding of science. Given that many theologians have

grappled with the problem of God's action in the world with only scant regard for the often conflicting scientific understanding of nature there is a great deal of material to consider in this context. The task is an absolutely necessary one for two reasons. Firstly to ensure that contemporary understanding of God has relevance to modern thought, and our current scientific worldview, and is not thus relegated to an antiquarian curiosity. Doctrine can only effectively be used as apologetic when it addresses the needs, concerns and contemporary understanding of the community it is addressed to – something St Paul was acutely aware of when he wrote the various letters to Christian communities that form a central part of the New Testament. Secondly, and more importantly, theological doctrine must be evaluated against wider scientific considerations for the simple reason that we want to get our understanding of God and creation as correct and as true to reality as possible. Inherent in this latter claim is an assertion that both theology and science are realist theories – that is to say our theological and scientific claims are in at least a limited sense related to what is actually 'out there', what actually constitutes the ontology of the world. Relating a realist interpretation of theological doctrine and scientific knowledge is no easy task – not least because very few philosophers of science would accept that there is a one-to-one correspondence between what science tells us epistemologically and the ontology of the world. That is to say that few scientists are naïve realists.

Indeed the difficulty in striking the above balance between an understanding of divine action based on what we know as human beings and God's transcendent nature becomes all the more complex by virtue of the constantly changing nature of human understanding of both science and theology. Scientific theories in particular are generally accepted to be provisional in the sense that they form the best understanding at the present, but with the caveat that the theory in question may be modified or refined in the future. Given that correct theological understanding of God must both be enriched by and be compatible with the present state of our scientific knowledge, this has profound implications for contemporary theology. In general theologians must come to accept that their theological understanding of God's creation is informed by *current* scientific thinking and thus must similarly be essentially provisional in nature. This need not lead theology to a sense of despair, irrecoverable relativism, or a pseudo-post-modernist assertion that as theologians all aspects of the truth about God will always remain veiled from us. Although it is a major change for many theologians to accept that some

aspects of their understanding and theological doctrine are only provisional in the sense that they may later be replaced or modified, so long as the replacements and modifications that later take place get us closer to a true understanding of the ontology of God, then they are surely both necessary if theology is to remain a valuable intellectual discipline, and wholly justified.

The fact that our knowledge of science is often only provisional in this sense has the consequence that it must be inappropriate to conceive of an overarching theory of divine action which seeks to explain the interaction between God and science in all its details. To do so ignores the fact that scientific theories are disproved and refined, and also that theological doctrine and understanding similarly develops on its own account. Surely the best approach to the question of divine action given these difficulties is to consider our current hesitant *models* of God's action in all their details while simultaneously acknowledging the inherent limitations of our human perspective and the provisional nature of our models. Despite these huge limitations on the scope of our study of divine action there remains a great deal that science can contribute to theological understanding, and it would be quite wrong to argue that we are consequently forced into the despair of the claim that theology cannot as a consequence make realistic claims about the nature of God.

Before we begin to consider these issues in depth it is important to be absolutely explicit about the approach adopted in this book to relating these very different concepts. Methodological issues pervade any meaningful discussion on the interface between science and theology and this book is by no means immune from the need to adopt a coherent framework for addressing the interface. It should be noted, however, that this is *not* a book on the theoretical relationship between the two disciplines. In essence it is assumed that they are *theoretically* reconcilable, although this is crucially not to make the claim that they are both methodologically identical. This book adopts the presumption that God exists and is active in the natural world in a continuing and particular sense (i.e. that God performs special divine actions in creation). Consequently science and theology are not equal methodological partners in the dialogue which follows. The approach adopted is to identify a set of theological demands which a limited conception of divine action makes and this largely sets an agenda for evaluating the models discussed. It is only after having pushed the claim that God is active as far as possible in connection with the various scientific approaches considered that conclusions are reached about the cogency of the initial premise, namely whether it is actually

defensible to assert still that God is active in the world. One potential criticism of this approach is that it is to a certain extent dependent on an implicit doctrinal tradition which guides the claims made about God's action. However the approach adopted bypasses this difficulty by discussing the claim that God is active in its most basic form, namely an assertion that God by acting initiates novel causal interactions in nature. Where there are strong claims against a critical realist interpretation of science, such as those propounded in relation to chaos theory, this fact is noted in the text. Indeed it may be, as is argued in the last chapter, that the strong sense of divine action which forms our theological inheritance is simply untenable in the light of our modern understanding of the natural sciences.

At the very least it would seem that some modification of our 'traditional' understanding of divine action would appear inevitable. As such the approach adopted is that we use theological models in an analogous sense to scientific ones, although there are clearly limits to the analogy. What must be clear, however, is that our understanding of the reality of God must be open to change and modification in the light of other evaluative criteria such as the natural sciences. Theologians are generally very scared about getting their theology 'wrong' and consequently endeavour to construct far wider grand syntheses than would ever be attempted scientifically. However, one of the principal implications of our relatively recent deepening understanding of the nature and structure of God's creation is that those theological models we inherit *must* undergo some kind of revision or evaluation process if we are to get closer to understanding the nature of God. While these evaluation criteria are much wider and more complex than analogous scientific ones, they are, I believe, none the less real or forceful because of this. It remains clear that the *ultimate* nature of God's action in the natural world will remain a mystery to human beings, but it must not be forgotten that the natural sciences and theology are both making claims about the ontology of the same creation and as such we cannot simply adopt a 'head in the sand' approach to these issues if belief in God is to have any intellectual coherence in this modern age.

The problem of how God acts in the world can appear truly intractable and there are a huge number of theological, philosophical and scientific factors that may be relevant. In an attempt to remain focussed on the relationship between science and theology readers will find little discussion in the following pages of the problem of evil, detailed examinations of the Biblical and other motivations for asserting God's actions, or a

comprehensive methodology of the relationship between science and theology.

In chapter 1 we examine the stimuli for asserting that God acts in the natural world. In particular the often cited 'Biblical' account of divine action is placed into the context of the Near Eastern approach to natural phenomena. We examine the Biblical theology movement and identify some of the implicit *scientific* assumptions that are made in this discussion. The conclusion reached is that a direct appropriation of Biblical accounts of divine action into a contemporary dialogue with science is very problematic and that consequently it is necessary to rely on other stimuli such as notions of doctrinal coherence.

Chapter 2 critiques some of the most common theological approaches to divine action. The discussion begins with an attempt to delineate special and general divine actions on the basis of the scientific particularity of God's action. It is emphasised throughout that an account of special divine action (SDA) must include statements about the causal operation of that action, even if these are very difficult to particularise. Attempts to claim parity between the world and God's body for the purposes of action are rejected on the basis of a detailed analysis of the concept of intentional action and the assumptions inherent in the world as God's body position. Similarly a notion of God's action in the human mind as distinct from that 'in nature' is rejected although it is acknowledged that the mode of operation of SDA in the mind may be fundamentally different. Finally a distinction is drawn between compatibilist and incompatibilist notions of SDA by analogy with the human free action debate on the basis of the initiation of causal sequences in nature by God.

We then turn to examine the relationship between incompatibilist SDA and the concept of laws of nature in chapter 3. After noting the reluctance of many modern scientist-theologians to appropriate the traditional understanding of miracle as a law-violation in discussions of SDA we consider some of the philosophical conceptions of laws of nature in detail. It becomes clear that there is considerably more consonance between the laws of nature and incompatibilist SDA than has been widely acknowledged, and that not only is the concept of miracle as a violation of the laws of nature theologically undesirable, but it is actually extremely difficult to support from the perspective of philosophy of science. Indeed it becomes clear that only on a naïve necessitarian interpretation of the laws of nature could SDA ever constitute a law-violation. On the other hand there is no equivalent of law violation in connection with

a regularist interpretation of laws of nature because of the primacy of individual events in this explanatory scheme. Accordingly the laws that the regularist asserts are formed around whatever events actually take place in the world be they 'naturally' or 'divinely' caused, and thus SDA becomes subsumed under law-like statements. The implications for combining this approach with a theistic assertion that God is regularly active in the world are considered in detail. The approach adopted throughout this chapter is to make the assertion that incompatibilist SDA is an objective feature of the world and then consider when on each of these interpretations of the laws of nature it becomes interventionist as opposed to non-interventionist. The conclusion reached is that for SDA to be asserted in a non-interventionist sense, given an essentially necessitarian reading of natural laws, we are forced into a detailed examination of what constitutes the scope of applicability of these laws and the possibility of probabilistic and indeterministic laws of nature. With regard to these latter approaches Karl Hempel's notion of epistemic ambiguity is discussed and the conclusion reached that a detailed understanding of claims for determinism in physical laws is a necessary part of an assertion of incompatibilist SDA.

Chapter 4 then considers the notion of indeterminism and its relationship to SDA in more detail. William James' ontological approach to determinism is adopted as the most theologically consonant and is discussed in relation to prediction by a detailed discussion of Karl Popper's use of the term 'determinism'. The relationship of a creator God to genuine indeterminism is discussed and the conclusion reached that if indeterminism exists then an implied divine kenosis may be required because of the dependence of indeterminism on God's sustenance. This has important implications for the assertion that God is active through indeterministic processes because it raises questions about the consistency and rationality of the assertion that God simultaneously sustains the world and indeterministic processes in being, while choosing to override the indeterminism on certain occasions to achieve particular actions.

In chapter 5 we consider some of the claims made by theologians who seek to relate SDA and quantum mechanics (which is generally interpreted as a paradigm indeterministic theory). It is shown how William Pollard, who is commonly cited as the precursor of this position, is actually one of a long line of physicists to make SDA claims in connection with quantum physics. Moreover a detailed reading of Pollard's work shows that it is quite wrong to assert that he envisaged God as active *solely* at a quantum scale. The similarities between his position and those of

Karl Heim, J. J. Thompson and Arthur Compton and others are discussed in detail as are later authors who have developed similar positions such as Thomas Tracy, Nancey Murphy and Bob Russell. Their positions are shown to be broadly similar save that they differ as to whether God is active in every or only some quantum 'events'.

Chapter 6 considers quantum theory in detail and questions whether it can really instantiate the notions of SDA that those theologians discussed in chapter 5 have asserted. It is shown how incompatibilist SDA cannot be related to the Heisenberg Uncertainty Principle, and it is argued that if God is active through quantum theory then this must take the form of a measurement interaction. The potential for asserting SDA in each of the most common interpretations of the measurement problem is discussed in detail and the conclusion reached that on our current understanding of the theory SDA is not supported by quantum mechanics in any of its forms.

Chapter 7 then considers the relationship between SDA and chaos theory. John Polkinghorne's arguments that God acts through chaotic phenomena are examined in some detail. It is shown how Polkinghorne's proposal is fundamentally a metaphysical *postulate* about a pervasive indeterminism operating in the real world which is only mathematically modelled by the deterministic equations of chaos theory. Furthermore Polkinghorne's argument is shown to be based on certain features of deterministic mathematical systems which are then taken to be indicative of this postulated ontological indeterminacy and the logical basis for this argument is critiqued. It is for these reasons that almost all of the common so-called 'critiques' of Polkinghorne's position on the basis that chaos theory is fundamentally deterministic simply miss the essential basis of his argument and do not address what is essentially a *postulate* about the nature of physical reality. An alternative critique is offered on the above basis and that of a detailed consideration of 'active information' input into chaos theory. It is shown that the implication of this latter claim for SDA without any energetic input into the system in question is that this can only take place at the point where chaotic trajectories converge at the infinite limit of a chaotic attractor. It is argued that the real world cannot instantiate the infinite fractal intricacy which forms an inherent part of chaotic modelling, and accordingly that SDA by the input of active information in chaos theory cannot be a correct approach to God's action in the real world.

Chapter 8 then considers Arthur Peacocke's notion of whole/part SDA and reaches some general conclusions about the types of physical

systems that might be suitable candidates for Peacocke's methodology. We then return to reconsider the relationship between laws of nature and SDA and whether an approach to SDA which is reliant on Nancy Cartwright's assertion that the laws of nature only form an explanatory 'patchwork' may be a fruitful direction for future research.

Chapter 9 draws the conclusions from the preceding chapters together and argues that the current state of coherent attempts to relate divine action and modern science is far less developed than is widely realised. The conclusion is reached that neither of the two major approaches to the issue in contemporary theology and science, namely the quantum- and chaos-based approaches, survives detailed scientific and theological scrutiny. In this light the conclusion reached is that the 'current state of the art' in this field constitutes little more than a number of bold metaphysical assertions such as that of whole/part causation and accordingly there is very little detailed contemporary support for SDA.

I am often aware that it is much easier to critique what others have written than it is to develop a novel approach of one's own and thus owe a great debt to the many scientists and theologians who have debated these matters in depth over the past forty years. I owe thanks to David Hoyle for getting me interested in theology in the first place and fostering such a conducive atmosphere to studying it as an undergraduate. I owe a particular debt to my academic supervisor, Fraser Watts, who did much to develop my understanding of the interface between science and theology and I am also grateful to the members of the Theory of Condensed Matter Group of the Cavendish Laboratory at Cambridge who so kindly took me into their midst – it was a wonderful experience being a scientist-theologian in the Cavendish Laboratory! I would like to thank my former colleagues at the European Laboratory for Particle Physics (CERN) in Geneva who constructively challenged much of my thinking. I have had stimulating conversations with John Polkinghorne, Arthur Peacocke, and Philip Clayton in particular, as well as Nancey Murphy, Tom Tracy, Richard Southern, Iain MacKenzie, Brian Josephson, Michael Redhead, Peter Smith, Keith Ward and several anonymous referees from Zygon and Cambridge University Press. I would also like to express gratitude to the staff of the Humanities 2 Reading Room of the British Library in London who have helped me to track down several more obscure publications. I owe thanks to the Humanities Research Board of the British Academy and the Epiphany Philosophers' Trust who provided financial support for my research. I was also grateful to receive the 1998 Research Prize from ESSSAT, the

European Society for the Study of Science and Theology, and an 'Exemplary Papers in Humility Theology' award from the John Templeton Foundation in 1999. I have presented the argument behind chapters 6 and 7 of this book in various forms at the ESSSAT conferences, undergraduate lectures and seminars at Cambridge University, and at the Ian Ramsey Centre at Oxford University, and I am indebted for the helpful feedback I received at those meetings.

I am particularly grateful to my mother for always supporting me in making the change from physics to theology and for her continuing support even when it was diagnosed that she had what unfortunately turned out to be terminal cancer. May she rest in peace. Finally my love and thanks go to Nicola my wife who has put up with the financial and emotional demands of me studying to qualify as a barrister while still working part-time as a theologian.

CHAPTER ONE

Motivations

On the day of his consecration the Patriarch Elect of the Coptic Orthodox Church of Egypt is traditionally led to the cathedral, having spent the previous night in chains keeping vigil by the dead body of his predecessor (Butler 1884, vol. II, 309). When he arrives at the cathedral he is taken to the altar and stands between two bishops as his deed of election is read aloud to the congregation:

> we besought the Spotless Trinity with a pure heart and an upright faith to reveal unto us him who (was) worthy of this meditation ... Therefore, by an election from above and by the working of the Holy Spirit and by the assent and conviction of us all, it was revealed unto us to have regard unto N for the Apostolic Throne of the divinely-prophetic Mark. (Khs-Burmester 1960, 58)

What is particularly interesting is the procedure adopted by the Copts to manifest most reliably God's choice and revelation of their new Pope – the election from above and working of the Holy Spirit is invoked by means of a very ancient tradition. In the election of their sixty-fifth Pope, HH Shenute II (1032–1046), the Copts adopted a process analogous to the Nestorian custom of choosing their patriarch by means of picking lots. Throughout the next nine hundred years this process was only used occasionally until it became accepted as the standard method of selection in the twentieth century with the election of the current patriarch, HH Shenouda III, on 31 October 1971 (Atiya 1991, 1999).

HH Pope Shenouda III was chosen by the process of *al-Qur'ah al-Haykaliyyah*, which literally means 'the choice of God from the Altar'. The names of the final three candidates for election are written on identical slips of paper and placed into a sealed box. During the Mass a very young boy is selected from the congregation. He is blindfolded and the priest opens the box. As the congregation pray the Lord's Prayer and chant 'Lord have mercy' the boy chooses one of the slips inside. The name picked is that of the new Patriarch.

Of course there are certain things we can say about how God brings about this revelation. Central to the modern Coptic ceremony is the belief that God helps to form the intentions of all of those involved in the selection of the three names that will be written on the lots and many intercessionary prayers are made to ask for God's guidance in this matter. In the ceremony of the young boy choosing the slip there are two further implicit statements about God – both of which have strong Biblical parallels: that God has knowledge of the configuration of the slips in the box and knows which slip has which name written upon it; and that God can make his specific intention known to the mind of one child who then chooses in accordance with that intention without himself knowing which slip to choose. Both of these are essentially claims about the extent of God's knowledge of the natural world – the exact configuration of the slips in the box, and the nature of the boy's thought processes. The latter element also includes a claim that God is capable of acting in the world on the level of human mental processes and accordingly instigates the child's movements.

A strong element of the selection of the Coptic Patriarch is that God is capable of guiding a chance-like process and has knowledge of how to effect that process in a suitable way to effect a desired result. Put another way, God acts with intention to determine an otherwise random selection by virtue of knowledge and foresight of the implications of that determination. These are claims that will recur many times in our discussion of attempts to link quantum theory and chaos theory to divine action.

The Coptic concept of invoking God's choice by means of casting lots is, of course, not without earlier precedent. Lots were cast by Israelite priests to perform predictions and oracular consultations long before they began to undertake altar and sacrificial work. When consulted on a particular issue, priests 'asked' God using objects called Urim and Thummim to make express his decision in the form of a 'yes' or 'no' answer. In some cases it was possible for an answer to be completely withheld, and occasionally written lots could be used when it was necessary to decide between a number of options (Huffmon 1983). There is no way of knowing exactly what the Urim and Thummim looked like, but it is clear that they formed part of the priest's breastplate and were worn even as late as David's time as an icon of priestly function. Indeed, this emphasis on the role of lot casting and the determination of chance-like events by God is not restricted to the Hebrew Bible. Early in the Book of Acts, for example, we see the Apostles attempting to decide

on who shall join them by casting lots to decide between Joseph and Matthias:

> Then they prayed and said, 'Lord, you know everyone's heart. Show us which one of these two you have chosen to take the place in this ministry and apostleship from which Judas turned aside to go to his own place.' And they cast lots for them, and the lot fell on Matthias; and he was added to the eleven apostles. (Acts 1:24–6 NRSV)

The lot 'fell' on Matthias, but this was no neutral or random process – it is clear from the Greek text that it was God himself who chose the appropriate lot; the parallel with the Coptic ceremony is particularly clear.

In each of these examples we have specific occasions when God is perceived to act in the world. The part of God's creation in which these actions occur is distinguished from all others by virtue of this action, and it is common for this mode of action to be called special divine action (SDA). The immense particularity of God's activity is found in even a cursory reading of the Bible. Not only does God originally create and continuously sustain the universe in existence, but we see a God who acts in particular times and places to determine the outcome of lots, admonish, and more generally guide the process of history. Indeed Christoph Schwöbel has demonstrated just how fundamental this concept of special divine action is to Christian belief: he identifies several key concepts such as thanksgiving, confessions of faith, petitionary prayer and proclamation in scripture, and emphasises their dependence on God's particular actions. Schwöbel argues that divine action is *constitutive* of many of these doctrines and emphasises that without a coherent account of God's actions the status of much theological doctrine is under question (Schwöbel 1992, 23–4). Theodor von Haering has argued even more strongly that a sustained belief in providence, in the broad sense in which he understands it, actually constitutes religion itself. On his account it is belief in divine action which is primary and other theological claims are merely subsidiary manifestations of that core belief (von Haering 1913, vol. II, 514). Von Haering's attempts to synthesise *all* theological doctrine into the context of divine action may be somewhat ambitious, however it is clear that, even if we deny such strong claims, a coherent account of divine action is a theological necessity. This need becomes particularly acute in any discussion of a personal God and is of particular significance for modern fundamentalist and apologetic theology with its corresponding emphasis on the workings of the Holy Spirit.

The aim of this book is to consider how coherently we can relate the theological assertion that God is active in particular times and places in creation to the demands raised by the natural sciences. Is there any truth, for example, in the common argument that science is such an accurate predictive tool that there is no flexibility within nature for the actions of God? As we shall see the answer to this question is deceptively complex and is reliant on developed understandings of the laws of nature, determinism and assumptions about the relationship between epistemological investigation and ontology. In the discussion that follows we shall focus in particular on the relationship between SDA and the description of the natural world which is offered by the relatively new disciplines of quantum theory and chaos theory. The importance of these two sciences is that they are widely claimed to be intrinsically indeterminate, or to contain enough inherent flexibility to accommodate the actions of God. However before we begin to discuss this relationship in detail it is crucial to clarify the status of Biblical material as a motivation and partner in our discussions about divine action.

THE STATUS OF BIBLICAL SOURCES

Even a cursory reading of the contemporary literature on the subject of SDA reveals it to be steeped in Biblical quotation, and these quotations are often used to support very specific and detailed notions of SDA like those identified above. Oliver Quick is a precursor of the sentiments of many of these authors with his assertion that 'the most obviously distinctive characteristic of Hebrew theology is its belief in God's guidance of history. We owe the familiar idea of providence to the religious legacy we have received from Israel' (Quick 1938, 69).[1] It would be wrong, however, to assume that this 'distinctive characteristic' is restricted to Hebrew theology because belief in SDA is a common feature of several major religions. Aside from Judaism upon which much of the Christian understanding is based, there are also analogous assertions of God's providential control of nature in Islam and Hinduism (Parrinder 1969). Indeed, even before we begin to examine the Old Testament conception of SDA in any detail, it is helpful to set it within the broader context of the ancient Near Eastern conception of nature and its understanding of providential control by the gods. It is remarkable that, given the appropriation of so much Biblical material into modern discussions of the

[1] Quick's terminology is that of providence, rather than special divine action. We shall discuss the relationship between these two concepts in more detail in chapter 2 below.

relationship between SDA and science, there has been relatively little detailed study in this context of the Biblical conception of nature. As we shall see, the Hebrew understanding of natural processes and the relationship between God and these processes owes much to its intellectual ancestors.

Man in the ancient Near East was daunted by the power and ferocity of nature – there are many surviving texts in which Near Eastern writers express that they feel battered by the enormity of the storms, winds and rain of the climate. Yet it is not true to say that they saw nature as utterly irregular and disordered. Underlying natural processes there existed a collection of powerful individual personalities and intentions that had the potential to conflict and contradict (Frankfort et al. 1977). Each of these wills was associated with a deity whose goals and actions had to be continually placated by man. Consider, for example, the following invocation from the Babylonian New Year's festivals:

> Asari, who grants the gift of cultivation,
> My Lord – My Lord, be calm . . .
> Planet Mercury, who causes it to rain,
> My Lord – My Lord, be calm!
> Planet Mars, fierce flame,
> My Lord – My Lord, be calm . . .
> The Star Numushda, who causes the rains to continue,
> My Lord – My Lord, be calm!
>
> (Pritchard 1969, 333)

Here we see a prayer to the various deities controlling the harvests, storms and fire. Each of the forces of nature was personified into a deity who is addressed by name and implored to stay 'calm'. It is particularly clear that the author of this prayer was concerned about the capricious personalities of these deities. In turn, the natural processes of the world were each associated with the expression of these personal wills, and just as human beings could be difficult and unpredictable, so too could the intentions of the different Babylonian gods. The consequence of this was the view that natural processes were fickle and that order and regularity were not things to be taken for granted – man felt precariously balanced at the apex of many divergent intentions, most of which he could only implore to remain calm and regular. It would be incorrect, however, to conclude that Near Eastern man saw nature as totally unpredictable. Just as human beings regulated their activity, so too did the gods, by integrating their wills in a social order and hierarchy.

It is clear that for the vast majority of Near Eastern writers the modern notion of causality within nature was largely explicable by reference to

the personalised powers of the various deities and their respective spheres of influence within the universe. In certain cases this power was derived from Enlil, the highest authority. Accordingly the cosmic 'state' mirrored social relations on Earth – it too had minor power groupings that had responsibility for particular physical entities and peoples (Frankfort et al. 1977, 148). The problem was that the groups sometimes came into conflict, with dire results for the workings of nature. It thus followed that, for the Near Eastern peoples, there was no fundamental partitioning of entities into either animate or inanimate – essentially, if the rain had not fallen, then it was because it had *decided* not to fall.

As a result of these many deities the universe was ordered as a society or state in which the authority of certain entities had power over certain others. The god Enlil, for example, was seen in the power to rage in a storm, and the power to destroy a city in an attack by barbarians (Frankfort et al. 1977, 150). However Enlil's supervision and control were limited in scope and accordingly the cosmos on a human scale remained mostly regular and predictable. His authority was, however, not unchallengeable and could be upset or usurped by other gods with the result that anarchy could break out in the same way as a war amongst humans. When these political power struggles between the Gods took place there was very little that human beings could do. The place of mankind in this universal hierarchy was very low and he had no 'political' influence with the gods and similarly no share whatsoever in the government of the natural processes in the world.[2]

Although this account has glossed over many of the complexities in the Near Eastern approach to natural phenomena, appreciating the broad nature of this background is crucial to understanding the various highly specific claims made about God's action in the Hebrew Bible. The claims for SDA that are so widely cited in contemporary science and theology literature must be seen in their original context both as products of the ancient Near Eastern world-view, and as highly dependent on the understanding of natural processes at that time. What made the Hebrews' account fundamentally different from its contemporaries was its radical insistence on monotheism. The Hebrews did not assert any form of competitive political polytheism but rather a conception of the divine in which

[2] A detailed cosmogony appears to have been absent until the development of the *Enuma Elish* or 'When on High' around the middle of the second millennium BC. It details the origin of the basic components of the universe from chaos and the establishment of the existing world order (Pritchard 1969, 60–72). There are very close parallels between the *Enuma Elish*, the Epic of Gilgamesh and the cosmogonies seen in Genesis chs. 1–3 – for a particularly clear exposition see John Romer (1988).

God was undivided and had supreme authority over everything in the world. While this assertion constituted a radical theological distinction from the other Near Eastern texts, the conception of nature employed in the Old Testament is, nevertheless, not so far removed. The Israelite account of nature is steeped in the terminology of other Near Eastern peoples, but the Hebrews did not view regularity in nature as the product of a balancing of many personal wills, but as an expression of the faithfulness of the one supreme Yahweh. Under the governance of the one God all of the same natural phenomena are described – He is the same God who gives breath to the people of Earth, brings rain and storms and provides bounteous harvests, and when He withdraws his breath causes death and destruction. Israelite belief in Yahweh thus represented a form of security and dominance over these natural processes that was almost unique in the context of other Near Eastern religions. Nonetheless, if Yahweh's constant power and guidance were withdrawn for even a second, the world would lapse into chaos and disorder. Underlying this is an interestingly dualistic aspect to the Hebrew conception of the world. Indeed, the victory of Yahweh over the forces of chaos is even sometimes seen as recurring – chaos was simply restrained rather than totally admonished (e.g. Job 26:12, 38:1–15).

Another crucial change that Israelite monotheism introduced was an elevation of the status of man in this cosmic scheme. In the Mesopotamian creation myth, the *Enuma Elish*, man is almost created as an afterthought because the primary explanation that the myth seeks to address is the establishment of the political hierarchy of the gods and their relative spheres of influence over natural phenomena. In the Hebrew Bible, however, the conquering of chaos and disorder by Yahweh has the focus of making the world ready for occupation by man. This aspect is particularly clear in the cosmogony presented in the Book of Genesis (itself heavily influenced by other Near Eastern sources) where the creation of man forms the climax of all God's creation. Accordingly, because of the central locus that mankind occupies in the Hebrew account of creation, it followed that human beings could naturally claim that Yahweh was providentially concerned with their future (Baker 1975, 98–102).

When seen in the context of this background it is unsurprising that there are strong claims that Yahweh has absolute power over the workings of nature – where once there existed a Near Eastern belief of clashing personalities and power struggles within nature, the Hebrews had one supreme God under whom *all* natural processes existed as expressions of

his personality and will. To make the claim that the workings of nature were amoral would, for the Israelites, have been analogous to implying that Yahweh himself was morally neutral. It is in this context that we see so many Old Testament accounts of Yahweh governing natural phenomena and using them as vehicles for his righteousness and judgment. Nothing in nature happened separately or in contradiction to Yahweh's will and consequently where natural events are described in the Old Testament they are usually described in the language of Yahweh's emotions and intention – from shaking the mountains when displeased to sending rains when satisfied.[3]

It is thus reasonable to argue that natural phenomena are highly personalised in Israelite religion – as Henri Frankfort has put it, for ancient man the surrounding world was not an 'it', it was a 'thou' (Frankfort et al. 1977, 4–8). Indeed, in the ancient Near East there is not even a word that can be translated into 'nature' and similarly there was no Hebrew term directly equivalent to 'nature' when taken in the modern sense of the word. This fact has a number of important implications for our study of the relationship between SDA and science.

The first and most obvious of these is that the modern conception of Biblical miracle as being objectively special because it is a violation of a closed system of causal laws is simply not found in the Old Testament because the basic presupposition is missing. There is simply no assertion of a closed or autonomous set of causal laws which God could violate, and the whole concept of the 'violation' or contradiction of some rule by Yahweh stands at odds with Hebrew claims about his absolute power. Indeed, given the 'thou' conception of natural events inherent in the Hebrew Bible, it is not at all surprising that the development of the natural sciences has made vast changes to our understanding of a Biblical world-view in which Yahweh continually admonishes, saves, and directs the workings of nature. What has been rarely appreciated, however, is that this challenge to the continual workings of God has at its root a primarily *conceptual*, rather than predictive, nature. To put this another way, the principal difficulty is not, as has been frequently assumed, that the natural sciences rule out any concept of special divine action because they so closely predict future events and thus deny any 'space' for God to act. The source of the problem is that the interpretation of nature which modern philosophy of science adopts distinguishes natural phenomena as fundamentally 'it', rather than 'thou'. Underlying this is an

[3] For a detailed discussion of illustrations of God's direction of the physical universe see Davies (1992).

assertion that natural laws are an autonomous creation of God. Indeed the very basic subject–object distinction that underpins much of the modern methodology of science is simply missing in the Old Testament. There is no conception of a universal law of nature, no parallel to the idea of an individual event, and in a sense the closest Hebrew thought comes to a modern notion of causation is simply 'being'.

This is not to argue that the Old Testament conception of nature was in any sense crudely animistic or personalistic. Consider, for example, the description of the parting of the Red Sea in the Book of the Exodus. In one account we are told that God chose to drive the seas back with a strong east wind (14:21), and in another, that the waters were made to stand up in a heap and 'the deeps congealed in the heart of the sea' (15:8 NRSV). The first account offers an explanation on the basis of God controlling the winds which in turn part the seas, whereas in the second God fundamentally transforms the behaviour of the water itself. It is a paradigmatic expression of Yahweh's continuing victory over the forces of chaos that he can transform the behaviour of water in this second sense, and this is implicitly contrasted with the normal behaviour of water. As modern readers it is tempting to push this comparison further and thus to conclude that what made this a remarkable episode for the Hebrews was solely the fact that God overrode the normal 'natural' behaviour of water or that God overruled a law of nature. To do so is, however, a radical reinterpretation of the text – Yahweh is principally depicted as a storm God whose power is measured in contrast with the Egyptian gods and is found to be vastly superior (15:11–12). The focus of this passage is that all nature is under His control and guidance, and accordingly there is simply no assumption that the processes of nature are somehow self-sustaining or independent to Yahweh and overridden by him on this occasion.

THE BIBLICAL THEOLOGY MOVEMENT

A different reappraisal of Biblical accounts of divine action formed the basis of the so-called 'Biblical Theology' movement of the 1950s and 1960s. A common thread in this often diverse school of thought can be found in the following two theological assertions: firstly, a rejection of modern criticisms of the plausibility of special divine action as described in the Bible; and a parallel claim that the Biblical account of divine action remains the most appropriate language in which to describe God's activity.

G. Ernest Wright, one of the main proponents of the Biblical Theology school, based his position on the claim that any confession of belief in God is composed of two distinct stages: an act of story-telling and identification that the story consists of genuine historical facts; and secondly an interpretative attempt on the part of the believer to make sense of this history. Where his proposal became more radical was with the stronger assertion that the latter of these stages could not take place independently from the former with the result that *all* of our claims about the nature of God's being are grounded in these action accounts. Accordingly Wright claimed that any concepts of justice, love, wrath, faithfulness and coherence that we may choose to apply to God are not abstract principles of divine behaviour but are rooted solely in the Biblical accounts we have of divine action (Wright 1952). The basis of these assertions is the deceptively simple claim that we can know nothing about God other than how he chooses to reveal himself to us. Theology, as Wright conceived it, consists of a confessional description of the historical events of God's action which finds its climax in the actions of God incarnate as Jesus. All of our other claims about the nature of the divine are parasitic on this basic description of God's action.

Unfortunately the strength of Wright's approach is also its weakness – while it describes and articulates what many practise as theologians, it does not attempt to explain the methodological criteria we need to understand and evaluate the Biblical description that lies at its core. As we have already seen, the vastly different world-view of the ancient Near East makes any direct translation of the language of the divine acts in the Bible into a contemporary scientific context extremely hazardous. Hence, although this notion of 'Biblical Theology' was widely heralded as a 'solution' to the contemporary problem of God's action in the world, it simply rephrased and made more acute the same basic question – namely the question of what methodological criteria we should use to interpret these Biblical accounts of SDA. In order to be a substantial attempt at a solution to the contemporary problems concerning divine action, the Biblical Theology approach needs nothing short of a comprehensive account of the criteria theologians can adopt in order to analyse Biblical SDA accounts in a modern scientific context.

This need for an interpretative framework was made explicit soon after the publication of Wright's thesis. Frank Dilley emphasised that the basis of the controversy lay in the extent to which Biblical divine action could be explained as mythical or legendary. Very conservative theologians, Dilley argued, assert that all divine action accounts in the Bible

are fact and none mythical; less conservative theologians would assert a key core of miraculous special divine actions in conjunction with other accounts; while 'liberal' theologians would interpret Biblical accounts either as particularly fortunate natural events, or as instances of general divine action on a cosmic scale (Dilley 1983, 46–7). Dilley's spectrum of interpretative responses again covers the outcome of applying different criteria to evaluate Biblical accounts, but it does not help us to establish categorically what it is that constitutes a 'very' or 'less' conservative theologian and what methodology each would apply to the Biblical sources in question. Indeed it is slightly ironic that these widely discussed critiques of the Biblical Theology movement do not themselves explicitly identify the assumptions that lie behind each of these labels. Undoubtedly the status accorded to scientific explanation lies at the core of any rejections leading to a 'liberal' view of Biblical SDA, yet throughout the various discussions the natural sciences rarely receive a mention.

Langdon Gilkey in a widely cited paper made a similar but earlier contribution to Dilley's. He identified that the Biblical Theology movement, as expounded by Anderson and Wright, existed as an uneasy fusion of conservative and liberal interpretations of the Biblical account. However Gilkey moved on from a mere identification of these criteria and crucially insisted from what he identified as a 'causality condition' that the liberal denial of many of the Biblical accounts of special divine action is justified (Gilkey 1961). Unfortunately Gilkey does not go into too much detail concerning his motivations for advocating such a condition, however it is clear from his paper that the basis of his claim is a strongly deterministic and causally closed interpretation of science. Essentially it appears that Gilkey was articulating the feeling that science presents such a causally interconnected view of nature that some Biblical accounts can no longer be justified. Without pre-empting too much of the discussion below, it seems from our modern understanding of science that Gilkey's 'causality condition' may be significantly challenged by quantum theory or chaos theory. It does not thus necessarily follow that what Gilkey conceives as the 'Biblical point of view' should be stripped of its 'wonders and voices' because modern science simply rules them out.

Despite these criticisms there is much in Gilkey's paper that remains of considerable importance. He is surely correct to identify that the Biblical Theology movement was itself highly dependent on the Exodus covenant episode and that none of the proponents of the position had gone into sufficient exegetical detail to justify their claims. The large number of voice and wonder events are taken simply to be Hebrew

interpretations of their own historical past, and post-Exodus events are understood in terms of the Israelite focus on the Exodus itself.

Gilkey adopts an explicitly causal interpretation of special divine action and convincingly argues that for the concept of SDA to be coherent we need to establish objectively what it is that makes a divine act divine as opposed to 'natural'. Dilley, in a later more detailed response, proposes three different conceptions of special divine action: to take what he calls the 'Biblical view' that God openly abridges the natural order;[4] that we can interpret special divine actions as events which appear to be 'natural' except to those who can recognise them as such through an act of faith; and finally, that God and natural processes act simultaneously (Dilley 1983, 52–3). It is interesting to note that much contemporary discussion of SDA cannot be fitted into Dilley's discussion – what we shall consider in detail later in this book is whether it is coherent to add a fourth option, namely that God acts at certain times and places through a flexibility inherent in the natural processes of creation.

However, missing from these critiques of 'Biblical Theology' are other, equally fundamental, issues. It is certainly true that if we are to base our theology on an understanding of special divine acts in the Bible we must be explicit about what criteria we use to judge the authenticity of Biblical accounts. However, if we return to the two initial assumptions behind the 'Biblical Theology' movement, we see the importance of the claim that knowledge of God can only be obtained from the scriptures. An integral part of any critique of the Biblical Theology movement must accordingly address the status of religious experience and natural theology as means of divine revelation.

BIBLICAL AUTHORITY AND SDA ACCOUNTS

Maurice Wiles in a helpful discussion of the use of miracle accounts distinguishes three different theological applications of Biblical sources (Wiles 1999, 41 f.). His account is focussed on miracles conceived as violations of the laws of nature, but can easily be generalised to encompass the whole set of claims for SDA. The first use, Wiles argues, is that some accounts of SDA, and in particular the resurrection, have been used directly as evidence and cited with the aim of proving the truth of the Christian faith. The problem with these claims is that it is difficult

[4] In this statement Dilley is himself making an uneasy fusion of liberal claims onto the Biblical account – as we have already seen the conception of 'nature' as distinct from Yahweh is simply missing in the Hebrew Bible.

to establish whether or not a particular miracle or SDA has genuinely taken place, an issue we shall examine in more detail in chapter 3 below. Another very different use that Wiles identifies is that miracles (and more generally SDAs) are seen as expressions of God's personal love and providential care over his creation. As he puts it, 'If there is such a thing as a personal relationship between God and the world, then must not that relationship find expression in divine response to human prayers as well as in human prayer to God?' (Wiles 1999, 41). In this second sense, then, we see claims about an interactive relationship between God and mankind that is conducted on the basis of a dialogue – SDA on the part of God, and the act of praying on the part of man. The third role Wiles identifies for the use of miracles is, he argues, the most fundamental. This is the claim that miracles are in some sense integral to the very substance of faith, one which we have already met in the context of the Biblical Theology movement. When seen in the wider context of Schwöbel's work and translating the assertion away from miracles to more general notions of SDA, we find the claim that faith in SDA is a necessary part of a coherent belief in God. This view is, perhaps unsurprisingly, very commonly adopted in contemporary accounts of divine action. Put simply it is the belief that without a developed and credible account of God's localised and specific actions in the world, much other theological doctrine crumbles irrevocably.

Despite these persuasive theological needs to articulate something about the nature of SDA, what is nevertheless emerging is the realisation that the 'modern' concept of God's special divine action owes much to sources beyond the Biblical accounts on which it is supposedly based. Indeed by placing such a fundamental emphasis on these sources an extremely important legacy of the 'Biblical Theology' movement was that it did much to elucidate these differences. One consequence of this is that attempts to make theological abstractions on the basis of these Biblical accounts are inherently far more complicated than is widely appreciated. To cite a Biblical source and then make extensive claims that God is active in this or that way is simply a naïve hermeneutical approach. As we have seen, the Old Testament accounts of divine action are a product of their intellectual ancestors and consequently adopt a world-view that is far removed from our current scientific understanding. This is not to argue, however, that there is no value whatsoever in these accounts, but merely that a certain amount of care must be used in translating them into a modern scientific context as stimuli for a discussion of the relationship between SDA and science. Terence Fretheim in what he

terms 'A Constructive Statement', developed as a response to similar perceived difficulties, has identified several features of the Hebrew accounts of God's action, some of which can be appropriated unproblematically into a modern scientific context. Aside from general assertions about the extent of God's activity in the world, Fretheim identifies the following Biblical principles: that God's action occurs from within the relationships established through creation; that God generally takes the initiative in acting in the world; that His mode of action is always situationally appropriate to a particular time and place; and that God's activity is not always inevitably successful (Fretheim 1997, 8–12).

One potential aid to the determination of which elements of the Biblical accounts can be translated into a modern context can be found in Gilkey's helpful contribution that any attempt at a one-to-one correspondence between Biblical and modern scientific world-views is fundamentally flawed. He argued that in modern studies of divine action there are essentially two types of theological language that are used – one which is 'true' to the Biblical account and considers divine action in the context of divine will and human response and revelation, and one which is a modern scientific abstraction of that account and attempts to make divine action objectively special on the basis of its distinction with the 'normal' processes of nature. Given the radically different approach to natural phenomena in the Hebrew Bible as 'thou' rather than 'it', it is not at all surprising that this later scientific abstraction has resulted in a widespread rejection of much of the Biblical account. We would be wise, however, also to express some reservation over the value of the first of these uses of language when it is applied in a vacuum independently from the changes in understanding that have occurred since the Biblical texts were written. Even considerations of SDA in the context of human response and revelation cannot remain divorced from modern scientific understanding if they are to have any ongoing credibility. Theology must not operate exclusively on the basis of a two-thousand-year-old understanding of nature – just as God's message was itself appreciated by the Biblical authors in the context of their contemporary world-views and using the terminologies that were familiar to them, so the challenge to contemporary theology is to interpret SDA in the light of today's understanding of the natural sciences.

Would it be reasonable then to adopt Marcus Ward's assertion that the arguments behind an assertion that God is active are far weaker than our faith in it (Ward 1969, 10)? This is not necessarily the case – merely that a certain amount of caution is needed in simply appropriating Biblical

material or forming an undeveloped 'Biblical account' and translating it to our modern world-view. Another approach would be to consider the hypothetical question, 'Are Biblical citations used as support of objective divine action no longer convincing?' Again it would be wrong to argue that in the light of modern science we can no longer ascribe *any* authority to the Biblical accounts of God's action, but the fact remains that our use of Biblical material as a stimulus for discussions of the existence of SDA is severely challenged by the tremendously different world-view which we adopt. There have been several recent Christian theologies which assert that it is particularly significant that accounts of God's action in nature are largely missing from the New Testament and that this in some sense justifies the claim that a truer 'Biblical' account of God's action is that God is not active in natural processes but only in human minds. Not only do such approaches ignore the many references made to the Hebrew Scriptures in the New Testament, but they also fail to appreciate the fundamental change in the writers' focus that occurred as a result of God's incarnation. It is true that in the New Testament SDA in nature is hardly ever depicted (with the exception of Jesus' baptism and transfiguration), but this 'narrative modesty', as Ronald Thiemann has called it, should not lead us to conclude that SDA is not a necessary part of the New Testament account. God's power is established subtly in the narratives of the four Gospels and remains hidden behind the actions of Jesus who occupies the central focus of the accounts (Thiemann 1985, 89).

If we leave the primary Biblical accounts of divine action aside, the necessity of SDA is also bolstered by a secondary set of philosophical demands that it is needed to support other revealed attributes of God. The value of Schwöbel's work is that it makes explicit the extent to which so much theological doctrine relies on this notion of SDA and this requirement for coherence considerably strengthens claims for the existence of SDA. Yet we need a realistic acknowledgement that while the Biblical accounts remain as motivations, the more developed forms of SDA discussed by contemporary theologians move far beyond them and exist as a fusion of modern ideas and assumptions onto the 'Biblical' views of nature. One issue, which we shall return to at the end of this book, is the question of whether belief in SDA remains really sustainable in the light of recent scientific developments.

Rudolf Bultmann grappled with similar issues about translating accounts of divine action into a modern context as part of his programme of demythologising. In a response to critics who had asserted that special divine action remained wholly mythological, he argued that mythological

thinking interprets God's actions as interventions in the finite sequence of events. This led him to the essentially paradoxical position identified by Dilley above: namely that God's action is within the chain of natural events and yet remains visible only to the eye of faith. Special divine action, Bultmann argued, can be seen not as actions on a cosmic scale, but in analogy with personal relationships (Bultmann 1958). The crucial question which still remains, however, is whether this is really an *account* of SDA at all – is it possible to make serious claims that God acts in the world whilst asserting that there is no effect on the causal chain of nature whatsoever? If we are to attempt any reconciliation between SDA and modern science what we need, as Gilkey argued, is to be able to develop a coherent account of how God relates to the ordinary 'natural' events in nature, what God's relationship to his 'special' actions in nature might be, and to describe the extent to which God has foreknowledge of the consequences of these 'special' actions. These issues shall occupy us for the remainder of this book.

CHAPTER TWO

Theological approaches to divine action

We have been introduced to a wide variety of God's actions in the preceding pages from lot casting, to Near Eastern and Old Testament statements about the power of God, and to the assertion that some forms of God's action derive a unique status from countermanding the autonomous regularity of nature. In the discussion we have also already used a number of criteria with which to evaluate claims about God's action and impliedly focussed on issues such as the development of scientific method, the coherency of God's nature, and whether it is meaningful to have a solely metaphorical interpretation of SDA. It is now necessary to set some of these concepts onto more solid philosophical foundations and in this chapter we shall consider some of the approaches that have been adopted to these issues.[1]

A necessary preliminary is to clarify the exact parameters of the study of God's action we are undertaking. Owen Thomas has helpfully produced a taxonomy of the different types of question we might ask about the nature of SDA based on the different potential meanings of the word 'action' (Thomas 1983). There are essentially five different types of question about God's activity in the world:

1. By what means does divine action occur? (E.g. quantum manipulation or overruling the laws of nature.)
2. What is the relationship between divine and finite causation? (E.g. complementary or mutually exclusive.)
3. How often does SDA occur? (E.g. continuous, only fitful or not at all.)
4. What is the effect that SDA achieves? (E.g. to heal diseases or inspire an individual.)
5. What is the purpose of the action having taken place? (E.g. promotion of divine justice or peace.)

[1] The discussion in this chapter owes a debt to Paul Gwynne's excellent bibliography (Gwynne 1996).

One important point which Thomas makes is that much confusion has resulted historically from conflating the latter two questions with the former three, and accordingly the focus of this book is on the philosophical coherence of the concept of SDA rather than trying to elicit answers to the questions of effect and purpose. Indeed, a strong argument could be made out that these latter questions rely parasitically upon the others, for without a coherent philosophical account of the nature of divine action it is highly problematic to make specific claims about the manifestation of any particular attribute of God such as promotion of divine justice. The philosophical questions with which we shall be occupied in the remainder of this book are accordingly of crucial importance – it becomes impossible to make higher-level claims about the promotion of divine attributes in the world if we have no persuasive approach to any SDA whatsoever.

SPECIAL AND GENERAL FORMS OF DIVINE ACTION

As a first small step in developing a coherent philosophical account of divine action it is necessary to be clear about not only what kinds of questions the theologian seeks to address, but also the scope of the 'divine action' term itself. In relation to this latter issue, it is extremely helpful to distinguish general and special forms of God's activity (hereafter GDA and SDA). These terms are widely employed by theologians and used in several different senses, and although not all discussions of divine action explicitly adopt such a distinction, a careful reading of those that do not will usually find an analogous distinction being made implicitly.

One distinction between GDA and SDA can be found in the work of William Sherlock, a Dean of St Paul's Cathedral in London during the seventeenth century. Sherlock distinguishes providences of 'preservation' and 'government' and is clear about the importance of making this differentiation (Sherlock 1694, 16–17). Preserving providence Sherlock conceives of as God permitting the action of entities 'according to their Natures, without changing, influencing, determining their Natures, otherwise than these Natural Powers would naturally act' (Sherlock 1694, 22). Of course, even a cursory reading of Sherlock's account reveals an equivocation on the sense in which he uses the term 'natural', yet the distinction he seeks to draw remains valuable and is often prosaically put:

> [preserving providence] is only like winding up a Clock, which puts it into motion, but gives no new preternatural motions to it, but leaves its motions to be guided by its own springs and Wheels. (Sherlock 1694, 24)

The image Sherlock presents in relation to 'preserving providence' almost immediately conjures images of the so-called clockwork universe – a world of levers and pulleys in which God is not active at particular times and places and denies, as Sherlock calls them, 'preternatural motions'. Although the extent to which Sherlock asserts determinism is questionable, the crucial point in his description is that this 'preserving providence' does not incorporate novel divine causal actions.

In a complementary discussion of God's 'governing providence', Sherlock draws a threefold distinction between God's specific actions in natural causes, accidental causes (such as chance), and the moral acts of free agents. Sherlock does however make it clear that God's governing providence does not act 'against the Laws of Nature', and it is thus tempting to identify him as a forerunner of many contemporary attempts to reconcile SDA and science along similar lines. Some caution is needed in making this claim, however, since it is clear that he asserts that all natural causes must still be directed by a 'Skilful Hand' (Sherlock 1694, 48–9). Indeed, despite the fact that Sherlock made appealing claims about God governing chance such as 'the most unexpected Events, how Causal [chance-like] soever they appear to us, are foreseen, and ordered by God', it is not appropriate to translate his work directly into a modern appeal to God being active through indeterministic processes (Sherlock 1694, 40).

Michael Langford offers perhaps the most useful contemporary discussion of the distinction between GDA and SDA, although his account also serves to elucidate the difficulties inherent in making the division. Langford defines GDA as 'the government of the universe through the universal laws that control or influence nature, man, and history, without the need for specific or ad hoc acts of divine will' (Langford 1981, 11). Langford's definition is parasitic upon a notion of 'universal laws', a topic we shall consider in more detail in the next chapter. GDA, he argues, suggests a planner who actively watches over the universe and not simply a creation that is subsequently ignored. Yet despite this acknowledgement of an intelligent plan lying behind creation, there is no sense in which GDA could be taken to be personal action on Langford's account. Indeed he is clear about the conceptual difficulties inherent in the claim that God is active in all natural processes – the concept is, he argues, inherently problematic as it remains easy to make this assertion but extremely complex to articulate precisely what it amounts to (Langford 1981, 13). SDA, on the other hand, concerns the specific actions of God in creation – even though in some cases the result of these

actions may be the same as those of GDA, such as bringing rain. It is thus not possible, he argues, to distinguish GDA and SDA solely on the basis of the phenomenon produced. In arguing this, Langford offers the following attempt at categorising SDA:

> the root of the distinction is not the individuality of the recipient of the providential care, but the individuality of the providential act. Special providence is analogous to a human decision, and it is for this reason that it is bound up with the idea of God as personal. (Langford 1981, 14)

In this definition Langford employs several different arguments. It is undoubtedly true that there is a strong sense in which our understanding of God as active is made by analogy with our own experience of human action. There are essentially two claims made here about SDA – that it is an 'individual' providential act, and that it is analogous to human decision and is thus intimately related to the concept of a personal God. However there are difficulties in using these claims as the basis of a distinction between SDA and GDA, not least that we may have gone full circle: there are strong arguments that support the existence of SDA as being fundamental to a conception of a personal God and here we see Langford developing the concept of SDA on the basis of God's personal action. Even if one of these arguments is denied, it remains extremely problematic to reconcile any posited distinction between SDA and GDA in the context of science on a 'personal action' basis for the same reasons that Langford raised in connection with GDA, namely that it is very difficult indeed to articulate in scientific terms what distinguishes personal from impersonal actions. Indeed it is arguable that this difficulty is clear from Langford's own account where he considers the difficulties inherent in praying for a providential break in a drought (Langford 1981, 12).

The approach adopted here, in contrast to Langford, makes the distinction purely on the basis of the particularity of God's action. The most simple approach to delineating the different forms of action is to look solely at their scope and physical effect, rather than stepping behind the physical account and raising more complex notions of intention and purpose. There are, however, two things that need to be made clear about forming a distinction on this basis. The first is that forming a definition of SDA and GDA in this exclusively physical sense only serves to demarcate the two different forms of action and does not deny claims that such action may remain personal – the argument is merely that in seeking to make a distinction the physical basis is the best one to distinguish but not to define SDA and GDA. Secondly, an implicit assumption made in adopting this distinction is that when God acts something physical

actually happens in the world. The argument is that there are causal implications of divine action – genuine physical effects that would not have occurred had God not chosen to act. It is worth noting at this point that some theologians deny this argument, although we shall see later in this chapter that for us to be able to speak intelligibly about the existence of SDA it is essential that God's actions actually have causal implications. On that basis let us attempt the following distinction between SDA and GDA:

- General Divine Action (GDA): Those actions of God that pertain to the whole of creation universally and simultaneously. These include actions such as the initial creation and the maintenance of scientific regularity and the laws of nature by God.
- Special Divine Action (SDA): Those actions of God that pertain to a *particular* time and place in creation as distinct from another. This is a broad category and includes the traditional understanding of 'miracles', the notion of particular providence, responses to intercessionary prayer, God's personal actions, and some forms of religious experience.[2]

It is important to note the inclusive nature of the term SDA as understood on this physical basis. It includes *all* actions of God that have local effects independent of any further categorisation as violations of the laws of nature or, on the other extreme, as non-interventionist actions for example. One potential weakness in the above distinction concerns situations on the borderline between GDA and SDA. Some theologians would wish to assert that as a component of universal general divine action God exerts a 'pressure' upon creation. Such a pressure, they argue, is applied universally on creation with the effect that the world is being steered

[2] It is important to add a technical explanation at this point of the potential relationship between particular SDA as conceived in this definition and the theory of relativity. One of the implications of relativity theory is that it becomes very difficult to assign a temporal sequence to particular events in the universe as a consequence of the finite speed with which any information can be transmitted. Einstein himself made it clear that the assertion that two particular events in nature are 'simultaneous' is problematic because simultaneity is itself highly dependent on which reference frames are used to study the two events in question. Accordingly there can be great difficulties in assigning a temporal sequence to particular SDAs – essentially claiming that one particular SDA took place 'before' another – by virtue of this problem. Despite the fact that the definition of SDA offered here presumes a largely classical notion of space–time (by reference to actions at particular times and places in creation), it would not be correct to assert that it is an improper basis on which to delineate SDA from GDA because of difficulties with relativity theory. While it is clear that relativity theory presents probably the most significant challenge to theological notions of a sequence of God's actions, it does not impinge on the theoretical basis of this action as considered in this book and for this reason the difficulties in relation to relativity lie outside the remit of our study. For an interesting discussion of relativity theory in a theological context see Barbour (1998, 177–81).

towards a particular end. While such a universal steering would, on this definition, be clearly a form of GDA there is a significant possibility for a cross-over into SDA should the pressure cause certain local aspects of creation to 'rupture' in a violent manner in analogy with a piece of metal fracturing under a continuously increasing force (Langford 1981). While the analogy of violent rupture is not the most appropriate to the actions of God in his creation, it does serve as a strong illustration of this concept of God's guidance over all creation simultaneously. The argument is essentially that certain local areas of creation respond more sensitively and in different ways to this pressure than others, and accordingly this claim relies implicitly on a developed understanding of the ontological structure of the universe. On the categorisation proposed above this would be a form of divine action that was fundamentally GDA, but that had SDAs associated with it. However, a crucial point is that because the action is fundamentally GDA it does not somehow let us off the need to articulate its relationship to science. Any positive assertions for divine action in this manner are still left with the knotty problem of articulating how local SDA effects of this sort can be reconciled with normal scientific regularity and thus face quite the same difficulties as a simple assertion of SDA. This need not present a problem for the discussion which follows because of the wide variety of claimed action types that can be incorporated in the notion of SDA. The common understanding of miraculous SDA as somehow violating the laws of nature will be considered in the next chapter, as will claims that another plausible approach to SDA is that God acts to decide otherwise indeterminate scientific events.

While it may at first sight be appealing to claim that terminologies of providence and SDA are in many cases directly equivalent, there are good reasons for resisting this assertion. The term providence carries with it the notion of divine foreknowledge (as one would expect from its Latin root *providentia* meaning foresight) and is used today in several different senses – the *Oxford English Dictionary*, for example, broadly distinguishes three different uses each of which implies a different extent of divine foreknowledge. In essence making a claim about providence is to make a claim that SDA has taken place in tandem with a certain, and often unspecified, degree of divine knowledge and planning.[3] These additional issues concerning God's foreknowledge are, however, distinguishable from more fundamental questions concerning the coherence

[3] For helpful discussions see Peacocke (1993, 136–7) and Langford (1981, 3f.).

of divine action and causation in relation to science and the extent of that action as either GDA or SDA. Given that the focus of this study is primarily the relationship between a theological world-view, which makes claims that SDAs occur in nature, and a scientific world-view that also makes some very specific claims about nature, we shall adopt the notion of SDA in the abstract throughout.

The great strength of making the SDA/GDA distinction in terms of the particularity of the causal action produced by God is that it has the benefit of making our metaphysical problem acute. If the concept of SDA is to have any coherence in a scientific world-view we need to be able to account for the particular and local actions of God in a manner that does not conflict with scientific methodology.

ATTEMPTS TO SUBSUME SDA INTO GDA

Of course one 'solution' to the problem of relationship between SDA and modern science is to attempt to include SDA in more general discussions of GDA with or without some form of universal divine 'pressure' on creation. We have already considered the possibility of God causing certain local effects as a result of this pressure, but many theologians have either simply denied the objective existence of SDA altogether, or asserted that it is a theologically unnecessary assertion when considered in the context of the full implications of GDA. One of the foremost proponents of this position, Maurice Wiles, has received a predominantly bad press in contemporary divine action circles. The principle reason Wiles' work has been criticised is that he has said many times that in his opinion the prospects for a traditional theistic understanding of SDA are bleak – as he put it in the context of a discussion of Austin Farrer's work on SDA, '[Farrer's work] has only served to strengthen my conviction that the process of trying to make sense of the biblical witness and of the experience of grace may well involve substantial modification of the concept of divine agency or even its replacement by some other conceptuality altogether' (Wiles 1981, 248–9). It is clear from Wiles' work that he does view that a substantial modification of the claim that God performs SDAs as defined above is absolutely necessary, even to the extent that it calls into question the very existence of SDA itself. Accordingly Wiles' attempt to view God as enacting the whole of history has been associated with a straight denial of special divine action and led to Brian Hebblethwaite coining one of his recent books 'God's Inaction in the World' (Hebblethwaite 1989), Malcolm Jeeves claiming Wiles advocates a 'sit

back and watch' God (Jeeves and Berry 1998, 100), and John Polkinghorne rejecting his work on the basis that his 'atemporal deism . . . is hard to reconcile with religious experiences of prayer and of the prophetic discernment of a divine special providence at work in history' (Polkinghorne 1998b, 86).

Wiles' position actually represents what is arguably the strongest possible interpretation of what we have identified above as general divine action when considered to not cause local effects – indeed he is quite explicit about ruling out SDA on the particularity of action basis which we have already delineated: 'I do not think that we can properly speak of God being more creative in one place than in another' (Wiles 1983, 186). The main reason why Wiles seeks to deny SDA is because he argues that there is implicit in the concept of a God who acts to favour one part of creation over another an overwhelming moral difficulty. He asserts that the reason this difficulty exists is that any account of God as personal and loving morally obliges God to be active to prevent major human and natural tragedies (Wiles 1999, 16–17). Throughout Wiles' work we see a theologian grappling to come to terms with the evil in the world and one of the results this has had is a straight denial of SDA. The other basis on which Wiles has recently rejected SDA is primarily scientific – the world, he argues, is increasingly predictable by science with the result that it is difficult to conceive of how any such notion of SDA could function. It is interesting to note that, while he mentions difficulties in the relationship between science and SDA in his earlier books, it is only in his recent work that he argues explicitly to reject SDA from a scientific basis. Indeed he appears to reject any direct relationship between SDA and science from a point of principle: 'even though it may seem most natural to think of the relationship of God to the world to which faith points as a straightforwardly causal one, parallel to the causal relationships that the scientist studies, that is a mistake' (Wiles 1999, 62–3). It should be becoming clear that this book is diametrically opposed to Wiles in this regard. It is implicit in the delineation of SDA presented above that God is active on a causal level, although we shall be discussing at length what that might actually mean and it is not the case that the causal processes of God's action are synonymous with those of autonomous natural processes. Wiles, in distinction, places emphasis on the limited nature of the human perspective and accordingly argues that any understanding of divine action can only be indirect and symbolic.[4] The best language, he

[4] For a discussion of the theoretical limitations to our understanding of God's action in the world see the Preface above.

argues, is that of 'presence' interpreted in a rich sense:

> Presence, admittedly, sounds on first hearing a rather tame and passive notion. But it often carries a much stronger and more positive connotation. As every lover knows and as every pastor knows, the presence of 'the other', or simply the presence of 'an other', can make all the difference to a situation; it can turn a sense of emptiness into ecstasy or an unendurable loss into a bearable sorrow. (Wiles 1999, 63)

It is crucial to notice, however, that at no point in this account does Wiles refer to any actual actions on the part of the person whose presence is referred to. Rather the effects such as ecstasy and mitigating feelings of loss are wholly the *response* of the person who stands in the presence of another. The net result of this approach is that any expression of religious believers should be focussed on recognising and acknowledging what God has provided for us but no more.

This theology does, of course, have rather bleak devotional consequences. Indeed, one argument which many other theologians seek to assert in response to this position is that God does not override creation by performing SDAs but rather exploits a flexibility which is built into creation – this is the basis of many of the later attempts to unite SDA and indeterministic physical processes as we shall see below. Wiles' position on the other hand is that God only acts on a cosmic scale with the effect that:

> 'playing an active role in the world', may not be an appropriate description of the God whose agency I have been seeking to describe. But that God is no dead God. He is the living God, the source of all life and the source of the authentic life which his worshippers seek to realize in grateful awareness of his all-pervasive and sustaining presence. (Wiles 1993, 108)

Wiles is surely correct to assert that a straight denial of SDA need not necessarily lead to a claim that God is 'dead', however his position is truly radical in its devotional consequences. This becomes particularly clear in his analysis of the plea to 'give us our daily bread' in the Lord's Prayer which is commonly interpreted to refer both to God supplying mankind's daily needs and to the wider notion of the messianic banquet. Wiles disputes whether this is really a petition for better provision of food, and in particular more active human bakers, and claims it is solely an acknowledgement of the contingent relationship between God and the world (Wiles 1993, 106). The prayer has value, he argues, in that it forces humans to recognise the extent of human creativity, and to acknowledge that it is co-operative human labour that is needed to turn corn

into bread. Wiles also asserts that there is a radical challenge presented through this claim to Western man since to fulfil it for Ethiopian children will require a fundamental change in our priorities. What is notable about his exegesis of this passage is that the focus of his discussion could not be further removed from a claim that God actually acts in his created world – indeed '[the Lord's Prayer] appears to be asking God to do something quite specific now, but that is not how we understand it' (Wiles 1993, 107). God's fundamental action is the bringing into existence and sustenance of this world, both forms of GDA, and Wiles clearly interprets this action in its broadest sense as a form of divine action. However in general his position is that those perceived local and particular actions of God are solely due to differences in human perception and responsiveness, rather than fundamental physical differences indicating the existence of SDA.

Wiles' study is of particular interest to us for two reasons – it pushes the concept of general divine action to its limits, and for our purposes consequently emphasises quite how important the concept of special divine action is by showing what devotional difficulties exist if it is denied. Whilst we have not sought to engage directly with Wiles' objections to SDA on the basis that there is too much unchecked evil in the world (a detailed treatment of that topic lies outside the scope of this book), it is worth mentioning that this problem need not necessarily lead to the wholesale abandonment of SDA as Wiles argues.[5]

We shall now turn to consider another approach that also seeks to exploit a similar 'single act' interpretation of divine action. One theologian who argued that SDA could be subsumed into GDA in this manner was Gordon Kaufman, although it must be emphasised that in his recent work Kaufman has moved away from the position considered below.[6] In his 1968 paper 'On the Meaning of "Act of God" ', Kaufman correctly rejects any difference in claiming that God is active in 'history' as opposed to natural processes. Acts, he argues, differ fundamentally from teleological development, such as an acorn becoming an oak, because of the necessity of intention – the characteristic feature of an act, he

[5] See, for example, Alvin Plantinga (1971) and other associated 'free process' defences which are based on the grant of autonomy to natural processes by God and which it would inconsistent for him later to revoke. Such 'defences' however beg the question that if such natural evil was inherent in those autonomous physical laws God chose to instantiate in the created world why God chose the particular set of laws he did.

[6] In his more recent work Kaufman describes divine action in essentially metaphorical terms and places emphasis on the difficulties of applying human concepts in elucidating the divine nature – see, for example, Kaufman (1993). Niels Gregersen in an interesting paper has argued that many of these 'single act' interpretations of divine action are based on the uniformitarian position of Friedrich Schleiermacher (Gregersen 1995, 165–6).

argues, is that it must have behind it a purpose and realise some objective even if very small (Kaufman 1968, 182). He is aware, however, that this definition of act in terms of intentional language does not accord easily with attempts to define actions in causal terms. The problem is one that the modern mind has not only in attributing supernatural causes to historical events but more fundamentally of conceiving of the events themselves. The modern view of science, Kaufman argues, is such that nature and history are seen as a web of interconnected events. Kaufman emphasises that he is not implying a wholesale determinism, but rather that the modern pursuit of scientific knowledge presupposes the existence of this unbroken web of events:

> it is no longer possible for us to think (when we think clearly and consistently) of individual or particular events somehow by themselves: every event is defined as a focal point in a web that reaches in all directions beyond it indefinitely; it is never grasped (in our modern experience) as an independent substance that can exist and be thought of by itself alone. (Kaufman 1968, 188)

Kaufman's position forms a particularly interesting case-study on the relationship between science and SDA for it is this set of wholly *scientific* claims about the interconnectivity of causal chains in nature that leads to his theology of divine action. Indeed it is precisely because of this claimed 'web' of causal interactions and lack of 'independent substance[s]' that Kaufman is led to assert that particular divine actions or SDAs are 'not merely improbable or difficult to believe: they are literally inconceivable' (Kaufman 1968, 189). The essence of Kaufman's argument here is that modern man is so imbued with this notion of causal interlinkage in nature that any particular actions from outside the web as propagated by God are simply incomprehensible. Pushed to its logical conclusion, however, this argument could extend further to make it inconceivable that humans could initiate causal chains in nature and thus leads to a strong compatibilist interpretation of human free will.[7]

Returning to the issue of SDA, Kaufman attempts an analogical reinterpretation of God's action in terms of 'master' and 'sub' acts. 'Master' acts, Kaufman argues, are overarching complex acts which are composed of many simple and particular acts. It is the 'master' act rather than the 'simple' acts that renders any particular piece of activity intelligible as an act by virtue of his earlier definition, namely for something to be regarded as an act there must be the essential element of intention. Thus,

[7] For more on the issue of compatibilism and incompatibilism and the possible application of the definition to divine action see below.

Kaufman contends, the customary interpretation of divine actions that are localised in space such as the crossing of the Red Sea, the virgin birth or resurrection of Jesus is too simplistic for it 'overlooks the significance of the relation of "simple acts" to "master acts" ' (Kaufman 1968, 190).[8] These individual SDAs are secondary and can only be properly comprehended he argues in terms of God's master act, which is the divine plan for the whole course of history. Kaufman then claims, rather obliquely, that this conception of God's 'master act' does not run into the same difficulties with scientific explanation as does the notion of independent 'sub acts' – he argues that to view the whole of the cosmic movement as a single master act accords closely with the scientific understanding of nature as being in constant evolutionary development. Thus Kaufman asserts that the specific SDA accounts in the Bible are only intelligible in the context of God's master act of enacting cosmic history itself. From a theological perspective this sounds a fairly orthodox statement, but let us not forget Kaufman's scientific motivations – what he argues is that specific SDAs like those described in the Bible are literally inconceivable as events caused by God given our scientific understanding of the web of causation.

The key to Kaufman's proposal thus lies in his interpretation of scientific explanation – something that has been overlooked in many critiques of his work.[9] In a crucial passage he states:

> If God is acting through the process of nature's development over billions of years to accomplish some ultimate objective, this would hardly be apparent in the observations of lowly men, with a lifespan of a mere three score years and ten ... one could hardly expect man to discern the teleological curvature of the movement of world history as a whole when he has accessible to his direct inspection scarcely more than an infinitesimal arc of that curve. (Kaufman 1968, 193–4)

Kaufman's argument is thus rather circular: his initial aim is to make acts of God intelligible in the light of modern science, but he ultimately achieves this by simply denying that we as humans can claim any knowledge of the vast causal chains in the universe by virtue of our temporal

[8] Further examples of sub-acts given by Kaufman include: the beginnings of agriculture and civilisation, the emergence of primitive religious thought, and the escape of Hebrew tribes from Egyptian slavery (Kaufman 1968, 197).

[9] See, for example, David Mason's discussion of Kaufman's position which focusses on two objections: firstly that the processes of evolution (i.e. natural selection) do not possess the unity required for a single act interpretation; and secondly, that Kaufman's master and sub-act scheme only is successful if there is a distinct beginning and end to every act. These criticisms lead Mason to propose a Whiteheadian process solution (Mason 1977).

limitations as human beings. However this approach is unduly scientifically despairing for two reasons: firstly, it is incorrect to presume that man only has access to scientific data from a time span of 'three score years and ten' – there is in fact a great deal that modern science can say about what Kaufman calls the 'teleological curvature' of world history, by means of geology and astronomy for example; and secondly Kaufman is incorrect to presume that 'sub acts' such as an experiment a scientist may perform are not intelligible in themselves. F. Michael McLain in a critique of Kaufman's position focusses on the difficulties arising from the notion that other agents may achieve God's acts (McLain 1969). He is correct to assert that the question of the plausibility of two agents for the same act is inimical to Kaufman's work, however the more fundamental difficulty that surrounds it is that in positing the existence of 'master acts' Kaufman does not do away with our necessity of being coherent in our description of 'sub acts'. Kaufman's appeal to the objective unknowability of scientific knowledge is surely severely wanting in this regard.

So despite the fact that many theologians have argued that there are strong similarities between Wiles' and Kaufman's approaches to divine action these exist only on a superficial level – indeed the fact they are arguing for quite different things is explicit from Wiles' own criticisms of the master/sub act distinction (Wiles 1993, 95f.). Wiles effectively denies any form of objective causal SDA whatsoever and consequently emphasises that human interpretations which might indicate that God acts in a particularist sense are simply subjective interpretations or readings of the same continuous forms of general divine action. Kaufman, on the other hand, uses intentional language to define the nature of a divine act and thus attempts to sidestep the causal difficulties inherent in the relationship between SDA and science. He accordingly relocates all divine action into the context of God's master act of enacting the whole of cosmic history, but ultimately relies on an unacceptable notion of scientific ignorance to support this relocation.

As we shall see later in this chapter, analogous notions of scientific ignorance are a common theme in many accounts of divine action that focus predominantly on the use of intentional language about God. There is, of course, a necessity for intentional language as a tool to help define what constitutes an act as opposed to any other causal interaction, but to use a focus on the element of intention to sidestep the necessity of making causal claims about SDA is misplaced. If we are really to assert that SDA actually occurs then we must have some account that intermeshes with the causal language of modern science.

SDA, occasionalism and divine determinism

We shall now consider what might be regarded as the opposite extreme – the claim that SDAs occur continuously and that *all* natural processes are in some sense an SDA. Possibly the approach closest to the 'Biblical' account is presented by those who assert that God is in control of every 'event' in the world.[10] This remains a surprisingly popular approach in contemporary science and theology, yet it raises substantive difficulties about human freedom and the autonomy or self-integrity of creation. Many understandings of God's action in every event owe much to Calvin: in the 1539 edition of his *Institutes of Christian Religion*, Calvin did not devote much of his argument to the role of special divine action, however this changed with the publication of the 1559 edition (Calvin 1979). Several Calvin commentators have suggested that he was keen to avoid any deistic implications of his theology and thus interpret Calvin to place a renewed emphasis on what he termed as the 'presence of divine power'. It appears then that Calvin had three positions he was keen to refute in his doctrine of special divine action: a vacant landlord God of deism; those who would claim that what happens in the world is mere luck or chance; and a stoical conception of predetermined fate. In response Calvin asserted what he claimed was a strongly Biblical position – focussing on the extent to which God controls every event of nature.

There are several recent authors who assert similar broadly 'Calvinist' positions. Vernon White in *The Fall of a Sparrow* begins from motivations based on general divine action and the notion that every event is made possible by the sustaining grace and regularity of God and asserts that every event is directly willed and caused by God himself (White 1985). His solution to the problem of evil in the world, something that led Wiles to reject SDA altogether, is essentially to claim that every seemingly evil event has a positive side to it, an argument he supports with the example of the crucifixion. It is, of course, perfectly acceptable to give due emphasis to the notion of GDA as foundational to any conception of the particular activity of God in SDA. Without God's creation and sustenance of the universe in its being any more developed assertions of SDA would be totally impossible, and in this sense the claim that God performs SDA is parasitic upon GDA. However, to assert that God is

[10] As we have already noted, there is some difficulty in this notion of a 'Biblical' account of SDA – see chapter 1 above. The Biblical passages most commonly cited in the context of a pervasive divine control of all natural events are Psalm 104 and Matthew 10:29–30. There is much to support the argument that this approach leads to the problem of occasionalism – see, for example, Freddoso (1988, 79–83).

directly responsible for causing every event within creation is to deny creation any functional integrity of its own and raises difficult issues of theodicy.[11] White's strategy of looking for the good aspect to every event surely falls short when considered in the light of the Holocaust or large-scale natural disasters such as the eruption of the volcano near Pompeii. In his position all GDA is effectively subsumed into omnipresent SDAs. It is clear that here, as in the previous discussions of Wiles and Kaufman's old position, the balance is wrong. Ian Walker has put this point well in the context of a discussion of the problem of evil:

> both the resurrection of Jesus and the falling of rain could, on this view, be called acts of God . . . But if God's action is applicable to every class of events and, in some cases, to every thing, then the words 'God's action' seem to me to have lost any substantive content either as that which excites wonder, on the one hand, or as individual enough to be construed as the separate class of acts, called 'God's acts', on the other. (Walker 1982, 29)

The problem is that not only are the falling of rain or any other natural events and the resurrection similar accounts of God's action, but they must be given an equal status in our theological understanding. It is remarkable how little attention has been paid to this redefinition of our knowledge about God – why on this account should theologians assert that the resurrection or Jesus' healing ministry have any more relevance to the attributes of God than does the Holocaust? It is accordingly clear that a separate set of criteria needs to be applied to distinguish 'important' divine actions from 'unimportant' ones; given no fundamental basis for distinguishing which divine events are windows into God's character and attributes, and which are not, theologians clearly impose their own conception of morality onto the attributes of God. Moreover, the problems in reconciling such a view with modern philosophy of science are greatly enhanced by the simple fact that this consideration means it becomes totally artificial to posit the notion of an isolated 'event' in science. All actuality becomes part of a continuous continuum of divine expression and control quite aside from other considerations about the problem of evil. In a sense, then, this position represents a denial of any autonomy to the created world and as such is as unsatisfactory as the opposite extreme represented by Wiles and Kaufman's old position. We need to seek a middle ground between these two views: one in which GDA is the continuous background to specific instances of SDA in which God may act in a personal manner. Moreover we need to be able to articulate

[11] On the notion of the functional integrity of creation see van Till (1996).

something of the causal basis of SDA in order to make this balance justifiable – as we shall see in the next discussion, exclusive appeals to intentional language do not satisfy this metaphysical requirement.

INTENTIONAL AND CAUSAL ACCOUNTS OF SDA

The key focus in these accounts is on some inherent notion of purpose or intention on the part of God. Indeed it is in this context that intentional language is commonly used to offer a 'definition' of divine action – essentially this element of intention makes a neutral 'event' into a positive 'act'. Let us reconsider Kaufman's categorisation above – he makes the distinction between neutral natural and historical events on the one hand, and those natural events which directly advance God's aims and purposes on the other. It is only this latter category, he argues, which can properly be considered to be manifestations of divine action.

There is nothing intrinsically wrong in adopting this distinction between natural events and events that occur as a result of some intention. Of course any attempt to articulate what categorises these different types scientifically becomes an extremely difficult problem – the notion of intention is unsurprisingly very difficult to define in any rigorous way. Where this distinction is misused, however, is when the focus on the element of intention is pursued to such an extent that the causal aspect to SDA is simply denied. John Macmurray in his 1953 Gifford Lectures, for example, accepts the value of causal accounts of action in certain circumstances, but has made claims that intentional language can sometimes surpass causal language as sufficient for the proper explanation of some events. Considering the example of a car trip to Edinburgh, Macmurray accepts that one level of explanation can be given in terms of mechanical movement, however:

> All these [mechanical] accounts are made possible by a deliberate choice to refrain from asking certain questions, which are in fact quite legitimate . . . The moment we ask, 'Why were you going to Edinburgh anyway?' the tracing of causal processes or continuant patterns must stop, because the answer must refer to an intention. 'Because I live in Edinburgh,' might be a sufficient answer. (Macmurray 1995, p. 160)

Even stronger claims have been made by P. West in the context of SDA. He has argued that holding a belief in the objective existence of special divine action does not necessarily require belief in a divine 'celestial mechanic'. It is simply not necessary on his account for divine action to

be justified in relation to scientific explanation (West 1985). Yet West's emphasis is surely getting close to a two languages approach to divine action, one in which science answers scientific questions while theology answers different questions about God. According to this approach there exists no need for an explanatory overlap between the two disciplines of science and theology. West may be right to object to the notion of God as a celestial mechanic, since it is generally not the mechanic who has built the engine, however the problem lies with his analogy and not the questions those who seek a causal account of SDA demand answers to. This approach, that there is a mutual exclusivity between scientific and theological accounts, is very difficult to maintain – given even a cursory understanding of each discipline it becomes overwhelmingly clear that they are both making differing claims about the same one reality. Whilst it is certainly clear that the same event can be given basic forms of explanation on a scientific or religious level, this does not mean that these explanations are necessarily exclusive.

It seems then that intentional language is used to answer a rather different type of question about the action of God (see above pp. 17–18). Attempts to rely exclusively on the basis of intentional statements about God's action necessarily circumvent the issue of the relationship between divine action and scientific predictability. Thus intentional language is of use in speaking about what might constitute an action of God and of the aims which God may intend to achieve as a result of that action, however it remains that no coherent discussion of divine action can be given without recourse to some element of the 'causality debate'. Moreover it is not the case that scientific and theological accounts of God's action are in some straightforward way complementary accounts of the same reality. It is simply inappropriate to claim that the concept of complementarity can be applied uncritically to such diverse notions, a point well made by Ian Barbour and others.[12] Returning to Macmurray's example of the car trip it seems the intentional description is answering the question of *why* we visited Edinburgh, while the causal description is answering the question of *how* we visited Edinburgh. Yet a complete description of our trip up north surely needs to answer both why we went there (to play the bagpipes?, buy a kilt?) and how we went there (by train?, by car?). I am not suggesting this is an exhaustive categorisation, merely that it goes some way to illustrate the different kinds of questions

[12] On the issues inherent in applying discussions of Kantian-type complementarity to science and theology see the useful caveats proposed by Ian Barbour in *Issues in Religion and Science*, and more recently developed in Barbour (1998, 170f.). See also MacKay (1974).

being asked by the two accounts. As Fraser Watts has put it:

> 'Why' questions are themselves quite heterogeneous, and there are certainly some 'why' questions that science can answer, especially biology – the function of a kind of animal behavior, for example. Also, not everything theology has to say is an answer to a 'why' question. (Watts 1998)

If we are seeking a coherent understanding of divine action then we simply cannot ignore the causal 'how' questions about God's action. After all, even our purely intentional descriptions of divine action owe much to our understanding and knowledge of God's causal activity in history. So while it may be true that an intentional description of events can give a more *useful* explanation of events in circumstances such as Macmurray's car journey, it is by no means true that this obviates the need for a causal account of SDA.

Another way of looking at this distinction can be developed by adopting Huw Owen's twofold categorisation of descriptions of divine action as either objective or subjective.[13] The objective interpretation, Owen argues, asserts that God actually determines events by means of a special mechanism that is different from the way in which he normally maintains and sustains the world. The subjective interpretation is that 'when we call an act specially providential [i.e. SDA] we mean merely that for us it is a special sign of God's general providence' (Owen 1984, 73). This latter subjective approach accords well with Wiles' claim that while we might claim that God is acting at one time and place in creation as opposed to another, these are merely differences in human perception rather than fundamental statements about the scope of God's action. The argument in the preceding pages can be summarised in the context of Owen's distinction thus: it is simply not a sufficient account of SDA to rely exclusively on subjective accounts. Nevertheless, the use of a concept of intention to delineate an action from an event is a necessary part of our description of SDA, yet while it goes some way to delineating what a divine action may be, it does not offer any account of its operation in nature. Moreover, as we shall see in later chapters, modern physics does not present as rigid a view of causality as many of the strict adherents of exclusively subjective descriptions presume and thus much of the implicit motivation behind those making these claims is dissipated. The modern

[13] The issue of how far we can apply language and metaphor to God is a vast topic, yet it suffices to note that contra Wiles, the argument here is that the notion of SDA can be taken in a literal sense. As Owen Thomas has noted in a review of Wiles' work there is in fact no reason why Wiles should be able to make *any* linguistic claims about the action of God, even in the broader context of GDA, given his claims about the inapplicability of human language to God (Thomas 1987).

view of science does, however, create other significant problems – as we have already seen, making an insistence that it is theoretically possible to articulate a causal account of SDA is not easily reconciled with the Biblical accounts of SDA, since it assumes the concept of an autonomous and relatively independent physical order. Yet, causal language has the enormous strength of separating SDA from normal natural events and thus it protects the status of God's action.[14] Consequently it is arguable that causal language is necessary for any apologetic appeal to SDA, but the problem remains of how we can articulate this causal account.

Austin Farrer was one theologian who famously interpreted SDA in predominantly intentional terms which led to him denying any specific talk about what he termed the 'causal joint' problem of SDA (Farrer 1967, 65). However this conclusion did not lead Farrer to a wholesale rejection of SDA – essentially what he implied was that it is beyond the capabilities of human reason to discuss the causal nexus of SDA. God is active, Farrer claimed, in the hidden ontological level that lies beyond the scope of any human epistemological investigation (Farrer 1967, 100). This amounts to a complex and essentially instrumentalist philosophy of science in which any claims about the ontology of SDA are denied. Consequently Farrer developed the paradoxical notion of 'double agency' in which God is held to be active while the autonomy of creation is simultaneously respected. Essentially Farrer's claim is that there is a certain class of event in which divine and natural causality are simultaneously active. However, many subsequent theologians have argued that this concept is not only difficult to articulate since it requires giving both agents equal importance in the act (e.g. Dilley 1983), but is actually inherently paradoxical. Farrer himself acknowledged that there were substantial difficulties with this notion when the two agents were considered to be 'on the same level', and circumvented this complication by making a linguistic claim that the notions of 'causality' and 'agency' can only be used analogically of God. Indeed, Maurice Wiles has argued that Farrer should take the next logical step in his argument and join him by abandoning the whole notion of SDA altogether:

> the understanding of divine agency offered [by Austin Farrer] is so distinctly analogical and so unrelated to the causal story that we tell of the happening of events, that we appear to be left without even a direction in which to look to give intelligibility to the concept of particular divine actions of the kind he affirms. So despite the fascination of Farrer's discussion, it does not seem to me

[14] This distinction between naturally and divinely caused events in creation becomes of particular importance in any apologetic use of divine action.

to justify the language of double agency as convincingly as he wants to claim that it does. (Wiles 1981, 248)

The crucial point that Wiles makes here is that Farrer's account is still implicitly reliant on a claim about the exclusivity of intentional language. The strict use of analogy employed by Farrer imposes fundamental limitations on the extent of the account of SDA he can offer, and not being allowed to talk about the causal issues implicit in his account does not necessarily mean that they are non-existent. For that reason Farrar simply avoids talking about many of the difficulties in relating scientific explanation with SDA – he makes the simple insistence that the 'causal joint' can play no part in his account. Unfortunately, we cannot adopt the same approach in any attempt to establish any coherence between SDA and the natural sciences. The argument here is that any persuasive account of SDA must include some discussion of the nature of the 'causal joint' of that action, however it is important to stress that this must be interpreted in a suitably broad sense. As we shall see in our later discussion of the whole/part notion of SDA, there may be a plethora of such joints in operation at different organisational levels within God's creation. More importantly there are also fundamental limits to the extent of knowledge that can be gained about God's operation by scientific investigation of the joint.[15] So, despite the fact that we have claimed that there must be a causal element to our discussion of SDA, a complete description of SDA cannot focus exclusively on it any more than we can on intentional language.

SDA and human action

Despite the fact that we have rejected an exclusively intentional account of SDA, there is an indisputable connection between the theological concept of God's action and our human experience of bodily movement. Indeed quite independently to the divine action debate several philosophers following John Locke have emphasised how closely linked our concepts of action and causation are to the description of our own movements as humans. Pushed to an extreme, this claim can arguably lead to a parallel assertion that creation should be viewed as God's body and that SDA takes place by analogy with human bodily actions. An alternative is presented by the claim that God must act in some disembodied sense, although there have been many difficulties in articulating what form this action may take (e.g. TeSelle 1990).

[15] For a more detailed discussion of the scope of this knowledge see the Preface above.

Much of the work in describing God's action by means of human analogy is dependent on an important argument developed by Arthur Danto where he posited a distinction between 'basic' and 'mediated' actions.[16] Danto begins by claiming that certain natural categorisations only apply to objects when we assume that they possess a particular causal history: accordingly a footprint only becomes a footprint as opposed to an impression in the ground when it is caused by a footstep. On this basis he argues that inherent in our terminology is a set of knowledge claims about the world – in effect his argument is that by using a vocabulary to describe the world, we have already made substantive assumptions about the nature of physical causality (Danto 1973, 79).

Adopting a strongly Humean analysis of causation, Danto makes a further distinction between actions performed by humans on their own bodies and actions in the external world. The latter case he considers as 'mediated' such that

> a man does or knows something through some other thing that he does or knows, and hence actions and cognitions which contain, as it were, other actions and cognitions as components. (Danto 1973, 28)

This seemingly complex definition amounts to quite a simple claim – 'mediated' actions are those that are themselves composed of other sub-actions and knowledge of various causal interrelationships. Danto contrasts this type of action with 'basic' actions which are not comprised of other component cognitions and actions. The actions of a human being on natural objects, such as making a car move, are forms of mediated action, while lifting one's arm is a basic action in which no sub-actions occur. Danto also distinguishes two further classes of non-basic action: composite actions which are series of basic actions performed in a sequence – Danto gives the example of dancing; and basic actions done in conformity with a rule which enables them to be re-described. As an example of this latter type he gives the example of a priest blessing their congregation (Danto 1973, 29–30). He concludes, however, that both of these classes are dependent on basic actions and can therefore be subsumed into this general class.

This distinction is adopted enthusiastically by Grace Jantzen who uses it to argue, on the basis that all human action in the world begins with bodily movement of one type or other, that God's action in the world must also take the form of a 'basic action':

[16] See Danto (1965) and Danto (1973, chs. 2 and 4). A critical discussion can be found in Carr (1980).

just as theists wish to affirm that God's knowledge of the world is direct and immediate, they similarly wish to say that God can act directly, without any intervening action or mechanism: God did not wiggle his fingers to cause a mechanism to operate which sent fire from heaven … But in terms of the present discussion, this means that any action of God on the world is a basic action: he does not have to do anything else first. (Jantzen 1984, 86)

In this passage Jantzen's motivations are quite explicit – the basis of her assimilation of Danto's basic action concept into a discussion of SDA is the claim that it is not necessary for God to have some mechanism, to 'fiddle with' natural processes, in order to act. In a sense then there are parallels in this respect between Jantzen's position and Farrer's – both theologians deny the possibility of the causal joint question. Jantzen does, however, go further than Farrer for she is making strict ontological claims about the mechanism (or lack of it) for SDA, while Farrer's elusive concept of double action moves ontological questions about the causal processes of SDA beyond the realms of human investigation without denying the existence of the mechanism in principle. Jantzen enthusiastically cites Anthony Kenny's claim that on Danto's definition of basic actions the world would be synonymous with God's body (Kenny 1979, 126f.). She is at pains to emphasise the analogy with human action can become strained on the basis that humans are quite limited in the variety of basic actions we can perform, and God's potential range of basic actions includes any physical action in creation whatsoever. Crucially this claim, that whatever form SDA may take it is still a basic action for God, leads her to the conclusion that the universe must be considered as God's body. Left with the problem of how to distinguish between the world and God and the possible pantheist implications of her position she argues that God is completely embodied with omniscient awareness of all parts of his body-creation at all times, while human beings are only partially embodied since we are often unaware of aspects of our bodies (Jantzen 1984, 88–9). In a sense, then, her reasoning moves full circle – it is stimulated by Danto's conception of a basic action which itself is formulated on the basis that human bodily movements are unmediated, she then makes a set of assertions about the world in identity with God's body on the basis that God's actions must be unmediated, and then concludes that humans are only partially embodied because they do not have a perfect knowledge of their bodies.

As Langford has noted, the advantage of making a direct connection between the world and God's body is that it leads us away from the view that God is somehow operating different types of celestial pulleys

and associated assertions that God is merely another cause or ultimately another object in the universe (Langford 1981, 68–70). He details two further positive features of this connection: that there are continuous and virtually automatic bodily actions, such as breathing, that correspond agreeably to GDA; and that, in human action, we have an action that is neither coincidence nor miracle. However it is unclear how 'continuous' subconscious human actions can be likened to GDA with its emphasis on God's upholding the world in being: actions like breathing on the part of a human preserve existence only in the limited sense of keeping one alive; GDA on the other hand is far more fundamental and preserves the whole space–time continuum.

It is of course wrong to presume that appeals of this sort to the notion of the world as God's body somehow obviate the difficulties in articulating a causal account of SDA. Indeed the fundamental problem with Danto's distinction is that human bodily movements can themselves be broken down into sub-movements such as nerve stimuli and the like. This is not an argument for a totally reductionist account of human and divine action, but rather the lesser conclusion that we must still account for the interaction between SDA and the causal processes of nature. Part of the scientific problem which lies behind these attempts is well characterised by Langford's connection between a causal account of SDA and some 'levers' in creation which lead inexorably to God becoming another object in his creation. But, as we shall see below, there is no need for causal approaches to SDA to be so crude – indeed despite the fact that Jantzen and Langford consider sidestepping the problems in relating SDA and science as a major positive feature of this approach, it is by no means clear that even on their account this is what they have achieved. In particular any description of the world as God's body needs to account for the potential conflicts with the principle of conservation of energy if God is active by means of basic actions. In short it seems totally inconsistent of God to establish such a principle in his creation and then continuously to violate it at the same time.[17] Of the several other theologians who have supported Jantzen's approach it is unclear whether they have developed any more sophisticated basis for doing so. Indeed, the true extent to which Jantzen's world-body claim can be derived from Danto's distinction is highly doubtful as we have seen. What her position really amounts to is an assertion that God is active

[17] For further discussion of the principle of conservation of energy and SDA see the discussion in chapter 3 below and the notion of active information discussed in connection with chaos theory in chapter 7.

in some unexplained direct sense without the need for mediating causal interactions.

A wholly different ground for the rejection of the analogy between the world and God's body can be found in the reflection that science has yet not disclosed any natural systems with the requisite level of complexity. In short, the common claim is that there is nothing even vaguely similar to a divine nervous system in creation.[18] Moreover, they argue, the universe appears to have a finite past and its history will end in either total collapse (a 'big crunch') or continuous expansion, decay and cooling – if this world is God's body then it is a world that has undergone and will undergo radical change and transformation. There is much persuasive argument in these claims and it is clear that the majority of the natural world appears far less complex than the human nervous system, yet it is doubtful that appeals of this sort could ever be a conclusive denial of the world-body approach. In contrast with the body analogy, the argument we shall pursue below is that God is active in a disembodied sense. Of course, the problem still remains as to how we can articulate a coherent account of non-embodied SDA.[19]

IS THERE A MENTAL/NATURAL SDA DISTINCTION?

One further question, which has come to the fore in recent debates about divine action, concerns an additional set of claims about the locus of its operation. Austin Farrer in *Faith and Speculation* made a distinction between SDA in systems of physical inanimate matter, the course of enacted history, and the actions of intelligent minds (Farrer 1967). In effect this threefold distinction becomes one between SDA in mental and natural events by understanding history as a result of the interaction of individual human minds and physical creation.

Before we consider in more general terms whether this division of the arena of special divine action is justifiable, it is valuable to note some of the motivations behind its exponents. David Pailin must be commended for his honesty when he notes that one of the primary

[18] John Polkinghorne, for example, rejects this connection on the basis that this would make God vulnerable to his creation in the same way a human is vulnerable to bodily injury (Polkinghorne 1989a, 18–21). He also states that while the universe may not look entirely mechanical it is certainly not organic either as its parts lack a sufficiently complex interrelationship for this analogy to be plausible (Polkinghorne 1998b, 88).

[19] A helpful discussion of the many issues inherent in developing this notion of non-embodied action can be found in Tracy (1984, ch. 7). Following Tracy it would appear that there should be no difficulty in making the assertion that a non-embodied entity can also be an agent, however the issues of how we can articulate this will occupy us for the remainder of this book.

attractions of the mental arena is that it appears to be a safe refuge from the explanatory power of scientific explanation (Pailin 1989, 145). Indeed there may be some justification for this approach – there exists an unresolved debate about the extent to which the principles of scientific reductionism and explanation apply to the human mind, and a scientific account of consciousness has remained the elusive goal of much recent brain science research.

Recently, work has centred on concepts such as 'non-reductive physicalism' which claims that there is an inherent limitation to reductive explanation in brain science (e.g. Murphy 1998a). If this approach is correct, and there exist states in the human mind which are not causally reducible to the sum total of their parts, then it is not surprising that the human mind is extremely attractive to theologians in this context. However, allowing the possibility of SDA in human minds is a big step from an insistence that all special divine action occurs there to the exclusion of other processes in nature. It is one thing to note that there are epistemological difficulties in describing the human mind, and quite another to make claims that there is an ontological denial of causal reductionism and further that God exploits ontological flexibilities to act in the human mind. Moreover simply allowing the possibility of SDA in human minds remains a big step from an insistence that all SDA occurs there to the exclusion of other processes in the non-mental arena. It may well be that there are different 'causal joints' in the human mind which arise by virtue of its extraordinary complexity and possibly because of the emergence of new phenomena, but that does not necessarily partition the world into two fundamentally different realms.

What, then, are the primary motivations behind the claim that SDA is only plausible in the mind and not nature? Whilst it appears obvious that it lies in an outmoded dualistic conception of mind and matter, there have been several sophisticated attempts to add plausibility to this view. Consider, for example, Karl Rahner's claim that God's revelation prior to the Christ event consists of God providing a particular interpretation of wholly natural events to the mind of each particular prophet concerned:

> What makes this history [before Christ] a history of revelation is rather the interpretation of this history as the event of a dialogical partnership with God, and as a prospective tendency towards an open future. (Rahner 1984, 167)

Rahner's position amounts to a denial of SDA in the world prior to the Christ event, and while he is not explicit about his motivations, the power of scientific explanation combined with a liberal interpretation of Biblical miracle episodes may well be contributing factors.

A number of modern theologians claim support for this dichotomy between mental and natural spheres of God's action on the basis of a denial of many miracle accounts found in the Bible. Essentially the distinction posited here is that the nature miracles attributed to Jesus in the New Testament were embellishments on what were in essence mythical events. Thus, the physically genuine miracle accounts are commonly taken to include Jesus' healings and exorcisms, but exclude many miracles which were primarily concerned with natural (as opposed to mental) events. John Meier has also argued from a solely exegetical basis that many of the nature miracles were simply fabricated by early Christians in order to give some support to their emerging religion (Meier 1991). This emphasis away from divine action in the sphere of the natural has also led to some scholars proposing limits to the efficacy of petitionary prayer in the natural world. H. Oppenheimer has argued along similar lines that it is pointless to petition God to act directly on the world (Oppenheimer 1970), and her position is paralleled by David Bartholomew who similarly asserts that the locus of the 'normal mode' of SDA is in the mind (Bartholomew 1984, 143).

Despite these claims, it is equally possible to interpret the New Testament account as making strong claims for God's action in the natural realm (e.g. White 1985, 102f.). Langford has argued similarly that: 'there is no doubt that the New Testament writers would not have wished to confine God's activity to the spiritual realm' (Langford 1981, 80). In short, it is surely correct to reject any dualism between mind and nature on both scientific and theological grounds. Of course, the determined proponent of a mental–natural SDA distinction who also denies any dualism could claim that only at the higher levels of complexity and organisation found in the human brain can a sufficient mechanism for SDA emerge. Such a position is surely possible for a dual-aspect monist, however it is extremely difficult to justify this metaphysical leap, and it certainly cannot be made in a manner which is strong enough to diminish the need for discussion of SDA in the natural realm.[20]

Crucially there are also important scientific reasons why we should reject any kind of dualism concerning special divine action. These occur not least because of the assertion that there is nothing 'magical' about

[20] 'Dual aspect monism' asserts that dualism is incorrect and that there is only one form of 'stuff' in creation, but that differences in its organisation and complexity give rise to what are commonly called 'mental' and 'physical' realms. It does not try to subordinate the 'mental' into the 'physical' as merely epiphenomenal, but remains committed to the 'dual aspects' of their nature in a strongly anti-reductionist sense. See, for example, the helpful discussion in Polkinghorne (1998b, 54–5).

the matter the brain is composed of and from a denial of any form of Cartesian dualism. As a fundamental part of the mental act of thinking (and of any mental SDA) involves changes in the movement of electrons inside one's brain, these electron movements have direct influences on exclusively natural phenomena such as the movement of air molecules in a room.[21] It is thus an arbitrary scientific distinction to claim that SDA can take place in the mental realm without *any* natural consequences. Moreover, there is no *prima facie* reason to assert that reconciling SDA and mental processes is any easier than natural processes. This last point has been well put by John Polkinghorne:

> if we accept a dual-aspect monism and regard human beings as psychosomatic unities, then there is no separate privileged realm of the mind to which God would have access in a way any less problematic than his relationship to the matter of his creation. (Polkinghorne 1994b, 69)

An exclusive appeal to mental SDA also creates difficulties in accounting for the action of God in a place of the scale of our universe. In particular there are two implications which are theologically unacceptable: that God is only active in our vast universe at those areas in which there exists a suitably complex organisation of matter to enable 'mental' SDA to take place; and secondly, that SDA was ruled out until the evolution of species with sufficiently complex minds – on Earth at least, God had to sit back and watch for around fifteen billion years. Both of these fundamental difficulties are raised even before we consider the difficult relationship between SDA and free will. In short, it seems that there is a gross anthropocentricity to the claim that God acts in mental processes alone. Thus, it is claimed here that God is active in both 'mental' and 'physical' events. However unless one holds to a strongly reductionist metaphysics, it would appear likely that the processes of SDA in both are different.

COMPATIBILIST AND INCOMPATIBILIST NOTIONS OF SDA

Despite the fact that we have rejected the notion that SDA takes place exclusively in the mental arena, there are nevertheless some further analogies with the action of the mind upon the body which are of importance

[21] This assertion is based on the frequently cited calculation that the genesis of an electron on the other side of the universe would by virtue of its gravitational influence lead to effects in the long-term molecular positions of the gas in the room in which we are sitting on Earth as a result of chaotic sensitivity – see Polkinghorne (1998b, 42). See also Peacocke (1993, 42).

to divine action. In particular many very similar questions are raised in considering the relationship between human free actions and the independent causal processes described by the natural sciences. This debate, much like theological reticence about the existence of God's action, is almost exclusively a product of the modern era. Questions focussing on the relationship between human freedom and determinism have been at the forefront of philosophy for the last three hundred years,[22] and the contemporary debates about divine action and science owe an often silent debt to this pedigree. If we set the issues surrounding the claimed association between God and his creation-body aside, there remain several useful distinctions that have been developed in the context of the free will debates that we may bring to our discussion of SDA. One of the most useful of these is that between compatibilist and incompatibilist approaches to human action.

Thomas Hobbes writing in the seventeenth century is widely considered to be the first to adopt a compatibilist position. His argument was essentially that determinism and freedom can be logically consistent – or that we as human beings can exist in a totally deterministic physical world and remain free. It is important to note, however, that distinctions have been drawn here between the concepts of free will and freedom. Hobbes crucially does not claim that we can both originate choices and simultaneously be subject to deterministic causal necessity, and it is, of course, not correct to make the assertion that the arguments of all compatibilists are totally uniform. Nevertheless Ted Honderich has identified the following similarities between the various compatibilist positions: firstly that they agree that the idea of initiating free choices is inherent in our language of action; and secondly that compatibilists argue that the idea of free choice is a choice that is according to the desires of the chooser (Honderich 1993, 100–2). Where incompatibilists differ is that they assert that not only must a free choice be in accordance with the agent's desires, but that also the agent can only be capable of being morally responsible if the free choice is not only voluntary, *but also causally originated.* This element of origination is the key difference between compatibilist and incompatibilist approaches to free human action. Only if determinism does not hold, the incompatibilists argue, can there be agent-originated choices.[23]

[22] The topic of determinism in considered in detail in chapter 4 below.

[23] For a more detailed discussion of compatibilism see O'Leary-Hawthorne and Pettit (1996). These authors delineate a number of different approaches to compatibilist action including a formulaic account such that 'X chooses freely to ψ if and only if the relevant antecedents of the choice leave

We can, of course, categorise the different approaches to SDA we have met on this origination basis. As we have already seen there are both differences and similarities between the free will and divine action debates: God as agent in the universe is not held to be embodied in the sense of a physical agent and yet God as agent may or may not be held to make originated causal actions. However, the position of compatibilist SDA need not unequivocally lead to the impotent God of seventeenth-century deism (as can be seen if we imagine that God exerts a universal force of some type on creation), or the complete assumption of all SDA into GDA. The fact remains, however, that many compatibilist approaches to SDA end up denying that anything has actually happened in the physical world at all, and accordingly the approach taken here leans heavily on the side of incompatibilist SDA. It is nevertheless important at this stage to appreciate that not all incompatibilist SDA is to be identified with the traditional understanding of miracle as a violation of natural laws as we shall see in the next chapter. The categorisation can be made in analogy with the free will debate by emphasising the role of the origination of causal processes:

- Compatibilist SDAs are the actions of God which may be accommodated in the existing causal sequences of nature without God initiating specific causal sequences which otherwise did not exist.
- Incompatibilist SDAs are those actions of God that are achieved by the initiation of new and original causal sequences in nature.

It is important to note that the concept of incompatibilist SDA developed here is distinct from William Hasker's well-known doctrine of 'Theological Incompatibilism', which posits that divine foreknowledge cannot be held simultaneously with an incompatibilist notion of creaturely free will (Hasker 1985, ch. 4). While this distinction may appear relatively undeveloped at this stage, it will be shown later how important it is to the discussion of 'non-interventionist' SDA.

SDA – THE THEOLOGICAL APPROACHES

Throughout the preceding discussion it should be becoming clear that there are difficulties associated with the theological assertion that God acts in the world. We have seen how the use of Biblical identifications of

the ψ-ing up to X'. They also consider other forms based on underdetermination, ownership and responsibility for the consequences of a given action. Each of these approaches can be adapted to a limited extent in connection with God's action in the form of SDAs.

God's action is fundamental to the modern debate and how the modern 'problem' of reconciling SDA and science owes much to the conceptual tools we use to do science. As we shall see, this is in no small part due to difficulties surrounding the concept of a 'law' of nature which forms such a basic part of our modern scientific understanding. We have rejected White's claims for total divine control of all events and the opposite position represented by Wiles that seeks to deny the role of objective SDA entirely. Similarly the use of intentional language is fundamental to a discussion of SDA, and yet it leaves wanting a causal approach which *must* be addressed if SDA is to be a coherent and justifiable concept. The approach typified by Austin Farrer – that ultimately we can assert no knowledge of the causal mechanism of divine action – is too despairing and scientifically unjustifiable, especially if we make claims that scientific epistemological studies represent ontology. We also reject any direct dichotomy between mental and natural spheres of SDA. Whilst it is reasonable to assert that there are some causal joints of SDA which can only occur within the realm of the mind, there appears no *prima facie* reason to reject the existence of 'natural' non-mental SDA on this account. Indeed the assertion that God might be active in mental processes alone is surely a symptom of a general retreat from the realm of scientific explanation. Moreover, while it is clear that our human understanding of God's action is constructed in analogy with human actions, it is highly doubtful that there exists a strong analogy between God's body as the world and human bodies.

Despite these problems we are still left with a pressing theological and devotional need to be able to assert some coherent account of God's action in the world. Given that both science and theology seek to describe aspects of the same creation and in many cases make conflicting claims, we simply cannot ignore the difficulties raised by science – to do so would be to assert a theology that is not only out of touch with modern society but also most likely to be fundamentally incorrect. However, this approach should not lead us to a wholesale rejection of theological doctrine on the basis that scientific knowledge is in some sense more secure and better established. If there is one important lesson from modern philosophy of science then it is that scientific theories are often provisional and uncorroborated. The rigid and naïve interpretation of scientific progress and explanation carried to an extreme by authors such as Peter Atkins and Richard Dawkins is simply untenable. We need to face the significant and exciting possibility that just as some theological doctrine is rejected on the basis that it is scientifically implausible, so too

must some scientific conjecture be considered unjustifiable on the basis that it is *theologically* unsound.

So what can we do to justify further the notion of special divine action in the light of science? Contemporary debates on the nature of SDA are frequently conducted in terms of 'determinism' and 'indeterminism' and often brief allusions to the 'laws of nature'. What is perhaps remarkable is that whilst some theologians feel in a position to be able to reject some proposals relating to SDA on the basis of deterministic arguments, there has been no thorough study of how much we can say about incompatibilist SDA in a world in which 'laws of nature' are held to operate, and on the fundamental basis of determinism. These topics will occupy our attention in the next two chapters of this book.

CHAPTER THREE

The laws of nature and miracles

It is a notable feature of contemporary debate about SDA from a science and theology perspective that there has been relatively little discussion of the vast philosophical literature on miracles. There appears to be a consensus amongst scientist-theologians that the concept of 'miracle' is misdefined when taken to be an SDA in violation of the laws of nature, and accordingly that a proper emphasis should be placed on its theological significance and context. Both John Polkinghorne and Arthur Peacocke have argued that the primary difficulty in relating miracles to science results from a theological misunderstanding,[1] and Philip Hefner spoke for many in a recent *Newsweek* feature on miracles when he said 'I pray for my friends and loved ones regularly . . . but I have no confidence that my prayers change the course of nature' (Hefner 2000).[2] The principal reason that Hefner is led to this rejection of SDA and violation-miracle in particular is that he feels it challenges the concepts of divine faithfulness and self-consistency: how can God uphold the laws of nature with one hand, whilst simultaneously overriding them by performing miracles with the other?

This rejection instinct is not entirely surprising given that much discussion of miracles has become peculiarly divorced from other theological discussions of divine action. Outside the mainstream theology and science literature there has been something of a philosophical free-for-all in recent years in discussions on the subject of miracles and it is a debate that has taken place without the theological underpinnings it requires. As an attempt to reunite these different concepts the approach adopted in this chapter is to deprive the concept of 'miracle' of any separate ontological status as a unique form of God's action and consider it as another

[1] See, for example, Polkinghorne (1989a, ch. 4) and Peacocke (1993, 208–69). See also Judge (1991).

[2] One notable exception to this general scepticism concerning the existence of miracles is Keith Ward who has recently written that 'God sometimes acts in ways that transcend all the natural powers and dispositions of objects – miracles do occur' (Ward 2000, 905).

example of SDA on the particularity basis as identified in chapter 2 above. Accordingly, the approach we shall adopt is to examine in detail differing philosophical accounts of the laws of nature to establish when the assertion of SDA can be considered to be interventionist or non-interventionist in each.[3] As we shall see, this discussion will reveal far more complexity in these issues than has been widely presumed.

At first sight it would seem impossible to offer a causal account of SDA in a world in which it is claimed that *all* physical events in creation are governed by a set of inviolable laws of nature. This impossibility can, the argument continues, only be overcome by God overriding the supposed regularity of his creation and thus acting in a highly 'interventionist' or self-contradictory manner. The possibility for self-contradiction comes from the basic *postulate* that these inviolable laws of nature *govern all events*, are a product of God's creation, and are continually maintained in existence by God. The obvious counterpart of this violation-miracle account of SDA is that of SDA 'within nature' which is itself reliant on an opposite postulate concerning the laws of nature, namely that they are claimed to incorporate enough flexibility and openness to accommodate the intentional actions of God. Discussions in this area have focussed on those sciences which may demonstrate indeterminism (see chapter 4 below). Yet there are considerable difficulties in forming a coherent notion of probabilistic causality for any agent, not least a disembodied one. Also, as we shall discuss in the next chapter, the concepts of determinism and indeterminism are considerably more slippery and imprecise than many have presumed. The straightforward dichotomy which is often posited between 'classical' or Newtonian mechanics as deterministic in comparison with quantum theory as indeterministic is unacceptably simplistic.

It is difficult to conduct the following discussion without using the terminology of those who have developed it, and for this reason it is important to acknowledge that when the term miracle is used below it is in the sense of an SDA that is taken to 'intervene' in the 'laws of nature'. The key to this definition of course lies in the meanings of the two terms highlighted. Upon a fairly simple reading in which the laws of nature are taken to be inviolable and universal by definition, all SDA in the world must be over and above these laws and is clearly miraculous in the above sense. Yet even this simple definition is missing from much contemporary discussion of miracles in which the term miracle appears to be used as a pseudonym for several different forms of SDA and even GDA.

[3] These terms are employed as synonymous with the notion of violation or non-violation of the laws of nature.

An example of this broad use of the term miracle can be found in the three senses of the term identified by James Kellenberger as 'contingency miracles', 'natural miracles', and 'violation' or 'intervention miracles' (Kellenberger 1979). Each of these categories makes quite different claims about the extent of God's action. Contingency miracles, as Kellenberger defines them, are essentially extremely rare natural coincidences that, when interpreted in a religious context, have particular religious significance. Kellenberger is quite clear that they operate within the realm of the laws of nature and are in principle wholly describable by naturalistic explanations. His approach here owes its origins largely to the work of R. F. Holland whose premise was that the conception of miracle as a violation of natural law was overly restrictive. Holland famously considered the 'miraculous' saving of a small child from almost certain destruction on the tracks of an express train. The driver, unbeknown to the child, had a particularly heavy lunch and passes out at the controls of the train with the result that the train automatically stops only inches from causing certain death. Holland goes on to argue that this is a genuine occurrence of a miracle since 'the kind of thing that, outside religion, we call luck is in religious parlance the grace of God or a miracle of God' (Holland 1989, 55). Essentially it is the context of the miraculous event which is crucial to its categorisation.

The point Holland makes here is that what a theist identifies as a 'miracle' takes place against the background of a religious tradition and the assumptions that are inherent in that background – essentially it is this religious interpretative framework that adds substance to the miraculous, and accordingly it cannot be presumed to be some form of divine interference with nature. Whilst Holland's later point is undoubtedly correct, it is difficult to perceive how God can actually be said to be *acting* in any true sense on this 'contingency' account. In effect the position appears to be quite close to Maurice Wiles' assertions about the human perception that particular acts of God take place despite the fact that God only performs universal actions on the whole of creation (see chapter 2 above). Accordingly it is important from the outset to acknowledge the widely different senses in which the term miracle is employed throughout the literature. Kellenberger makes strong claims about the coherence of Holland's approach and makes a parallel claim that God's 'thankability' constitutes a sufficient test for the miraculous (Kellenberger 1979, 156). Despite his argument that implicit in the notion of thanking someone is an attribution of responsibility, it seems to be overstating the case to assert that this constitutes a sufficient test for the miraculous or indeed

any form of SDA. Implicit in his approach is a blurring of the distinction between GDA and SDA – we can thank God continually for creating the contingent world in which we live and yet still have a world devoid of genuine SDA like that conceived by Wiles.

It is along similar lines that Kellenberger develops a second category, that of 'natural' miracles:

> Natural miracles occur through God's agency; they are not instances of God's direct action. There is no intervention by God, but God, as creator, is deemed thankable for establishing the ground of natural events. (Kellenberger 1979, 157)

This short definition deserves some unpacking. Kellenberger holds the concept of God's agency in tension with the fact that no intervention in the natural world takes place. Clearly this notion of agency is derived from his earlier assertions concerning God's thankability as being a sufficient identifier of divine action. A limited analogy exists, Kellenberger argues, in the example of a father who established an education fund to pay for his child through university – while the child's examination results and final degree class are in no part the work of his father, the father is deemed thankable for establishing the grounds for the child's study.[4] Moreover, on the basis of this analogy, it is quite clear that the father has acted to set up the fund in the first place. Some caution is needed, however, for there appears to be no real distinction on this account between a 'natural' event and one of God's actions. Kellenberger's response to this problem is again based on the notion of thankability as a sufficient test for the miraculous – he differentiates between a natural and divine event in terms of its meaning as interpreted by human beings, and thus reaches the conclusion that to make an affirmation of a miracle is to assert that God is in some sense responsible for that event and is thus thankable. Accordingly by again shifting the emphasis away from causal questions Kellenberger feels able to assert that someone who identifies and believes that a particular event is a natural miracle will be thankful to God for its existence, while if the event is seen as only natural this element of thankfulness will be missing (Kellenberger 1979, 160).

In common with much of the argument in the preceding chapter, it is surely extraordinarily difficult to find any substantive ontological content in either of these two categories of the miraculous.[5] It would be

[4] In relation to this distinction between the grounds of an action and the act itself recall the above discussion concerning the necessity of God's action as GDA on a foundational basis for SDA – see above pp. 18–23.

[5] A helpful discussion of religiously significant coincidences can be found in Gaskin (1975).

incorrect, however, to dismiss Kellenberger's taxonomy as being without theological precedent: St Augustine, for example, in a letter to Honoratus his Manichaean friend, defines miracle as anything which appears to us to be unusual and beyond the powers of the one who witnesses it. Following the distinctions developed in chapter 2 above, Kellenberger's first and second categories of miracle correspond to rich interpretations of GDA, but do not make any substantive assertion that SDA takes place. Indeed the focus on the interpretation of the event by the observer and whether God is deemed thankable or not is a highly subjective approach to SDA – in essence the claims about SDA made in both these distinctions are about the nature of an interpretational framework rather than assertions that the nature of God's causal activity in the world is different. The same difficulty is, however, not inherent in Kellenberger's third category of miracle which we now consider.

VIOLATION OR INTERVENTION MIRACLES

The predominant concern in the large literature on the subject of miracles concerns those instances of SDA that are taken to act against the 'laws of nature'. One of the first to make this position explicit in the context of natural philosophy was John Wilkins (one of the founding members of the Royal Society) who held that a miracle was a 'violation' or 'disordering' of the 'universal laws of nature' (see Harrison 1995, 535). In the debates concerning this notion of violation that have followed there are essentially three different types of argument which have been developed: considerations of the value of testimony in order to establish epistemologically that a given violation-miracle has actually taken place; discussions of the philosophical issues inherent in holding belief in violation-miracle SDA simultaneously with belief in laws of nature; and attempts to reconcile belief in violation-miracle SDA with 'laws' from a predominantly theological perspective. The lack of success of these latter two enterprises has led to many modern theologians denying the feasibility of violation-miracles altogether. Yet the issue is perhaps more complex than many have presumed and is highly dependent on what ontological conception of the laws of nature one adopts. Indeed, it is remarkable that many of the contemporary debates surrounding violation-miracles appear to bypass so much of the well-developed philosophical work on the status of the laws of nature. A better approach is thus offered by considering SDA as an objective feature of nature and asking the question when a particular SDA becomes considered as a violation-miracle

under each approach to the definition of lawfulness. As we shall see, this is highly dependent on what ontology of the laws of nature one allows.

Before we begin to discuss these latter issues in detail, it is helpful if we distinguish them from what has historically been a primary interest in the philosophy surrounding violation-miracles. The issue of testimonial evidence is of great importance in any apologetic reliance on SDA – it is not enough simply to debate the coherence of the concept itself without a corresponding assertion that an SDA has actually happened.[6]

The possibility of defining a miracle as a violation of a law of nature only, of course, occurs when we have a well-established law of nature to violate. The essence of David Hume's famous argument was that the quality of evidence needed to establish that a particular law of nature had been violated was such that it was most unlikely that there would ever be enough detailed historical fact to establish this when considered against the vast amount of contradictory evidence for that particular law's operation. Thus, in accordance with his earlier comment in his *Enquiry Concerning Human Understanding* that it is fundamentally impossible for weaker evidence to overrule stronger evidence, Hume effectively *defines* the laws of nature and the miraculous in such a way as to remain mutually exclusive. This point has not been lost on his critics, C. S. Lewis parodies it thus: 'He first answers, "Yes" to the question whether Nature is absolutely uniform: and then uses this "Yes" as a ground for answering, "No," to the question, "Do miracles occur?" (Lewis 1947, 107). As Lewis notes, given this approach to definition it is hardly surprising that Hume should seek to establish that there was not only no satisfactory evidence for a miracle, but that such evidence was fundamentally impossible.[7] David Bartholomew, in one of the best-sustained discussions of testimonial value in relation to violation-miracles, shows how there also existed a number of contemporary theistic counter-claims. Charles Babbage, for example, sought to demonstrate that if the probability of a miracle taking place was 1 in 10^{12}, then only twelve independent witnesses would be required to establish that the event in question had actually taken place (Bartholomew 1996, 92).

Despite the fact that such discussions are a very interesting case-study in the interaction between science and theology, we must leave them

[6] For a detailed discussion of the epistemological issues involved in claiming that a violation-miracle has taken place see, for example, Odegard (1982).

[7] It has been recently argued that the received view of Hume is fundamentally incorrect and that Hume's account actually comes close to necessitarianism (see below). According to these accounts the scepticism he showed was purely epistemological and supported by an underlying belief in the physical necessity of natural laws.

to one side. There exists a vast literature on the range of assumptions that Hume and his contemporaries have made, and the proper basis for making use of testimonial evidence in relation to miracle assertions.[8] These issues can, however, be quite neatly severed from the more fundamental ones of the coherence of the theoretical relationship between SDA and the laws of nature and the most appropriate theological account of miracles. For the purposes of this study we shall focus on these problems.

Let us begin by considering the work of Anthony Flew who has developed three widely cited arguments against belief in the miraculous. Firstly Flew rejects any historical or probabilistic arguments advanced to support occurrences of the miraculous. He points out that the basis of these citations is a belief in the regularity of nature that leads to the concept of miracle becoming *prima facie* contradictory (recall Lewis' comment above). Whilst it is clear that belief in violation-miracle does presuppose that nature follows a prescribed pattern, it does not necessarily imply that this pattern is universal in the sense which Flew's argument requires. Flew's response to this is that we now have no control over what constitutes a satisfactory explanation of a particular event once we permit the possibility of natural law violations (Flew 1966). Implicit in this account is Flew's considerable emphasis on the necessity of *repeating* experiments to establish that some physical effect actually takes place – a fact that becomes particularly clear in the parallels which exist between his discussion of miracle and a separate rejection of the phenomenon of parapsychology (see Flew 1976). Moreover, Flew points out, we cannot be entirely certain that it is actually God who is responsible for a particular miraculous event. As he emphasises, it is common in theological discussions to assert the unknowability of God and his purposes, and he consequently questions the extent to which the causal actions of God can ever be known in principle.

These arguments served as the stimulus to one of the most widely discussed miracle theologies developed by Richard Swinburne which placed emphasis on the concept of miracle as a *non-repeatable* counter-instance to the laws of nature (Swinburne 1970). His position stands in stark contrast with those philosophers who claim that inherent in any concept of agency is the notion of potential repeatability at will. The concept of the laws of nature developed in the ancient period, Swinburne

[8] John Earman has recently written a helpful commentary on what he terms Hume's 'abject failure' concerning the argument on miracles (Earman 2000).

argues, and these laws may be either 'universal' or 'statistical'.[9] Adopting Hume's approach, Swinburne asserts that a miracle is a violation of a law of nature. Accordingly a genuine law of nature is formed, he argues, by scientists seeking the most 'natural' generalisation or extrapolation of a given set of experimental results. Swinburne's comments here are echoed to a certain extent by Richard Feynman's discussion of the scientist's role as that of guessing nature's laws. Feynman, unlike Swinburne, is clear about what a slippery concept this feeling of 'naturalness' is – as he puts it, when presented with conflicting theoretical accounts of some phenomenon, it is no easy decision to determine what should be thrown away and what integrated into a new theory (Feynman 1992, 156–73).

In parallel with the concept of naturalness, Swinburne develops a simplicity condition such that there is no theoretical basis known to science which fits a given set of data in a more simplistic way. He illustrates this notion by considering two different mathematical ways to model some simple data points. However, the problem with imposing these simplicity conditions as a test to determine what is acceptable as a law of nature is that they soon become very difficult to assess in the world of real physics.

Swinburne acknowledges that in the practice of physics it is common for there to be a number of competing formulae of similar simplicity that are compatible with given experimental data (the example he gives is the Big Bang and Steady State cosmological models), however he still makes a direct connection between a formula being the simplest known account of experimental data and a provisional assertion that the formula in question is a law of nature. The provisionality means that should some more simplistic account be discovered then the earlier law will be abandoned. Despite this condition, Swinburne's philosophy of the laws of nature is clearly unsatisfactory. The very example he cites, namely the distinction between steady state and big-bang cosmological models ironically shows that there is more to a particular theory being labelled a law of nature than mere simplicity.[10] Indeed, in a discussion

[9] Swinburne argues elsewhere that the concept of experimental predictability led to the development of laws and the notion of events happening by necessity (Swinburne 1994, 63). Similarly Swinburne asserts that the concept of causation is a precedent to the concept of a law of nature. It is, he argues, precisely our experience of acting and being acted upon which leads to the notion of causality (Swinburne 1994, 244).

[10] Yuri Balashov in a technical discussion of the acceptance of big-bang cosmology highlights the complexity of its relationship with steady state models (Balashov 1999). Moreover some philosophers have suggested that the acceptance of the big-bang model in general scientific circles was in no small part implicitly influenced by the corresponding assertion that it was God who 'sparked' the big bang – see the Preface above.

of McKinnon's regularity approach to the laws of nature, Swinburne makes more claims about what successful laws must provide: they must, he argues, describe events in a regular and predictable way. When events take place that are fundamentally unpredictable and irregular they are of a type that can *never* be satisfactorily described by the laws of nature (Swinburne 1970, 26).

This last statement thus appears to be the primary motivation for Swinburne's non-repeatability criterion for 'miraculous' SDA. Adopting Ninian Smart's earlier position, Swinburne defines a violation-miracle to be a 'non-repeatable counter-instance to a law of nature'. In essence Swinburne's argument is that, by definition, violations of laws of nature must be non-repeatable since the laws of nature would be modified if there were repeatable counter-instances – it is not, however, clear how this claim fits in with the simplicity criterion discussed above. By positing a distinction between a formula being a law and a formula being universally true and holding without exception, Swinburne reaches the conclusion that miracle talk must not presuppose that all events universally obey natural laws.

Accordingly, Swinburne's example of the phenomenon of levitation can be turned to a good case-study of the circularity of his argument: he considers the levitation, E, of a holy person which is contrary to the 'otherwise well-substituted laws of nature L' (Swinburne 1970, 30). E, he continues, would be a repeatable counter-instance of L if it were possible to construct L', a comparatively simple set of laws which explained E. If we were to adopt L', then it would be reasonable to assert that under certain circumstances people levitate and that thus E was not a violation of a law of nature. However it might be, Swinburne argues, that no successful modification L' can be found, in which case it is reasonable to assert that E violates L. The weakness of this non-repeatability condition is thus clear. To pre-empt the following discussion, it is formulated on the basis of a regularity approach to the laws of nature under which it is extremely difficult to categorise 'miraculous' SDA as being ontologically different from any other event.

Thus, as we have seen, there is no developed distinction in Swinburne's *The Concept of Miracle* as to the difference between laws of nature as *descriptive* of events in the world or *prescriptive* as to what can possibly happen. More recently, however, Swinburne has been more explicit about his understanding of the laws of nature – he argues that they are not to be considered as simple regularities in the patterns of events, 'but regularities in the patterns of which events of which type cause which events

of which other type, that is, which substances have which causal powers and the liability to exercise them under which conditions' (Swinburne 1994, 65). This is an interesting approach to laws of nature which, as we shall see, combines elements of a regularity account with a structuralist one.

Alistair McKinnon, in an equally influential account, distinguishes two forms of the 'miraculous': events which involve the suspension of a law of nature; and, mirroring Augustine's definition, as events conflicting with our understanding of nature (McKinnon 1989, 49). In a similar argument to Flew considered above, McKinnon asserts that the former of these is *prima facie* contradictory. Natural law does not have a 'legislative' or 'prohibitive' force, he argues, since it does not limit or constrain the potential course of natural events. The approach he adopts is to deny any ontological status to the laws of nature which are thus merely indicative of actually occurring individual events. It is easy to see how, given this approach, there can be no conception of violation-miracle since his definition of the laws of nature is so inclusive as to accommodate both natural and divine events in their entirety. If SDA is an objective feature of nature, then on McKinnon's account of the laws of nature, it presents a challenge for science to accommodate the full scope of the world's events in these shorthand descriptions. It is thus rather surprising how much ink has been spilt in refutation of his position. McKinnon has effectively defined what Swinburne takes as 'miracle' into non-existence. Under his scheme the laws of nature only *describe* the workings of the world and as such do not raise any ontological questions concerning the possibility or not of SDA. It is precisely because of this that McKinnon's work is potentially confusing because in tandem with this approach to natural laws he insists on understanding a miracle as a violation of natural law. Essentially he first defines natural law in such a way that it cannot conflict with any SDA whatsoever, and then claims that there is an inherent contradiction between violation-miracles and the concept of the laws of nature. Given this approach it is hardly surprising that he is led to conclude that 'all the properly descriptive senses of miracle are logically improper' (McKinnon 1989, 52).

Another approach is that given by Richard Purtill with his assertion that the relationship between miracle and the laws of nature mimics that of a presidential decree in relation to the laws of the USA. He argues that the source of a presidential pardon is outside normal legal processes, but once granted a pardon has consequences in these processes. A pardon, he argues, is not illegal in the sense of violating laws, nor does it

fundamentally suspend the operation of normal laws at a particular time – by analogy miracles do not violate the laws of nature or change them universally (Purtill 1978, 70–1). The basis of this analogy actually rests on an assertion that in the same way that the legal system tolerates exceptional pardons, natural regular processes also permit certain exceptions known as miracles. However this analogy can only be limited at best. Leaving aside the fact the only reason the President can overturn such rulings is because of the *legal* authority vested in them and the fact that the right to do so is enshrined in the US system of justice, the principal problem here is that the laws of nature and the legal system are fundamentally different entities. If Purtill's analogy with the laws of nature is correct, then there must exist an objective system by which God can act according to his will. Moreover this system must be enshrined in the complete set of natural laws, and is thus arguably epistemologically knowable to scientists in the same way that US lawyers know about the possibility, and examples, of a presidential pardon. However, the admission of this system by which God can overturn nature *implies* the possibility of SDA and thus Purtill is able to reach his conclusion that miracles are a possibility without overturning the laws of nature.

What we have seen in Swinburne's, McKinnon's and Purtill's discussions of miracle is that there is a wide discrepancy between scholars as to the factors inherent in what it is that they attribute to being a law of nature. In an attempt to develop this debate we shall thus consider in detail the basis of the claim that laws of nature exist ontologically and consider the implications for SDA under each of the main schools of thought. Before we begin this discussion, however, it is crucial to acknowledge that there are strong theological influences in the development of the concept of natural law.

Edgar Zilsel has argued convincingly that it is important to distinguish the development of the concept of laws of nature from the development of experimental science. It was not necessarily the case that those experimental regularities studied by the philosophical virtuosi several hundred years ago were interpreted simultaneously as reflections of divine laws. Indeed, Zilsel claims that the scientific concept of a 'law of nature' developed in parallel with that of Royal Absolutism – it is no coincidence, he asserts, that the Cartesian conception of God as a divine legislator developed only forty years after Jean Bodin's conception of legislative sovereignty (Zilsel 1942, 279). The forerunners of the modern conception of a 'law of nature' Zilsel finds in the quantitative rule sets which were developed by early artisan-scientists. The example he gives

concerns an Italian gunnery expert, Tartaglia, who in 1546 produced a table of gunnery ranges and turret elevations. Despite this widespread use, Zilsel argues that it was Johannes Kepler who was the first to use the law metaphor for experimental regularities.

Differing accounts of this development can be based on the idea that the concept of imposed law finds much of its origins in the early Jewish monotheistic assertions that Yahweh was the supreme force behind all natural processes or alternatively in the Greek concept of immanent natural law.[11] Francis Oakley argues that the source of the assertion by seventeenth-century virtuosi that the laws of the world were imposed on it by God finds its roots in medieval theologies of creation and particularly in the writings of William of Ockham. What Descartes did when he spoke of God's imposed laws of nature was simply to translate Ockham's moral order into the realms of natural philosophy (Oakley 1961, 437). It seems clear that subsequently Robert Boyle and Isaac Newton owed much to the development of this medieval theological tradition, however it is far from certain that this tradition exerted a uniform influence in succeeding generations. Indeed it is particularly interesting to note that many of those figures who were at the forefront of advocating a mechanistic interpretation of nature, such as Robert Boyle, Thomas Sprat and John Wilkins, were also strong advocates of violation-miracles. Boyle, for example, wrote that whilst God established the laws of nature, 'he has not bound up his own hands by them, but can investigate, suspend, overrule, and reverse any of them' (see Harrison 1995, 535f.).

Given this reading of the development of the concept of laws of nature we should not be particularly surprised that there has been a great deal of difficulty in reconciling SDA with natural laws. If the latter are taken to be universal in scope it is clear why it is that many instances of SDA have been characterised as 'miraculous'. Yet it does seem strange that two such closely allied theological concepts as natural law and SDA should be so widely considered to be *prima facie* irreconcilable. The reasons why this has become the case can only be fully understood in conjunction with a thorough study of the development of the concept of laws of nature. Such a study has not yet been undertaken, and we are thus left with the task of reconciling two closely allied and highly developed concepts: SDA and 'natural law'. As we have seen, use of the term 'law of nature' is often rather vague in science and theology literature. Indeed, the question of when a particular SDA is taken to be a violation-miracle relies heavily on

[11] For more on the Hebrews' approach to natural events and the impossibility of 'violation' accounts in their methodology see chapter 1 above.

which reading of the philosophical status of natural law we accept. The clearest approach to addressing this question can be given by considering the various accounts we have of laws of nature in a world in which causal SDA is predicated to be a fundamental feature of reality.

DIFFERING PHILOSOPHICAL APPROACHES TO THE LAWS OF NATURE

Before we start to discuss the various accounts of laws of nature, it is helpful to begin with some distinctions that are generally accepted by all of the various positions. Friedel Weinert in a useful account of the complex terminology surrounding the philosophy of the laws of nature has identified a number of helpful features. The first and most fundamental of these is that between natural laws and scientific theories: the former provide algorithmic compressibility of phenomena and conceptualise them, while the latter conceptualise and explain laws. It is thus commonly asserted that there exists a chain of explanation from a fundamental law through a theory to human understanding (Weinert 1995, 4). A second differentiation is that which is commonly made between laws of nature and laws of science. Laws of nature have an ontological basis such that their existence is claimed to be independent of whether humans have discovered them or not. They are thus not necessarily symbolically cast into the usable form of laws of science. Accordingly, it is perfectly possible for the laws of science, our working tools, to be limited or modified in their validity whilst leaving the more fundamental laws of nature untouched. Certainly it is widely accepted that the laws of science provide a useful insight into what the laws of nature might be, but philosophers of science differ widely as to the extent to which we can know the laws of nature. The spectrum of the level of this claimed knowledge is broadly in keeping with that for other general assertions concerning the extent of realist claims in the natural sciences.

Another helpful distinction exists between 'lawful' statements and 'lawlike' statements. Only the former are expressions of the true laws of nature and are commonly mathematical descriptions of the physical structural features of a system; 'lawlike' statements on the other hand are expressions of accidental regularities and have no ontological significance. Weinert cites a helpful illustration developed by Hans Reichenbach: it is *lawful* that all solid spheres of uranium have a diameter less than one mile; it is *lawlike* that all solid spheres of gold have a diameter less than one mile. The former is ruled out by the physical

necessity of uranium forming a critical mass and exploding, while the latter is simply an observation of the size of gold deposits, but is not ruled out in principle (Weinert 1995, 17). Astute readers will appreciate that this distinction itself presumes a broadly necessitarian reading of laws, and we are thus already in deep philosophical water. Yet despite this complex and sometimes confusing terminology, the distinctions between the various main positions on laws of nature are fairly easy to grasp. We shall consider four such positions: the regularity view, the instrumentalist view, the necessitarian view, and the statistical or probabilistic view. This latter approach, that the laws of nature are fundamentally probabilistic, can easily be combined with regularitarian approaches to the laws of nature, but arguably runs into theoretical difficulties with the necessitarian school of thought. As we shall see, each of these positions raises quite different issues in connection with SDA.

Regularity accounts

The regularity view of the status of laws of nature in its early form identified laws with a constant conjunction view of regularities inspired by Hume.[12] There are, of course, major problems with this approach. There is no possibility of a distinction between laws of science and laws of nature, and there exist both vacuous and functional laws that form a basic part of scientific explanation (Weinert 1995, 31). An example of a vacuous law is Newton's first law, for the simple reason that all matter in the universe is constantly subject to a number of forces including gravity. Similarly, the Second Law of Thermodynamics has an equally unclear status on this account since it is unlikely that there really can be a closed system in our universe. Functional laws, on the other hand, are those that permit extremely high or low values that no real parameter could obtain, and thus cannot be simply derived from epistemological regularity criteria (Weinert 1995, 32). In essence then, regularity accounts are based on ontological assertions about the primacy of events over laws; what laws exist only do so as a result of a number of closely related events.

It is actually extremely difficult to be an out and out regularist – it is so inimical to the modern world-view that physical laws owe their origins

[12] Fred Wilson and others have argued that this over-simplistic reading of Hume's work on regularities is misplaced: Hume's *Treatise* distinguishes between laws and accidental generalisations. As Wilson points out, Hume placed much emphasis on 'necessary connexion' and this enabled him to distinguish between proper causal associations which lead to laws and those that occur simply by chance (Wilson 1985, 10–13).

to some source other than the facts of the world. Whether this source is attributed to God or simply a result of the structural features of the world (or both) is a matter of opinion, however, for the true regularist the very notion of violation-miracle is simply illogical. As Norman Swartz points out, Hume was himself quite inconsistent in his approach by adopting a law-breaking conception of the miraculous: 'Thus the mere possibility, the bare logical possibility, of God's performing a miracle is inconsistent with the Regularity Theory. One cannot preserve a Regularity account and allow that God could (although He does not) perform a miracle' (Swartz 1985, 109).

It is vitally important not to misinterpret this quotation as implying that SDA as opposed to violation-miracle is *prima facie* impossible in a regularity account of laws. The argument it derives from is based on a lack of consistency between the concept of miraculous law-violation and the regularity account. However once we move away from insisting upon this notion of law-violation, and move simply to consider the possibility of objective SDA in the world in relation to a regularity approach to laws, the problem totally dissolves. The argument is that it is basically impossible for God to suspend natural laws on a regularity account, something we should not be surprised about given the discussion above. In connection with the claim that causal SDA objectively takes place in the world, the conclusion is actually quite the opposite – because of the ontological primacy of individual events it is theoretically possible to subsume into a regularitarian methodology of laws any SDA claims whatsoever. Thus if we make the theological assertion that SDA is a fundamental feature of the world, a broadly applied regularity approach will simply attempt to describe the world on the basis of the different singular events within it, and consequently include *all instances of SDA*. Swartz's discussion is thus really about the contradiction of *defining* two mutually inconsistent entities and then finding them irreconcilable.

It does not take much imagination, however, to realise that widespread SDA would soon render any account of natural phenomena extremely difficult under this approach. Indeed, in a parallel with the occasionalist problem discussed in chapter 2 above, there appears to be no objective sense on this account in which we are able to distinguish between SDA and natural events. This is not to argue that we are forced into a position of having to identify all events as SDA, or to assume that only GDA takes place. The problem is that any account of natural, non-SDA processes in nature is made vacuous by the operation of SDA in the past and the new regularities it consequently asserts.

One possible solution to this difficulty can be attempted by formulating a 'time-limited' or 'contextualised' regularity theory that can easily accommodate SDA. In essence what this 'time-limited' regularity account presupposes is that there exist certain regularities which hold for particular stretches of time and which are replaced by other, different, regularities at subsequent times. The problem is now that our account may accommodate so much as to be practically useless. In the context of an example consider the miraculous healing of a patient with severe cancer in a hospital. We could formulate the following contextualised regularity law to account for this particular divinely caused event: 'Whenever six doctors and eight nurses attend to a man aged fifty-three with very advanced cancer in a London hospital on the sixth of April he will make a spontaneous recovery.' Of course this law seems very contrived and in connection with cancer care policy it is virtually useless, however to dwell on this aspect misses the point that according to a thoroughgoing regularity account of the laws of nature, it is not the law that has been formulated which is contrived, but the historical evidence upon which it is based which is counter-intuitive. In essence, those remarkable situations which arise as a result of SDA have the consequence on this account of forming remarkable laws (cf. Swartz 1985, 112f.). The problem, of course, is that with such a superabundance of laws all purporting to explain a particular event under different contingent circumstances, we cannot make any meaningful development of science. Indeed the job of making an experimental prediction becomes rapidly impossible since one never knows the full details of the contingent application of each law.

The solution left open to those wishing to hold a regularity view is to make a distinction between an event which 'falls under' a particular contingent physical law, and an event which is *explained* by a physical law. That is to say that only some physical laws are found suitable for use as a scientific law, and the vast majority of our physical laws will not be invoked in attempts to explain the workings of the world scientifically. Nevertheless there is no way on this reading that we can ever evaluate whether a particular natural law is true or not, unless it is also used as a scientific law. Consequently even those contrived laws which accommodate SDA such as the example of the cancer recovery above will not be explanatory in a scientific sense. The corollary of this claim is that, while SDA is easily accommodated as laws within a regularity account, it is extremely difficult to make any strong claims for its existence because there is no direct link between being a law and a satisfactory explanation. Certainly it is easy to accommodate any particular SDA into a regularity

account of the laws of nature, however, the ease with which we can do this also belies the general difficulty with the theory and in general this view of the laws of nature has frequently received a bad press in the literature.[13] The main difficulty that exists with regularity accounts is that they give us no insight into why these regularities exist in the form they do. They fail to incorporate any regulatory mechanism that we could visualise as producing the regularity in question. Similarly this account leaves us with a growing body of laws which describe the past history of the world and no *prima facie* reason to assert that they should continue to describe the future. In conclusion then, there is no problem in asserting that SDA occurs in a regularity account of the laws of nature. Indeed, by the very nature of the regularity account, no SDAs can ever be categorised as interventionist, since the laws of nature simply reform around the epistemological consequences of each SDA under this view. Similarly the traditional understanding of miracles as violations of the laws of nature is methodologically impossible in the regularity account.

Instrumentalist accounts

The instrumentalist account of laws of nature is deceptively appealing in a divine action context for the simple reason that it appears to say little that might conflict with the ontological basis of SDA. The basis of all instrumentalist accounts is that laws exist as descriptions which rational (although not necessarily human) minds impose on an external world of events. Thus the purpose of scientific research is to organise and categorise natural observed phenomena into the most economic and coherent network of explanations possible (Weinert 1995, 26–8). Because of this process of ordering, the instrumentalist approach is primarily directed towards establishing laws of science and not laws of nature, since the origin of the laws themselves is to be found in the capacities of human organisation and *not nature itself*. However some instrumentalists also hold that there is a corresponding material element to their account which physically imposes order in the human mind and thus claim that their account does not stand totally divorced from ontology. The mainstream

[13] It would be wrong to presuppose, however, that there are no consistent regularity accounts of laws of nature. The Mill–Ramsey–Lewis approach to laws of nature is at its root fundamentally a regularity account, and imposes an additional criterion of simplicity on the set of laws which results (cf. Richard Swinburne's account of miracles considered in the previous chapter). In essence the relationship between this account and miracles is, however, the same as that of the so-called naïve regularity position discussed here.

position is that there would continue to be regularities in nature even if human minds did not exist, however:

> the idea of law involves ... more than just factual regularity as such, since lawfulness is bound up with nomic necessity and hypothetical force. To say that these factors do not represent objective facts but result from man-made imputations is not to gainsay the objective reality of regularities in nature. Rather, it is to recognise that laws play a role in our conceptual schema that imposes requirements going beyond mere regularity. It is not the regularity claimed by a law but the lawfulness it builds into this claim that is mind-dependent. (Rescher 1970, 117)

What Nicholas Rescher argues here is that the concept of a law of nature has far more to it than simple claims of experimental regularity. Essentially, on his account, there could be absolutely no laws of nature were there not human beings or other rational minds to formulate them. Thus laws of nature are to be seen as wholly a construction of the rational mind on observed regularities in nature, which in turn leads to inherent restrictions in our expectations of natural events. This latter conclusion is particularly important in our discussion of SDA. Ernst Mach made this feature of the instrumentalist account particularly clear by placing importance on the fact that the laws of nature function to delimit the possibilities which rational minds expect nature to pursue. These restrictions, he argued, can have the effect of limiting those things which we conceive of as being possible and thus govern and organise our expectations in any particular natural situation (Mach 1960, 267–9).

This progressive tightening is, Mach argues, the process by which humans come to represent reality. Of course, given Mach's expectational emphasis, almost all manifestations of SDA are potentially contradictory to an instrumentalist account of laws of nature. If the character of a miracle is such that it is a sign (to use St John's language), or at least appears distinctive or unusual in some way, then such a manifestation will contradict normal human expectations. Accordingly on this account of the laws of nature, all observed miracles which have this property of being essentially unexpected or contrary to our physical expectations will necessarily be violation-miracles. There is arguably a strong consonance between this approach and the first and second forms of the miraculous identified by Kellenberger and discussed above.

Again, rather than saying anything about the possibility of SDA in ontological terms, the instrumentalist account necessarily conflicts with one approach to the very essence of the miraculous, namely the ability

to inspire human wonder. Consequently it is fair to say that the instrumentalist account both permits and does not permit objective SDA. It is potentially permitted because the theory makes no ontological claims about the actual workings of nature (and can thus accommodate the *hidden* actions of God which are not contrary to our naturalistic expectations), but SDA is not permitted in the sense that the narrowing of these human expectations rules out any human acknowledgement of particular SDAs unless they are violations of our expectations.[14] Essentially if we postulate the existence of SDA in the world, then on this reading of the laws of nature we are permitted to make broad assertions of God's hidden activity, but any unusual events in nature that we attribute a divine authorship must accordingly be classed as interventions in the laws of nature.

Necessitarian accounts

Given that it is quite possible to predicate the existence of SDA in both of the previous accounts of the laws of nature, and it has become clear that the notion of miracle as law-violation is quite inappropriate in each of these accounts, we now turn to consider the one approach in which SDA can be held to intervene with the laws of nature. In contrast with the regularity account and its basis on the actual instantiated connections in the world, the necessitarian account makes the claim that physical laws ontologically *determine* which possibilities are open to the world and which are not. Thus the regularities we observe in nature are merely the manifestation of these laws, rather than their constitution. Accordingly, in contrast to the regularity approach, the laws of nature are ontologically prior to actual events which occur under them and thus it is common to these necessitarian views to find the claim that the laws of nature prescribe and permit certain physical outcomes.

The predominant and most defensible view behind this claim is that laws exist because of certain structural physical necessities. This argument is typified by claims for the existence of 'natural necessity', and as

[14] Although this strongly instrumentalist view of laws of nature appears to have few followers today, there has been a resurgence of pseudo-instrumentalist models such as that developed by Bas van Fraaseen. Laws of nature, in his view, are statements which derive from the attributes of the models we use to do science. Van Fraaseen's science is thus anti-realist and the notion of law serves to describe the structure of any possible world allowed by a particular physical theory – they delineate the structure of one's scientific models, not the ontology one is modelling (van Fraassen 1989, 13). Ronald Giere, in a realist reformulation of van Fraaseen's position, claims that models capture the ontological structure of physical systems (Giere 1988, 78-91).

Martin Leckey and John Bigelow have put it, 'laws are concerned with what must happen, and what could not possibly happen, rather than merely what does and does not happen' (Leckey and Bigelow 1995, 92). The emphasis in their account sits squarely on a set of ontological rules determining the nature of reality without exception.

David Armstrong in one of the most clear expositions of the necessitarian approach argues that 'It is a law that Fs are Gs' cannot be analysed as 'All Fs are Gs', but instead must be assessed as either 'It is physically necessary that Fs are Gs' or 'It is logically necessary that Fs are Gs'. Placing his emphasis on physical necessity as the basis for the F–G connection, Armstrong questions what the ontological ground for such a relationship could be and concludes that it must be inherent in the very nature of F-ness and G-ness (Armstrong 1983, 77). Moreover the necessary nature of this connection must, he argues, imply some feature common to all Fs, and correspondingly something identical in each G that makes it a G. It is only when this common thread is found in F-ness that we can start to say that being an F necessitates being a G. This natural necessity arises from the interaction of various properties of things in the world – the claim is that they are necessary relations that hold among universals. Consequently these relationships exist in a potential sense, quite regardless of whether any actual physical systems have actually instantiated them.

In this context SDA faces a rough ride. Indeed, the necessitarian perspective is really the only one that could instantiate the traditional violation-miracle understanding of SDA, a more technical account of which is that God at certain times and places in creation chooses to override this necessary connection to perform an action. However, recall Armstrong's delineation of the necessitarian account into a set of claims about either logical necessity or physical necessity. If we adopt the latter, then to assert that God performs violation-miracles is synonymous with an assertion that God fundamentally changes the nature of F-ness and G-ness, for example, at the time of that action. At the point of the violation-miracle taking place the 'usual' relationship between Fs and Gs is 'replaced' with a new one. On the basis of logical necessity, a violation miracle occurs by God overriding the necessary logical relationship between two entities.

Turning to assertions of SDA in general as opposed to the particular class of violation miracles, we are crucially not forced into the same assertions that one set of physical properties is 'replaced' with another. A potential theistic response would be to assert that it is inherent in the

nature of F-ness and G-ness that there is a certain flexibility in their relationship such as to accommodate the operation of SDA. The necessitarian account, taken at face value, would support such a claim because it does not require any actual instantiated instances for the law to remain valid – recall that it is the law that is ontologically primary and not the event. *This is precisely the point at which the issue of determinism begins to figure in debates about SDA.* As we shall see in the next chapter, asserting that a particular physical system is deterministic is to make an assertion about the intrinsic physical interrelationship between different ontological entities in that system. If a system is indeterministic, on the other hand, then it *may* be that there is enough inherent flexibility in the interrelations of its parts to accommodate SDA within a necessitarian account of physical laws.

In making the above assertion about possible flexibility incorporated within the necessitarian account we have, of course, adopted a position that is at odds with the claim that there exists a *necessary* relationship between these universals. This is the basic theoretical difficulty that arises in attempts to incorporate probabilistic laws (such as those commonly cited in relation to quantum mechanics) within a necessitarian methodology. The problem is essentially that if it is within the constitution of a particular F to be related in one way at one time to a G and have a different relationship to that G when SDA happens at another time, then it begs the question of how this transient F-ness and G-ness are related to the claim that the laws of nature must necessarily exist. It is crucial to acknowledge, however, that we are employing two different senses of the term necessary in this connection. Few necessitarian philosophers of science would make the claim that there is *only* one possible relationship between two given entities, a more defensible position is that the scope of all of the different possible relations between the entities in question is pre-determined in the form of a law of nature. Whether this scope is wide enough for it to be consonant with SDA is a matter we shall return to later.

We are, of course, left with the possibility that SDA might work in tandem with necessitarian laws. Such an argument has not been widely discussed, and it is difficult to see how we could articulate such an account. One proposal from Leckey and Bigelow raises the suggestion that even God's action is itself law-like and that thus it might be possible to frame some necessitarian laws of nature which would encompass it. On their approach the only consequence of making assertions of this type would be to limit the circumstances in which other laws would

apply (Leckey and Bigelow 1995, 116–17). This discussion is rooted in the authors' distinction between natural and non-natural states of the world as inimical to the concept of necessity. Yet, even without accepting such a distinction, or claiming that God's action is fundamentally nomological, it may be possible to limit the domain of applicability of necessitarian laws in such a manner as to accommodate some or other mechanism of SDA. Indeed this is a theme which we shall reconsider in chapter 8 of this book in relation to Nancy Cartwright's claim that the laws of nature only provide a 'patchwork' of explanation. Leaving this approach aside for the time being, however, it remains clear that there is little we can say about the hypothetical relationship between non-interventionist SDA and necessitarian accounts of laws without a more detailed knowledge of the mechanism of God's action. In order to be able to develop a substantive understanding of non-interventionist SDA in this light we need to investigate what features particular Fs and Gs might have in order potentially to support SDA. This task will occupy us when considering quantum and chaos theories below. So let us now turn to consider what has been widely claimed to be the most positive interpretation of the laws of nature from the perspective of SDA.

Irreducibly probabilistic laws

The claim that some, or even all, laws of nature are irreducibly statistical in form is relatively recent and was only fully articulated at the end of the nineteenth century. It has been enthusiastically welcomed in the context of non-interventionist SDA and particularly in connection with quantum SDA.[15] The early proposal that statistical laws might exist was probably first developed as a response to perceived difficulties in the necessitarian account by Charles S. Peirce (Peirce 1892). According to Paul Hanle there are echoes of Peirce's position in the work of a Viennese physicist, Franz Exner, whose argument in turn was adopted wholesale by Erwin Schrödinger and caused him to think along similar lines in the context of quantum theory (Hanle 1979, 227f.).

Leaving these historical issues aside, and using an analogue of Armstrong's physical necessitarian terminology discussed above, a paradigm

[15] The term quantum SDA is used throughout this book as shorthand for those attempts to link quantum mechanical indeterminacy with God's action. A detailed discussion of this position can be found in chapter 5 below.

statistical law would be of the form '99 of every 100 Fs are Gs'.[16] It would be a mistake, however, to presuppose that laws of this type necessarily imply indeterminism – it might be that G-ness is an expression of some more fundamental factor, and is thus only representative of a deterministic population count. One commonly discussed example to illustrate this fact considers a genetic trait lying behind the probabilistic law that almost all ravens are black (e.g. Dupré 1993, 178). The opposing assertion that *all* laws of nature are fundamentally statistical has, however, been argued by several influential advocates. Arthur Eddington, for example, made this claim as a result of his view that quantum mechanics was irreducibly statistical. Indeed he went so far as to deny that there was any such thing as strict causal behaviour anywhere in nature – all physics, he argued, is based fundamentally on probabilities behind which there are no more fundamental causal laws (Eddington 1928, 309). This claim had particular consequences in Eddington's emphasis on the contingency of future deductions on the basis of current laws of nature. Indeed he held, in an interesting parallel to John Polkinghorne's notion of downward emergence (see the discussion in chapter 7 below), that determinism was only an illusory perception of a more flexible underlying reality:

> Classical physics foists a deterministic scheme on us by a trick; it smuggles the unknown future into the present, trusting that we shall not press an enquiry as to whether it has become any more knowable that way. The same principle extends to every kind of phenomenon that we attempt to predict. (Eddington 1928, 308)

The key to Eddington's notion of illusory determinism lies in his statement above concerning bringing the future into the present, something he termed 'retrospective velocity'. When we attribute physical quantities to entities Eddington contends that these are anticipations of their future properties. Hence he argued that all scientific understanding of nature is fundamentally partitioned so that knowledge of one aspect of an entity precluded knowledge of other aspects until the world is considered retrospectively when all physical quantities become knowable. We may be forgiven for thinking that Eddington's proposal is rather extreme and possibly a little illogical – indeed he effectively denies any possibility of explanation in connection with statistical laws. One consequence of this position of forgoing claims about causality was that Eddington felt able to assert that he had resolved the free will debate to a certain extent as

[16] A classic example of a statistical law is the nuclear decay equation which relates the proportion of atoms of a particular type to a decay over a given time to a decay constant.

it relives any difficulty in relating the outcome of thought processes with deterministic laws (Eddington 1928, 332). And, while he did not discuss the implications of his position for SDA explicitly, he did make some interesting comments on the general possibility of supernatural agency in an analogous move to his free will argument:

> Another charge launched against these lectures may be that of admitting some degree of supernaturalism, which in the eyes of many is the same thing as superstition. In so far as supernaturalism is associated with the denial of strict causality . . . I can only answer that that is what the modern scientific development of the quantum theory brings us to. (Eddington 1928, 347)

Eddington's position is particularly interesting given his motivations from quantum mechanics. While it is clear from comments like these that he initially felt that the indeterminacy of quantum theory was a solution to the free will problem, he later retracted these comments. This was somewhat ironic because Eddington's famous popularisation of quantum theory clearly inspired many later attempts to posit a connection between free will (and analogously SDA) and quantum indeterminacy. In his 1934 lectures at Cornell University, Eddington suggested that the width of the Heisenberg Uncertainty might be a 'measure' of human freedom (Eddington 1935, 88). However only four years later he retracted similar comments as 'nonsense' (Eddington 1939, 182). It is clear, however, that Eddington is doing rather more than taking a simply statistical interpretation of the laws of nature in the positive assertions discussed above. He conflates indeterminism with his conception of natural law, makes claims about the ontological priority of indeterminism in nature, and consequently denies any strict causality. Of course under his interpretation SDA could be an objective possibility, by providing God is able to act in some kind of a causal mechanism.

Of course one is not required to follow Eddington's statistical assertion and Ernest Nagel and others have also attacked the quantum mechanical basis of his proposal. Indeed, Nagel argues that this interpretation of the laws of nature is based on the assumption that macroscopic objects are large-scale manifestations of fundamentally statistical quantum laws. This argument, he claims, is less than reliable – even if one considers the ambiguity surrounding the role of determinism in quantum theory (Nagel 1982, 312). Without getting involved in the intricacies of quantum theory (we shall leave these until chapter 6), it suffices to say that Nagel's argument is not as clear-cut as he presumed. Despite Nagel's insistence that the quantum origins of Eddington's position are highly questionable,

it is not the case that his critique can be applied to the more general work of Exner and Peirce who both developed a statistical interpretation of laws well before the advent of quantum mechanics. Indeed, if we take the less extreme viewpoint that only some laws of nature are statistical, then this viewpoint does appear to offer the only possibility for a coherent account of SDA that does not either raise insurmountable problems for natural explanations and conflate both natural and divine causality (like the regularity approach), or require a highly developed understanding of the mechanism of SDA for its coherence (like the necessitarian approach).

Robert Gleason has argued along these lines in connection with the laws of statistical mechanics which are generally presumed to be irreducibly stochastic. His definition of miracle encompasses three elements – that the action is physical, that it is observable and that it is produced by the action of God (Gleason 1962, 28). By placing an emphasis on the fact that the statistical laws of physics do not *rule out* the possibility of remarkable events taking place, Gleason asserts that miracles do not violate any natural or scientific laws whatsoever. He considers as a case-study the event of a man walking on water. In purely scientific terms, he argues, this event is explicable as an exceptionally unlikely statistical freak while remaining true to the laws of statistical mechanics. He sets the odds against things such as this happening as being of the order of 1 in $10^{1010000000000}$. He accepts, however, that the mere possibility that a particular event is physically possible does not necessarily mean that it provides a satisfactory explanation for a particular event, but when seen in a religious context that explanation becomes satisfactory.

Although it is tempting to reject Gleason's position solely on the improbability of its statistical basis, and the numbers involved are truly enormous, there are stronger *a priori* reasons why his claim is unsatisfactory left as it is. Implicit in his arguments are claims about the way in which entities governed by statistical laws can be determined by God. Accordingly, we further need to address how it is that SDA can be claimed in a sense which does not conflict with scientific understanding. This shall be examined in connection with Carl Hempel's notion of inductive-statistical explanation in the next sections.

THE POSSIBILITIES FOR NON-INTERVENTIONIST SDA

Before we begin to discuss the precise relationship between SDA and statistical laws it is interesting to consider the work of those who have

claimed non-interventionist incompatibilist SDAs in connection with other philosophies of the laws of nature. Most of these attempts have at their root a denial of the objective status of natural laws, and any basis of scientific law which focusses on their nature as descriptions rather than prescriptions is, of course, more open to the ontological possibility of SDA. Other theological discussions of the relationship between violation accounts of SDA and natural laws place emphasis on the inductive nature of law statements, and the fact that there is no *prima facie* reason to assert that our experience should repeat itself in the future (e.g. Coulson 1968, 70). There are similar and related arguments concerning the universality of scientific laws, and claims that they do not provide a blanket coverage of reality. Indeed philosophers such as Nancy Cartwright have suggested that laws only cover a patchwork of natural phenomena, rather than presupposing that a law exists for every physical interaction. We shall discuss this possibility in greater depth in chapter 8 below, but now turn to consider the possibility of God acting beneath the nexus of operation of natural laws.

Robert Larmer in an interesting book attempts to reconcile belief in SDA with that in objective laws of nature. He argues that it is possible to believe simultaneously in the possibility of miracles defined as God choosing to override natural processes, and yet not have to assert that in the process a violation of the laws of nature takes place (Larmer 1988, x). A miracle, he argues, has four essential elements: it is a physical event which goes beyond what nature can achieve on its own; it is produced by a rational agent; it is of an extraordinary kind; and it has religious significance. The first two of these define the essential character of the miraculous, whilst the latter two enable recognition that a miraculous event has taken place.

A law of nature is, for Larmer, a scientific law that is also a true representation of ontology (Larmer 1988, 19). Laws inherently not only contain terms that may be confirmed or denied on the basis of empirical evidence, but also consist of other terms which do not refer to observed regularities in nature but to other observable properties. Because of these two different types of term, Larmer argues that it is not possible for there to be direct confirmation of a physical law on the basis of observation alone. By speaking of a law of nature as explaining a particular event, Larmer argues that the laws cannot by themselves explain the particular occurrence. Thus scientific explanation cannot help but make reference to the underlying entities, or as Larmer calls it the 'stuff' of nature, upon which the laws operate. The basis of his argument is

that changes in this mass/energy substratum can be achieved outside the nexus of operation of the laws of nature and so provide a potential locus for miracle. As Larmer puts it, 'If God creates or annihilates a unit or units of mass/energy He breaks no law of nature, but He does . . . change the material conditions to which the laws of nature apply. He would thereby produce an event which nature on its own would not have produced' (Larmer 1988, 20).

Implicit in this quotation is the claim that knowledge of the complete set of the laws of nature entails a complete description of the workings of nature. God, in his scheme, performs SDAs by creating and annihilating mass/energy in crucial places such that the laws of nature are preserved, whilst the substratum on which they operate is continually changed. Of course, the substantial difficulty which Larmer is left to overcome is that such creation and annihilation of mass/energy by God would seem to violate one law of nature, namely the first law of thermodynamics. In order to overcome this problem he posits weak and strong versions of the law: in the former energy is conserved only in a causally isolated system; the strong version, on the other hand, states that energy cannot be created or destroyed (Larmer 1988, 61). This strong form, Larmer contends, cannot be adopted by a theist since the claim by definition rules out the possibility of *creatio ex nihilo.* Under this account, Larmer insists, the universe must be considered to be uncreated and indestructible. Larmer surely overstates his case here, and his theology is decidedly suspect, not least because it is an arguably sound theistic argument to assert that the laws of nature are products of God's creation of the world and are contingent upon it. It is thus not reasonable to make retrospective claims concerning the limitation of divine freedom in creating the world out of nothing on the basis of a set of laws which have only evolved due to its establishment.

The strong form of the principle of conservation of energy Larmer interprets as a defining postulate of physicalism and thus claims that it is actually *prima facie* contradictory with theism. As there exists no body of evidence that can confirm the strong form of the principle due to its essentially ontological character, Larmer feels that it can be abandoned and replaced with a weaker form which is more compatible with the possibility of miracle. Unsurprisingly Larmer's thesis has come under some criticism. Neil MacGill for example, focusses his discussion on whether Larmer successfully shows that miracles never violate a law of nature, and claims that conservation laws play a more fundamental role in physics than Larmer allows (MacGill 1992, 82). MacGill contends that

conservation of the 'stuff' of mass/energy is fundamental to law operation, and thus that Larmer's account is just as fundamentally challenging to existing scientific theory as law violation.

It is difficult to resolve these issues without a complex study of the philosophical basis of the laws of thermodynamics. It does appear clear, however, that at the very least Larmer's approach requires a radical reinterpretation of the claim that mass/energy is conserved in physical processes. However, were it possible to perform this reformulation to a satisfactory extent, it remains interesting to conjecture whether this type of 'behind the laws' proposal would be a possible approach to non-interventionist SDA. While it seems reasonable to reject the basis of Larmer's acceptance of the weak first law of thermodynamics because of his cosmological argument, were it possible to restrict the scope of the first law in the manner he seeks then he might be on firmer ground.[17] Indeed it is interesting to note that Larmer's position is not without earlier precedent. C. S. Lewis in his own inimitable style argued for basically the same approach to miracle:

> If I knock out my pipe I alter the position of a great many atoms: in the long run, and to an infinitesimal degree, of all the atoms there are. Nature digests or assimilates this event with perfect ease and harmonises it in a twinkling with all other events. It is one more bit of raw material for the laws to apply to, and they apply . . . If God annihilates or creates or deflects a unit of matter He has created a new situation at that point . . . The laws at once take it over. (Lewis 1947, 72)

Indeed it appears that Lewis' argument is clearly rooted in an assertion that laws of nature do not cause events to occur. An event, in both Lewis' and Larmer's accounts, is the operation of a natural law on some mass/energy in creation. What both of their arguments come down to is the claim that instead of asserting that God interacts with the laws of nature, he acts directly on the other element of each event – namely the matter which follows the laws. While it is certainly possible to claim that SDA operates by God altering the substratum of the universe in Larmer's and Lewis' manner, it seems difficult to claim that this is not achieved in a fundamentally interventionist way. Indeed such an approach is inherently at odds with the physicalist necessitarian approach to laws of nature in which the laws derive from the intrinsic properties in the nature of the

[17] Larmer's thesis may derive some potential support from the recent discovery of supermassive black holes in the centre of a large number of galaxies. The singularity at the root of these holes is a potential violation of the mass/energy conservation assumption he wishes to disprove. For a further discussion of the issue of singularities see Earman (1995).

entities they govern. Both proposals are moreover highly reliant on the feasibility of this weak interpretation of the first law of thermodynamics as outlined by Larmer.

Another approach to the claim that SDA is non-interventionist can be found in attempts to assert that SDA operates by means of an 'additional factor' in creation. This position was first clearly articulated by Sir George Stokes in his 1891 Gifford Lectures who emphasised that theists were not obliged to assert that God suspends the laws of nature in order to perform miracles, but acts by the 'addition of something not ordinarily in operation, or if in operation, of such a nature that its operation is not perceived' (Stokes 1891, 24–5).

Whilst this approach may initially sound attractive, there are great difficulties in articulating what form such a factor might take. Stokes' own approach to this difficulty was simply to deny that we can have any knowledge of it, however this hardly adds support to his positive proposal. Robert Young, in a recent and more sophisticated analogy to Stokes' claim, also argues that a miracle occurs by the addition of a 'new factor' to an existing system (Young 1972, 121–2). Young's proposal is to abandon the violation approach to miracle and focus on what he terms the doctrine of 'plurality of causes' – by this he means that sometimes there exists in nature more than one sufficient condition for a particular event to happen. Thus, Young argues, there are two kinds of laws: those which specify a sufficient condition of the effect and those which do not specify a sufficient condition; this latter class he refers to as making the effect only 'tacitly' specified. Young perceives God as performing SDAs without violating such laws – God only acts to change certain situational factors. In analogy with the fact that water boils at lower than 100°C in a region of high altitude, Young claims that God acts by providing new 'factors' in the situation such that the laws of science provide a different outcome. Given that there might be several possible sets of factors each of which is sufficient for a particular event to occur, Young's argument is that God as an active agent replaces one set of factors for another – a switch which, he argues, can take place without violating any natural laws.

His example, however, goes to show the complexity of articulating this account fully. The reason water boils at less that 100°C at high altitude is due to the fact that the pressure is lower. It is, however, difficult to imagine God acting in a non-interventionist manner in altering the air pressure in the world. It is also interesting to note that Young's concept of the plurality of causes *necessarily requires ontological indeterminism* as we

shall define it below. It thus makes sense to consider his proposal only in those areas of creation in which it is argued that physical processes are fundamentally indeterminate. Given this the plurality of causes account is really an adjunct to the claim that God is active in determining otherwise indeterminate entities.

INDUCTIVE STATISTICAL EXPLANATIONS AND SDA

We now turn to consider the relationship between SDA and the statistical interpretation of laws of nature in more detail. Much of the work on the nature of explanation in probabilistic laws finds its origins in Carl Hempel's famous *Aspects of Scientific Explanation* and is dependent on a distinction between inductive and deductive statistical explanations. The latter involves deductions of statistical statements from sets of explanans that themselves contain at least one statistical law. In essence a deductive statistical explanation is an explanation that is framed in terms of the probability of a class of events made on the basis of other probabilities (Hempel 1965, 381). Yet, as Hempel notes, this deductive notion is not of use in any discussion of particular events for it only explains ensembles of many events, and it is for this reason that he posits inductive statistical explanations. Considering the possible link between taking penicillin and recovering from an infection, Hempel concludes that all that can be said is that penicillin will give a cure in a high proportion of cases. But, unlike non-statistical explanations, it would be incorrect to presume that taking penicillin leads inexorably to a recovery, only that it does so with a high likelihood (Hempel 1965, 382–3). For this reason explanations of this type only derive their authority on the basis of a particular background of evidence (in this case that people have recovered by taking penicillin in the past) and accordingly probabilistic explanations of this sort can only be formed by inductive reasoning from this evidence.

So far we have been rather imprecise about this notion of explanation in both these inductive and deductive senses, and it is crucial to realise that in both the term is employed in quite different ways. Hempel argued explicitly that explanations were possible from probabilistic laws, but that they were composed of a fundamentally different logical character. Citing Richard von Mises' work with approval, Hempel argues that there is a fundamentally different sense of 'because' which applies in the case of this inductive statistical explanation (Hempel 1965, 393). Statements of the type that 'because the die was loaded' the number six shows more frequently (to cite von Mises' example) are logically different to deductive

explanations and yet, he argues, still remain a true sense of explanation for the particular phenomenon taking place.

One fundamental difference between deductive nomological explanation and inductive statistical explanations is what Hempel terms the 'Problem of Explanatory Ambiguity' (Hempel 1965, 394–7), and it is precisely within this ambiguity that claims about SDA are often located. Returning to Hempel's example of curing an infection by taking penicillin, the law invoked there only asserts that one will recover as a result of taking penicillin in a high percentage of cases, and there is no certainty of a cure being effected by the treatment in all cases. When a large number of reported cases are viewed together it becomes possible to frame statements using the different sense of 'because' identified above, but again there are significant problems when one seeks to explain a *particular* event. We may, for example, be correct in stating that 98% of microbial infections are cured by taking penicillin, but we cannot be certain that the infection carried by a particular person consists of microbes that fall in the 2% that cannot be treated by this means. Indeed for a given singular event, there will simultaneously be different probabilistic explanations which seek to explain it. The difficulty is that we are left with no firm grounds to be able to determine which of these explanations is good and which bad. Returning to the example of curing an infection it may be that the infection was cured by taking penicillin, lots of fresh air, eating lots of carrots, or indeed the action of God. The problem that Hempel highlights as an explanatory ambiguity is that there is no way of determining which of these equally good explanations is the correct one for that particular case. There is simply no analogy of this problem in simplistic forms of deductive nomological explanation – the reason being that if the premises of the argument are true, then the conclusions will also be true by implication (Hempel 1965, 394–5).

As an attempt to develop the above argument, Hempel considers the set K_t of all statements asserted or accepted by empirical science at a given time t. As our understanding of science changes so does the set K_t – new theories and assumptions are admitted into it, and others might be discredited and excluded. On the basis of this notation Hempel offers the following definition of this ambiguity:

> The total set K of accepted scientific statements contains different subsets of statements which can be used as premises in arguments of the probabilistic form just considered, and which confer high probabilities on logically contradictory "conclusions." . . . If one or two such rival arguments with premises in K is proposed as an explanation of an event considered, or acknowledged, in

science to have occurred, then the conclusion of the argument, i.e., the explanandum statement, will accordingly belong to K as well. And since K is consistent [Hempel assumes that the set K is closed under logical implication such that it contains every statement logically implied by its various subsets] the conclusion of the rival argument will not belong to K . . . No matter whether we are informed that the event in question (e.g., warm and sunny weather on November 27 in Stanford) did occur or that it did not occur, we can produce an explanation of the reported outcome in either case; and an explanation, moreover, whose premises are scientifically established statements that confer a high logical probability upon the reported outcome. (Hempel 1965, 396)

This is a complicated definition and it deserves some unpacking. Some of the constituents of this 'snapshot' of all current scientific knowledge, *K*, explain the same particular event in different ways. Given a statement that the particular event in question actually took place it is possible to produce contradictory explanations for that event while still remaining within *K*. Hempel also formulates a requirement of maximal specificity for inductive-statistical explanations. Essentially what this means is that we should ensure that our explanation takes into account all the information provided by empirical science, *K*, which is of potential explanatory relevance to the explanandum event. Thus, *all* relevant statistical laws, and facts relating to the operation of those laws must be included for a satisfactory explanation. Accordingly Hempel concludes that those statistical explanations that are possible are only relative to the current state of knowledge represented by *K* – there is, as he put it, an 'epistemic relativity of statistical explanation' as I-S explanations are only relative to the state of knowledge in *K*. Patrick Suppes has essentially combined this concept of epistemic ambiguity with a conservation of energy criterion to reach the conclusion that the issue of the operation of human free will is now replaced with questions about how non-energetic information can be introduced into causal systems (Suppes 1970, 95).[18]

We might be forgiven for asserting that in this notion of epistemic ambiguity we have a real possibility for the theoretical operation of SDA in a manner that does not conflict with the experimental regularities of the natural sciences. Yet, the situation is not as clear-cut as this. Firstly, while the ambiguity argument does seem to be an *epistemological* possibility for SDA, it remains unclear how SDA relates to ontology on this

[18] There are parallels between Suppes' account and the assertion that God acts by means of 'active information' – i.e. that he causes physical events to happen by inputting organisational information into a physical system rather than inputting energy. The great advantage of this approach, if it can be developed, would be that there is no potential conflict between agency on the basis of non-energetic information input and the energy conservation laws discussed in relation to Larmer and Lewis above.

account. This is despite the fact that it may be we can never accordingly scientifically *deny* a claimed particular instance of SDA in a probabilistic law on the basis that, were we to include theological assertions into our explanatory scheme, it could be argued that we have two potential explanations for a particular event – one as an SDA and one as a natural event. Viewed crudely the reason why accounts of SDA benefit from Hempel's 'epistemic ambiguity' is because it can never be said with certainty in an ambiguous probabilistic explanation for a particular event that God was *not* the cause of the event in question. The difficulty that remains, however, is that while such an ambiguity cannot rule out the possibility of SDA, it makes no positive assertions about its existence either. Crucially it offers no comment about how SDA might interact with natural causality and the ontological questions implicit in any claim of SDA. Indeed these questions can only be answered by considering those theories that are claimed to be irreducibly statistical or, to put it another way, ontologically indeterministic. It is thus not enough simply to claim that SDA occurs in those regions of epistemic ambiguity, one still needs to consider how indeterminism might be instantiated by particular physical theories.

A second problem with this simplistic connection between ambiguity and SDA is that many philosophers have doubted the coherence of Hempel's account and one such criticism is made forcefully by Nancy Cartwright. She distinguishes causal laws and 'laws of association'. The former, she argues, have the word 'cause' in them – Cartwright's examples include 'Smoking causes lung cancer'; the latter, on the other hand, are the familiar ones that explain how two or more quantities or qualities are associated with each other and can be either deterministic or probabilistic (Cartwright 1983, 21). Attempts to make claims for the existence of probabilistic causality such as that of Suppes fail according to Cartwright because, while it may appear that a cause should increase the statistical frequency of its effect, there is no way to distinguish whether other background correlations are producing the increase in frequency without us being aware of them. In connection with a claimed statistical law that a certain percentage of smokers contract heart disease, Cartwright considers the possibility that smoking may be linked to a predilection for exercise. Thus, even though smoking may make one more likely than average to have a heart attack, the fact that smokers also exercise more outweighs this factor and actually results in the contrary conclusion that smoking makes one less likely to have a heart attack. It would be wrong, she claims, to argue simplistically that smoking causes heart disease in this case (Cartwright 1983, 22–3).

Essentially all the arguments against the coherence of inductive statistical explanation take this form and emphasise the role of some unknown factor outweighing that which the explanation was originally dependent on (e.g. Salmon 1971). What this means is that it is necessary for there to be an additional condition on probabilistic causality such that the causal association claimed must operate the same way were the situation to be repeated. In connection with a purported anomaly in the application data for the graduate school at Berkeley, Cartwright concludes that

> only partitions by causally relevant variables count in evaluating causal laws. If changes in probability under causally irrelevant partitions mattered, almost any true causal law could be defeated by finding, somewhere, some third variable that correlates in the right ways to reverse the required association between cause and effect. (Cartwright 1983, 38)

All of this appears extremely positive from the perspective of our quest to attain a causal account of SDA. Yet, despite the two sources of ambiguity now identified in the above discussion, we are still left with the need to justify how it is that a particular theory can instantiate these statistical laws. It is for this reason that the role of indeterminism is so central to any discussion of SDA on these terms. It is important, however, to note that any epistemic ambiguities ripe for exploitation by a believer in SDA can only be used in the framework of the theory itself. In this sense assertions of SDA through statistical laws are rather more restrictive than the more general notions we have considered above concerning mass/energy changes for example. Indeed, when we turn to consider the possibility of SDA in a paradigm case of a statistical law – the projection postulate of quantum mechanics – we shall see how these restrictions can lead to a very limited non-interventionist account of incompatibilist SDA indeed.

CONCLUSIONS

Despite the fact that the development of the concept of natural laws is arguably parasitic upon belief in a creator God, it is notable that in the past two hundred years almost all accounts have sought to downplay the theistic element. Indeed in necessitarian accounts in particular there remains a large extent to which the concept of a divine planner has simply been replaced with an autonomous notion of physical necessity. As Swartz has put it,

> The Necessitarians' nontheistic view of the Laws of Nature surreptitiously preserves the older prescriptivist view of Laws of Nature, viz. as dictates or edicts

to the natural universe, edicts which – unlike moral laws or legislated ones – no one, and no thing, has the ability to violate. (Swartz 1999)

As Swartz shows, a result of this assumption is that necessitarian claims that a particular physical event is ruled out by the laws of nature (and thus must in some sense be a violation of them) are actually *factual* statements about the non-existence of the particular event, rather than the nomological claim that such an event is not physically possible. The implication in terms of SDA is that in order for a necessitarian to claim that an event is a miracle he or she would need to specify the logical or physical basis upon which such an event is impossible. Where the laws of nature are taken to be deterministic this is potentially possible, however when the laws are irreducibly statistical and Hempel's notion of epistemic ambiguity comes into play, the task becomes significantly more complex. In short we are forced to move again from these general considerations of God acting through 'natural laws' to the actual instantiated laws themselves. It is only when SDA is considered in the light of each physical law and the domain of applicability of each law known that we can formulate any detailed position on the subject of violation-miracles.

Moreover we have seen how little the other main conceptions of the laws of nature conflict with an non-interventionist understanding of incompatibilist SDA. The regularity account simply formulates new laws on the basis of any SDAs (and free actions of human beings) that take place in the world, and accordingly the traditional understanding of violation-miracle becomes *prima facie* impossible. The instrumentalist account denies interventionist SDA on the basis that laws of nature are merely human constructs, but raises significant issues about the human identification of surprising and visible SDA events. Again, however, it does not rule out the possibility of hidden forms of incompatibilist SDA.

The view that the laws of nature are inherently statistical can be easily absorbed into a regularitarian account, but more significant issues are raised in connection with the necessitarian necessity assumption. In particular there are difficulties in relating the proposition that 50% of Fs are Gs with any physical notion of F-ness and G-ness and this led Karl Popper to what he termed the propensity theory of probability. Yet a common theme throughout all of these questions about the status of SDA is that a detailed understanding of how particular physical theories do or do not instantiate determinism is a required element of any coherent account of SDA, and these are the issues to which we turn in the next chapter of this book.

CHAPTER FOUR

Determinism and SDA

The first point which is regularly made about the concept of determinism is that it is a *positive assertion* about the interconnectivity of the causal sequences that exist in the world. Arthur Eddington put this point starkly when he described himself as an indeterminist for the same reason that he was an 'anti-moon-is-made-of-green-cheese-ist' (Eddington 1932, 238). The point he sought to make was that, just as the green-cheese interpretation of lunar construction is a conjecture, so too is the claim that all the natural processes of the world are deterministic. Both, he argued, are fundamentally irrefutable claims about the nature of reality of a type that can be invented *ad nauseam*. Of course since Eddington wrote this passage man has been able to land on the moon and verify that it is not constructed of cheese, and it is arguable that his green-cheese conjecture is experimentally verifiable. The point still remains, however, that making the claim that the world is determinate and fully interconnected is essentially a metaphysical assertion about the interconnectivity of ontology. Indeed because it remains an assertion which is exceedingly difficult to 'prove' on a universal scale, as this would require perfect knowledge of every physical mechanism in the world, many philosophers have been keen to assert that it is belief in widespread indeterminism which is the more natural and justifiable approach.

This concept of indeterminism is one which is fundamental to many of the modern debates about the relationship between science and theology. It is presented in a variety of forms: for example, in contrast with a series of closed causal processes; as the lack of a relationship between universals embodied in the essence of matter; and as an implication of the lack of experimental predictability of the future. There has, however, been relatively little work at unpacking these various notions of indeterminism in the context of SDA and also relatively little in examining what it is that makes a particular system determinate or indeterminate. While it is commonly believed, for example, that Newtonian physics is

deterministic and thus 'rules out' SDA, and that quantum physics on the other hand is indeterministic and open to the possibility of divine causation, the construction of deterministic models in science is actually far more complex and subtle than might be first assumed. Many theologians draw heavily on these bold assertions about the nature of determinism and indeterminism with only scant regard for the philosophical underpinnings of their work. In particular we shall see how it is important to recognise that there is a large gap between the basic notion of determinism as embodied in a particular physical theory and more general metaphysical assertions concerning the closed causal nexus of the whole of nature.

Before we begin, however, it is necessary to examine more closely what it is that we mean by 'determinism'. Roy Weatherford has distinguished eight different forms: physical, psychological, theological, logical, special, Marxist, sociobiological and cultural (Weatherford 1991, 3–7). Each of these, Weatherford argues, is characterised by different features and makes different corresponding claims about the nature of physical reality. For the purposes of relating SDA to science, however, we shall focus almost exclusively on physical determinism – or an examination of what 'determinism' means in the context of the natural sciences. It is not particularly easy to formulate a definition of this notion of determinism. Any attempt which exclusively finds its roots in the terminology of linked causes and effects cannot remain unambiguous because of the obscurity surrounding the notion of cause in modern philosophy of science. Moreover from the perspective of SDA it is helpful to be able to consider determinism in relation to particular physical laws and theories, and the concepts of 'event' and 'cause' are not used univocally across the entire remit of science (Butterfield 1998, 35). Furthermore John Earman has argued that the concept of determinism may remain fundamentally elusive for a similar reason:

> we cannot begin to discuss the implications of physics for the truth of the doctrine of determinism until we know what determinism is; on the other hand, no precise definition can be fashioned without making substantive assumptions about the nature of physical reality. (Earman 1986, 4)

Earman is surely correct to note this basic circularity inherent in any attempt to define determinism precisely. The problem is that the nature of these assumptions about reality varies as we move from one sphere of science to another. Newtonian physics is, as Earman convincingly shows, built on quite a different framework to general relativity or quantum

theory, and accordingly our definition of determinism must be different in each theory. Hence it is quite possible to be precise about what we mean by determinism in special relativity, for example, but any definition framed in that theory necessarily breaks down when we try to apply it univocally to quantum mechanics. This problem of course makes it particularly difficult to justify broad assertions that the whole world is deterministic when framed on the basis of determinism as understood in one particular theory (often Newtonian mechanics). Indeed it makes it clear quite what a theory-laden assertion it is that a particular physical system is deterministic.

Despite this difficulty there surely remains a sense in which scientists and theologians are quite at home with this basic concept of causal interconnectivity despite the fact that it can be fiendishly difficult to articulate fully. As an attempt to circumvent this problem as much as possible, let us consider two possible notions of determinism which formulate quite precisely what we mean by the concept, and yet still remain reasonably distinct from the difficulties surrounding the concept of cause (and by implication prediction). The first is that described by William James in an address to the Harvard Divinity students in 1884:

> It [determinism] professes that those parts of the universe already laid down absolutely appoint and decree what the other parts shall be. The future has no ambiguous possibilities hidden in its womb: the part we call the present is compatible with only one totality. Any other future complement than the one fixed from eternity is impossible. The whole is in each and every part, and welds it with the rest into an absolute unity, an iron block, in which there can be no equivocation or shadow of turning. . .
>
> Indeterminism, on the contrary, says that the parts have a certain amount of loose play on one another, so that the laying down of one of them does not necessarily determine what the others shall be. (James 1979, 117–18)[1]

James continues by associating determinism with a denial of the ontological status of alternatives and indeterminism with the existence of open possibility, features that are widely claimed in contemporary discussions of SDA. In accordance with Earman's argument above concerning the contextual nature of determinism claims, it is important to note that James' identification is based on a classical world-view with its

[1] James distinguishes between 'hard' and 'soft' varieties of determinism and this has led to some confusion. It is crucial to note that this distinction is not based on any ontological difference – rather 'soft' determinism shrinks from applying the same 'harsh words' and repudiates fatality and necessity placing its focus on claims of freedom. The difference is thus purely semantic rather than epistemological or ontological (cf. James 1979, 117).

corresponding emphasis on observer-independent simultaneity. Indeed James could hardly have been aware that the very 'iron block' he refers to as so paradigmatic of determinism is in fact composed of a lattice of positive ions surrounded by a potentially indeterministic quantum-mechanical-electron-cloud! In parallel with James' identification above, indeterminism shall be taken for the purposes of this book to be the simple logical negation of determinism.

It should be becoming clear why it is important to stay clear of the concept of cause in formulating our definition. The world, for example, can be described as deterministic on James' account if we make the assertion that the state of the world at any particular moment is the *cause* of the state to follow inexorably from it. However some caution is needed even here, for as Earman notes, the claim that every event has a cause does not necessarily imply that there are no ambiguous possibilities in nature's womb (Earman 1986, 6). At the root of James' approach are parallel claims about the interconnectivity of causal sequences and that no events can take place if they do not have a naturalistic cause. Despite these difficulties, it is precisely James' focus on 'ambiguous possibilities' and 'loose play' as characteristics of indeterminism that makes his definition so germane to contemporary debates about SDA. It is precisely in this 'loose play' or 'gappiness' in the causal interconnectivity of nature that many claims for SDA are expounded.

A second and closely related way of describing determinism has been given using more formal logical apparatus by Richard Montague. Essentially Montague argues that determinism is a property of a particular theory, and such a theory is deterministic if for any two such systems: iff, at a particular given time, they are in an identical state then, according to the theory, they will at all future times be in identical states to each other (Montague 1974). Montague makes a distinction between historical and futuristic determinism and asserts that a particular theory is deterministic when both hold – i.e., that the determination of states proceeds in both temporal directions (Montague 1974, 321). As Butterfield points out, it is of course possible to extend Montague's work by contextualising specific physical theories. If we adopt James' 'vision' of determinism as categorising a world in which SDA is an objective impossibility, we must go some way towards providing criteria by which we could assess whether ours is such a deterministic world. It is precisely upon these considerations that much contemporary debate about SDA focuses. However, as we shall see, much of the basis of these discussions may be misplaced.

INDETERMINISM AND PREDICTABILITY

It is certainly natural for scientists to make a connection between being able theoretically to predict a particular phenomenon and it being governed by a deterministic mechanism. Stephen Hawking is one such author who makes a direct connection between the lack of prediction in quantum theory and a denial of Pierre Simon de Laplace's conception of a deterministic universe (Hawking 1998, 63). Indeed, Laplace provided what is perhaps the most influential definition of determinism constructed on the basis of predictability. His short discussion *Concerning Probability* contains the widely quoted passage in which he begins to offer a causal definition of determinism and then develops it in terms of prediction. Laplace begins with a statement of the principle of sufficient reason – that events cannot occur without a cause producing them. This, he argues, leads to an assertion that

> We ought to regard the present state of the universe as the effect of its anterior state and as the cause of the one to follow. Given for one instance an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings which compose it . . . for it, nothing would be uncertain and the future, as the past, would be present to its eyes. The human mind offers . . . a feeble idea of this intelligence. (Laplace 1951, 4)

This is Laplace's famous predictive demon who, assuming that humans are denied incompatibilist free will, and that incompatibilist SDA does not also take place, and further that the universe is deterministic, could predict the outcome of every physical event in the world. The crucial point about Laplace's definition above is that it is framed in terms of predictive capabilities and thus is highly dependent on what level of epistemological knowledge is attributed to the demon. Leaving aside the large literature on the problems in reconciling Laplace's definition with human free thought (e.g. Green 1995, 149), it remains clear that a fundamental feature of Laplace's approach to determinism rests on the extent of the knowledge that the demon possesses. To claim that a given system (or the whole world for that matter) is deterministic is, however, a claim about the ontology of the world and thus fundamentally different to the claim that by using a law of science we can predict its operation. To recall the distinction between laws of science and laws of nature discussed in the previous chapter, to make a claim that the world is deterministic is to claim that the laws of nature are deterministic. The argument is not, of course, that epistemological scientific prediction can tell us nothing about this ontological reality, to do

so would be to adopt a radically anti-realist approach to science. What we do need, however, is to keep a sense of proportion in relating these two closely allied concepts – it follows that, given sufficient knowledge of its operation, a deterministic system is predictable, but it does not necessarily follow that an unpredictable system is indeterministic. As we shall see in our discussion of chaos theory below, it is quite possible to consider systems that are inherently unpredictable, even if there existed a computer the size of the known universe to calculate them, and yet which remain governed by very simple and wholly deterministic equations.

Karl Popper in his well-known work *The Open Universe* makes a direct connection between predictability and determinism. Popper was a proponent of the position that the world is fundamentally indeterminate on a similar basis to Eddington's claim that determinism remains a positive assertion about the operation of physical processes (Popper 1982, 41). He distinguishes between 'religious' determinism, which he argues is characterised by Luther and Calvin, and 'scientific' determinism which originates, he argues, from replacing God with an autonomous conception of nature (Popper 1982, 5–6). Indeed in a direct analogy with 'religious' determinism, Popper makes similar claims for the omnipotence and omniscience of non-deified 'nature'. These claims are so strong that Popper asserts that the basis of 'scientific' determinism is that

> the structure of the world is such that every future event can in principle be rationally calculated in advance, if only we know the laws of nature, and the present or past state of the world. But if every event is to be predictable, it must be predictable with any desired degree of precision: for even the most minute difference in measurement may be claimed to distinguish between different events. (Popper 1982, 6)

This paragraph deserves some unpacking. Popper begins by setting determinism on a similar ontological footing to the one we are advocating here, yet he conflates this ontological account with a requirement of 'rational calculation in advance'. Thus he creates an ontological ground for epistemological predictability. The problem he is left with, of course, is that any assertions about the predictive calculability of a particular system cannot give us information as to the status of its determinism without adopting a naïvely realist philosophy of science. In a helpful discussion Earman critiques what he calls Popper's 'wrong headed' position (Earman 1986, 8–9), however there is more complexity in Popper's thought that Earman acknowledges. Indeed crucially Popper also

identifies a third type of determinism which he claims is fundamentally 'metaphysical' in character:

> all events in this world are fixed, or unalterable, or predetermined. It does not assert that they are known to anybody, or predictable by scientific means … Everyone knows what we mean when we say that the past cannot be changed. It is in precisely the same sense that the future cannot be changed, according to metaphysical determinism. (Popper 1982, 8)

This sense of 'metaphysical' determinism is much closer to the ontological spirit of James' definition which we have adopted as the most useful theologically. Indeed the parity Popper seeks to draw between the past and future being unchangeable accords closely with James' notion of the future being 'fixed from eternity' or an 'iron block'. This form of determinism is, Popper emphasises, not scientifically investigable and he consequently dismisses it for the reason that it remains a conjecture that can never be fully tested or verified. Despite these claims, Popper still asserts that if either a pervasive scientific or religious determinism exists then metaphysical determinism is also implied and hence there must also exist an unempirical element to both of these concepts. Indeed it is by criticising scientific determinism that Popper concludes he has similarly undermined metaphysical determinism (Popper 1982, 89f.).

Given that the more theologically interesting notion of metaphysical determinism is parasitic on Popper's account of scientific determinism, a close study of that concept is necessary. Popper defines his scientific determinism in an attempt to replace the vague idea of Laplace's emphasis on foreknowledge with that of 'predictability in accordance with rational scientific procedures of prediction' (Popper 1982, 33). When this predictability is complete for a given closed physical system such that a future state can be predicted to any required degree of precision by these rational procedures, then that system is scientifically deterministic. Popper reconceived Laplace's demon as a 'super-scientist' who was supposed to be only capable of those things that human scientists can do, except that he performs his experiments with infinite precision. Moreover, Popper's demon is not able to ascertain initial conditions with infinite precision and acts as an embodied agent in the world he is trying to predict (Popper 1982, 30–4). Given this definition we should not be at all surprised that Popper's 'scientific' determinism fails, not least because his approach seems contrived to a world in which chaos theory exists.

Popper's discussion is thus more an argument about the epistemological limits of scientific prediction than any notion of determinism in

the ontological Jamesian sense. While it is at first sight remarkable that no theologian has picked up on Popper's famous argument for indeterminism and connected it to SDA, this may be no bad thing since what Popper really teaches us is not so much that determinism fails, but that establishing predictability as a sufficient test for determinism is simply incorrect. In short, it is perfectly reasonable to identify predictability as a 'symptom' of determinism; it is incorrect, however, to say that just because a particular system is predictable it is therefore determinate.

THE THEOLOGICAL STATUS OF INDETERMINISM

So far we have dealt with the concept of determinism and its corollary, indeterminism, in the abstract. We have seen how crucial it is to the connection between SDA and indeterminism that the latter is taken in an ontological sense as a statement about the construction of the world, rather than our knowledge of it. Much of the rest of this book will be occupied with evaluating the various claims made for indeterminism in particular physical theories and SDA.

If we deny that there is any fundamentally dualistic aspect to the world as created by God, we have some difficulty in describing the nature of indeterminism in the context of creation *ex nihilo*. Indeed, at first sight, it seems difficult to see in what sense indeterminism might be created and sustained by God or, to put it another way, how indeterminism and general divine action might be related. Given the common assumption that indeterministic processes form part of the physical universe we inhabit, we naturally beg the question as theologians to describe how God is related to those processes. Indeed the only sense in which indeterminism appears coherent is as a product of a divine kenosis, or God voluntarily withholding his knowledge, concerning its mechanism. However if this is the case then we must address the problem of how God is active in some indeterminate processes without compromising this mechanism or his lack of knowledge of it.

An extreme position could be represented by the claim that the only real source of indeterminism in creation are those events which arise as a product of SDA – i.e., all indeterminism in creation is a result of the free will of God. That position can find balance in the opposite extreme, advanced by Arthur Peacocke in connection with the Heisenberg Uncertainty Principle in quantum theory, that SDA is prevented in some indeterministic regimes since God cannot 'see behind' indeterministic events

any more than we can (Peacocke 1998, footnote 31).[2] The compromise position between these two extremes is rather more complex than many have given credit, and only rarely has this issue been discussed. As John Wren-Lewis has noted,

> The modern use of the concept of randomness, however, forces the problem on us in quite a different way . . . I do not think theologians who have considered this issue have recognised its full gravity. They have mostly been content to argue that even if we don't know exactly how an electron is going to jump from one atomic orbit to another, God does – but that begs the question completely. For the whole point of the so-called 'laws of chance' governing collections of random events is that they presuppose that there is no order whatsoever in the individual events: that being so, just what does the statement that they are under God's control mean? (Wren-Lewis 1958, 276)

While the indeterminacies of quantum theory may well be ontological in the sense that no amount of human scientific development will ever shed any light on their operation, it must remain an open question whether this indeterministic ontology is also extended to God. It is a central presupposition of all arguments for the action of God in irreducibly statistical processes that God can 'see behind' the indeterminism and thus control and manipulate it to his own means. But the theologian is left with the sticky problem of how it is that God might be active without overruling this indeterminism entirely. David Bartholomew is one of the few people to have appreciated the difficulty of this problem:

> I find it impossible to frame any statement about God's action in generating random events which avoids the notion of design on his part and so justifies us in saying that chance events are without any explanation whatsoever . . . To allow the existence of pure chance [ontological indeterminism] is rather like saying that God can choose to act so that his left hand does not know what his right is doing. Or to put it more formally: that there must be sources of independent action within the one Godhead. (Bartholomew 1984, 102–3)

The problem is actually quite closely related to the basis on which many scientist theologians have been led to reject violation miracles, namely inconsistencies with the principle of divine constancy and reliability. Indeed, given the fact that the majority of claims about God's action through indeterministic processes also reject violation miracles, the issue

[2] It is argued in chapter 6 below that this reading of the Heisenberg Uncertainty Principle is misplaced for the reason that the principle concerns the limits of our epistemological knowledge, rather than the underlying deterministic evolution of the wavefunction under the Schrödinger equation.

of how processes can be both indeterministic and occasionally determined needs to be addressed in considerably more detail. The Biblical account of a 'chaos', which was overcome by the faithfulness of Yahweh's actions, may be somewhat more helpful in this regard since it posits an intrinsic duality in nature. Unfortunately this fundamentally dualistic approach is denied by the later doctrine of *creatio ex nihilo*, and we are thus left with the need to articulate a selective divine kenosis of indeterministic events. Essentially the position must be that God only chooses to know about the indeterministic processes he sustains on the occasions of his action, and does not 'pay attention to them' at other times. Another approach to this issue could be formulated by placing emphasis on the fact that the contradiction is dependent on the human concept of design. One of the assumptions behind the difficulty is that *all* physical processes have behind them some design and mechanism, and if this argument is denied then it becomes considerably easier to assert that God is active in determining only some otherwise indeterminate processes. Such a move is, however, extremely costly in the sense that it effectively partitions off the indeterministic processes from human speculation and challenges much of the basis of the assertion of general divine action as constitutive of the world.

If we leave these problems aside, we should also appreciate quite how difficult it is to devise a coherently deterministic interpretation of physics. John Earman's important book (to which this chapter owes a debt) has been responsible for a radical shift in the understanding of determinism – he has shown precisely how difficult it is to construct physical theories that satisfy even the Laplacian epistemological requirements for determinism. Considering Newtonian mechanics, Earman is famous for his insistence on the importance of boundary conditions in order to prevent causally active 'space invaders'. Essentially Earman's argument is that because there is no limit to the speed with which causal entities can propagate in Newtonian space–time, it is possible for causal factors to 'zip in' to a given situation and thus break determinism (Earman 1986, 33–5).[3] More fundamental objections have recently been raised in this connection by those who claim that there exist singularities in Newtonian mechanics that are not collision dependent (e.g. Xia 1992).

It is widely accepted by most proponents of non-interventionist SDA that the world contains at least some irreducibly statistical laws of nature.

[3] There are those who have argued that this approach is of little relevance to the real physical world because Newtonian physics remains an abstraction at the very best. Indeed a helpful critique of Earman's position can be found in Wilson (1989).

The view is essentially that these laws specify only the variety of events possible, and if sufficient factors are known, can be used to derive the probabilities of their occurrence. Yet, as Hempel notes (see chapter 3 above), any given event may be influenced by a large number of probabilistic factors of which one might be an SDA. Moreover, there may often be no way in principle of being able to tell whether a particular proposed cause actually is needed for the production of a given effect. All of these features of statistical laws and indeterminism lead the theologian naturally to posit SDA in these processes. Certainly, if Inductive Statistical explanation is correct, there is no danger of the progress of science closing the epistemological holes left open. Indeed, it is important to note that this is the case in principle regardless of which particular set of statistical laws are claimed to instantiate SDA (be they quantum, chaotic or whatever).

This short discussion of determinism complements that on the laws of nature above because of the necessity of exploring particular physical laws and interactions to determine whether they bear any consonance with SDA. Throughout the discussion we have been dealing with these concepts in the abstract and it is time to perform some more detailed analysis of the particular physical theories. We shall return to more general issues about the relationship between the laws of nature, indeterminism and SDA in the final chapters of this book, but the time has now come to consider the very common claim in contemporary science and theology that God is active in an incompatibilist sense by determining otherwise indeterministic quantum events.

CHAPTER FIVE

Divine action and quantum theory

Up to this point we have been dealing almost exclusively with the theoretical concepts of indeterminism, the laws of nature and various theological approaches to SDA. The next three chapters of this book consider in detail the two areas of modern science that are most commonly claimed to be consonant with SDA, namely quantum theory and chaos theory. In the discussion that follows it is presumed that the reader is reasonably conversant with the historical background to the discovery of both theories and the principal philosophical consequences of the different interpretations of quantum theory.[1]

It may seem from a cursory reading of current scholarship on the potential relationship between SDA and quantum theory that the proposition that God determines quantum processes is relatively recent. It is clear, however, that this assertion has been a consistent element of the philosophical wrangling over the interpretation of quantum theory for at least the past sixty years. Indeed, while William Pollard's famous work *Chance and Providence* set the agenda for contemporary debates (Pollard 1958), it is erroneous to view this work as the sole origin of the proposal that God is active in quantum events. As we shall see, it is clear that Pollard was himself influenced by Karl Heim and adopted a very similar notion of God's interaction with quantum theory to that proposed by Heim. We shall also survey some of the other pre-Pollard attempts to link quantum theory and SDA (hereafter referred to as 'quantum SDA'), as expounded by Arthur Compton, Eric Mascall, Edmund Whittaker and George Thomson, as well as the recent revival of quantum SDA in contemporary science and theology scholarship. This speculation about a potential connection between an indeterministic interpretation of quantum theory and divine action did not occur in a philosophical vacuum.

[1] An introduction to the philosophy of quantum theory can be found in Rae (1986) and Polkinghorne (1979). A detailed historical account of the various philosophical interpretations of the theory can be found in Jammer (1974).

Indeed the highly bizarre nature of the implications of quantum theory occupied the founding fathers in parallel with their experimental studies. However we shall not focus on the history of the development of quantum mechanics in this study, nor on the broad cosmological and theological speculations that were made by these scientists as these issues remain on the periphery of our focus on divine action.

Almost all of the founding fathers of quantum theory accompanied their mathematical work with abundant philosophical speculation and in many cases this included theological thought. However, much of this argument as it relates to the philosophy of religion has been motivated by very different objectives on the part of the very different personalities of quantum physicists, and before we begin to discuss the claims for quantum SDA it is helpful to attempt a basic taxonomy of these discussions. It would appear that there are three broad types: broad cosmological assertions as a result of quantum theory; discussions in which quantum theory is used metaphorically to develop an element of theological doctrine; and assertions that traditional theological doctrines are supported by quantum mechanics.

The first type finds its origins contemporaneously with the development of quantum theory and was commonly advanced by practising scientists as opposed to theologians (such as Einstein, Bohr, Schrödinger, and more recently Hawking) who were fascinated by the philosophical implications of their theoretical scientific work. In general these reflections deal primarily with questions relating the cosmological implications of quantum theory to the doctrine of creation. Frequently they begin with an axiom of the theory of quantum mechanics and proceed to find wider implications for that axiom. It is possible to sub-divide them further into two groups: scientists such as Heisenberg and Eddington who concluded that, because of quantum mechanics, rigid causality has no real validity; and those such as Planck, Einstein, and more recently Penrose (1989), who have argued that current quantum theory is inadequate and that there exists a better, as yet unknown, model (although they differ greatly in their assertions as to what form this model should take).

A second mode of discourse concerned the appropriation of quantum mechanical concepts into theological discourse. Two common examples make this approach clear. Some theologians have claimed that the wave/particle duality inherent in quantum theory is a metaphor for the dual human and divine natures of Christ. Another more widespread example is seen in those theologians who have sought to adopt the related notion of quantum complementarity into the context of theological

explanation. This latter move is particularly in vogue in some circles of the theology and science debate and is taken to support the general notion that theology and science are complementary and mutually exclusive perspectives on the same reality. Ian Barbour has argued very convincingly against this wholesale appropriation strategy, and has developed a number of useful checks on its more limited application (Barbour 1998, 170f.).

A third mode of discourse takes as its premise elements of theological doctrine (such as divine action, the trinity and the resurrection) and then attempts a predominantly apologetic use of quantum theory to support these doctrinal concepts. Discussions using these theological bases often sit uncomfortably on what is frequently referred to as 'traditional' or 'Biblical' theology which, as we have seen in the context of divine action, are both inherently slippery concepts. Moreover it is common for these modern-day apologetic strategies to be widely, and sometimes unfairly, criticised as 'God of the Gaps' (or, more accurately, God of the stop-gaps) theology. This phrase owes its origins to Dietrich Bonhoeffer and is a warning against using God as an explanatory principle for plugging gaps which scientific explanation might close at some future date. Bonhoeffer's position was essentially that it is wrong to invoke God as an explanatory principle where human knowledge is incomplete. Probably the clearest expression of his view can be found in his letter to Eberhard Bethge on 29 May 1944:

> Weizsäcker's book *The World-View of Physics* is still keeping me very busy. It has again brought home to me quite clearly how wrong it is to use God as a stop-gap for the incompleteness of our knowledge. If in fact the frontiers of knowledge are being pushed further and further back (and that is bound to be the case), then God is being pushed back with them, and is therefore continually in retreat. We are to find God in what we know, not in what we don't know; God wants us to realize his presence, not in unsolved problems but in those that are solved. (Bonhoeffer 1971, 311)

The point Bonhoeffer was making is that having God as a 'stop-gap' to plug holes in human knowledge is a risky strategy because the holes might be plugged by other means. The claim is stronger than this, however, because Bonhoeffer limited his theological enquiries to those problems he considered 'solved', and was thus solely occupied in an examination of the implications of what we have knowledge of, rather than speculation about the unknown. The precise limits of what he considered known and unknown are rather unclear, but various comments about the nature of

scientific knowledge throughout his letters lead to the conclusion that he would have resisted any detailed discourse between science and theology at all on similar grounds.

This final mode of discourse is the one into which most of the authors we consider in this chapter fall, and many of them have addressed Bonhoeffer's caution head on. It is important to note at this stage, however, that Bonhoeffer's God of the stop-gaps argument is not of such force that it renders meaningless any attempt to link God and the scientifically unexplained. We are at liberty to disagree with Bonhoeffer's highly conservative stance concerning the remit of theological investigation, and accordingly his argument forms nothing more than a salutary note of caution about such speculative links rather than an argument from principle.

When reading this literature on quantum SDA it is important to note the fact that these differing modes of discourse can lead to very different perspectives on the same relationship. The famous example of Einstein's comment that 'God does not play dice' was as much a statement about the nature of quantum indeterminacies as the essence of the divine. Einstein believed passionately in a deterministic and predictable world underlying the science of quantum theory and thus rejected any interpretation of quantum theory that claimed that the probabilities inherent in the theory were indicative of indeterminism.[2] The same subtlety is needed to appreciate the different objectives of the physicists considered below. As we shall see, a later consideration of several contemporary proponents of quantum divine action emphasises how little the original quantum SDA thesis has been developed despite the radically different theological perspectives brought to this discussion.

PRE-POLLARD QUANTUM SDA

We shall begin with one of the most interesting early discussions of the relationship between quantum theory and free will: Arthur Compton argued extensively for the process of a selection of otherwise indeterminate quantum phenomena. Compton was principally known for his celebrated X-ray scattering experiments which provided direct and early confirmation of quantum mechanics. In keeping with his fellow physicists

[2] As Einstein once said, 'I cannot bear the thought that an electron exposed to a ray should by its own free decision [aus freiem Entschluss] choose the moment and the direction in which it wants to jump away. If so, I'd rather be a cobbler or even an employee in a gambling house than a physicist.' Einstein quoted in Jammer (1974, 124).

he also maintained a strong philosophical interest throughout his work and particularly focussed on the question of free will. Although Compton was relatively quiet about the general possibility of SDA, he did make an explicit connection between divine action and the processes of evolution, and his discussion of free will is particularly interesting because it pre-empts many later attempts to formulate more developed notions of quantum SDA.

Compton describes a photon diffraction apparatus whereby a photon from a source passes through a slit and might be diffracted in several different directions. He is explicit about the need to link free actions with a mechanism which does not violate the laws of nature (Compton 1935, 60). Compton's work is particularly important in this respect because it may well represent one of the earliest insistences on connecting the concept of agency with non-intervention in quantum processes. The approach Compton adopts to this relationship is quite esoteric. He considers what he terms an 'imaginary mechanism' whereby it is possible to show that determination of an event by non-physical factors need not consequently involve any violation of physical laws. Compton's thought experiment concerns a situation in which a photon is emitted from a source and passes through one slit behind which there is a 'good' photocell and another 'bad' photocell. Upon detection in the 'bad' photocell the photon triggers the explosion of a stick of dynamite whilst detection in the 'good' photocell disarms the dynamite.[3] Central to Compton's model of agency is the possibility of a daemon controlling a shutter over the slit:

> Being directly conscious of these nonphysical characteristics [Compton imagines the daemon to be conscious of the quality of the photons, either 'good' or 'bad', prior to their arrival at the slit] which will determine their direction, the daemon may then close the shutter to all approaching 'bad' photons until a 'good' photon has passed through and saved the day. Has the daemon in this way contravened any physical laws? (Compton 1935, 61)

Compton's answer to this question is an emphatic no. He works from the assumption that it is equally probable that a given photon will enter either the upper or lower photocell. As the experiment is repeated time and time again, he argues, the number of photons in each cell would be approximately equal if the experiment was correctly set up. When

[3] While this arrangement may appear at first sight to be similar to the Schrödinger's Cat experiment, it is crucial to note that this is not the case. Schrödinger was making a point about the nature of quantum superposition (of the dead and alive cat), and its resolution on measurement. Compton's argument, on the other hand, is really based on the statistical features of quantum theory and assumes measurements take place throughout.

the daemon operates his shutter to block a 'good' or 'bad' photon he determines only an individual event which, because the laws of quantum mechanics only concern large ensembles, will remain physically undetectable. The notion of an individual event leads Compton to draw an analogy with human deliberate actions since these, he argues, are also individual events in the sense that they cannot be predicted from any set of probabilistic laws. The mechanism of human action he envisages is that consciousness in some manner selects a desirable brain 'current' at the junction of two neurons; despite this it is unlikely that Compton would have argued that there is anything faintly analogous to a daemon operating shutters in the brain.

There are thus three steps in Compton's model of agency which many later models of quantum SDA have in common: his emphasis on non-interventionism and the lack of violation of physical laws, the assertion that quantum theory is irreducibly statistical and indeterminate, and the claim that by determining individual events within the scope of results allowed by the theory (i.e. a choice of 'good' or 'bad' but no other) the bulk ensemble predictions of quantum theory are not violated. The latter argument that the single event in question is really an individual act and thus, because of its uniqueness, the laws of statistical regularity do not apply, is particularly important and closely related to Hempel's explanatory ambiguity concept discussed in chapter 3 above. Indeed Compton's implicit assertion that the individual event he describes is not affected by the bulk statistical laws of quantum theory and thus can be determined in such a manner is exactly the same as the epistemic difficulties that Hempel describes. As with Hempel's work, however, despite the fact that epistemological explanation of the particular event in question is limited by the ambiguity arising from the existence of different equally satisfactory explanations, Compton's account says nothing about the ontological basis of his mechanism for free agency. What Compton needs is to justify an assertion that determinations of this sort do not violate these statistical laws, and this is quite a different assertion to the one he makes.

There are several further similarities between Compton's position and later attempts to describe quantum SDA. Compton emphasises the importance of foreknowledge of the result of quantum events in order to sustain meaningful agency. It is only because his daemon could tell 'good' and 'bad' photons apart *before* they had been measured by the appropriate photocell that any intention or purpose can be achieved. Current scholarship in the form advocated by Murphy, Russell and others,

focusses exclusively on the concept of quantum 'events', and while they presuppose the same extent of foreknowledge as Compton's daemon, there is a large difference between these positions. What Compton essentially proposes is a *filtering* of entities that are already determined as 'good' or 'bad' photons instead of a determination by God as to whether a *particular photon* should be 'good' or 'bad' at the point of measurement in the photocell. Indeed, although Compton attempts to propose a non-interventionist model of agency, it is difficult to conceive of how the operation of a filter can satisfy this especially when considered as a mechanism unless the ontological laws of nature 'permit' such manipulation. Nevertheless, what he does have in common with many of the later protagonists of quantum SDA is the assertion that certain key quantum events can achieve macroscopic outcomes.

Another scientist to appreciate the importance of quantum indeterminism for the concept of agency was Sir Edmund Whittaker, among other things Professor of Mathematics at the University of Edinburgh. Whittaker asserts that there is a tendency 'in Newtonian circles' to conceive of God's relationship to the world as being unnecessary and detached. The basis of his argument was that he interpreted classical physics as deterministic and this, he argued, leads inexorably to a detached deistic and impotent God (Whittaker 1946, 95–6). In making this connection between determinism and deism it is clear that Whittaker was strongly influenced by nineteenth-century arguments about God as a divine watchmaker who set the universe in operation and then stood back without intervening in its operation. Modern physics, Whittaker argues, is fundamentally unlike this on account of relativity and in particular quantum theory. In a discussion entitled 'Creation and the Five Ways' concerning Aquinas' famous causal argument for a proof of God's existence, Whittaker makes an argument for a plurality of different causes producing a given singular effect and the breakdown of deterministic causality as a result of quantum theory:

> Thus it does not warrant the view, so common among the deistic Newtonians of the eighteenth century, that the system of the world is absolutely closed and has developed according to purely mechanical laws . . . On the contrary, the recent trend of physical thought (as will be evident from what has been said about the principle of causality) is in favour of the view that in the physical domain there is a continual succession of intrusions or new creations. The universe is very far from being a mere mathematical consequence of the disposition of the particles at the Creation, and is a much more interesting and eventful place than any determinist imagines. (Whittaker 1946, 126–7)

This is an interesting argument, although it is not absolutely clear that indeterminism combined with the possibility of causal chains branching and combining should lead unequivocally to the assertion that there is a continual 'succession of intrusions or new creations'. Indeed Whittaker's language here may be significant – he characterises SDA through these indeterministic processes as 'intrusions', a term which conjures up notions of law-violation. Despite the fact that Whittaker has not made his motivations entirely explicit in this discussion, it remains significant for the reason that he got very close indeed to positing a direct connection between quantum indeterminacy and SDA. Meanwhile, almost contemporaneously in Germany, Karl Heim began to make exactly that connection explicitly.

Heim is an important precursor of much of the contemporary debate about quantum mechanics and divine action. Formerly a professor of dogmatics at Münster and Tübingen, Heim retired in 1939 and continued publishing his major series of works *Der evangelische Glaube und das Denken der Gegenwart* in which he attempted to develop a theology consonant with scientific developments. Heim's work is also of particular historical interest to us in this study as it may be reasonable to assert that William Pollard echoes much of Heim's thesis concerning quantum events. It is certain, at least, that Pollard was aware of Heim's work whilst writing *Chance and Providence*. The latest work in which Heim discusses divine control of quantum events was published in German in 1951 and translated into English in 1953. The latter predated the publication of *Chance and Providence* by five years and it is clear that Pollard was aware of Heim's quantum thesis as he critiques Heim's view of the relationship between God and nature on the basis that it is non-Biblical (Pollard 1958, 26–7). Pollard does not, however, make any comment or acknowledgement of Heim's earlier discussion of quantum SDA despite the many similarities between their positions.

Despite Pollard's interest, Heim's work was generally badly received at the time of its publication in the English-speaking world and continues to have been largely neglected ever since. Indeed even one of his translators, W. A. Whitehouse, later distanced himself from Heim's position by asserting that he found Heim's 'appropriations' of science as arbitrary as the illustrations in well-meaning sermons, and inherently unconvincing (Whitehouse 1982, 269). While we shall not enter into a detailed critique of Heim's broader theological position, it is important to note the possible influence of these 'appropriations' in later studies despite Whitehouse's sentiments.

Heim's discussion of quantum mechanics must be placed in the wider context of his aims in relating religion and science. He developed concepts of theological space and polarity and coined the term 'supra-polar space' to signify the metaphysical transcendence of God. Modern physics, Heim argued, has demolished the absolute concept of causal necessity with the result that causal laws are no longer exact but contain gaps associated with bulk statistical predictions. The causal view of science presented man with a psychological anchorage for his belief which gives him justification for faith and 'firm ground' for the existence of his being. Its loss, Heim continues, presents man with two options: either he can focus on the true significance of his being in a pseudo-existentialist manner, a policy which can lead only to dread and anxiety; or, he can seek an 'inner support' in the New Testament and see the words of Jesus as a ground to existence and belief (Heim 1953, 154–5). It is in the latter context that Heim interprets the breakdown of causality he argues is indicated by quantum theory. Humans can have faith in the context of this potentially unknown future, he argues, if they adopt the approach that God is in direct control of it. The basis of this assertion can be found in Heim's citation of Matthew 10:29–30 and in this context Heim explicitly considers quantum processes: given the assertion that God is active in the fall of every sparrow, it is not surprising that he also asserts:

> No quantum transition occurs without your Father in Heaven. The saying shines in its true light in the context of today's atomic physics. Here we are before a fundamental law which runs through the whole of creation. All events, however great, we today know to be the cumulation of decisions which occur within the infinitesimal realm. (Heim 1975, 155)

Even though Heim does not attempt a detailed discussion of divine action, and the connection between God and quantum indeterminacy above appears to be motivated primarily by human psychological concerns about the justification of faith in the face of indeterminism, the above passage clearly makes a strong claim for quantum divine action. What marks Heim apart from many of the other theological approaches we shall consider in this chapter is that his discussion is based on the principles of a personal struggle between the forces of philosophical theology, rather than having a primarily Biblical motivation. Heim does not, for example, begin with a contemporary apologetic agenda, the so-called 'problem of providence', and then turn to relate it to quantum processes. Rather he sees divine action in quantum mechanics as an essential 'inner support' in which God's faithfulness extends to even the most minuscule

processes of his creation. Indeed it may be possible to conjecture that his motivation for claiming quantum processes are divinely determined is in part also due to the fact that quantum theory describes some of the smallest entities in creation in analogy with the reference to the numbering of human hairs in Matthew 10:30:

> The great faith ... which alone is able to give us peace and freedom from anxiety in the midst of storm-ridden world processes, is the belief that precisely in these smallest areas it is not an impersonal causal mechanism which rules, but a personal will which steers every elementary particle, without which no sparrow falls to the ground and no hair can fall from our heads. None of these smallest events, says Jesus, of whose interaction the world is constituted, occurs 'Without the Father'. (Heim 1975, 156–7)

Heim clearly asserts here that God is active in determining *every* quantum event, an assertion that is paralleled by Pollard although for rather more explicitly apologetic reasons. This approach has been questioned on theological grounds in discussions of Calvin and Vernon White in chapter 2 above. At first sight it might appear a strange policy to adopt in the context of quantum indeterminism. After all, Heim begins by questioning the validity of faith in the face of open and indeterminate causal sequences, and then effectively asserts that this indeterminism is only illusory because the personal will of God directs even the smallest events in nature. We shall return to this partial circularity in our discussion of Pollard's position below.

Another author adopting a similar position to Heim is Eric Mascall who also proposed a connection between divine action and the workings of quantum physics in his 1956 Bampton Lectures. The result of the development of quantum physics, Mascall argues, is that we cannot give a complete physical account of a given phenomenon in terms of physical causes alone (Mascall 1956, 200). Paralleling Compton's underdetermination approach to human agency, Mascall asserts that God has only given finite agents enough autonomy to specify the relative probability of certain events occurring or not and has left the final determination of a particular event to himself. Consequently Mascall proposes a model of divine action in which God is active in determining all quantum events. This point he makes explicitly:

> That there is a ten percent chance that a click will be heard during the next minute in a loud-speaker which is connected to a particular Geiger-counter may be a fact that follows from the precise degree and type of determinacy with which God has endowed the finite world; that a click will – or alternatively will

not – be heard at a specified instant may be due solely to the primary causality of God. (Mascall 1956, 201)

Again we see an interesting tension between asserting that the world is genuinely indeterminate, or at least that there is a limited extent to determinacy, and the determination of every Geiger-counter click by God. In Mascall's approach there is no such thing as a 'natural' event, a point he states explicitly in his claim that, for the theist, nothing ever 'just happens'. In Mascall's scheme secondary causes, such as the actions of creatures and natural processes, only determine the range of probabilities concerning a particular event. The final decision is left to God as to whether the event in question actually occurs 'in the last resort' upon God's choice and an operation of his will (Mascall 1956, 201). One might be forgiven, however, for questioning what ontological status this range of probability has if it is continually determined by God.

A more limited set of claims were made by Sir George Thomson, son of the famous J. J. Thomson, and himself winner of the 1937 Nobel Prize for physics with C. J. Davisson. In an address given in the University Church at Cambridge in 1957, Thomson argued that most of the laws of physics are to be understood as probability statements. Accordingly, he argued, it is not in general possible to predict the result of a particular experiment but only the bulk statistical results of a number of similar ones (Thomson 1959, 53). Were this notion of statistical law to be used theologically, Thomson conjectured, then the approach would be to suppose that some or all of the actual events within the probabilities are directly controlled by God. This is a position, he argued, which is epistemically neutral, there being no evidence either to support or deny it.[4]

It would be possible for a finite but immensely intelligent being, who possessed the power of controlling which probability was in fact selected, to direct the world to a substantial, though not to an unlimited, extent, without his action being discoverable with anything like certainty by any experiment we could make, at least with our present abilities. A fortiori it would be possible for an infinite being to do so. A theory of the efficacy of prayer could be constructed on these lines, but it does not seem to me very attractive as applied to the major miracles of Christianity. (Thomson 1959, 53–4)

It should be clear that Thomson's attitude was rather more reticent and cautious than his predecessors'. Not only does he assert that God is not

[4] Note the similarities again between this position and Hempel's epistemic ambiguity concerning the explanation of individual events in a probabilistic conception of the laws of nature – see chapter 3 above.

active in every quantum event and may only determine some of them, but he also mentions fundamental limits to the extent of divine influence over the natural world. He makes an explicit distinction between what he considers the more plausible limited actions required to give efficacy to intercessionary prayer, and the large-scale actions by God which would be necessary for producing Biblical miracles. Quantum divine action, Mascall argues, is suitable for the first, but not the second of these modes of action. In making this distinction, and in particular not emphasising that God is active in every quantum event, he stands apart from the vast majority of the proponents of quantum SDA and Pollard himself, whom we now turn to consider.

WILLIAM POLLARD

William Pollard was a former professor of physics at the University of Tennessee and worker on the Manhattan atomic bomb project, and after being ordained an Episcopalian priest began attempting to reconcile what he saw as the intolerable differences between science and theology. In *Chance and Providence* he examined the doctrine of divine action in detail and identified it as *the* central problem in relating science and theology by virtue of the fact that he found it extremely difficult to conceive of any 'loophole' in physical causality which would permit the actions of God (Pollard 1958, 12). The detailed consideration of quantum SDA in *Chance and Providence* made Pollard's work the forerunner of that of many subsequent theologians. Indeed, his methodology in this work has become something of a paradigm for later studies and broadly consists of three parts: firstly the Biblical notion of providence is identified and shown to be incompatible with a deterministic view of science; secondly, determinism in science is shown to be undermined by the indeterminacies of quantum phenomena; and finally, the indeterminacies of quantum theory are shown to be a nexus for the purposeful interaction of God and his creation. We shall consider each of these steps in some detail.

Pollard begins with what he identifies as the Biblical motivations for a doctrine of divine providence. He cites Psalms 65, 95 and 104 (in which Yahweh is praised as creator and providential maintainer of the habitable universe) as an example of this. It is, perhaps, not entirely surprising that the Old Testament conception of providence Pollard cites should be difficult to reconcile with modern science given the vastly different approach to nature in the ancient Near East.[5] Pollard's discussion of the

[5] See the discussion in chapter 1 above.

Biblical motivations for the doctrine of providence is erroneously based on the assumption that the Biblical authors he cites relied on similar classical notions of causality and law and that consequently their claims for SDA can be translated directly into a modern scientific context. In parallel with his Biblical assertions Pollard also argues from a philosophical perspective that petitionary prayer requires divine action within creation in a manner analogous to the Psalmist's assertions about the providential maintenance of creation. He thus concludes that neither scripture nor the practice of petitionary prayer expresses an interpretation of nature in which events are completely determined 'from within' and that God must be active within the physical world.

Pollard categorically rejects any interventionist interpretation of SDA on Biblical grounds for, he argues, this results in a conflict between God and nature as two different causal agents (Pollard 1958, 26). Thus, Pollard argues, it is incorrect to conceive of God as a physical force or as a probability-modifying factor. This latter argument is of crucial significance in connection with quantum mechanics. The fact that Pollard rejects the notion of God modifying the probabilities inherent in the theory on the basis that such a mode of action is fundamentally interventionistic is particularly interesting and shall be considered in detail in the next chapter. Given that any divine action must be non-interventionistic to satisfy Pollard's approach, he then presents a picture of scientific determinism that, he argues, cannot allow for any meaningful concept of divine action. He then asserts that the preceding contradiction between classical science and Biblical belief is in fact wrong because modern physics has demonstrated indeterminacy in the world – and accordingly that a truer comparison should be drawn between Biblical doctrinal claims and an indeterministic world-view.

It is at this point, however, that Pollard makes wider claims for his model. He takes the view that the development of quantum theory represents a paradigm of good modern scientific method. Moreover, and Pollard has been almost universally misrepresented on this point, he also makes claims that the statistical nature of much of non-quantum science will also have at its root indeterminacies operating analogously to the Heisenberg Uncertainty Principle of quantum theory:

> Elsewhere in these sciences where variability, alternatives, and probability are found, we must suppose that they arise out of as yet undefined principles or sources of indeterminacy proper to biological organisms or man as such. Such indeterminacies are probably very different from and unrelated to the Heisenberg principle appropriate to the submicroscopic world of atoms. (Pollard 1958, 56)

Pollard has been unfairly criticised for locating divine action through indeterministic processes solely at the quantum level. Ian Barbour, for example, totally misstates Pollard's full argument when he asserts that there is a fundamental and unjustifiable reductionism to the position that God only acts on the atomic level. Indeed Barbour's own 'extension' of this approach by suggesting that there might be 'novelty and freedom as well as lawfulness at all levels of reality' does not appreciate the fact that this is exactly what Pollard argues for in *Chance and Providence* (cf. Barbour 1966, 430f.). Moreover, Pollard goes to great lengths to demonstrate what he identifies as the irreducibly statistical nature of much of contemporary science. Having established the widespread indeterminacies of nature, Pollard continues by arguing that this allows for a multitude of possible histories for the universe – the future, he argues, is thus potentially open to the actions of both God and mankind. From this assertion he concludes that it is possible for any particular event (both on a quantum scale and in higher order indeterminate processes) to be simultaneously fully in accord with 'natural laws' and divine intention. It is not however totally clear how this assertion follows logically from Pollard's premise concerning the open nature of future events. It may be possible at this point that Pollard is advocating an implicit version of Heim's argument concerning divine knowledge of an otherwise unknown future (see above).

What is clear is that Pollard is explicit about the fact that God acts to determine every otherwise indeterministic event in nature, quantum and otherwise. When the history of the world is considered, he asserts that God must have acted to determine every event to achieve the direction that he intended rather than any other probabilistically possible pattern (Pollard 1958, 114, 122). In parallel with this assertion he considers miracles to be events which remain within these natural processes: the Biblical miracle accounts, he argues, are the result of extraordinary combinations of chance and accident and do not involve any instances of law breaking, an argument which finds its modern parallel in the work of Robert Gleason.[6] It is, however, reasonable to argue that this statement concerning miracles is symptomatic of another set of fundamental inconsistencies in Pollard's position. Putting aside the difficulties in transposing the concept of natural laws onto the Biblical accounts of SDA, it is not clear how Pollard can assert on the one hand that God determines every event and simultaneously maintain a concept of natural laws and their violation as distinct from that action. Given that the notion of any

[6] A detailed discussion of Gleason's work can be found in chapter 3 above.

'natural' as distinct from divine action becomes potentially vacuous on this account his argument may be logically inconsistent.

Pollard's theology of indeterministic SDA goes further than those previously considered because he is acutely aware of the difficulties of reconciling human free-actions with his account. Interestingly it is another principle from quantum mechanics, namely that of complementarity, which Pollard associates with a solution to this difficulty. By drawing analogies with the classical debate between predestination and human freedom, Pollard categorises the relationship between free will and SDA as inherently paradoxical. Rather than attempt to resolve this paradox, however, Pollard simply accepts it by analogy with paradoxes in criminal law and the Bible, and asserts that it is 'ingrained' in the way the world operates (Pollard 1958, 138). However, the principle of quantum complementarity, Pollard argues, also seems necessarily paradoxical. What lies at its root is the fact that scientists offer complementary descriptions of a single physical reality and accordingly it is not capable of any resolution but again reflects an irreconcilable characteristic of reality (Pollard 1958, 141). Pollard was certainly not the first to cite the principle of quantum complementarity outside the field of physics. Indeed Niels Bohr himself extended his work by drawing analogies with psychology, biology, human culture and language (see Pais 1991, 438–47). However, as we have already hinted, at the root of many of these applications of the principle of complementarity are wider claims about the inapplicability of scientific language to theological inquiry. Pollard's stance is unconvincing because it does not seek to explain why it is that these two seemingly paradoxical issues should be related – it is not enough simply to cite two paradoxes without drawing sufficient parallels between them.

By means of a long discussion involving the nature of quantum wavefunctions and particle duality, Pollard unconvincingly attempts to construct an epistemology whereby paradoxes resolve into apparent rather than real contradictions. The key to his argument, however, lies in the distinction he posits between scientific and historical conceptions of time. The real world, Pollard argues, exists in historical time (this is also the 'time' in which he asserts God is active) and each entity in historical time has an indeterministic future 'pregnant with alternative possibilities for it' (Pollard 1958, 145). When dealing with an entity scientifically, however, it is methodologically necessary to strip the elements of historical time such that each open possibility is represented by an associated probability of its occurrence. The foundation of the distinction between scientific and historical time which Pollard relies on is somewhat doubtful,

especially when given his parallel claims about the universality of scientific explanation. Because of this difference in the descriptions of a single event, it is reasonable, Pollard argues, to reject the one-to-one correspondence between the world and human knowledge of the world; a position which results, he argues, in divine determination of events being no longer paradoxical. It is, he continues, a move which has a Biblical basis – St Paul, he argues, held a similar position: 'I yet not I but the grace of God which was with me', is an analogous statement of the fact that there exists a single ontology which can *only* be understood by humans in complementary terms (Pollard 1958, 151).

Despite these attempts to sidestep the implications of Pollard's thesis of the divine control of every event, several issues surely remain. The most fundamental of these is one we have already met in chapter 2 above, namely that if every event is the result of a divine determination, then there is no sense in which there exist real natural propensities and nature cannot really be said to provide a framework for divine activity. Indeed we are left with no real concept of natural causality or independent event whatsoever. However, if this is the case, and we also reject with Pollard the thesis that God acts as a cause among other causes or by modifying the probabilities for natural caused events to occur, then we are forced to conclude that God alone determines whatever events actually occur in the world and that there is no causal autonomy of nature. The implication of this statement is that Pollard is really concluding that there are no causal agents other than God – the position of occasionalism. This view reached its most mature form as a result of the development of the Cartesian dualism between mind and body. The occasionalist position was to deny the possibility of any direct connection between two such fundamentally different entities as mind and body and make the assertion that whenever the mind decides to act, God directly produces a corresponding action of the body. The same approach can be applied to divine action claims by analogy that all natural processes are a direct result of God's purposive action.

The implications of this position extend further than this, however, if we recall Pollard's initial dilemma in relating a concept of providential divine action to a causal deterministic view of science. Pollard concludes that if God is to be able to act in the world, if there is to exist a 'loophole' as he put it, then there must exist indeterminism at the quantum and other levels for this action to occur. However, by concluding that God is determinatively active in every event, Pollard is really stating that the indeterminism he found so necessary earlier in his argument is nothing

other than illusory. His entire project is thus rather circular, as he argues: (1) God cannot act non-interventionistically in a world in which every event is causally determined; (2) quantum mechanics and other processes show that the world is not deterministic; (3) God cannot act as an 'agent amongst agents' or modify probabilities of a particular event occurring; and (4) God is thus active in every event by determining otherwise indeterminate processes. Of course, it would be wrong to claim that this 'divine determinism' is synonymous with the unguided 'natural' determinism to which Pollard objects so fundamentally, yet there remains a strong sense in which the conclusion to his work is in direct contradiction to his initial premise. Despite these criticisms, Pollard's (and implicitly Karl Heim's) work started a large following of protagonists of quantum mechanical divine action. What is perhaps remarkable is that, as we shall see, many of the same criticisms can be levied against this later scholarship.

POST-POLLARD QUANTUM SDA

The publication of Pollard's *Chance and Providence* began the start of a relative lull in the formulation of detailed assertions for quantum divine action. In the past ten to fifteen years, however, the approach has been met with renewed interest and became the dominant theory in a series of important conferences sponsored jointly by the Vatican Observatory and the Center for Theology and the Natural Sciences in Berkeley, California. As an editor of many of the published collections of essays resulting from these conferences, Robert Russell has probably written more about the potential connection between quantum theory and SDA than any other theologian. As one of the few full-time scientist-theologians in the world, and one of the most influential and persuasive thinkers in this field, Russell is in a strong position to advocate such a connection.

Russell combines both theological and scientific motivations in asserting a doctrine of quantum SDA and these are backed by a set of claims about the contingency of God's creation. God's sustenance of the world at every moment is the ultimate source of nature's causal efficacy, he argues, and those scientific regularities that exist do so as an expression of God's faithfulness (Russell 1998, 191). Moreover Russell argues that this contingency may place constraints on any expression of God's freedom subsequent to his creation:

> In effect, if contingency is an aspect of the doctrine of creation, reflecting the freedom of God in creating this universe, we must conclude that God is not

entirely free: God's choice of the values of these fundamental constants, once taken, determines not only the gross properties of the universe as a whole but also the local features in tremendous detail. (Russell 1996, 35)

Providence extends the doctrine of creation, Russell argues, by not only insisting on the dependence of all there is upon God, but by also stressing that God is the cause of the meaning and purpose behind it (Russell 1997, 48). It is in this context that he asserts quantum processes underlie the macroscopic features of the world, and accordingly that divine action on the quantum level consists of God not only bringing about specific events in the world, but also maintaining fundamental properties such as the impenetrability of matter.

Citing Arthur Peacocke's rebuttal of Jacques Monod's argument that blind chance renders theistic assertions impossible,[7] Russell has frequently asserted the general point that it is possible for God to utilise chance in connection with purpose (e.g. Russell 1996, 36). Moreover, if we assert that God is active in chance-like processes, the primary question becomes the kind of chance through which God can operate (Russell 1988, 367). Yet, Russell argues, we should not forget the contingency of creation which implies that 'God cannot be an explicit "part of the equation," as it were, since this would introduce an entirely necessary element into what should be an entirely contingent argument' (Russell 1994, 560). For this reason Russell asserts in common with many of the authors considered here that it is essential for the activity of God to be non-interventionist. Moreover, echoing Pollard's concerns, Russell asserts that quantum SDA does not reduce God to the status of another natural cause if we understand indeterminism in an ontological sense. Science, he argues, does not provide any sufficient natural cause for a quantum event to occur, and thus God's role in determining quantum processes is quite unlike natural causality. Following the advent of quantum mechanics and its indeterministic interpretation, Russell asserts that it is no longer necessary to conceive of divine actions as intervening in the regular processes of nature:

I believe we can construct a new view of special providence, which holds both that God acts in the world objectively and that God does so without intervening

[7] Jacques Monod in his famous work *Chance and Necessity* raises epistemological chance to the status of a metaphysical principle of interpretation of the universe. He concluded that evolution is based on pure chance and thus that it was purely accidental that the products of evolution should have led to the development of human beings. For more details see Peacocke's excellent refutation of this position (Peacocke 1993, 117f.).

in or suspending the laws of nature. This is what I mean by 'noninterventionist objective special divine action.' (Russell 1997, 51)

Despite his focus on quantum mechanics in this connection, Russell is keen to emphasise that he does not argue that the providential action of God is in any way restricted to quantum processes. He is quite explicit about quantum SDA forming only part of a wider range of divine actions which may be expressed more adequately in terms of whole–part arguments (Russell 1997, 51). Free will, Russell argues, transcends the categories used in physics, including indeterminacy, and without the existence of quantum chance as evidence of ontological indeterminacy 'it is hard to see how human – or divine – agency really makes sense' (Russell 1996, 33). Yet, despite his admission that God's action is possible by higher order processes, Russell still maintains a considerable focus in his work on quantum SDA – in particular, in connection with the early universe he argues that the higher levels required for top-down or whole–part causality had not yet been formed because of the lack of complex structure.

Writing as a physicist Russell describes in great detail the role of quantum mechanics in the framework of an open universe (e.g. Russell 1988). His discussion of the nature of chance in quantum processes is notable for its clarity and the distinction Russell draws between Bose–Einstein and Fermi–Dirac statistics (Russell 1995, 112). Russell is also sensitive in his philosophical appreciation of quantum theory – he not only accepts that ontological indeterminism is not a necessary interpretation of quantum processes (he has also written on Bohm's pilot wave suggestions and divine action), but even argues that it is likely that current quantum theory is only an approximation to an, as yet undiscovered, better model (Russell 1997, 57). Accordingly Russell states quite explicitly that his position can only be regarded as tentative and essentially hypothetical. Indeed he accepts that it is as yet undecided as to whether quantum physics can be fully interpreted in the context of a critical realist framework (Russell 1996, 30).

Adopting the 'orthodox' interpretation of quantum unpredictability as indicative of ontological indeterminacy, in common with all of the authors considered in this chapter, Russell sees strong theistic overtones in the operation of chance in quantum mechanics:

Quantum chance suggests that the structures of the Kingdom are constructed out of the random flow of ordinary processes, and that a hidden pattern seems to correlate, if not direct, all that happens. (Russell 1988, 355)

Quantum physics, Russell argues, is the fundamental ground of human macroscopic experience, and not only do quantum events build into macroscopic processes, but they also sometimes trigger highly sensitive causal chains. Despite this connection with chaotic type amplifications,[8] Russell is not persuaded by claims that God is providentially active in the processes of chaos theory itself, and has argued strongly against John Polkinghorne's interpretation of SDA (Russell 1995, 115). Accordingly he asserts that the mode of divine action in quantum processes can occur thus:

> God acts together with nature to bring about a quantum event. Nature provides the necessary causes, but God's action together with nature constitutes the sufficient cause of the occurrence of the event. In short, and metaphorically, one could say that what we normally take as 'nature' is in reality the activity of 'God + nature.' Alternatively, from this perspective, we really do not know what the world would be like without God's action . . . God acts in all quantum events, but in some cases, the effects 'matter' in the classical world more than in other cases. (Russell 1997, 58, 60)

Russell argues that God acts in conjunction with nature to bring about quantum events and that these events give rise to the classical world. This is not an interventionist argument, he continues, since it rests on assertions concerning ontological indeterminism and not simply epistemological ignorance. In sum, divine action occurs through all quantum processes, according to Russell, without overriding or intervening in natural processes: God's acts take the form of 'realizing one of several potentials in the quantum system, not of manipulating subatomic particles as a quasi-physical force'. Quantum mechanics Russell concludes offers the best 'bottom-up' possibility. Non-linear, non-equilibrium thermodynamics, cosmology and neuroscience offer possibilities for a top-down and/or a whole–part approach (Russell 1997, 64–5).

In his recent work Russell is particularly keen to advocate a potential connection between quantum SDA and God guiding the processes of evolution, something that Pollard himself saw as a logical extension of his quantum SDA thesis. In connection with evolution he has argued that God acts in all quantum events until the appearance of organisms capable of primitive levels of consciousness, and then may abstain from acting in those quantum events which interfere with the developing consciousness (Russell 1998, 215). Russell essentially claims that God acts in specific

[8] We shall examine in detail this potential connection between quantum indeterminacy and chaos theory in chapter 8 below.

quantum events within the DNA molecule to realise certain genetic mutations which then get amplified by the germ line and are eventually expressed in the phenotype of the organism. Perhaps the most remarkable aspect of Russell's discussion, however, is the fact that he very rarely mentions the process of natural selection. Surely if his thesis of divine input into the processes of evolution is to be effective, then he needs to account for how God might ensure the subsequent natural selection of divinely mutated progeny in the natural world.

By these quantum determinations, Russell asserts, God can guide and control the processes of evolution. Many theologians have doubted such a possibility, not least Philip Clayton who has written that

> A God who allows countless billions of organisms to suffer and die, and entire species to be wiped out, either does not share the sort of values we do, or works in the world in a much more limited and indirect way than theologians have usually imagined. Since revelation rules out a pernicious God, it may ultimately be that one must let go of the idea that God directly brings about the details of the evolving biological world. (Clayton 1998, 18)

Clayton's argument on the basis of the abundance of evil in the world sits uneasily with Russell's assertions that God controls evolution providentially by means of quantum manipulation (and, in the pre-conscious universe at least, in every quantum event). Indeed it is not clear how his approach to theodicy, namely that the doctrines of creation and providence offer an inadequate framework for addressing the issues, can resolve this difficulty. In contrast Russell argues that 'The long sweep of evolution may not only suggest an unfinished and continuing divine creation but even more radically a creation whose theological status as "good" may be fully realized only in the eschatological future' (Russell 1998, 223). It is, he argues, only in the context of a theology of redemption and new creation that the implicit issues of theodicy can be fully addressed, but this move is one that needs far more detailed argument for it to become a convincing defence.

Despite these difficulties, Russell has done much to refine Pollard's position. One crucial difference between their accounts is that Russell rejects the pervasive divine determinism inherent in the claim that God determines every quantum event under certain conditions. In many ways his more detailed claims concerning the divine control of evolution are a natural extension of his basic quantum SDA position, and his account remains sufficiently sensitive to scientific developments to remain immune from a naïve application of Bonhoeffer's God of the stop-gaps critique.

An alternative basis for quantum SDA is offered by Nancey Murphy who makes clear assertions that God is active in every quantum event. She has brought her philosophical reflection to recent discussions on the subject of divine action and is one of the most vocal advocates for quantum mechanical divine action. Her approach to quantum SDA is primarily motivated by *theological* concerns and echoes Heim's argument that, if God is active in everything in creation, then this action must extend logically to encompass quantum events. This is expressed as part of her explicit theological goal of finding a modus operandi for the acts of God at a macroscopic level (Murphy 1995, 342).

Two positions that Murphy is loath to adopt are deism and occasionalism. With regard to the former Murphy correctly argues that God's action would be restricted to an initial act of creation, which includes ordaining the laws that govern all successive developments. Occasionalism, on the other hand, she presents as the unacceptable view that God is the 'sole actor' in creation and solely responsible for all causality in the world (Murphy 1995, 332). Indeed, she has argued that any notion of 'natural' causation on this account becomes a mere illusion (Murphy 1998b, 6). Against the background of these positions, Murphy is clear about the theological objective of her approach to quantum SDA as an attempt to develop a coherent concept of divine action which 'steers a course' between the two extremes (Murphy 1995, 353). Her objective is thus closely allied to that asserted in chapter 2 above, despite the fact that we have expressed the course that needs to be adopted as comprising a balance between SDA and GDA, rather than deism and occasionalism.

Murphy's stimulus for considering quantum processes stems from her other major theological motivation, namely the avoidance of an interventionist account of divine action. She places emphasis on the notion of God's reliability and has also emphasised a non-interventionist approach on the related basis of God's morality, her argument being that it is consistent with God's refusal to overrule or dominate creatures. Divine action is, Murphy asserts, a metaphysical problem and one that cannot be resolved by anything less than a radical reformulation of our notion of causation (Murphy 1995, 326–7). In common with the other scholars considered in this chapter she rejects any 'God of the stop-gaps' critique by asserting quantum indeterminacies to be ontological rather than epistemological. Given this, it is not necessary, Murphy argues, to assert causal indeterminism in higher levels of organisation (other than the human level) since God's will is 'assumed to be exercised by means of the macro-effects of subatomic manipulations' (Murphy 1995, 327).

Her assertions concerning quantum SDA are notable for their clarity. God, Murphy argues, has two modes of action within the created order: one at the most reductionistic or quantum level and the other through human intelligence and action (Murphy 1995, 339). Nevertheless, Murphy continues, 'The apparently random events at the quantum level all involve (but are not exhausted by) specific, intentional acts of God' (Murphy 1995, 339). This is a clear statement that God is active in the determination of every quantum event and thus allies Murphy's position on quantum SDA closely to Heim's despite the different theological approaches they adopt. Her account of SDA in nature, as opposed to mental processes, thus hinges on the 'intentional orchestration of the vastly many micro-events' (Murphy 1995, 346). This bottom-up divine action is limited in two ways: firstly, God respects the 'integrity of the entities with which he cooperates'; secondly, God restricts his action so that he produces a world which, 'for all we can tell is orderly and law-like in its operation' (Murphy 1995, 340). Grappling with the potential occasionalistic implications of her position, Murphy asserts that it is incorrect to conclude that each sub-atomic event is solely an act of God and that quantum entities are endowed with 'powers of their own' (to use her terminology). Moreover, Murphy argues, 'if God were completely in control of each event, there would be no-thing for God to keep in existence' (Murphy 1995, 341).

Whilst questioning what might cause a particular radioactive decay, Murphy concludes that one of four possibilities must occur: either decays are completely random and indeterminate; are determined by the quantum entity itself; are externally determined by something else in the physical system; or are determined by God (Murphy 1995, 341). By an analogy with Jean Buridan's indecisive donkey failing to choose between two piles of hay, Murphy reaches conclusions concerning the ontology of quantum processes.[9] Quantum entities are, Murphy argues, 'miniature "Buridian" asses', and are incapable of deciding of their own volition whether to decay or not (Murphy 1995, 341). This leads Murphy to conclude between either the first or last of her four possibilities and she asserts that 'divine determination' is the better option: 'To put it crudely, God is the hidden variable' (Murphy 1995, 342). While it is clear from Murphy's argument that she can rule out the second

[9] The analogy is particularly interesting because Jean Buridan's own approach to natural events was arguably based on the assertion that what we know of natural processes can only be developed by means of induction and is thus conditional on an assumption that nature will continue in its common course without interference – see Moody (1970, 605).

option above, there does not appear to be any reason why one should not still assert that quantum entities are determined by something else in the physical system other than God. Moreover, her grounds for deciding between the first and last of these options (complete indeterminacy or divine determination) are also rather unclear and appear to be based on the assertion that 'traditional' theology presupposes divine control of every event. Recently, Murphy has spoken of a more direct connection: 'if we reject an interventionist account of divine action, we are left with two options: either God does not act at all within the created world, or else God acts at all times in all things' (Murphy 1998b, 6).

Murphy also argues from a philosophical perspective for divine determination: God must be active in every micro event as a necessary but not sufficient condition for that event to occur. She makes the interesting suggestion that quantum non-locality may also reinforce the claim that God is active in every event (Murphy 1995, footnote 33). Divine action, then, occurs by God actualising one of the possibilities inherent in a quantum entity (Murphy 1995, 343). Her point is that God does not fundamentally alter the nature of quantum entities, but merely triggers aspects of behaviour that already exist within the entity's repertoire. In recent discussions with the author Murphy has expanded on this argument and emphasised the importance of the distinction between God triggering the action of an entity and God's performing that act himself. Essentially her position is that it would not be paradoxical to claim that God affects the frequency over time of a particular quantum event without altering the nature of the entity in question.

However it is highly questionable whether quantum theory actually supports such an approach, and we shall consider this question in more detail in the next chapter below. Without pre-empting too much of this discussion, Murphy's use of the term 'event' in quantum mechanics is also overly vague and leads to technical difficulties with the theory. At the root of these problems is an equivocation between quantum states and quantum events. The fact is that on her account the observables which arise are a direct result of God's action and have no other basis. The quantum state serves only to provide a constrained 'palette' of selections for God to choose amongst and there is no direct causal connection between these possibilities and the one that is finally selected. Moreover if this assertion is made in tandem with the claim that God is active in every quantum event, or that every choice from the palette of quantum states is made by God alone, then it is very difficult

to see how Murphy can successfully avoid the same occasionalistic difficulties that both Heim and Pollard run into. As we shall see, the distinction she relies upon, between God's triggering an action of an entity and a direct control of that entity, is untenable in orthodox quantum theory.

There are limits to the scope of her claims for this divine control, however, and Murphy has recently asserted that human beings limit the action of God significantly: 'God is working at all times in all things to bring about the good, but the extent to which God can realize those good plans is, by divine decree, dependent upon the cooperation of all-to-often-recalcitrant creatures, both human and non-human' (Murphy 1998b, 14). However, necessarily such an account of quantum SDA in tandem with SDA in human minds raises difficult questions about the relationship between human thought and action and its underlying quantum basis. It is clear that quantum processes are constitutive for human thought and action, however there is no widely accepted account of how quantum indeterminacy might be related to emergent properties such as consciousness. Despite these difficulties, Murphy's proposal represents a systematic attempt to develop a revised notion of causality with the aim of encompassing SDA. As such it has an internal self-consistency that is almost unique among proposals for quantum SDA. Indeed, as we shall see in the next chapter, this approach (occasionalistic difficulties aside) may also represent a coherent and little discussed 'solution' to the quantum measurement problem.

As a committed Quaker and professor of mathematics, George Ellis offers one of the most scientifically detailed discussions of the relationship between science and theology. His theology is distinctive amongst the authors considered in this chapter for the emphasis it places on revelation and it is in this context that Ellis considers the possibility of quantum divine action. Indeed Ellis is the only author to develop a detailed argument for quantum SDA within the human mind.

In common with many of the authors considered in this book, Ellis asserts that there are significant limitations to scientific explanation. These, he argues, arise because of the non-reductive supervenience of some physical phenomena,[10] the range of applicability of certain theories (Ellis 1993a, 8f.), and the fact that scientific models themselves do not imply certainty. This leads to his assertion that any scientific modelling can

[10] See, for example, Ellis (1998, 3), in which he argues that 'It is clear that the higher level descriptions cannot be fully reduced to those at the lower levels, indeed the language used for the higher level descriptions is simply inapplicable to concepts available at the lower levels.'

in principle only give a partial representation of the ontology it purports to describe (Ellis 1998, 2). In keeping with these views, Ellis' recent work has focussed on the relationship between reductionistic assumptions and top-down divine action (Ellis 2000). In keeping with Russell and Murphy he argues contra Polkinghorne that chaos theory cannot provide a solution to the problem of causal gaps for divine action (Ellis 1995, 361).

In a 1993 paper, Ellis develops a taxonomy of divine action in three fundamental forms: the initial act of creation and maintenance of physical laws; the manifestation of God's nature in the life of Christ; and divine actions in terms of revelatory mental interventions (Ellis 1993b, 397–8). That, however, is the extent of God's action, which is 'not in any other way forcing or influencing their lives or intervening in natural processes' (Ellis 1993b, 398). Indeed, Ellis wholly rejects quantum divine action in the processes of nature in general:

> It is indeed true that one could envisage quantum uncertainty allowing a channel for intervention that would, for example, through amplification allowed by equations evidencing 'chaotic' behavior, be able to influence weather patterns and so allow a 'steering' of daily physical events by influencing the behavior of inanimate objects. However to allow such interventions seems to greatly exacerbate the problem of evil. (Ellis 1993b, 398)

In this paper Ellis focusses on quantum processes in terms of revelation, by arguing that quantum SDA constitutes a potential basis for belief in objective revelation by God to individuals, without any associations of law-violation (Ellis 1993b, 397). Accordingly God as creator and sustainer can directly provide 'images of the desired life and the nature of reality to humankind' (Ellis 1993b, 396). The kenotic aspect of creation is realised because God's primary purpose in creation,[11] Ellis argues, is to design the laws of physics 'so as to enable the emergence through processes of self-organisation of ethically aware beings, able to respond to moral issues in a kenotic manner' (Ellis 1998, 5). The existence of revelatory events requires, he continues, some kind of channel of communication that is consistent with the laws of physics – this channel is an effective mode of divine action in the world, and quantum mechanics provides one way that it could function:

> The supposition is that this quantum effect would be amplifiable through brain processes – similar perhaps to photon multipliers – to macroscopic levels where

[11] Ellis defines these kenotic aspects as being 'a freely giving, joyous, kind, and loving human attitude that is generous and creative, and – if needed – willing to give up selfish desires and to sacrifice on behalf of others, but in a humble way, avoiding the pitfall of pride, and doing this all in the light of the love of God and the gift of grace' (Ellis 1998, 5).

they could influence feelings or thoughts. This is a wide enough channel to convey to us all that is needed for revelation, and to be recognizable as such by those with eyes to see. (Ellis 1995, 389)

Ellis is undoubtedly correct to identify quantum measurement processes in this context, as we shall see, and sides with Murphy in claiming that there is a specifically theological motivation for demanding that there is openness in physical laws (Ellis 1995, 393). As Ellis has adopted the immanence position advocated by Murphy in which God is active in every quantum event, he thus makes the conclusion that the necessity for God to respect the 'randomness' in physical processes is unnecessary. This randomness, Ellis argues, 'is just the openness required in physical reality in order that God's action can be effective without destroying the possibility of higher levels of order' (Ellis 1995, 394). Quantum divine action, Ellis contends, thus happens exclusively in the brain as a revelatory process. This can then lead, he continues, to macroscopic changes in the natural world as a result of bodily agency:

God's action is then able to lead to action in the world through directed downwards causation in the body [of human beings], and so to effective changes in the world. (Ellis 1995, 394)

Nevertheless it is questionable how strong a sense of divine action in nature Ellis can maintain by demanding the creaturely response above – not least because of his parallel assertions concerning the existence of free will. It is also difficult to conceive of how Ellis relates the existence of true free will to the fact that God is somehow active in the quantum substratum of human consciousness. In his more recent work it is clear that his position has changed to incorporate top-down causal actions of a whole on its constituent parts, while still maintaining the general thesis that God is active at the level of quantum processes. Indeed he connects this latter mode of SDA to amplification processes in nature such that individual quantum signals are multiplied to produce macroscopic effects in nature (Ellis 2000). While his position may have now moved closer to that of Russell, Ellis' earlier work remains particularly interesting for its focus on revelation in the human mind.

Another approach to quantum SDA is offered by Thomas Tracy who is Professor of Philosophy at Bates College, Maine. He has written widely on the subject of divine action (and in particular on the analogy with human action) and has endorsed the possibility of quantum SDA (Tracy 1995). His work on this subject is widely recognised to be amongst the most thoughtful proposals for quantum divine action. The

basis for his proposal is his discussion and subsequent rejection of various compatibilist accounts of SDA. He rejects Austin Farrer's notions of 'double agency' as incoherent and argues, contra Farrer, that whilst there are profound conceptual and epistemic limits to what we can say about God's agency, these limits do not warrant an appeal to paradox (Tracy 1994, 79–83). Similarly Tracy argues that Brian Hebblethwaite's theology of God acting both in and through the causal powers of creatures without any gaps in the natural order also leaves the crucial problem of causality unanswered (Tracy 1995, 304–6).

These rejections lead to Tracy concluding that 'If by an "act of God in history" we mean a divine initiative (beyond creation and conservation) that affects the course of events in the world, then it is at least very difficult to see how such an action could leave a closed causal structure untouched' (Tracy 1995, 310). In this assertion he echoes Pollard's concerns that SDA may be denied without the existence of, as Pollard crudely put it, a 'loophole' in which God acts. In this context Tracy considers it a theological necessity that God's creation must be 'gappy' to allow specific actions. He accordingly proposes a theology of divine action whereby God acts in history by means of exploiting those 'gaps' in the natural order which are ' "open" in ways that accommodate divine action without disruption' (Tracy 1995, 310). These gaps, Tracy continues, will be open to the possibility of SDA if,

> (a) the lock-step of complete causal determination (by antecedent conditions together with the laws of nature) is broken at certain points, and (b) these departures from perfect determination are an integral part of the order of nature, rather than being disruptions of it, and (c) these under determined events can make a difference in the course of events which follows them. (Tracy 1995, 311–12)

Tracy's criterion 'b' is analogous to what Russell and others have identified as the requirement for 'non-interventionist' divine action. Tracy does not exclude miracle as a possibility, however, contra Pollard, as he sees no reason to assert that the creator cannot override the causal powers he grants. There are two different kinds of events that could satisfy these conditions, Tracy continues, namely indeterministic chance and free intentional action (where free will is taken in an incompatibilist sense). He distinguishes causal chance and chaotic unpredictability from true indeterminism. Chaos theory, Tracy argues, shows epistemological unpredictability such that it denies Laplace's dream of an entirely calculable world, and yet it does not introduce the 'ontological openness'

which is necessary for theological assertions of SDA:

> Chaos theory, therefore, reveals that we are behind a 'veil of ignorance' with regard to the determining conditions of many events in our world. It is certainly possible for the theologian to claim that God is at work on the other side of this veil. But such divine actions are just as much a matter of miraculous intervention in natural causal chains as any astonishingly mighty act of God in history. (Tracy 1995, 313–14)

Given Tracy's rejection of these two possible openings it is not surprising that he then turns to consider an indeterministic interpretation of quantum mechanics in more detail. Indeed Tracy identifies two further conditions which would be necessary for quantum SDA to be plausible apart from the necessity of indeterminism: firstly the indeterministic chance that appears in quantum mechanics must exist in the context of an 'ordered structure' (Tracy 1995, 316); and secondly, this indeterministic chance would need to cause objective difference to 'the way events unfold in the world' (Tracy 1995, 317). Quantum mechanics supports the first of these conditions, Tracy argues, as it is satisfied by the probabilistic distributions of chance in quantum mechanics. Moreover, if quantum events sometimes have significant macroscopic effects that are more than just the maintenance of stable lawfulness, then quantum SDA becomes plausible:

> This providential determination of otherwise undetermined events will not transgress natural law; as long as this divine action operates within the statistical regularities . . . Nor will God's activity at the quantum level require that God act as a quasi-physical force, manipulating sub-atomic 'particles' as though they were determinate entities . . . Rather, God will realize one of the several potentials in the quantum system (the 'wave packet'), which is defined as a probability distribution. (Tracy 1995, 318)

Tracy emphasises that he is not asserting that God is active solely in quantum or other 'gappy' natural processes. He also rejects the possibility that his proposal results in a portrayal of God as simply another agent 'jostling for influence in the midst of many others on the cosmic scene' (Tracy 1995, 319). In making these assertions Tracy has much in common with the other proponents of quantum SDA considered in this chapter. However, one substantial difference between Tracy's and Pollard's theses is that Tracy asserts that God leaves some quantum events undetermined (Tracy 1995, 320). In his most recent published work on this subject, Tracy again emphasises the possibility that God may determine occasional quantum events and remain within the scope

of the theory (Tracy 2000). Yet, he makes the point that any account of quantum SDA can only form a small and limited part of the traditional affirmations about divine providence. Indeed Tracy's proposals for quantum SDA are based on a tentative and reflective attitude far from that of Pollard or Heim with their triumphalistic apologetic 'solutions'. In this vein he argues that the divine determination of individual quantum events still remains a significant possibility, even in the light of several recent critiques of the position. A detailed examination of Tracy's claims is not possible until we have studied quantum theory in depth, and we shall thus return to his position in the next chapter.

Tracy's assertions concerning the possibility of occasional quantum SDA are echoed by Philip Clayton who has argued strongly that in general theological claims should be subject to wider reflection and consideration on the basis of science. In this light Clayton has attempted to develop an intellectually honest approach to theology which permits multiple models and open-ended discussions on the issue of God's action in the world. It is undoubtedly an approach which theologians in general would be wise to acknowledge, albeit with a recognition that it becomes increasingly difficult to determine which competing theories are better than others. It is in this context that Clayton makes the assertion that it is easier to make a case today for divine intervention than any time since Newton (Clayton 1997, 173). In common with all of the authors considered in this chapter, Clayton argues that ontological quantum indeterminacies are not gaps that will be closed at some future date by science. Indeed, quantum physics is, Clayton continues, an area of physics which exhibits this kind of ontological limitation, and accordingly:

> Given billions and billions of such minute [quantum] interventions – the potential number would be limited neither by science nor by inability on the part of God – God might be able to effect significant changes on the macroscopic level. (Clayton 1997, 194)

Moreover, Clayton asserts, these divine interventions might be amplified by further sensitive 'chaotic' dependencies to achieve macroscopic aims. Clayton says very little about the precise details of mechanism for his proposed 'causal joint' and, although cautious, clearly supports the general thesis that God is active in determining some but not all quantum indeterminacies.

SUMMARY

These authors mark out the scope of the contemporary claims that quantum SDA is an objective feature of the physical world, although it is important to note that there have been other proposals of quantum SDA developed that are similar to Pollard's claims.[12] Throughout this discussion a number of differing theological and scientific approaches to the issue of divine action have been adopted, and it is helpful to draw parallels between these positions. It has become clear how ubiquitous the notions of quantum 'events' and 'entities' are to this debate, and yet there has been a surprising lack of any detailed discussion as to what exactly an 'event' is in quantum theory. As we shall see in the next chapter, the answer to this question is actually quite complex.

Perhaps the most fundamental difference between the various accounts of quantum SDA can be found in the question of whether God is held to be active in all quantum 'events'. On this issue there is a full range of opinion, from assertions by Heim, Pollard and Murphy that God acts in every quantum process, through Russell's claim that God is active in all quantum events before the development of consciousness and higher-order complexity, to the approach that God is active in only some 'events' as typified by Tracy and Clayton. Those theologians that assert a form of universal divine quantum determinism have difficulties escaping the charge that their theology is occasionalist, while advocates of the latter position have the difficulty of expressing an exact relationship between those indeterministic quantum events sustained by GDA, but which remain 'natural', and those which are determined by God and instantiate quantum SDA.[13] A further area of difference concerns whether quantum SDA is expressed by God choosing from the range of events permitted by the theory (we shall discuss what this means in more detail below), or by modifying the probabilities behind a particular quantum event. William Pollard significantly rejected the latter approach as fundamentally interventionistic, but even a cursory reading of this chapter reveals that the notion of probability in quantum theory is another topic which we must fully address.

Leaving aside differences in these authors' theological objectives, there also exist great differences in the scope of their claims for quantum SDA. On the one hand we have an attempt radically to reformulate causality

[12] In particular by Mary Hesse (Hesse 1975) and Donald MacKay (MacKay 1978).

[13] This theoretical difficulty in relation to the assertion that indeterministic processes exist and are sustained in a creation *ex nihilo* was identified in chapter 4 above.

such as that undertaken by Murphy, and triumphalistic claims that the paradox of God's agency has been solved by Heim and Pollard, to really very limited and speculative claims about the relevance of quantum SDA made by Tracy. Moreover there are distinctions between these authors on the basis of whether they conceive of quantum SDA in individual quantum events as triggers for macroscopic classical or chaotic amplification. Given that this is an element of the proposals of Russell, Ellis and Tracy, we shall consider in detail the relationship between quantum theory and chaos theory in chapter 9 below. A final difference between their positions arises from those theologians who adopt an essentially dualist approach to the mental/natural quantum SDA distinction.

The parallels between their positions are nevertheless extensive. All of the authors here make the assertion that quantum mechanics is ontologically indeterministic, and as we shall see the theory of quantum mechanics by no means forces one into such an interpretation. Another common feature in their accounts is that SDA can take place through these indeterministic processes by God determining some or even all of the events that arise. Moreover they assume that God's relationship to indeterministic events is such that he has foreknowledge of the consequences of his actions and is capable of interacting with these events. This latter assumption is necessary for God to be able to act purposively and achieve some objective as a result of his action. Yet, as we have already seen in chapter 4 above, this implies quite a complex relationship to God's GDA which presumably includes the sustenance of indeterministic processes. A common theme that runs throughout this scholarship is a reliance on the notion of non-interventionism on the part of God in physical laws, and this is itself grounded in a set of implicit assumptions about the nature of physical laws. As we saw in chapter 3 above, were one to assert an essentially regularist approach to natural laws then the issue of non-interventionist SDA evaporates on the basis that *any* SDA that God performs is described by an appropriate law of nature. Inherent in their assumptions must, therefore, be an approach to the laws of nature which permits a notion of law-violation such as the necessitarian stance. However, as we shall see in the next chapter, any Armstrong-like approach to natural laws on the basis of physical necessity faces a rough ride in the context of quantum theory, not least because it is theoretically very complex to accommodate indeterminism within a philosophy of the laws of nature that permits law-violation.

Notably lacking from almost all of these accounts of quantum SDA is any detailed treatment of what the implications are scientifically and *how*

quantum SDA may be accommodated by the theory. Quantum theory is a precise science, and it is simply wrong to characterise it as a realm of universal fuzziness. Indeed even in those interpretations of the theory which assert indeterminism, the scope for potential non-interventionist incompatibilist SDA is actually very limited indeed. As we have seen in the previous chapters, simple broad assertions about the existence of SDA will not suffice, and the onus is on those theologians asserting the theory to substantiate their claims. Simply asserting that God influences quantum theory is not enough, there is, as we shall see, far more that we can say about how this influence may operate if God acts consistently with the theory. Indeed it is only when the full technical detail of the theory of quantum mechanics is considered that the possibility of quantum SDA becomes more clearly articulated. In the next chapter we shall attempt to determine exactly what the scope of these claims can be.

CHAPTER SIX

Does God cheat at dice?

Soon after the initial development of quantum mechanics Albert Einstein made the famous statement that he could not conceive of a God that 'plays dice'. The theologians we considered in the previous chapter seize upon this claimed indeterminacy and have linked it to a theology of special divine action. As we have seen, however, there has been little technical discussion of the possibilities for SDA in quantum theory. It is the aim of this chapter to evaluate this work from a scientific perspective and consider the extent to which God can be said to 'cheat' at playing dice.[1] The approach adopted in this chapter is again to consider the claim for quantum SDA in its most basic form – namely the possibility of God determining all or only some quantum events. We shall leave to one side the many different theological motivations for this claim, and consider in detail whether it is a proposal that appears consonant with our current understanding of quantum mechanics. The most constructive approach to assessing the claims considered in the previous chapter is to push the claim that quantum SDA objectively exists as far as possible and examine more closely which theoretical features of quantum mechanics may be taken in support of a notion of non-interventionist SDA. As we saw in chapters 3 and 4, this will necessarily involve a detailed discussion of the understanding of indeterminism in quantum theory and, as we shall see, shall raise the possibility of both compatibilist and incompatibilist interpretations of SDA.

Before we begin, however, it is important to place this debate into the more general context of the notion of incompatibilist SDA in irreducibly statistical laws. The accounts considered in chapter 5 implicitly assert

[1] This discussion will involve a necessarily technical treatment of quantum theory. A classic introduction to the mathematics of quantum theory can be found in Landau and Lifshitz (1974). A different approach is seen in Feynman, Leighton and Sands (1983) and Landau (1990) offers a more advanced treatment. Probably the best general discussion of the significance of quantum theory for theology can be found in Russell (1988).

a broadly necessitarian position that permits the possibility of interventions in the laws of nature (a claim which is impossible in a regularitarian methodology), and consequently espouse a *non-interventionist* approach to quantum SDA. In chapter 3 we have already seen how SDA may be possible without *epistemological* conflict with statistical explanation through what Carl Hempel termed the problem of 'epistemic ambiguity'. However, as we noted then, this concept of explanatory uncertainty does not necessarily imply that the physical systems in question are open to SDA in the required indeterministic sense. We may not be able to frame detailed and unequivocal causal explanations in the context of a particular statistical law, but without corresponding assertions both that the law is indeterministic, and that God can act through that indeterminism, then we have made no *positive* claims for the existence of SDA. The key point with making claims of this sort is that it places the burden of proof onto the theologian to show that the particular statistical theory or theories that they claim will instantiate SDA are ontologically indeterminate. However we have also already seen how slippery the notion of indeterminism can be, and it is naïve to presume that epistemological unpredictability leads uncritically to ontological indeterminism. In short, then, the question of the feasibility of quantum SDA hinges on technical arguments concerning the status of indeterminism in quantum theory.

Before we begin to look at quantum theory in detail, it is interesting to note that several physicists have reacted against the possibility of quantum SDA. Stephen Hawking's reserve in this respect is typical:

> With the advent of quantum mechanics, we have come to recognize that events cannot be predicted with complete accuracy but that there is always a degree of uncertainty. If one likes, one could ascribe this randomness to the intervention of God, but it would be a very strange kind of intervention: there is no evidence that it is directed toward any purpose. Indeed, if it were, it would by definition not be random. (Hawking 1998, 201–2)

Exactly what notion of divine action Hawking envisages here is unclear, and his references to the 'intervention of God' may indicate a parallel to Einstein's dice comment, although for more explicitly theological reasons because, unlike Einstein, it is clear that Hawking interprets quantum theory as indicative of indeterminism. Equally interesting is the connection Hawking makes between *evidence* of purpose and the existence of quantum SDA. Certainly none of the authors considered in the previous chapter (or the present one) would argue that there could be an experimental

'confirmation' of the existence of quantum SDA, and yet such an approach remains quite natural to physicists. While working at the Cavendish Physics Laboratory at Cambridge the question I was most frequently asked by colleagues was whether I had devised an experiment to prove the existence of divine action. Such comments were not generally made facetiously but arose out of the natural instinct of physicists to seek experimental verification for any theory. Of course modern philosophy of science teaches us that the assumptions made in the practice of physics concerning whether a particular theory gains acceptance in preference to another are highly complex, and those made in quantum theory are particularly so. As such this 'working attitude' of many scientists is philosophically unsatisfactory, but it is fairly ubiquitous and undoubtedly lies at the root of many of the 'gut instinct' reactions of physicists against quantum SDA. This is not the place to consider the role of quantum mechanics in natural theology, and it suffices to note here that methodologically the theoretical assertions made in theology are of quite a different nature to those in the natural sciences. Despite this difference, it is an essential element of the conception of SDA considered throughout this book that God's action in the world does achieve causal physical effects, be they in the natural world or the minds of intelligent beings. As genuine physical phenomena they would surely be epistemologically open to scientific analysis, however the extent to which law-like statements could be constructed as a result is surely very limited indeed.

It is quite remarkable that none of the protagonists of quantum SDA has made a detailed study along these lines despite their collective expertise in these issues. The problem is that the accounts considered in chapter 5 do not go far enough, they all claim 'quantum events' as a locus of SDA and yet do not explain how this might be the case, or even what they take to be an 'event' in quantum mechanics. This point has been well made by Michael Langford in connection with a criticism of Pollard that applies equally to later work in this area:

> Pollard's approach does not in fact advance any view as to how God influences events, only that the nature of the physical universe does not rule out such influence. A location for divine influence is suggested, but no real progress is made with regard to its manner. (Langford 1981, 80)

The burden of proof is on those proponents of quantum SDA to develop their assertions of quantum SDA. This is crucial because, despite the fact that quantum theory has clearly gripped the imagination of many

theologians, it is simply not the case that 'anything goes'. As John Bell put it in the title to a 1984 paper, there really is 'Speakable and Unspeakable' in quantum mechanics.

One of the difficulties in discussing the relationship between SDA and 'quantum theory' is that there are actually a number of different mathematical formulations and philosophical interpretations of quantum processes, and the claims for and against a relationship with SDA are clearly different in each of them. The points of discrepancy between the various theories generally arise in connection with the measurement problem and accordingly the following discussion is split into two halves – the relationship between SDA and the Heisenberg Uncertainty Principle (HUP) which is the same in most of the main philosophical approaches to the theory, and the relationships between SDA and various interpretations of the measurement problem.[2] Finally we shall consider the potential role of non-locality in relation to quantum SDA.

THE DETERMINISTIC BASIS OF QUANTUM MECHANICS

One of the fundamental assertions that led to the development of quantum theory was Louis de Broglie's idea that matter may in certain circumstances behave in a wave-like manner. The description of a particle in space described in the quantum theory that ultimately resulted was as a wavefunction very similar to the wavefunctions used in classical physics and electromagnetism. However one crucial difference with these theories is that in quantum theory the space in which this wavefunction exists is a multidimensional Hilbert space which contains as a small subset classical Euclidean space. As de Broglie postulated, there are times when matter behaves in a wave-like manner and in these circumstances any description of a quantum system using the terminology of classical mechanics is simply impossible. Despite this the wavefunction in quantum mechanics is commonly postulated to contain *all* of the information about a particular quantum system.[3]

The basis of quantum theory is the evolution of particular quantum systems described by wavefunctions with time as governed by the

[2] Several of the interpretations of quantum theory go beyond claims about measurement alone. In particular the Continuous Spontaneous Localisation, Transactional Interpretation and the de Broglie–Bohm pilot-wave approach to quantum mechanics are reformulations of the whole theory. The consequences of these interpretations for quantum SDA claims are considered in detail below.

[3] De Broglie's own account of the differences between classical and quantum wave mechanics remains one of the best treatments of these issues (de Broglie 1973, 341–57).

Schrödinger wave equation.[4] This equation is absolutely central to quantum mechanics and occupies a similar status in the theory to Newton's laws of motion in the classical regime. Despite the fact that it is formally impossible to derive Schrödinger's equation from classical physics it is possible to give less rigorous explanations of the assumptions involved. Given a particular physical situation, such as an electron in a box, any physically possible states of the quantum system in question are generally given by wavefunctions that are solutions of the Schrödinger equation. However it is important to note that in many practical situations it can be fiendishly difficult to find exact mathematical solutions to the Schrödinger equation and accordingly the vast proportion of quantum mechanical studies rely on numerical techniques to establish features of the system in question.

Looking at the Schrödinger equation from a purely deterministic viewpoint, there is *absolutely nothing* about this equation (and in consequence the time dependent evolution of any quantum system) that is in any way different from the corresponding situation in classical mechanics. This is not to assert, however, that the Schrödinger wave equation is purely classical in form, merely that it is composed of the same deterministic elements of mathematics as classical mechanics. This inherent determinism is a point that Ernest Nagel has expressed particularly clearly:

> although the word 'cause' does not occur in these equations [Newton's equations of motion], they are sometimes said to express 'causal relations' simply because they assert such a functional dependence of the time-rate of change in one magnitude (i.e., the momentum) upon other magnitudes. However, the characterization of mechanics as 'causal' on this basis alone does not adequately clarify the sense in which quantum mechanics is allegedly noncausal, since on this criterion the equations of quantum mechanics also constitute causal relations. (Nagel 1982, 278)

The point that Nagel is making in this passage is that the 'causal' nature of classical mechanics is shared by the time dependent evolution of a quantum wavefunction under the Schrödinger equation, and for the purposes of this discussion we can read causal in Nagel's statement as meaning deterministic. Essentially the point is that the time evolution of a quantum state under the Schrödinger equation is no less deterministic

[4] We shall use the so-called Schrödinger picture in this discussion. Heisenberg also formulated quantum mechanics in terms of Hamiltonian differential operators and Hermitian matrices. The fundamental difference in his account is that the states are left fixed in time and the deterministic time evolution applies to the operators themselves. In 1926 Schrödinger realised that his and Heisenberg's accounts were formally equivalent.

than a model Newtonian mechanical system (leaving Earman's discussion of 'space-invaders' aside).[5] This is an absolutely crucial point for the relationship between SDA and quantum mechanics – the basis of quantum theory is a paradigm deterministic theory. Indeed, despite the fact that quantum theory ultimately rests on a quite different set of physical postulates to classical mechanics, it remains totally determinate as Nagel notes:

> an examination of the fundamental equations of quantum mechanics shows that the theory employs a definition of state quite unlike that of classical mechanics, but that relative to its own form of state-description quantum theory is deterministic in the same sense that classical mechanics is deterministic. (Nagel 1982, 306)

Nagel's statement about the fact that quantum determinism is true in the context of its own state description is very important for the state description employed by quantum theory is, nevertheless, abstract and difficult to interpret along classical lines. What leads Nagel to these deterministic assertions is the fact that the wavefunction must be continuous, single-valued, and have a finite value at any particular point at which it is considered. Moreover, given an initial value of the function at some particular instant, Nagel concludes that the unitary evolution under the Schrödinger equation yields a unique set of finite values at any subsequent time (Nagel 1982, 306). If we recall William James' notion of determinism as discussed in chapter 4 above, this description seems the perfect embodiment of his claim that a deterministic and causally closed system has 'no ambiguous possibilities hidden in its womb'. Thus, with reference to our discussion of incompatibilist SDA in chapter 2, it appears that when the Schrödinger time evolution of quantum states is operational (and is taken to provide a complete description of the quantum system under study), incompatibilist quantum SDA is not possible in a non-interventionist sense.[6]

In actual fact it may be that any quantum SDA occurring when the Schrödinger equation determines the evolution of a quantum system is 'more interventionistic' than SDA in classical mechanics conceived in the

[5] Of course, in drawing the analogy with classical mechanics, Nagel wishes to emphasise that quantum theory is deterministic. Nagel himself adopts a different position to that taken in this book in adopting classical mechanics as an ideal deterministic system.

[6] As we have already noted in our discussion of the protagonists of quantum SDA, any notion of non-interventionism implicitly assumes a conception of the laws of nature which supports the hypothetical possibility of an intervention – see chapter 3 above for more details on the relationship between laws of nature and SDA.

traditional sense of violation-miracles. The basis of this assertion arises from a detailed discussion of determinism in quantum theory undertaken by John Earman who has claimed that in many ways quantum theory is actually *more* deterministic than classical mechanics (Earman 1986, 200). The basis of this claim can be seen, following Earman, if we compare the Schrödinger equation with other second-order differential equations, such as the classical heat diffusion equation. While mathematically the two equations look directly equivalent, quantum mechanics alone consists of a number of further assumptions that have the effect of greatly restricting the range of physically permissible wavefunctions. While both equations formally permit the propagation of infinitely fast influences, Earman's space-invaders, the heat diffusion equation is not time reversal invariant, and in this respect is quite unlike the Schrödinger equation which is (assuming we accept that the complex conjugate of the wavefunction is taken to represent a state reversal).[7] Moreover, and this point is crucial in connection with determinism, any given quantum particle must be 'found' at some point in space – that is to say that wavefunctions are normalised for all values of t:

$$\int_{-\infty}^{\infty} |\psi(x, y, z, t)|^2 \, dxdydz = 1$$

This condition arises from Max Born's postulate that $|\psi|^2 d\tau$ represents the probability density of 'finding' a given quantum particle within the elementary region $d\tau$ around the point in space and time at which the value of the wavefunction is evaluated. The normalisation condition above essentially means that, for a given quantum system, any particle must be found *somewhere* in space. Earman emphasises that this condition, when combined with the single-valued nature of the Schrödinger equation, implies determinism and a unique value of the wavefunction at all subsequent times.

Given that the evolution of the quantum state as just described does not appear to be an opening in the theory which is consonant with non-interventionist incompatibilist SDA, we shall move from these general considerations to the status of the Heisenberg Uncertainty Principle (HUP) in relation to determinism and SDA. The key point which we shall be making in the following discussion is that the HUP, in the form in which it is normally discussed, reflects difficulties in prediction which

[7] Indeed the time reversal invariance of the Schrödinger equation was used by John Cramer to develop the transactional interpretation of quantum mechanics – see below.

result from the problem of constructing a quantum mechanical description in terms of the classical concepts of position and momentum. It does not, however, change the deterministic basis of the Schrödinger equation that we have just considered. The relationship between SDA and the HUP is thus not simplistically that the HUP introduces an indeterminism into quantum mechanics which would be suitable for the action of God – in actual fact the HUP changes nothing about the ontological status of determinism in quantum physics despite the fact that it raises potentially insurmountable epistemological difficulties.

The reason that these *epistemological* difficulties arise can be understood when one appreciates how difficult it is to import the classical concepts of position and momentum into quantum theory at the same time. Nagel again expressed this difficulty clearly:

> Newton's mechanics allows a strictly causal prediction of the positions and velocities of mass points which are regarded as the physical reality described by this theory . . . It [quantum mechanics] only loses its causal character if we regard the positions and momenta of particles as the state variables which describe the physical reality . . . Therefore, we cannot compare them as to the greater or smaller validity of the law of causality. (Nagel 1955, 478–9)

Nagel develops this argument in relation to determinism, and it is his work here that is of primary importance to us in our study of SDA. Indeed it is crucial that he rejects arguments for indeterminism in quantum theory merely on the basis that the HUP precludes the existence of precise simultaneous values for position and momentum. Nagel's rejection is primarily based on the inapplicability of classical concepts to quantum mechanics. He argues that concepts of 'position' and 'momentum' cannot be transferred simplistically from classical mechanics – with the result that claims based on this conjugation of uncertainty do not translate easily into deterministic language (Nagel 1982, 305).

In the context of incompatibilist SDA, the more important contribution that Nagel makes concerns the determinism of quantum mechanical state descriptions. He grants that, given the HUP limitations, any state description of quantum mechanics that is formulated in terms of position and momentum alone will be *prima facie* indeterministic. However, as we have already seen, this is precisely not the way in which quantum theory is formulated. This point has been helpfully drawn out by Stephen Hawking:

> These quantum theories are deterministic in the sense that they give laws for the evolution of the wave with time. Thus if one knows the wave at one

time, one can calculate it at any other time. The unpredictable, random element comes in only when we try to interpret the wave in terms of the positions and velocities of particles. But maybe that is our mistake: maybe there are no particle positions and velocities, but only waves. It is just that we try to fit the waves to our preconceived ideas of positions and velocities. The resulting mismatch is the cause of the apparent unpredictability. (Hawking 1998, 207)

The last sentence in this quotation is of key importance: Hawking interprets the HUP as an 'apparent . . . mismatch' – and, if we adopt Nagel's more technical arguments, one which results from attempts to develop a state description in terms of position and momentum simultaneously. Thus, on the reading suggested here, the HUP is one of the most misapplied features of quantum mechanics – and certainly so in a theological context. Indeed, according to Max Jammer, Heisenberg in his 1927 paper describing his famous uncertainty principle used two quite different terms: *Ungenauigkeit* or inexactness/imprecision is used heavily (at least thirty times) whilst *Unbestimmtheit*, or indeterminacy, is used only three times (Jammer 1974, 61).

The HUP arises simply as a mathematical consequence of the construction of quantum mechanics, and is quite unrelated to the notion of complementarity which is an extraneous addition to the theory.[8] Indeed it is perfectly possible to interpret the HUP without any recourse to complementarity whatsoever. The well-known form of the Heisenberg Uncertainty Principle relates uncertainty in position with that in momentum, is an implication of the wave mathematics used to do quantum theory, and follows simply from the transformations used to convert between momentum and x-space in Fourier mathematics. Crucially, though, at no point does its derivation challenge the deterministic evolution of the wavefunction under the Schrödinger equation.

Patrick Suppes, echoing Nagel's comments about the difficulty of expressing quantum mechanics in classical terms, has devised the following

[8] It is easy to derive the HUP by considering a periodic function in x-space expressed as a Fourier series. The basic relation $\Delta x \Delta k \geq S$, where S is a constant dependent on the form of the function, arises naturally from general properties of Fourier series and wavefunctions and has nothing to do with the postulates of quantum mechanics as such. Using the postulate $\hbar k = p$ we obtain the standard form of the HUP $\Delta x \Delta p \geq \hbar$. What this means is that any attempt to construct a wave mathematically that is localised in x-space will be delocalised in p-space. Because of the minute size of $\hbar$ it is only for microscopic systems that this inequality conflicts with normal classical assumptions. As a matter of historical background, it is worth noting that Bohr's own solution to this problem was to claim that wave and particle behaviours could only be studied by means of mutually exclusive experimental apparatuses. This broadly instrumentalist stance does, however, raise more important questions about the realism of quantum mechanics (Teller 1996).

useful checks on the interpretation of the HUP:

> The first thing to note is that this inequality [the HUP] for the product of the standard deviations of two random variables in itself tells us nothing about the process of measuring the values of these random variables . . . It is commonly said that the Heisenberg principle shows we cannot measure both momentum and position simultaneously with arbitrary position . . . The real point is that the uncertainty relation does not represent a genuine statistical relationship at all, for there does not in general exist a joint probability distribution of the momentum and position random variables. The real claim to be made is that when a proper joint distribution of momentum and position does not exist, then these two properties are not simultaneously measurable at all. (Suppes 1961, 384–5)

This passage deserves some unpacking. Suppes describes a misleading approach to the HUP based on difficulties associated with simultaneously measuring position and momentum with arbitrary precision. A closely related argument is that, because of the minuscule size of quantum particles, and the fact that in order to make any position measurement we must interact with the quantum system, this interaction results in the uncertainty on the part of momentum. This fact is often expressed along the lines that by observing a particle with a photon, the photon must rebound off the particle, and thus gives it an unknown kick of momentum. While this consideration may have some practical significance, it could not be further from a correct understanding of the status of the HUP. At no point in the mathematical derivation of the HUP is the process of measurement assumed, and although this approach may be a helpful way of picturing the consequences of the HUP, it is not the reason that it exists.

In conclusion it is reasonable to assert that the HUP places strong limitations on any conception of Laplacian *epistemological* determinism – it is simply impossible to be able to measure the initial conditions simultaneously which are required in Laplace's scheme for subsequent determination of the world. However, if we recall William James' *ontological* notion of determinism, it is not the case that the HUP introduces any open possibilities into nature's womb, and it is this *ontological* sense which is crucial for the assertion of quantum SDA. The Heisenberg Uncertainty Relation is certainly a limitation on the human perception of reality, however there is no point in which the determinism of the Schrödinger equation is violated solely by the HUP formulation itself. To recall Nagel's earlier statement, nothing has happened – the wavefunction is still continuous, single valued and finite at all times. This fact has also been succinctly put by Gino Tarozzi:

if it is true that Heisenberg's principle exorcises once for all the Laplacian demon, it is equally true that from a strictly logical point of view this principle does not represent a refutation of deterministic causality. (Tarozzi 1995, 437)

Unfortunately, however, the situation is not quite this simple. The reason that this is the case is that in order for Laplacian determinism to fail by means of the HUP, one has to attempt to make a measurement of the quantum system in question. Nevertheless, as we have already noted, there is nothing in the derivation of the uncertainty relations that assumes measurement *per se*. Rather they result from the standard pre-quantum treatment of waves, and the phenomenon of optical diffraction can be analogously understood as a limitation on the extent of an optical wave. The greater the extent of limitation, the greater the extent of the spreading. As Roland Omnès has put it: 'the uncertainty relations [HUP] are only witnesses to the wave character of the underlying physics' (Omnès 1994, 11).

Of course, the ontological value of the HUP remains deeply linked to the philosophical assumption that what cannot be known has no existence. This is, of course, much in common with the Copenhagen interpretation. However it was not long before this fundamental assumption was questioned in order to make realist claims for quantum mechanics. Thus, if one accepts an essentially realist interpretation of quantum mechanics (which surely we are required to do if we are to link it to SDA), then one is also at liberty to claim that the wavefunction remains a real entity at all times despite the epistemological limitations the HUP imposes. Thus it seems quite clear that the HUP does not modify the deterministic difficulties noted above in relating quantum theory to SDA.

In an interesting study, Rollin Workman has argued that the status of the HUP is such that it could not be clearly taken to indicate ontological indeterminism (Workman 1959, 251–4). He acknowledges that the fact that the HUP denies simultaneous measurement of both position and momentum of a given particle leads to insurmountable difficulties in establishing any form of prediction, however, Workman emphasises, this does not lead to any solid conclusions about the truth of ontological indeterminism:

Newtonian mechanics supported determinism by assuming (1) each elementary particle has a single valued position and momentum at each instant and (2) the position and momentum can, at least theoretically, be exactly measured. The Heisenberg principle seems to support indeterminism by denying (2). The

supposition must still be made that (1) holds. The same kind of argument, however, that denies (2) also denies (1). Hence the Heisenberg support for indeterminism fails. (Workman 1959, 253–4)

Workman is essentially arguing that the concept of indeterminism is itself applicable only to the classical regime in which particles possess single valued state variables. Workman finds himself reaching the conclusion that 'It may be that the hegemony of quantum theory in physics will force philosophers to drop the terms "determined" and "indetermined" in order always to use "predictable" and "unpredictable" instead' (Workman 1959, 259). Although such a radical conclusion remains outside the discussion in this book, there is a reasonable sense in which we can assert, *contra* Workman, that it is possible to use the term 'indeterminism' in a precise manner in the context of quantum mechanics. The assumption Workman's position is based upon is that there exists no possible way to formulate determinism (which, he argues, remains an essentially classical concept) in anything other than terms based on the assumption of particles and the movement of these particles, a basis which is simply not found in quantum mechanics. However a distinct benefit of adopting William James' broader description of indeterminism based on flexibility and open futures in nature is that it transcends this classical basis with the result that indeterminism can remain a meaningful concept in quantum mechanics.

The problem with Workman's position is that his argument essentially rests on the assumption that determinism can only be defined in terms of classical concepts of position and momentum. This strategy can only lead to a definition of determinism which is appropriate to classical mechanics and that does not transfer into other physical theories. As Earman has noted, the notion of determinism is itself parasitic on substantive assumptions about the physical reality in question, and this leads to an inherent circularity.[9] Despite this difficulty, it is clear that James' approach to determinism is suitably precise to remain a yardstick for assessing deterministic claims in many different theories. As such it is clear that neither the unitary evolution of the wavefunction with time as governed by the Schrödinger equation nor the HUP introduces any of the flexibility it requires as indicative of indeterminism. Consequently *no appeal can be made to either the HUP or the evolution of the wavefunction with time under the Schrödinger equation, as being features of quantum theory that would support an incompatibilist notion of non-interventionist quantum SDA on an*

[9] For a detailed discussion of determinism and SDA see chapter 4 above.

essentially necessitarian interpretation of the laws of nature.[10] The implication of this pervasive determinism in quantum theory is that quantum SDA is *only* a viable assertion in a non-interventionist incompatibilist sense at points where the deterministic evolution of the quantum system under the Schrödinger equation is punctuated, and these points are generally known as 'measurements' in quantum mechanics.

WHAT IS AN 'EVENT' IN QUANTUM MECHANICS?

We have already seen in the previous chapter how frequently the concept of a quantum mechanical 'event' is used by protagonists of quantum SDA. God is held to manipulate quantum 'events' in order to guide the workings of nature (including the human mind), and we have already stated that a misunderstanding of the concept of event in quantum mechanics is at the root of Nancey Murphy's approach. The key point for the purposes of quantum SDA is that *no quantum 'events' take place until the point of measurement.*[11] Consequently, it is an implication of the theory of quantum mechanics that where those authors considered in the previous chapter assert that God determines quantum 'events' non-interventionistically what this claim translates to scientifically is the claim that God interacts by means of a quantum measurement process. In a discussion of the theory of quantum mechanics, Henry Stapp has reached a similar conclusion in relation to this 'event' language:

> If one tries to use the wave function and the Schrödinger equation of quantum mechanics then one finds that the 'event' never occurs. Rather, every possible event occurs: there is no singling out of the one event that actually occurs from the myriad of possible events that might occur. (Stapp 1987, 258)

In this quotation Stapp has identified one of the key difficulties with quantum theory – namely the question of whether it is reasonable to assert that the superpositions of wavefunctions, the 'myriad of possible events' as

[10] The caveat 'on an essentially necessitarian interpretation' is crucial for, as we have already seen in a general discussion of the relationship between laws of nature and SDA, the status of whether SDA can be taken to intervene in the laws of nature is highly dependent on what philosophical approach to these laws of nature one adopts. Indeed the whole non-interventionism approach assumes that the laws of nature generally *prescribe* those events that take place in nature rather than simply *describing* them. Those authors considered in the previous chapter in relation to quantum SDA generally implicitly make an assertion that the laws of nature are necessitarian in this sense, and on the whole their approach appears to accord very closely with Armstrong's notion of physical necessity as discussed in chapter 3 above.

[11] Alberto Cordero has posed these problems starkly by considering the emission of an alpha particle from a uranium nucleus in its ground state (Cordero 1990, 264).

he terms them, are a *realistic* component of the theory. The Copenhagen approach was to assert that the 'event' only takes place on measurement, and the difficulty is that quantum mechanics naturally supports a superposition of states simultaneously (recall Schrödinger's Cat which is *simultaneously* both dead and alive). Indeed there is nothing in the deterministic operation of the Schrödinger equation, or the Heisenberg Uncertainty relationships, that makes anything in quantum mechanics happen other than in a linear and deterministic manner. This point is of crucial importance for our study of the relationship between SDA and quantum mechanics for it means that if God is active on a quantum level, and quantum mechanics is held to offer a complete description of microscopic physics, then quantum SDA can only occur by means of a 'measurement' type interaction between God and creation. Measurement in this sense simply means some break from the deterministic evolution of the superposition of wavefunctions under the Schrödinger equation. This, of course, means that we must examine the measurement problem of quantum mechanics in detail, *and consequently the possibilities for quantum SDA are different in each philosophical interpretation of the quantum measurement problem.* We shall focus in the discussion that follows on the so-called 'orthodox' or neo-Copenhagen interpretation of quantum mechanics because this is the interpretation of the theory that makes the strongest claims for indeterminism and is universally promulgated by those theologians who assert quantum SDA.

It is an unfortunate fact about quantum measurement theory that it does not in general make any predictions which could be incorporated into experiments aimed at its own test.[12] Consequently, despite the remarkable success of the predictions of quantum theory and its experimental verification, virtually no experimental studies have been focussed on testing the various interpretations of quantum measurement theory themselves.

So, how might we go about relating quantum measurement theory and the determination of an indeterministic quantum measurement 'event' by God? As a preliminary it is important to be clear about the problem measurement theory is designed to address; Josef Jauch has identified two fundamental features about measurement that are inconsistent with the deterministic time-dependent evolution of the wavefunction under the Schrödinger equation. The first of these is the fact that a typical

[12] Possibly the best succinct description of the problem of measurement in quantum mechanics is to be found in Wigner (1963); see also Busch, Lahti and Mittelstaedt (1991) for a more technical treatment.

measurement process ends with the establishment of a permanent and irreversible record, and the permanency of such recordings appears to contradict the time-reversible Schrödinger equation; a second problem is that a given individual recording of the result of measurement is one of *several* permitted alternatives – a fact which is incompatible with the principle of unitary evolution of the wavefunction under the Schrödinger equation which always transforms pure states into other pure states (Jauch 1973, 684).

These difficulties were brought into sharp relief by an infamous thought-experiment devised by Schrödinger himself. Despite the many differing descriptions of his Cat experiment in contemporary texts on quantum mechanics, perhaps the clearest account of the theoretical difficulties Schrödinger envisages remains that given in his original paper. Schrödinger begins by placing the unfortunate animal in a sealed chamber with a vial of cyanide that may be shattered if a particular quantum decay event takes place. If the atomic decay happens the triggering device will be fired, and the cat will be killed, however:

> If one has left this entire system to itself for an hour, one would say that the cat still lives if meanwhile no atom has decayed. The first atomic decay would have poisoned it. The [wavefunction] of the entire system would express this by having in it the living and the dead cat (pardon the expression) mixed or smeared out in equal parts … which can then [only] be resolved by direct observation. (Schrödinger 1980, 328)

Let us put this situation into a basic quantum formalism. The cat has two possible states, dead or alive, and the cyanide-triggering device can be in two potential states, 'triggered' or 'not-triggered', each of which corresponds to whether or not a particle from the atomic decay has been received by the mechanism. The initial state of the whole system in the box (cat + cyanide-triggering device) is

$$|not - triggered\rangle \otimes |alive\rangle$$

i.e. the cat is placed in the box alive and the triggering mechanism has not previously fired. When the lid is closed the system evolves into the following superposition:[13]

$$|not - triggered\rangle \otimes |alive\rangle + |triggered\rangle \otimes |dead\rangle$$

The left-hand term again corresponds to the triggering mechanism not having fired and the cat being alive; the right-hand term represents the

[13] The normalisation constants have been omitted for clarity.

situation where the triggering has happened, the cyanide vial has broken, and the cat is dead. In this superposition the cat is, as Schrödinger put it, 'smeared out in equal parts'. He did not mean that there was some kind of cat purée, or that there were two cats in the box, but rather that the one cat is both dead and alive at the same time. However, when the lid of the box is opened and a measurement made in which we determine the vitality of the cat, then the cat is observed to be either dead or alive *but not both.* Something fundamental must, therefore, have taken place at the point of measurement to resolve the linear superposition of two different states (dead and alive) into one or other state – just dead or alive.[14] What this process is and what actually causes it is the basis of the famous 'measurement problem' in quantum mechanics.

A helpful approach to this measurement problem is to consider what theoretical steps we can take to eliminate all but one element of the cat superposition.[15] At the point of measurement one half of the superposition of dead *and* alive is eradicated, and consequently we observe only the remaining half – either dead *or* alive. To represent the result of measurement on this formalism there are several different approaches we could pursue as a counterpoint to the standard unitary evolution of the wavefunction under the Schrödinger equation.[16] Indeed there are essentially seven broad approaches to quantum measurement that have been adopted:

1. We can introduce object-like or field-like entities to represent actual physical things. This approach leads to the de Broglie–Bohm notion of a pilot-wave in which classical particles are guided by a wavefunction representing all of the possibilities offered by the quantum system in question. This approach is much more than a solution to measurement alone and constitutes a completely deterministic reformulation of the basis of quantum theory.
2. We could dualistically partition the world into two types of entities: quantum systems and measuring devices. This attempt has been made in association with the claim that measuring devices are systems that contain more than a certain number of classical interacting particles (a neo-Copenhagen approach), or on the basis that the conscious mind is fundamentally different from other matter. The latter position

[14] Technically the difficulty arises because neither of the components of the superposition is itself an eigenstate of dead-ness and accordingly something must happen at the point of measurement to resolve this.

[15] For an interesting discussion of what the world would be like if quantum superpositions were maintained into the realm of human experience see Gamow (1965).

[16] What follows is an extended discussion based on the approach adopted in Stapp (1987, 258).

was proposed by Eugene Wigner and is very close to a form of solipsism.[17]

3. We could introduce idea-like entities which occupy all of the different possibilities resulting from the superposition of the wavefunction. This leads to the many-worlds/minds approach in which the other worlds must be interpreted as objectively real in order to make any distinction from the standard Schrödinger evolution of the wavefunction. When the totality of possible worlds/minds is considered this option is again a totally deterministic interpretation of measurement.
4. We could introduce action-type entities to eliminate the unrealised superpositions in the wavefunction at the time of measurement. This is commonly achieved by the postulate of wavefunction 'collapse' upon measurement and is a postulate in the neo-Copenhagen or 'orthodox' interpretation. This approach is also known as wavefunction 'reduction' or, more technically, the projection postulate. Unlike the previous approaches, it is common to assert that the selection of the particular element of the superposition upon measurement is indeterministic.[18]
5. Or, we could modify the basic Schrödinger equation in such a way as to introduce an element of non-linearity into the fundamental wave equation of quantum physics. The separate notion of measurement then becomes redundant because superpositions only exist for extremely short times. This is the so-called continuous spontaneous localisation (CSL) approach and has been popularised by physicists such as Ghirardi, Rimini and Weber and it potentially incorporates an indeterministic claim.
6. We could claim that God decides which component of the superposition is realised at *every* measurement.[19] This is a form of quantum

[17] This approach shall not be considered in detail below because the claims for indeterminism it makes are similar to those made in the orthodox theory, the only difference being in which physical objects are identified as measuring devices as opposed to quantum systems undergoing evolution under the Schrödinger equation. A good critique of Wigner's approach on the basis that it challenges notions of independent reality can be found in Rae (1986, chapter 5).

[18] The following discussion will not focus on the possibility of hidden variables in quantum mechanics. These are generally presumed to be a series of underlying *deterministic* functions which are expressed in quantum measurements, and as such are not relevant to the quantum SDA proposals considered in the previous chapter unless God's action is asserted in a predetermined unintentional sense. Moreover, there are a number of conclusive arguments against the existence of these underlying variables – see, for example, the discussion in Sklar (1992, 202f.).

[19] It must be noted here that from a philosophical perspective the assertion that God determines the outcome of only *some* quantum measurements is not a satisfactory approach to the measurement problem on its own. We shall reconsider this position below in a more general discussion about quantum SDA, but it suffices to note here that occasional determination of measurement results

SDA but is very close to the occasionalist position discussed in the previous chapter. It does, however, deserve to be more widely considered by the scientific community at large as another potential solution to the quantum measurement problem. It is, at the very least, no more bizarre than many of the competing interpretations.

7. Finally, we could approach the problem in terms of the interaction of advanced and retarded waves which propagate backwards and forwards in time. This is the 'Transactional Interpretation' of quantum mechanics and was developed by John Cramer. Again it is a fully deterministic approach to quantum measurement.

One feature of this very brief survey of different approaches to the measurement problem that should be immediately apparent is that the majority of the approaches to measurement are deterministic. For the avoidance of any doubt, the implication of this is that non-interventionist incompatibilist quantum SDA as considered in the previous chapter is not possible on any of these deterministic approaches to the measurement problem, and the precise details of this claim shall be worked out in detail below. As we have already mentioned *the claims for quantum SDA are by necessity quite different in relation to each of these approaches to quantum measurement*, and in keeping with the methodological approach adopted elsewhere in this book, we shall consider each of them in turn.[20] We shall thus begin our study with the relationship between SDA and the third approach above – so-called 'orthodox' interpretation incorporating the projection postulate.

THE ORTHODOX INTERPRETATION

The Copenhagen Interpretation is essentially a codification of the philosophical position developed by Niels Bohr.[21] Part of the intricacy

by God cannot be considered a 'solution' to the quantum measurement problem unless it is also combined with elements of the Copenhagen interpretation to explain the status of non-divinely determined measurements. The assertion that God determines the result of every quantum measurement, however, does constitute a self-consistent approach to quantum measurement, albeit one that we have rejected theologically because of its occasionalistic implications.

[20] Broadly speaking the methodology that is propounded here is that we must work out the details and implications of our various hesitant models of God's action in as much detail as possible – see Preface above.

[21] Bohr asserted that a consequence of the notion of quantum complementarity was that there exists an irreducibly probabilistic element to quantum theory. His approach to quantum measurement was purely epistemological and he denied that any knowledge of the ontology of these processes could be obtained. As he put it, 'in quantum mechanics, we are not dealing with an arbitrary renunciation of a more detailed analysis of atomic phenomena, but with a recognition that such an analysis is *in principle* excluded' (Bohr quoted in Goldstein 1998, 42). Consequently, Bohr never

surrounding the Copenhagen interpretation is unfortunately due to the fact that Bohr never wrote a full systematic discussion of his philosophy. As Roland Omnès has noted, this has resulted in a very unusual situation for contemporary physics – even today, and this book is no exception, Bohr's interpretational musings are frequently cited long after they were written, and consequently the most important books on the Copenhagen interpretation are simply collections of papers written by the original physicists involved. Much of the reason for this reliance on the early papers stems from the fact that Bohr seems to have positively avoided using any detailed technical and philosophical language in his discussions; indeed Louis de Broglie once described Bohr as ' "the Rembrandt of contemporary physics", with a predilection for "obscure clarity" ' (cited in Honner 1987, 24). Bohr's approach is surely unsatisfactory in that it goes no way as to explaining what is actually happening at the point of measurement – indeed, it seems reasonable to question Bohr's basic assertion that classical mechanics must constitute the norm of good explanation. His approach, whilst informative, is too despairing by half. Indeed, the mere existence of the pilot-wave theory surely shows us that we are not forced into accepting Bohr's notions of complementarity and indeterminism on experimental grounds alone. It is, however, important to acknowledge at this stage that most physicists consider the philosophical difficulties of measurement to be adequately addressed by the Copenhagen approach and have thus awarded it a somewhat unfair priority in discussions of the foundations of quantum mechanics.[22]

It is crucial to distinguish Bohr's views from the later additions of wavefunction collapse or reduction. Indeed, it appears fairly clear that any attempt to connect SDA and Bohr's pragmatism concerning measurement cannot lead to coherent statements about the action of God through quantum SDA. Leaving any speculation about Bohr's theological position aside, it would have been consistent for him to assert that the principle of complementarity simply precludes any meaningful

addressed the measurement problem in any detail – he acknowledged that there were difficulties in this area, but doggedly focussed on applying classical concepts as a tool for interpretation. The difficulty in applying these classical concepts led to Bohr effectively asserting that we simply cannot have any detailed knowledge of quantum measurement because it is denied to us by virtue of complementarity.

[22] Indeed the priority accorded to the Copenhagen interpretation has led to research in other deterministic approaches to quantum measurement, most notably the de-Broglie–Bohm pilot-wave approach, being significantly underfunded and undeveloped. It is tempting to conjecture whether the pilot-wave methodology would be more widely accepted had it been debated with the same vigour as the Copenhagen interpretation.

discussion of quantum SDA. We shall thus turn to consider what Eugene Wigner has labelled the 'orthodox' theory of quantum mechanics in which the wavefunction is held to collapse or jump from a superposition of several states to a choice of only one of these states. John von Neumann's approach, which is considered below, is not merely a refinement of Bohr's views – rather it constitutes a radically different programme. Instead of adopting Bohr's reliance on the primacy of classical concepts in describing quantum systems, von Neumann's focus was effectively quite the opposite, namely a complete *quantum* description by making the assumption that quantum theory was valid at all scales. This left him with the problem of identifying the distinction between the measurement apparatus and the system in question, and it is for this reason that he developed the notion of the projection *postulate* as it was subsequently called.[23]

The projection postulate and SDA

The notion of wavefunction collapse was first formulated by John von Neumann as a deduction from experiments on the scattering of light by electrons (von Neumann 1983, 549–647). In the following discussion we shall follow von Neumann's original treatment of the measurement problem and his introduction of the wavefunction collapse postulate.[24] We have already met the unitary deterministic evolution of the quantum wavefunction under the Schrödinger equation, but von Neumann postulated a second kind of quantum process that works by puncturing this determinism:

> we found [earlier in his treatise] a peculiar dual nature of the quantum mechanical procedure which could not be satisfactorily explained. Namely, we found that on the one hand, a state ϕ is transformed into the state ϕ' under the action of an energy operator $\hat{H}$ in the time interval $0 \leq \tau \leq t$:
>
> $$\frac{\delta}{\delta\tau}\phi_\tau = -\frac{2\pi i}{h}\hat{H}\phi_\tau$$
>
> so if we write $\phi_0 = \phi$, $\phi_t = \phi'$, then
>
> $$\phi' = e^{-\frac{2\pi i}{h}t\hat{H}}\phi$$

[23] The associated phenomenon of decoherence is now widely accepted *not* to be a potential solution to the measurement problem of quantum mechanics, despite several claims to the contrary. For this reason the following discussion does not explore decoherence phenomena in any detail – for further details see Omnès (1994).

[24] An excellent summary of von Neumann's approach is given in van Fraassen (1991, 245–58).

which is purely causal. A mixture U is correspondingly transformed into

$$U \rightarrow U' = e^{-\frac{2\pi i}{h} t \hat{H}} U e^{\frac{2\pi i}{h} t \hat{H}} \tag{2}$$

Therefore, as a consequence of the causal change of ϕ into ϕ', the states $U = P_{[\phi]} \ldots$ go over into the states $U = P_{[\phi']} \ldots$ On the other hand, the state ϕ – which may measure a quantity with a pure discrete spectrum, distinct eigenvalues and eigenfunction $\phi_1, \phi_2, \ldots$ – undergoes in a measurement a non-causal change in which each of the states $\phi_1, \phi_2, \ldots$ can result, and in fact does result with the respective probabilities $|(\phi, \phi_1)|^2, |(\phi, \phi_2)|^2, \ldots$ That is the mixture

$$U \rightarrow U' = \sum_{n=1}^{\infty} (U\phi_n, \phi_n) P_{[\phi_n]} \tag{1}$$

Since the states go over into mixtures, the process is not causal. (von Neumann 1983, 619–20)[25]

In this discussion von Neumann identifies what he terms the 'causal' and 'not-causal' natures of processes (2) and (1) respectively. Elsewhere in his treatise he refers to the causal process (2) as an 'automatic' change which takes place with the passage of time, and process (1) which takes place on measurement as 'arbitrary' (von Neumann 1983, 553). The difference between his processes (1) and (2) is totally fundamental, and von Neumann made this fact quite clear: 'quantum mechanics describes the events which occur in the observed portions of the world, so long as they do not interact with the observing portion, with the aid of the process 2 ... but as soon as such an interaction occurs, i.e., a measurement, it requires the application of process 1' (von Neumann 1983, 622). Upon his scheme therefore there are two fundamentally different types of quantum evolution – process (2) takes place at all times other than when process (1) measurement interactions take place. It is clear that in this sense his initial premise of applying quantum mechanics to phenomena at all scales necessitated this bold metaphysical *postulate* that there should exist a second quite different form of quantum state evolution to that under the Schrödinger equation.

This has important implications for the relationship between SDA and quantum theory. Von Neumann's process (1), or wavefunction collapse as it is also known, is *the only place in the 'orthodox' theory of quantum*

[25] The operator notation has been modernised and the labels (1) and (2) have been added to identify the two different quantum processes. In this description U is a statistical operator, and hence $(U\phi_n, \phi_n)$ is a fraction of the original ensemble.

mechanics in which true ontological indeterminism might be accommodated. The indeterminism arises solely from the fact that, upon measurement and the operation of wavefunction collapse, there is no determination of *which* of the various elements of the superposition will be realised in that particular measurement. Returning to the Schrodinger's Cat experiment, on von Neumann's interpretation there is absolutely nothing that determines whether the result of applying process (1) to the cat (i.e. opening the lid of the box and making a measurement) will be that it is dead or alive. There is a 50% probability that we shall obtain each of these results upon process (1), and there is no way to go behind this percentage. Thus the notion of 'event', as applied by the proponents of quantum SDA in the previous chapter, can only refer in the orthodox interpretation to those times when process (1) takes place, and correspondingly the *only* possibility for non-interventionist SDA is by means of God determining this indeterminacy as invoked in a measurement-type interaction.

Von Neumann's approach was to *postulate* this different form of wavefunction evolution upon measurement and we are thus left with the difficulty of justifying this notion of wavefunction collapse. One potential support for his approach was identified by von Neumann himself and concerns the possibility of repeated measurements: if we repeat a measurement on a quantum system 'just after' a previous measurement we should get virtually the same result as the first measurement every time (to within a good statistical accuracy). This explanation, however, is not as clear-cut as may be presumed, and a lot of the difficulty involved in verifying it arises from the basic experimental problem of making the first quantum measurement without destroying or altering the quantum system under study.[26] From a practical perspective, the postulate can be supported, but again not theoretically justified, on the basis that at some scale it must be necessary for quantum superpositions to be broken. On the level of human experience we simply don't see dead and alive cats, or buses turning left and right, at the same time.

Given this understanding of the projection postulate and the interpretation commonly accepted as the neo-Copenhagen or 'orthodox' view, we can ask in what ways God can be active in determining quantum mechanical events. Indeed there are four possible senses in which this could take place and each is reliant on a marginally different interpretation of quantum measurement in the orthodox interpretation. Given that we

[26] Von Neumann's account has itself come under some criticism on the basis that it is reliant on an equivocation between state preparation and state measurement – see e.g. Margenau (1936).

have deterministic wavefunction evolution which is 'punctuated' by indeterministic collapses of the wavefunction on measurement, there is a fairly rigid set of possibilities open to the proponent of non-interventionist quantum SDA:

God alters the wavefunction between measurements

This is perhaps the most fundamental sense in which God could act within the theory of quantum mechanics. The basic position is that God chooses to alter the mathematical state expression or wavefunction of the quantum system by some or other means between measurements when the wavefunction's evolution is governed by the Schrödinger equation. This could be achieved in two different ways: either God could radically alter the original wavefunction by simply replacing it with another, or God could change it to represent not only the previous system but also include as a superposition a new state that he wishes to become a possible outcome of a given measurement.

Let us reconsider Schrödinger's Cat – on a basic interpretation of the problem the superposition prior to measurement is as follows (recall the above discussion):

$$|not - triggered\rangle \otimes |alive\rangle + |triggered\rangle \otimes |dead\rangle$$

Now let us presuppose that God wishes to add a third desired state into this superposition that he wishes to become a physical result by virtue of quantum SDA. On this approach to quantum SDA the superposition changes to:

$$|not - triggered\rangle \otimes |alive\rangle + |triggered\rangle \otimes |dead\rangle + |desired\rangle$$

in which $|desired\rangle$ is the state that God wishes to make realisable by virtue of quantum SDA. We should note several things about the differences between these two superpositions. Firstly, whether the addition of this new 'desired' state is in fact a highly interventionistic act is dependent on our understanding of the reality of superpositions in the wavefunction. In essence the question is whether Schrödinger's cat is *really* both dead and alive simultaneously, or simply, following the naïve Copenhagen interpretation, that we cannot talk about the reality of the superposition until the time of measurement. Either we accept the weird quantum implication of the dual state of the cat, or we deny the existence of the cat after the lid of the box is shut. If we accept the

first option then the addition of this component of the superposition is a highly interventionistic form of SDA, no less so than 'miraculous' action in the macroscopic world. Moreover, even if we deny any reality to the quantum superpositions between measurements, then there is doubt as to whether a veil of complementarity rescues this approach. The reason this is the case is that the addition of new elements into the superposition, or the alteration of existing elements, is a highly interventionistic action when the wavefunction is *deterministically* controlled by the edicts of evolution under the Schrödinger equation (von Neumann's process 2).

Secondly, there are very strong quantum mechanical limitations on what the state 'Desired' can be. It would obviously be a very radical intervention to presuppose that the state desired by God might be that of the cat transformed into a dog for example, and that a dog superposition was added to those in Schrödinger's box. In more technical terms the eigenstate–eigenvalue link in quantum mechanics implies that the state 'Desired' must *still be an eigenstate* of whichever observable God wished subsequently to be measured. This would necessarily require large-scale co-ordination between various quantum measurements to ensure that the 'right' kind of interaction took place. Indeed, just altering the result of one intentional measurement may not be possible without co-ordinating the results of very many others.

The normalisation factors (omitted from the above equation) have also necessarily changed. The result of this is the unsurprising consequence that on measurement there is now a one-third chance of getting either a dead cat, an alive cat or the result God desired. Given that the 'odds' of this form of quantum SDA being successful are only 1 in 3, this is not a particularly successful strategy for God to be able to determine an intentional result.

Moreover, there would still be no divine *determination* of the next particular event (i.e. measurement): at the point of measurement there would be no guarantee that the result God intended would occur (again von Neumann's process 1 would apply). As we normally consider divine action in the context of macroscopic phenomena it is difficult to see exactly how this element of indeterminism can be allowed to remain – it is surely necessary for God to 'switch off' indeterminacy to be able to determine a desired result.[27] Finally, and perhaps most importantly, the deterministic

[27] It should be noted at this stage that one of Arthur Peacocke's objections to quantum SDA arises precisely because he denies that God can 'switch off' indeterminacy in this manner. Taking indeterminacy seriously, Peacocke argues, means that events are unpredictable by God himself

time evolution predicted by the Schrödinger equation does not permit the sudden introduction of a component into the wavefunction. In order to incorporate this into quantum mechanics we must introduce another non-linear operation similar to wavefunction collapse. We shall consider in the context of Continuous Spontaneous Localisations below the possibility that the Schrödinger equation might be reformulated along these lines.

God makes his own measurements on a given system

The second of the possible modes of interaction between SDA and orthodox quantum theory concerns the possibility of God making his own measurements on a quantum system. Given the deterministic nature of the evolution of the quantum state between measurements it is possible that God could make measurements on a quantum system in order to break this determinism. The basis of this claim is that God chooses to trigger von Neumann's process (1) events himself. Again, reconsidering the example of Schrödinger's Cat, what we are examining is whether it would be possible for God to 'open the lid of the box' and thus cause an indeterministic quantum measurement event to occur.

There are a number of difficult conceptual issues with this approach. Firstly, there is the issue of the relationship between quantum SDA and human quantum experimentation. When we make measurements on a given system we get results with a statistical distribution consonant to the probabilities that correspond quite normally to the superposition state we posit exists prior to the new measurement – this is the fundamental reason why quantum mechanics is such an empirically successful theory; there have been no intermediate wavefunction collapses. Secondly, we have returned to the difficulties surrounding the notion of God as a causal agent in the world. As all measurements in quantum mechanics, as we understand them, involve interactions between parts of God's creation, it is difficult to reconcile this proposal with standard quantum theory unless God has 'tentacles' which would then in principle form an observable part of his creation. It is necessary for 'something' (a human brain?, a macroscopic recording device?, etc.) in the universe to perform the measurement. The requirement in the theory for this separate measuring device cannot be easily reconciled with quantum SDA unless God acts in an interventionist manner by setting up the device in the first place.

(Peacocke 1998, note 31). See also Peacocke's most recent discussion of quantum SDA in which he agrees with the present author (Peacocke 2001, 107–8).

Thirdly, and perhaps most significantly, it is difficult from a theological viewpoint to understand how God may achieve any intentional purpose by this method. After all, and like the first proposal, it is not possible for God actually to *determine* the result of any quantum measurement. On this account God decides precisely at what time he wishes to 'toss the dice' and discover the outcome of the *still indeterministic* measurement selection. It is a basic tenet of SDA that God is active in a purposeful way and does not merely act randomly in creation – under this proposal it is unclear how this purposefulness could be accommodated unless God decides not only when to measure something, *but also what the result of that measurement shall be*. We shall now turn to consider the two possible ways in which this latter objective may be achieved.

God alters the probability of obtaining a particular result

When a quantum mechanical measurement is made in the orthodox interpretation, the possible results of that measurement are related to the wavefunction of the measured system. More precisely, according to the Born probability rule, there is a certain probability that each result will be achieved which is related to $|\psi|^2$. One possibility is that God alters the probabilities behind a measurement so that the value he wishes to be obtained during measurement is more likely than it would otherwise have been. Indeed, given this possibility, there is no reason why God should not influence the probabilities such that they are of a trivial nature (i.e. 1 or absolute certainty) to ensure his outcome.

This option is reliant on a particular philosophical conception of the nature of quantum mechanical probabilities. In essence, for this proposal, we must assert that the probabilities exist as a propensity in nature *prior to* the results of measurement being obtained.[28] This is not an un-'orthodox' approach, but the probabilities must precede the results and as such prescribe the nature of physical reality in some way. If we recall our earlier discussion of the laws of nature in relation to SDA, this approach to quantum probabilities is broadly consistent with a physicalist-necessitarian reading of the laws of nature. The status of these probabilities as law-like is, however, highly questionable if we simultaneously assert that God frequently alters them. In short, if we still wish to claim that quantum theory makes an attempt to represent the workings

[28] The alternative approach is that quantum measurement probabilities are formed as a result of those measurements that actually take place in the world, i.e. that they are subsequent to measurements. For a detailed discussion of the different probability assignments that can be made in orthodox quantum theory see Halpin (1991).

of the world in a realist way, we are forced into accepting Tracy's proposal of intermittent divine action over Pollard's notion of divine determinism in every quantum event. This conclusion is quite independent from any theological conclusions concerning occasionalism.

However, since the probabilities of a particular outcome are *so* closely related to the wavefunction, it is an implication of this claim that in shifting these probabilities God is also altering the nature of reality *prior to a measurement*. Again, recalling our discussion of the necessitarian approach to laws of nature, the question is whether God is fundamentally changing the nature of the quantum system between measurements by altering these measurement probabilities. If this is the case then this form of quantum SDA is every bit as interventionist as the first option, namely God altering the wavefunction between measurements.

This conception of altered probabilities in relation to measurement has been examined by Henry Stapp in his work on Weinberg's nonlinear generalisation of quantum mechanics (Stapp 1994). Stapp at the time was working on purported empirical violations of orthodox quantum mechanics reported by parapsychological researchers. While staying clear of the question of whether the parapsychological research was valid, Stapp did manage to develop a model using Weinberg's work that accommodated a certain extent of probability shifting. It is possible to extend his work to model divine action via the same methods, however there are problems concerning the relationship of God to his created world. Stapp relies on a localised agent 'wishing' the shift in probabilities, and God is not localised in the same manner. Even if it were possible to alter his model to accommodate this, it is questionable how we could also accommodate the other principal conclusion of his work, namely that the Planck constant becomes a complex number function, within quantum mechanical 'orthodoxy'.

The notion that Born's probability rule (i.e. that these measurement probabilities are related to the wavefunction as $|\psi|^2$) can be interpreted as a measure of the potential possibilities in quantum measurement was first developed by London and Bauer (London and Bauer 1983). Heisenberg himself also made a similar interpretation of measurement probabilities as an analogue of Aristotle's notion of potentiality (Heisenberg 1959). The most detailed development of Heisenberg's approach is that seen in the work of Vladimir Fock, whose position emphasised a realist interpretation of measurement probabilities. These probabilities, he emphasised, belong to the individual object in question, and are totally characteristic of its own potential possibilities. Consequently,

in this approach the manipulation by God of quantum measurement probabilities remains fundamentally interventionistic for it changes the fundamental nature of the object in question.[29]

So, in summary, the question of whether this represents a reasonable approach to quantum SDA depends critically on the ontological status of measurement probabilities in quantum mechanics. For non-interventionist SDA to occur these probabilities must:

1. be ontologically prior to the measurement and thus represent some feature of the system in question; and
2. be modifiable by God *without* an intervention in the quantum wave-function itself (which evolves deterministically under the Schrödinger equation).

However, it is not possible on the orthodox account to hold these two aspects in tension together. The question the proponent of quantum SDA by this means must answer is how it is that the probabilities of obtaining a particular result at a quantum measurement can be both prior to the measurement and changed without somehow changing the quantum system itself in an interventionist sense. It is not possible to accommodate this within standard quantum mechanics. Indeed, it interesting to note that William Pollard himself rejected an analogous proposal because he considered it interventionist (although he did not make his reasoning explicit).

God determines the result of each measurement

The final approach to quantum SDA in the 'orthodox' interpretation of quantum measurement is the assertion that God simply 'ignores' the probabilities predicted by the orthodox measurement theory and controls the outcomes of particular measurements. Again there are complex technical issues in this proposal, and the sense in which God might or might not be interventionist in this manner is highly debatable. Notably, for a non-interventionist interpretation, we are obliged to accept an opposite conception of the measurement probabilities to the proposal above: the probabilities must be held to be ontologically *derivative* from the measurements themselves and thus not representative of the ontology of a particular quantum system.

This approach, however, is clearly very close to a regularitarian interpretation of the laws of nature. As such the probability laws simply reform around whatever actual measurement results have been obtained – as

[29] A similar approach has been adopted by Redhead, who has argued that propensities in quantum measurement are only properties of the object in question and unrelated to the experimental or physical conditions which the object finds itself in (Redhead 1989).

we noted in chapter 3 above, this approach is characterised by an assertion that individual events are ontologically superior to laws. In the context of SDA, this approach *cannot* be reconciled with the notion of non-interventionist SDA as expounded by protagonists of quantum SDA. It is theoretically incompatible with any notion of law-violation and is instead a clear application of a regularitarian interpretation of laws of nature in the context of quantum mechanics. Indeed, it is quite at odds with the implicit violation-permitting account of the laws of nature adopted by protagonists of quantum SDA. Such an approach begs an important question – if one asserts that quantum SDA takes place on this regularitarian scheme, then why consider SDA in quantum processes at all? All SDA on the philosophical assumptions behind this account will be non-interventionist, be they SDAs in classical physics, special relativity or whatever. The assumption behind this position simply cannot be reconciled with the necessitarian approach to laws implicitly adopted by the protagonists of quantum SDA we considered in the previous chapter and, moreover, it is not logically possible to combine necessitarian and regularist approaches to the laws of nature in this way.

Secondly, this proposal brings the conception of God as active in determining all quantum measurements into sharp relief – if this is the case then these probabilities either are a deception in that they have no relationship with physical reality whatsoever, or they are a representation of the chance of God acting in the same way on a subsequent occasion. Both of these conclusions are unsatisfactory and we are thus again scientifically obliged to side with Tracy in claiming that God only determines some quantum events.

The technical substance of this approach is to deny that Born's probability interpretation of the wavefunction has any ontological priority and assert that it is simply an approximate relationship between ensembles of identical systems for a given measurement repeated a large number of times. The next move is to interpret quantum laws in a regularitarian methodology – a move that is quite at odds with the position of every proponent of quantum SDA considered above. The proposal is then that quantum SDA occurs by means of God 'ignoring' or intervening against the measurement probabilities 'predicted' by the orthodox theory.

Summary

These four different options cover the entire range of claims that can be made for quantum SDA in the orthodox interpretation of the measurement problem.

It is clearly highly interventionist for God directly to manipulate the wavefunction of quantum theory, either by adding a new state in superposition or by simply swapping a given wavefunction for another. Secondly, it is unsatisfactory for God simply to cause wavefunction collapses without determining their result in some sense if God is held to act in a purposeful manner. Moreover, there is considerable difficulty in making the claim that God performs measurements without also claiming that God acts interventionistically in bringing two parts of creation to interact with each other.

It is not possible to accommodate the possibility of God acting to alter quantum probabilities prior to measurement without similar implications of interventionism on the basis that by changing the probabilities behind measurement God alters the wavefunction itself. The final option, that God determines the outcome of measurements, is itself reliant on a regularitarian approach to quantum measurement which, if it is pushed to its logical conclusion, permits non-interventionist SDA in any physical process and at any scale whatsoever. As such it is in direct contradiction to any understanding of laws of nature that permits even the slightest possibility of an intervention.

Before we mull over the precise implications of these difficulties for the claim that quantum SDA actually takes place we shall turn to consider the other main approaches to quantum measurement and the implications of non-locality.

CSL THEORIES AND SDA

The central idea behind Continuous Spontaneous Localisation (or CSL) theories is that they attempt to introduce the concept of wavefunction collapse into the formalism of quantum mechanics in such a way that the notion of distinct 'measurements' becomes unnecessary.[30] What CSL theorists have attempted to do is to modify the Schrödinger equation so that non-linear wavefunction collapse (i.e. an analogue of von Neumann's process 1) is incorporated as a feature of the time-dependent evolution of a quantum system. This is generally achieved by modifying the Schrödinger equation itself. Accordingly, the projection postulate is no longer an addition to the remainder of the theory – in the CSL approach wavefunction collapse becomes an integral part of the most basic equation in quantum mechanics.[31]

[30] An introductory account of CSL theories can be found in Yam (1997, 108–9).

[31] CSL theories have been proposed by, for example, Diosi (1992), Ghirardi, Rimini and Weber (1986) and Gisin (1989). The following discussion has been influenced by the treatment in Dickson (1994).

The basis of the CSL approach is that the wavefunction does not evolve deterministically as it normally would under the Schrödinger equation (cf. von Neumann's process 2). Instead, the Schrödinger equation is modified to incorporate a small, probabilistic component which acts as a perturbation on the wavefunction. This perturbation is postulated to have a negligible effect on 'small' quantum systems composed of only a few particles, but results in a collapse of the wavefunction in 'large' quantum systems (such as those on the scale of human experience). It is important to note, however, that CSL theories do not specify the particular conditions under which wavefunction collapse will occur – rather, they introduce a factor into the Schrödinger equation such that collapse is inevitable. When the system under study consists of only a few particles this probabilistic element is negligible, however when we consider systems which have many particles, the perturbation part of this new time-evolution overwhelms the normal Schrödinger evolution with the effect that the particle becomes localised in space. Effectively this is a form of 'automatic' quantum measurement.

However CSL theories simply bypass rather than fully address the problem of measurement in quantum mechanics. Wavefunction collapse is no longer reserved exclusively for measurement processes, but instead becomes a fundamental process that affects all quantum systems. Recalling von Neumann's approach discussed above, the assertion generally made in CSL theories is that it is not necessary to postulate two distinct forms of wavefunction evolution. When a large number of particles are collected together in a superposition of macroscopically different states (and Schrödinger's cat which consists of a large number of particles in 'dead' and 'alive' states would be an eminently suitable system), the result is, proponents of CSL theories claim, a wavefunction collapse such that objects like cats are always well localised.

The most famous form of CSL developed by Ghirardi, Rimini and Weber (1986) asserts that a system of N particles is subject to the normal deterministic evolution under the Schrödinger equation, except that approximately every $\frac{10^{15}}{N}$ seconds the wavefunction is suddenly multiplied by a normalised Gaussian of a certain width. This multiplication has the result that the wavefunction becomes centred, although the selection of the point at which this centring takes place is postulated to be indeterministic. According to the Ghirardi, Rimini and Weber model (GRW), the width of the Gaussian and the frequency with which it is multiplied to the wavefunction (i.e. the choice of 10^{15} above) represent two new fundamental constants of nature.

Leaving aside whether this approach is justified, and it suffices to say here that many physicists have attacked it as being totally contrived, the highly localised state which results from the Gaussian multiplication is *not the same as a completely localised state*, and it is for this reason that the relationship between CSL and measurement is not as clear as it may appear at first sight.[32] When a typical quantum measurement is made in the laboratory, it is commonly asserted by proponents of the collapse interpretation of measurement that the wavefunction is totally collapsed. CSL theory does not localise to this extent in a finite time – the result of this is that when a measurement is made on a CSL system, there still remains a small probability of obtaining a result outside the localisation.

These difficulties with localisation have led to a forceful set of criticisms of the CSL approach on quite a different basis to the claim that it is essentially contrived. Albert and Loewer characterise this lack of full localisation in CSL theories as a remaining 'tail' of Schrödinger's Cat (Albert and Loewer 1996). As an example they apply to the cat: assuming there are approximately 10^{20} particles in a cat, it would only be a very short period of time (approx. 10^{-5} s) before the GRW Gaussian multiplies itself against any superposition of 'dead' and 'alive' states. However, if we apply the eigenstate–eigenvalue postulate to this situation, we see that there still exist 'tails' of Schrödinger's cat in the other result: 'so it follows from the eigenstate–eigenvalue rule that the cat is, as a matter of fact, not determinately alive (or dead)' (Albert and Loewer 1996, 86). Indeed, as these authors point out, this difficulty cannot easily be overcome by considering square or any other multiplying waves instead of Gaussians:

> The trouble here is with the basic dynamical structure of quantum mechanics, the trouble is with the incompatibility of position and momentum, the trouble is that that incompatibility entails that any wave function which at a certain instant somehow manages to lack tails – tails extending everywhere – will always instantaneously grow them back. (Albert and Loewer 1996, 86)

The benefit of CSL theory from a physicist's point of view is that, unlike the wavefunction collapse postulate, it offers one basic law for all quantum interactions which does not incorporate any distinct notion of 'measurement'. Despite this there is a difficulty in that any such theory appears basically contrived: for a microscopic quantum system with a

[32] Even though the probability of 'finding' a particle outside this localisation is very low, it would be wrong to assert that it is impossible and accordingly the wavefunction is not entirely localised in the formalism of CSL. The localisation would only be theoretically complete after an infinite time has passed and for this reason the CSL approach is quite different to von Neumann's postulate of wavefunction reduction.

very small number of particles N, the multiplication of the Gaussian becomes so infrequent as to be practically undetectable; moreover the width of the Gaussian appears to be chosen to be sufficiently big to ensure that any energy conservation violations which arise as a result of its multiplication would be very small and are thus experimentally undetectable. Nevertheless the question remains as to whether this highly contrived multiplication of the wavefunction by a Gaussian remains sufficient to resolve the measurement problem of quantum mechanics. The 'tails' of Schrödinger's cat remain after the time of multiplication:

> What GRW [The Ghiraldi, Rimini and Weber version of CSL] needs is an argument which shows that it suffices to solve the measurement problem to get pointers almost into eigenstates of position and cats almost into eigenstates of aliveness. Alas, in so far as we are able to judge, that argument may prove very difficult to cook up. (Albert and Loewer 1990, 284)

Of course, it is possible to consider an analogous model of SDA in which the Schrödinger equation as we know it is only an approximation to a more fundamental equation which is essentially non-linear and accommodates SDA. Quantum SDA might then take place by an analogous multiplication event, or it could even be argued that the GRW's choice of new fundamental constants represents the frequency of quantum SDA. However despite the initial attractions of such an approach, there remains no consistent way in which the remaining 'tails' of Schrodinger's cat are eliminated unless God is also active in a highly interventionistic manner by eradicating them. Moreover under this connection between quantum SDA and the CSL approach to measurement, God still does no more than determine when interventionistically to 'toss the quantum dice' and get a probabilistic result. The theologian is still left with the burden of describing how it is that God might obtain a purposive result under this scheme, and it seems that this problem raises similar issues to those considered in connection with God causing measurements in orthodox quantum mechanics. It is thus unlikely that CSL theories in their current state of development can be of much support to a theological assertion of quantum SDA.

SDA and the many worlds/minds approach

The many worlds interpretation of the quantum measurement problem has been the focus of some of the most speculative philosophical discussions of quantum theory. The basis of these approaches can be

found in Hugh Everett III's relative state formulation of quantum mechanics which consists of an attempt to apply the principle of quantum superposition in tandem with an assertion that quantum mechanics applies at all scales. Consequently in Everett's interpretation there is no wavefunction collapse on the occasion of measurement-like interactions (Everett 1957). Everett's original proposal remained relatively overlooked despite initial support from John Wheeler and other members of the Princeton faculty, and it was only when his work was popularised by Bryce DeWitt in the late 1960s that it started to become so widely discussed (see DeWitt 1970). DeWitt's position was not, however, a mere restatement of Everett's – in his original work Everett does not assert that the other superposed elements in the wavefunction are objectively real, and it is only in a brief footnote that he mentions the possibility of a 'splitting process'.[33] Indeed it is possible to conceive of ways which favour one particular, really existent, branch in Everett's theory, and several physicists have worked on single-branch conceptions of the theory which are not reliant on the claim that the alternative branches ontologically exist.

Leaving aside these single-branch theories, what subsequently became known as the many-worlds interpretation views the various superposition terms in the wavefunction as ontologically real and co-existing separate 'worlds'. Accordingly, there is no notion of wavefunction collapse or any need to eliminate elements of the superposition – there exist a phenomenal number of real worlds which arise as a result of every quantum measurement-like interaction. The term 'measurement-like' is a necessary consequence of the formalism of this interpretation because there is no requirement in the theory for anything actually to *perform* a measurement.

In the many worlds interpretation of the Schrödinger's cat experiment there are essentially two different worlds formed. The radioactive decay at the root of the triggering device is held to cause a measurement-like interaction because it is a non-reversible process. In one of the resulting pair of worlds the cat is alive and in the other it is dead. From the alive cat's perspective it is unaware of its dead replica, and of the consequences of its 'near miss' with the triggering device. Were we to place the surviving cat into another copy of the experiment then another two worlds would be formed as subsets of the world in which the cat survives the first

[33] In a discussion on the differences between their theories, Yoav Ben-Dov also argues that many of the common criticisms of the many-worlds position (such as the fact that the exact moment of the split is not sufficiently specified) are applicable only to DeWitt's later reformulation and not Everett's original thesis (Ben-Dov 1990).

experiment. These other worlds exist as elements of multidimensional Hilbert space,[34] and a central postulate of the interpretation is that no two worlds formed by a particular branching either are aware of each other or can inter-communicate. As DeWitt put it, 'every quantum transition taking place on every star, in every galaxy, in every remote corner of the universe is splitting our local world into myriad copies of itself'.

The relationship between theology and these many minds/worlds interpretations is potentially quite interesting. Leaving misjudged criticisms on the basis of William of Ockham's razor aside,[35] still the number of universes implied by the theory is truly phenomenal, there would superficially appear to be a potential parallel between the genesis of these alternative universes and the doctrine of *creatio continua*. Indeed, if we consider all the alternative worlds to be ontologically real, then it would also be possible to reconcile this account with *ex nihilo* creation on the basis that *all* of the alternative worlds are within the care and sustenance of God just as our own is. However, this assertion raises interesting issues for theodicy – for every 'good' quantum event God sustains in the world of our experience, there is a corresponding 'bad' event in another world which is also sustained by God. Of course the terms 'good' and 'bad' are used here in relation to higher level notions of morality and as such are distinct from quantum mechanics. Nevertheless if we assert, in keeping with the many-worlds interpretation, that quantum phenomena take place at all scales in creation, then it would be reasonable to assert that underlying moral phenomena we characterise as 'good' and 'bad' there are quantum events. Taking this point to its logical conclusion, the consequence is that God maintains perfectly 'good' and 'bad' worlds in existence, the latter being a world in which every manifestation of evil that could ever have possibly happened has actually taken place. God's

[34] One interesting philosophical aspect of the many-worlds interpretation is the potential relationship between these co-existent worlds and a theory of quantum gravity. The General Theory of Relativity describes gravity as distortions in the space–time fabric of the universe – if a theory of quantum gravity exists, then an additional requirement on the worlds in this interpretation would be that they consist of similar distributions of mass/energy.

[35] William of Ockham was a medieval scholastic theologian who stated 'pluralitas non est ponenda sine necessitate'. The philosophical principle that subsequently became known as his 'razor' is that given any two competing explanations one should always adopt the most simplistic. However much, of course, turns on exactly what criteria we use to determine simplicity. A simple assertion that Ockham's razor attacks the large number of resulting universes is surely wrong. Proponents of the many worlds interpretation have correctly argued that as their theory actually requires virtually no extraneous additions to Schrödinger's equation *it is the many worlds interpretation which is simpler* than the 'orthodox' interpretation with its *addition* of wavefunction collapse upon measurement. Upon their reading Ockham's razor should attack the 'orthodox' and other more complex interpretations and not the large number of universes which result.

creation of such a world, and its maintenance in being by means of GDA, are potential *theological* reasons to reject this interpretation of quantum measurement.

Turning to the relationship between quantum mechanics and SDA, there is significant difficulty associated with the use of 'event' language in this approach. Whilst the splitting of the worlds at the time of a quantum measurement-like interaction is one possibility, there remains no sense in which we can claim that there is any indeterminacy here since all of the superpositions in the wavefunction are still realised in alternative worlds. Moreover, and this was the motivation for Everett's original formulation, there is no point at which the deterministic evolution of the Schrödinger equation is punctuated by indeterminacy. Thus when we view the complete collection of realised worlds in this interpretation *as a whole* it is still fully deterministic, and while our world may appear to be indeterministic *to us* (we are unaware of the alternative worlds coexisting with our own), there is no point in the theory which introduces any form of ontological indeterminism.[36] Thus in relation to quantum SDA any mode of action on this account would be fundamentally interventionistic when viewed in relation to the complete set of worlds maintained in existence by God at any one moment (recall the difficulties discussed above in relation to superposing God's 'desired' state onto the wavefunction). The only sense in which probabilities can be artificially introduced into the theory is for the subjective chances of subsequently finding oneself in a particular universe following a measurement-like interaction. However, if we recall James' interpretation of determinism, these probabilities are purely subjective to the observer in question, do not introduce any open possibilities into nature's womb, and thus the theory remains fully deterministic. After all, the basic assertion that led to the development of this interpretation was that the evolution of quantum systems under the Schrödinger equation offers a full account of quantum phenomena. Thus the many worlds/minds approach rules out the possibility of non-interventionist incompatibilist SDA. Despite this, there may be interesting possibilities for a notion of compatibilist SDA, interpreted as God choosing between an expression of which elements of these various deterministic world-histories are sustained in which particular worlds.

[36] It should be noted, however, that this conclusion is not necessarily applicable to some 'single-branch' interpretations of Everett's original work. Henry Stapp, for example, introduces a probability in relation to each potential branch which he interprets as the probability that a given observer will later find themselves on that particular branch (Stapp 1980).

SDA AND DE BROGLIE–BOHM MECHANICS

In 1927, Louis de Broglie presented a paper at the Solvay Quantum Mechanics Conference which developed the idea of an essentially classical particulate account of quantum interference experiments (Instituts Solvay 1928). In the conference his work was largely discredited owing to his poor response to a critique by Wolfgang Pauli, and de Broglie subsequently abandoned the approach. Indeed it was not until 1952 with the publication of David Bohm's reformulation of quantum mechanics that the pilot-wave approach was reconsidered. Bohmian mechanics is a totally fundamental reformulation of quantum theory and for this reason should not be viewed simply as a proposed 'solution' to the quantum measurement problem.[37] In the theory there are essentially two fundamental equations of quantum mechanics – the standard Schrödinger equation and an additional evolution equation both of which are fully deterministic. The basis of Bohm's work was to consider the electron as a particle that was acted upon by both an electromagnetic potential and also a quantum potential. Crucially, and unlike the orthodox interpretation, the quantum potential does not just represent a probability amplitude but is a realistic feature of the theory and is quite independent to any probabilities derived from it. Moreover, Bohm's approach is explicitly non-local in that the quantum potential necessitates large groups of spatially separated particles being causally interconnected.

The resulting formulation of quantum mechanics relies exclusively on a standard classical notion of particles, each of which always possesses a definite position in space and time. The pilot-wave envisaged by the theory co-ordinates the motion of these particles and controls where they move to and when. One helpful way to picture this movement is by the limited analogy of surfers riding waves towards a beach. The water waves which guide the surfers' movement are akin to the pilot-wave, and if we imagine that the surfers could not themselves 'steer' their surfboards, then the movement of the surfers is wholly determined by riding on the various underlying waves.

James Cushing, in support of Bohm's original assertion, has argued that it is possible to derive all of the statistical predictions of standard quantum mechanics on the basis of this methodology, despite the fact that in Bohmian mechanics there is no type of observation other than a position measurement. Consequently there is no such thing as an

[37] The most detailed treatment of Bohm's work can be found in the discussion posthumously published with Basil Hiley as Bohm and Hiley (1993).

electron spin measurement in this approach other than the physical reading of a pointer on a dial measuring spin (Cushing 1996, 168). The quantum superposition principle does not exist in this formulation (consequently there is no analogue of Schrödinger's cat paradox), and the act of making a measurement in the theory is simply the classical act of finding where the particles in question are at any particular moment. In relation to quantum SDA the crucial implication of this principle is that this approach to quantum phenomena is wholly deterministic. Similarly there is no equivalent of wavefunction collapse because particles in the theory always have definite positions at all times and these are guided by the pilot-wave. Where statistics do arise in the theory they represent a lack of *epistemological* knowledge about the initial conditions under study, rather than any principle of indeterminacy or lack of ontological coherence. Thus, given a particular probability distribution for an initial state, the pilot-wave theory will subsequently produce a probability distribution for the final state. However all of these probabilities can only be interpreted as epistemic uncertainty rather than as indicative of indeterminacy – the pilot-wave account is itself a paradigm deterministic theory.

This approach to quantum mechanics has been criticised because of its reliance on the Schrödinger equation and its apparently contrived character. In the context of quantum SDA it is of importance because its mere existence illustrates that we are not forced to interpret quantum phenomena along a wholly indeterministic scheme. Aside from these general conclusions about the lack of any metaphysical priority of indeterminacy claims in quantum theory, it is quite clear that the deterministic nature of the de Broglie–Bohm approach makes any appeal to quantum SDA totally interventionistic. Even if God's action is fully predetermined and as such could constitute part of the implicate order which is commonly cited in connection with the pilot-wave, then this would arguably be another form of GDA rather than SDA.[38] It is quite clear that there is no possibility of accommodating anything like the intentional non-interventionist quantum SDA that those authors we have previously considered assert.

SDA and the transactional interpretation

We have already noted the fact that the Schrödinger equation is time-reversal invariant in connection with the measurement problem of

[38] For more discussion of the notion of implicate order see Bohm (1987).

quantum mechanics. What this means is that there is no inherent directionality in the way time is assumed to flow in the formalism of the theory – the Schrödinger equation, just like Newton's laws, does not distinguish between time flowing forwards and time flowing backwards.[39] John Cramer's transactional interpretation of quantum mechanics makes use of this fact and is based on the time-reversal invariance of electrodynamics and the absorber theory originally developed by Richard Feynman and John Wheeler (Cramer 1986). The absorber theory is dependent on ordinary waves travelling forward in time which are termed 'retarded', and 'advanced' waves which travel backwards in time and have a negative energy – in effect precisely the opposite of normal retarded waves. It is postulated that any process in which a quantum particle is emitted forms not only normal retarded waves, but also equal and opposite advanced waves which have the same amount of energy (but as negative energy), and travel backwards in time. This notion of waves having negative energy and travelling back in time may appear to be contrived, but the notion of negative energy is something that physicists use frequently and relativity theory arguably forces us to abandon the classical model of flowing time. The key question, and one that has remained largely unaddressed, is the extent to which the transactional interpretation makes defensible realism claims in respect of these entities.[40]

The theory itself is that when the retarded wave is absorbed at some point in the future then a 'handshaking' or cancellation process takes place that annihilates any traces of the advanced wave. There are essentially four steps in this handshake in the case of the quantum emission of a particle followed by its subsequent absorption:

1. When the emission process takes place advanced and retarded waves are formed from the emitter equally.
2. When the retarded wave from the emitter reaches the absorber, the absorber then cancels it by emitting another retarded wave that is completely out of phase from it. The net effect of these two waves is zero.
3. Simultaneously with its emission of an out-of-phase retarded wave, the absorber also makes an advanced wave with negative energy that travels back in time exactly along the path taken by the original retarded wave from the emitter.

[39] For further discussion of time reversal invariance and the concept of arrows of time in physics see Fagg (1995, chapter 9).

[40] There is virtually no literature on the philosophical implications of the Transactional Interpretation except a discussion by Phil Dowe which supports the interpretation and purports to enable it to be empirically verifiable on the basis of a 'fork theory' of causality (Dowe 1997).

4. The advanced wave from the absorber travelling back in time reaches the emitter at the exact moment of the emission taking place but the advanced wave from the emitter (which is produced when the emission takes place) is completely out of phase with it and so the net effect of these advanced waves is that they cancel each other out.

The total effect of these processes is that there are no net advanced waves left by an emission-absorption interaction with the result that epistemologically the interpretation sits foursquare with the standard results of quantum theory. The process of advanced wave emission is hidden from epistemological investigation, and consequently scientists only observe retarded waves with positive energy travelling forward in time.

The philosophical consequences of this approach are very interesting, not least because non-locality and the interaction of the 'future' with the present become central features of the theory. As Cramer has put it,

> This advanced retarded handshake is the basis for the transactional interpretation of quantum mechanics. It is a two-way contract between the future and the past for the purpose of transferring energy, momentum, etc. . . . The transaction is explicitly nonlocal because the future is, in a limited way, affecting the past (at the level of enforcing correlations). It also alters the way in which we must look at physical phenomena. When we stand in the dark and look at a star a hundred light years away, not only have the retarded light waves from the star been travelling for a hundred years to reach our eyes, but the advanced waves generated by the absorption process within our eyes have reached a hundred years into the past, completing the transaction that permitted the star to shine in our direction. (Cramer 1988, section 2)

In this quotation Cramer highlights one of the most interesting aspects of the theory, namely that one of the implications of advanced waves travelling back in time is that it requires a correlation between future events and those that we observe as the present. As theologians it may appear tempting to link this notion with some sense of divine planning or interaction with the future *parousia*. This assertion in its simple form would, however, be misplaced because it conflates an essentially classical understanding of the temporal ordering of events, the 'flowing-time assumption' which is at the core of our theological understanding, with a more complex notion of space–time interdependence.[41] There

[41] It is arguable that the classical interpretation of time which is at the centre of much theological discourse is itself highly dubious in the light of the theory of Relativity. Indeed Relativity theory, probably more so than any other physical theory, presents a radical challenge to any traditional understanding of time in theology. The approach adopted to Relativity theory by the

are nevertheless interesting theological implications of the transactional interpretation for discussions of free will and the problem of evil.

The status of indeterminism in the transactional interpretation is potentially quite complex because of the intricate space–time interaction that lies at the core of the theory. The emitter, as we have already seen, sends out a retarded wave to the absorber, and itself receives an advanced wave from the absorber. Generally there exist a very large number of potential absorbers for each given emitter and consequently the emitter at the instant of emission is bombarded with a large 'menu', as Cramer calls it, of different potential transactions to choose from:

> the probability [of a particular absorption] . . . is proportional to the 'connectedness' of the participants as indicated by the size of the echo which the absorber sends back to the emitter. The emitter is presented with echoes from potential absorbers which form a weighted list of possible transactions, from which only one may be chosen. The future absorbers can influence the past transmission event only through the strength of their echo entry on this list but cannot influence which entry is actually chosen for the transaction. (Cramer 1986, section 3.8)

Accordingly Born's probability rule is to be interpreted in the Transactional Interpretation as the probability of a given transaction taking place which is proportional to the amplitude of the advanced wave received by the emitter for that particular absorber. The crucial point to note about this is that, despite the fact that transactions are explicitly atemporal, the Transactional Interpretation implicitly postulates that the choice of these possible transactions from the 'menu' is probabilistic:

> And so while the TI does not alter the essentially statistical character of quantum mechanics it has provided a glimpse of the 'dice' which are at work in the statistical process. The dice work to ensure an outcome consistent with the quantum boundary conditions of a transaction and are 'loaded' in proportion to the magnitude of the echo which the emitter receives from potential absorbers. (Cramer 1986, section 3.8)

Cramer himself notes that this notion of the future influencing the present raises difficulties with the notion of cause and effect. He seeks to avoid these difficulties by distinguishing strong and weak versions of the principle: the former he characterises by the general claim that cause must always precede effect in any reference frame; the weak form, on the

Transactional Interpretation makes the standard move of interpreting Schrödinger's equation to be the limiting case of some more general, and as yet undiscovered, relativistically invariant wave equation of the form of the Klein–Gordon equation (Cramer 1986, section 3.3).

other hand, consists of the same claim but limited in that it only applies to observer-to-observer communication and macroscopic observations (Cramer 1986, section 3.9). It is not, however, clear that this distinction is entirely successful. In particular by defining the weak form so that it only applies to macroscopic observations he has effectively avoided addressing the problem in any detail. While his claim that there is only experimental support for the weak form of the principle may be true, this does not sufficiently address the question of whether his limitation of the scope of the weak form in this manner is justified.

Leaving these difficulties to one side, any assertion of non-interventionist SDA on the basis of the Transactional Interpretation would presumably be based on the possibility of God either adding waves to the 'menu' Cramer identifies, or by determining which of the different advanced waves the emitter enters into a transaction with. The former strategy is clearly interventionist on the same grounds as God adding elements to a quantum superposition in the orthodox interpretation considered above. The latter claim that God determines which of the advanced waves to select is also not easily accommodated within the interpretation. Cramer postulates that the magnitude of the echo of each item on the 'menu' of the advanced waves is proportional to the probability for it entering into a transaction – any violation of this principle by God as a means of quantum SDA would raise similar interventionist implications to those considered in connection with determining the measurement probabilities in the orthodox interpretation. On this basis quantum SDA in the Transactional Interpretation is also inherently interventionistic.

QUANTUM NON-LOCALITY AND SDA

These different interpretations of the measurement problem form the complete possible scope of claims for quantum SDA in the current understanding of quantum-scale processes. As we have already seen, none of them establishes even the mere possibility of non-interventionist quantum SDA. As we shall now see, this problem is compounded in relation to another feature of quantum theory that places further constraints on claims for quantum SDA. It is notable that the implications of quantum non-locality have virtually never been widely discussed in a theological context despite the frequent claims that God determines quantum indeterminacies. Of those theological accounts that do discuss non-locality the general level of the remarks is that there are implications of holism

and unity of God's sustenance throughout the universe. However, as we shall see, the implications of non-locality raise further difficulties for the proponent of quantum SDA.[42]

As a preliminary consideration we should consider whether it is possible for quantum SDA to take place solely by means of non-locality relationships. Both the Einstein–Podolsky–Rosen and Bell correlations would indicate that there is a disposition for certain results to be realised on measurement. However, two features of these relationships need to be noted in connection with quantum SDA. Firstly, for there to be a correlation of this sort there must have been an initial measurement and the claim that quantum SDA takes place through non-locality is thus parasitic on the above considerations concerning quantum SDA in measurements. Secondly, there are strong theoretical arguments against the possibility of any such non-local anomalies being expressed at a macroscopic level. If the theory of quantum mechanics holds exactly then any such quantum SDAs would be potentially self-annihilating at macroscopic scales (Eberhard 1978).[43]

It is clear for the above reasons that it is not possible to appeal to non-local phenomena in themselves as supporting a conception of quantum SDA without associated claims about God causing measurements. Indeed, on a more general level, there are strong arguments that non-locality would act as a further restraint on what determinations God could make at quantum measurement interactions. Were it possible for God to determine the outcome of quantum measurements in the 'orthodox' interpretation, then God would be acting interventionistically should he determine outcomes for measurements that were part of a non-local correlation. The extent to which this additional criterion would limit the scope of quantum SDA is dependent on how many measurements in the real world are non-locally correlated in this way. Currently there is little we can do but speculate about the genuine extent of non-local interactions in the world, but those experimental confirmations we have of non-locality suggest that a great many measurements may be correlated in this way.[44]

[42] We shall not describe the basis of non-locality in quantum theory in any detail here for the sake of brevity. There is a good account in Rae (1986, chapter 3), and for a full philosophical treatment of the problem see Omnès (1994).

[43] See also Bussey (1987).

[44] One possible avenue for further exploration concerns the development and justification of a complementary account of quantum non-locality in the context of quantum SDA analogous to that attempted by Brian Josephson and Fotini Pallikari-Viras (1991) in relation to biological organisms.

One interesting discussion suggests that these non-local correlations might actually be an entirely necessary feature of the maintenance of order in a universe containing ontological indeterminism. Sandu Popescu has argued that the indeterminism of quantum theory is *required* so that non-local correlations do not transmit information faster than the speed of light in violation of General Relativity (Buchanan 1998, 30). Essentially his position is that God maintains links between spatially separated regions of the universe by means of non-locality, and it is the existence of indeterminism which enables him to do this very tightly without violating the laws of relativity. Indeed the possibility of God determining these entangled non-local measurements to perform quantum SDA also raises similar issues of potentially violating the laws of relativity theory by faster than light signalling. In conclusion non-locality relationships in the orthodox interpretation are clearly a further restriction on the scope of quantum SDA.

QUANTUM SDA – FINAL CONCLUSIONS

The time has come to draw together the conclusions of whether quantum SDA is a viable approach to God's action. As we have already noted, there is, of course, a limit to the extent to which we can evaluate claims about the nature of God's action. However the arguments made by the proponents of quantum SDA are, when understood technically, very specific and translate to assertions about the orthodox interpretation of quantum measurement. It could, of course, be argued that there exists some as yet undiscovered form of quantum mechanics which supports quantum SDA, and there is no way in which we could rule out such a possibility in principle. However, in keeping with the argument in the previous chapters, the burden of proof rests on the theologian asserting such a model to explain and develop it. What is clear, however, is that all the existing claims for quantum SDA in relation to current understandings of quantum theory fail.

It has been argued by some authors that the existence of a number of different interpretations of quantum measurement should make us very loath to link it to theology. There is some justification for this approach on the basis of Bonhoeffer's 'God of the stop-gaps' but, as we have already noted in the previous chapter, such considerations cannot rule out the possibility of quantum SDA in principle. Indeed, in keeping with the general methodological approach adopted here, the existence of multiple interpretations of the theory need not, of itself, lead to a rejection of

quantum SDA. What we need is to be explicit about the precise focus of our claims – i.e. quantum SDA on an 'orthodox' interpretation, quantum SDA on the many worlds interpretation etc., and to acknowledge that our understanding of God's action in the world is potentially open to modification in the light of wider criteria of coherence with current scientific thought.[45] In relation to the previous rejection of quantum SDA, the conclusions reached in this chapter apply against those interpretations of the measurement problem that have been considered above. It accordingly must be accepted that it is still potentially possible for some, as yet unknown, future interpretation of quantum measurement to accommodate both SDA and experimental quantum theory.

All of the possibilities for quantum SDA considered in this chapter have considerable problems either for scientific reasons, or because they make contradictory assertions about the philosophy of laws of nature. Moreover, it is far from certain that any of the above potential modes of quantum SDA in the orthodox interpretation of measurement can be combined in such a way as to become non-interventionist. This difficulty is considerably compounded on consideration of the non-local restrictions on God's action determining the outcome of measurements. Indeed all of the claims for quantum SDA in various different approaches to quantum measurement have their own problems and it is thus vital that the debate over quantum SDA is moved into a more explicit consideration of the philosophical and scientific claims that Pollard, Tracy, Russell, Murphy et al. make.

One general issue which has been little addressed is the relatively uncontentious implication of their theses for classical scale effects. David Jones has discussed the possibility of God altering parameters by less than their Heisenberg uncertainties with reference to the extermination of dinosaurs by a divine act of steering an asteroid to collide with the earth (Jones 1997). His conclusion is that God would have had to have started the strategy some 100 million years previously, at which time the required adjustments to the appropriate asteroid would be below the Heisenberg limit. Whilst Jones' calculation is theologically insensitive because it limits God's action to quantum processes (and ignores the possibility of action directly upon the dinosaurs), it does go some way to illustrating quite how

[45] Broadly speaking the methodological position adopted here is similar to that recently propounded by Thomas Tracy who has written that 'the particular interpretative approach one favors should not be presented as *the* conclusion to be drawn from quantum mechanics. Secondly, proposals about the theological relevance of quantum theory should be regarded as tentative and provisional hypotheses' (Tracy 2000, 896).

many quantum correlations are needed to achieve even a basic cosmological effect of this sort. Indeed this is before we consider the difficulties posed by human observation and the action of other autonomous natural processes in frustrating God's quantum orchestration. Of course it could be argued that God acts at 'critical moments' by a quantum SDA which is then amplified by chaotic means and we shall consider this possibility in detail after discussing the relationship between chaos theory and SDA in chapter 7 below.

In conclusion, as I have argued elsewhere,

> The thesis that God determines all quantum events is not only scientifically irreconcilable with quantum theory but also theologically paradoxical. There are also fundamental philosophical difficulties to be overcome if we hold to the thesis that God influences only some events at a quantum level. Moreover, the scale of the providence required for divine action through quantum physics is truly phenomenal: it takes millions of years of action to achieve even the most simple effects. If it is also held that human beings have free will, then this situation becomes absurd. By making quantum measurements we are determining the state of divine determinations in a way that must significantly increase the already considerable amount of time God requires to achieve anything. The linking of divine action to quantum mechanics must take place by some kind of measurement interaction, and this also places God in a subordinate position to creation, and the episodic nature of measurements places severe limitations on the possible actions God could achieve . . . it seems reasonable to conclude that a theology of divine action that is linked to quantum processes is theologically and scientifically untenable. (Saunders 2000, 541–2)

Despite this bleak picture, it may be possible in the future to develop a quantum mechanics which accommodates SDA entirely – such a development must clearly be based on a better understanding of the interplay between indeterminism and determinism in the theory. Such a hope should derive some support from the remarkable proliferation of quantum entities in our universe, but *on the terms of our current understanding of quantum theory, incompatibilist non-interventionist quantum SDA is not theoretically possible.* In the next chapter we shall turn to consider whether the claim that God acts through chaos theory is more easily sustainable.

CHAPTER SEVEN

Chaos Theory and divine action

The recent 'discovery' of chaos theory owes a huge debt to the development of the computer. It is in essence a mathematical phenomenon, much of which had been developed by Henri Poincaré and was known for almost a hundred years.[1] Chaos theory is consequently quite unlike quantum theory or relativity in that it introduces *no new postulates* about the workings of the universe. In the previous chapter we considered the projection postulate and the Schrödinger equation, neither of which is a feature of classical mechanics. In chaos theory, however, there are simply no parallels to these and the models used in the theory are generally a construct of classical physics described in a basically Newtonian manner. This fact has been well drawn out by Theodor Leiber:

> Physical chaos research does, however, not constitute a new research programme, or a novel theory of physics: The theoretical core (or negative heuristic) is still constituted by the axioms and theorems of classical mechanics ... [this] has led to a certain 'renaissance' of classical mechanics by emphasizing the (general and possibly unifying) question of (algorithmic, effective) computability of dynamic systems. (Leiber 1998, 367)

The central issue in relation to chaos theory that Leiber identifies is the computability or predictability of dynamical systems. As we shall see, the issue of determinism in chaos theory is more complex than many scientist-theologians have acknowledged, and especially as it has been applied in the context of claims for the existence of chaotic SDA.[2] Despite the fact that chaos theory is parasitic upon classical physics, it does raise a number of very interesting issues in relation to theology. The argument

[1] As with the discussion of quantum theory above, this chapter assumes that the reader is conversant with the basics of chaos theory. Good popular accounts of the theory can be found in Gleick (1998), Kellert (1993) and Hall (1991).

[2] This term is used in analogy with 'quantum SDA' as meaning a model of SDA related to chaos theory. It is not intended to imply that this model suggests any less purposefulness, a connection with the Biblical notion of chaos, or 'chaos' in the non-scientific sense of anarchy or lacking in purposive intention on the part of God.

developed here is, of course, contrary to John Houghton's and other scholars' assertions that there are no valuable theological implications of a study of chaos theory (Houghton 1989, 49–50).

The possibility of chaotic SDA has been widely discussed in the science and theology literature. With the notable exception of John Polkinghorne's work, the option has been almost universally dismissed. The erroneous basis of this rejection will be discussed in more detail below, but the rejection can be easily understood by considering the following comment of James Gleick:

> Watch two bits of foam flowing side by side at the bottom of a waterfall. What can you guess about how close they were at the top? Nothing. As far as standard physics was concerned, God might just as well have taken all those water molecules under the table and shuffled them personally. (Gleick 1998, 8)

Gleick's comment that God might have 'shuffled' the water molecules personally is clearly valid for the simple reason that, as we shall see, long-term epistemological prediction in chaos theory is extraordinarily difficult. However, detractors of chaotic SDA maintain, the underlying physics remains classical and thus fully deterministic. As such, they correctly argue that non-interventionist chaotic SDA is not possible. However this attack has at its root a fundamental misunderstanding of Polkinghorne's thesis; and we shall see below how Polkinghorne's claims for chaotic SDA really need to be assessed in relation to his implicit assertions concerning the fractal intricacy of nature.

The mathematical study of chaotic phenomena has found many *parallels* in the physical world (the word 'parallel' is important here because, as we shall see, the question of how chaos theory models reality is quite complex). Examples include the erratic motion of a driven pendulum, fluid flows and turbulence, changes in fish populations, share price fluctuations, particle accelerators and heart cells. All of these systems have in common the fact that they are reliant on non-linear relationships and mathematical chaos concerns the behaviour of often very simple sets of non-linear equations.[3] Often there are no analytical mathematical solutions to these sets of equations, and consequently chaotic phenomena can only be studied in detail as a result of numerical simulation on a

[3] Technically a linear operator is one that supports a linear superposition such that $O(x\alpha + y\beta) = xO(\alpha) + yO(\beta)$. Essentially this implies that a non-linear phenomenon in nature is one in which an initial change in the behaviour of one variable does *not* result in a proportional change in the behaviour of that or another variable. The fact that linear superpositions are denied in chaos theory is one of the many problems in relating quantum mechanics and chaos.

computer. In general this non-linear behaviour is a necessary, but not sufficient, condition for the development of chaos.

The most fruitful approach to discussing the possibility of chaotic SDA would appear at first blush to give a definition of chaos and rely on that. Stephen Kellert has attempted to offer just such a definition with his claim that chaos is 'the qualitative study of unstable aperiodic behavior in deterministic non-linear dynamical systems' (Kellert 1993, 2f.). Whilst Kellert's definition gets very close to the mark, to make a rigid definition of this sort is to miss the point that the term 'chaos theory' is employed by physicists as a blanket name for several quite different types of phenomenon and in very different mathematical models. Indeed, it is only in the special case of the so-called 'logistic map' produced by iteration of a function such as $x_{n+1} = kx_n(1 - x_n)$ in the region where the constant k is between the values of 3.57 and 4,[4] that theorists have agreed as to the exact properties that constitute mathematical chaos.[5]

Recalling Kellert's attempt at a definition of chaos, it is important to note his emphasis on qualitative as opposed to quantitative description – the primary practical use of chaos theory in modelling physical systems is to give an idea to the general long-term behaviour that may be expected under certain conditions, rather than specific predictions in individual cases. Because chaotic systems show sensitive dependence on their initial conditions, it is extremely difficult and often technologically impossible to give precise numerical predictions using the theory, and this is the reason why Laplace's epistemological determinism fails. Nevertheless chaos theory has significant qualitative predictive power – it helps us to understand the future behaviour of physical systems on a large scale, without going into the full details.

One crucial distinction missing from this definition is that there exists a fundamental difference between chaos in dissipative systems, such as physical models that include an element of heat loss to the surroundings, and conservative systems, such as idealised planetary motion governed by Hamiltonian equations.[6] In a conservative system in which E represents the amount of energy of that system at a particular time, and is invariant

[4] An excellent description of the behaviour of the logistic map can be found in Wildman and Russell (1997), although they do not consider in any depth the general difficulties in framing a definition of mathematical chaos. See also Schuster (1995, 37–78).

[5] See, for example, Peitgen, Jürgens and Saupe (1994, ch. 1). These properties are commonly interpreted to be topological in nature and include sensitive dependence, dynamical mixing in phase space, and high density of period points in phase space. Peitgen et al. show that for any function defined to have the latter two properties, sensitive dependence is implied automatically: the three properties are thus closely interrelated.

[6] For a useful classification see Schuster (1995).

subsequently, the trajectories in phase space are confined into surfaces of constant E. In a dissipative system, however, like most 'real world' chaotic systems, the dissipation acts to diminish E because energy is progressively lost from the system to the surroundings. This results in the trajectories ultimately becoming trapped in a particular region of phase space with the consequence of attractors. Accordingly, the dynamics of conservative and dissipative systems are fundamentally different. This distinction has crucial implications for the possibility of chaotic SDA in relation to 'active information' as we shall see. For the purposes of our current discussion about the difficulties in framing a definition of 'chaos' the existence of these two fundamentally different types of chaotic systems can only compound the problems associated with defining the phenomena. The approach adopted below shall thus be to consider the paradigm example of a dissipative system, namely the Lorenz equations, in detail in connection with the possibility of chaotic SDA. Then we shall turn to consider the wider status of determinism and the possibility of chaotic SDA in conservative systems.

Before we discuss the mathematics of chaos theory and its possible application to physical systems in detail it is helpful to consider the claim that chaos theory and free will are related. There have been several attempts to posit a connection between the openness of chaos theory and incompatibilist free will and many of the same arguments are raised in relation to chaotic SDA.[7]

In a famous article describing chaos theory James Crutchfield et al. provide a wide range of philosophical claims about chaos that are accompanied by a number of assertions about a possible link between free will and chaos (Crutchfield, Farmer, Packard and Shaw 1986). Their philosophical approach to determinism is far from explicit – we are told, for example, that 'simple deterministic systems with only a few elements can generate random behavior. The randomness is fundamental; gathering more information does not make it go away' (Crutchfield et al. 1986, 38). The last clause in the second sentence is, of course, not entirely correct for *in principle* gathering more information (in actual fact an infinite amount) will make the randomness go away if chaos theory is correctly interpreted as fundamentally deterministic. There are strong technological limitations on the amount of information that could be gathered about a particular chaotic system's starting point, but it would be wrong to argue that this leads to indeterminism. Similarly Crutchfield et al. conclude

[7] For more on the distinction between compatibilist and incompatibilist notions of free will and their relationship to SDA see chapter 3 above.

on the basis of these epistemological limitations to prediction that 'after a brief time interval the uncertainty specified by the initial measurement covers the entire attractor and all predictive power is lost: there is simply no causal connection between past and future' (Crutchfield et al. 1986, 45). This last statement is remarkable as there is no *prima facie* connection between predictivity and the existence of a causal interconnection between past and future, and when combined with general assertions to the effect that chaos amplifies small microscopic features of the world, the argument leads these authors to the following speculation concerning free will:

> Even the process of intellectual progress relies on the injection of new ideas and on new ways of connecting old ideas. Innate creativity may have an underlying chaotic process that selectively amplifies small fluctuations and moulds them into macroscopic coherent mental states that are experienced as thoughts. In some cases the thoughts may be decisions, or the exercise of will. In this light, chaos provides a mechanism that allows for free will within a world governed by deterministic laws. (Crutchfield et al. 1986, 49)

It is difficult to conceive of how Crutchfield et al. can actually claim that ideas introduced by means of a deterministic chaotic mechanism are objectively 'new'. Indeed, unless the small fluctuations they refer to are due to some genuinely indeterministic or creative source (for which quantum indeterminacy may be a candidate), it is difficult to see how free will is anything more than a subjective perception of an underlying determinism in their scheme. Certainly it is unclear how it might be that chaos allows for free will within a deterministic scheme unless this free will is viewed in a strongly compatibilist sense.

Given a compatibilist reading of free will, the determinism is potentially in keeping with our *subjective* notions of free choice or spontaneity – the mind's thought processes operate by switching between different attractors of brain functioning all of which are epistemologically unpredictable. In relation to incompatibilist claims for SDA, however, the assumed underlying deterministic nature of chaos theory raises insurmountable problems for non-interventionist action.

So, without pre-empting too much of our discussion of the relationship between chaos theory and determinism below, it appears that mathematical chaos theory is not *prima facie* successful in reconciling incompatibilist free will with a mechanistic conception of the universe. Chaos is highly significant, however, because it rescues us from total predictability. The option is open, as Dennett has shown, of placing emphasis on the fact

that chaos theory is not predictable in principle by any finite computing device, but such an approach is only epistemological.

CHAOS IN LORENZ'S MODEL

As we have already suggested, the term 'chaos theory' refers to a fairly wide range of mathematical behaviours which are non-identical but share some common features; indeed, the solutions of even simple non-linear equations can behave in very unusual ways. This fact was first fully investigated in the 1960s with the publication of two important papers on the subject of non-linear equations. The first was that by S. Smale and was an article discussing a particular type of mathematical map for which it was possible to prove rigorous chaotic solutions (Smale 1967). Smale was interested in the topology of mathematical solutions and developed several conservative Hamiltonian chaotic systems which did not have attractors. While this work was of considerable theoretical interest, it was largely ignored by physicists because it appeared to lack any epistemological application. Most subsequent attention was focussed on Edward Lorenz's attempt to model the convection of air in the atmosphere and the 'discovery' of dissipative chaos.

Lorenz worked on the assumption that the atmosphere behaved like a turbulent fluid and combined the standard classical Navier–Stokes equations for fluid flow with that for thermal energy conduction (Lorenz 1963). Lorenz made various simplifying assumptions to his model and arrived at the following three basic equations:

$$\dot{x} = \sigma(y - x)$$

$$\dot{y} = -xz + rx - y$$

$$\dot{z} = xy - bz$$

There are three variables in these equations (x, y and z) – x is proportional to the intensity of the convection, y depends on the temperature difference between ascending and descending currents and z is proportional to the distortion of the vertical temperature profile of the air from linearity (Lorenz 1963, 135). The rate of change of each variable is dependent on the values of the other two at each instant, and on a number of constants σ, r and b which are related to the viscosity and temperature of the convecting air and other things. If we consider the equations Lorenz derived purely as mathematical entities for a moment, it is easy to see that they are a very difficult system of equations to solve analytically.

The functions on the right are continuous with respect to any chosen initial values, and Lorenz consequently investigated their behaviour by numerical integration on an early computer. His computer internally represented the accuracy of x, y and z to, say, six decimal places. Lorenz however printed out the results of the equations to only, say, three decimal places. One day Lorenz fed data from his computer printout, with only three decimal places of accuracy, into the computer which represented six, presuming that the difference was negligible.[8] What he found by accident was quite remarkable:

> two states differing by imperceptible amounts may eventually evolve into two considerably different states. If then, there is any error whatsoever in observing the present state – and in any real system such errors seem inevitable – an acceptable prediction of an instantaneous state in the distant future may well be impossible. (Lorenz 1963, 133)

The 'imperceptible amount' Lorenz refers to here was exactly the difference between the accuracy of his printout and the internal accuracy of the computer. The conclusion Lorenz reached was that long-term weather prediction was rendered technologically impossible because of the accuracy with which the initial conditions needed to be known (Lorenz 1963, 141). This sensitive dependence on initial conditions is one of the hallmarks of chaos theory. Indeed, the sensitivity of Lorenz's system is such that, if we needed to know just the direction of convection in the Lorenz model one hundred seconds into the future we would need to know the initial values of x, y and z to an accuracy in the region of forty decimal places.

Sensitive dependence on initial conditions has been widely discussed in many popular works on chaos theory and is commonly known as the 'butterfly effect'. The term was first used by Lorenz in the title of a talk in 1972; apparently Lorenz had first used a seagull for this metaphor, but later adopted the more prosaic example of a butterfly (Hilborn 1994, 40). The basic idea is that the extent of the sensitivity of the world's meteorological systems is such that the flap of a butterfly's wings in South America could have a direct effect on the weather over the south coast of England (or any two other points on the surface of the planet that one chooses). The point Lorenz wished to make concerned the difficulty of long-range weather prediction: if chaos theory correctly models the

[8] For an interesting discussion of the circumstances of Lorenz's discovery see Gleick (1998). The exact number of decimal places to which Lorenz's computer internally represented numbers appears to be a matter of some dispute between historians of chaos theory – some writers say six, others nine!

natural process of weather formation, then no correct prediction can be made which does not take account of all the butterflies in the world. In actual fact the situation is *even* more sensitive than this – actually an infinite level of accuracy in the initial position of the air molecules is required to make an accurate prediction of their subsequent position at any time in the future. Indeed if *any* finite specification of initial conditions is made, no matter how accurate, in general there exists another set of initial conditions arbitrarily close to it which will diverge at a subsequent time by any specified distance.[9]

One rarely considered implication of this sensitive dependence on initial conditions is that it raises significant problems for the practical study of chaos because any computer only represents numbers to a particular precision (often of the order of fifteen to twenty decimal places). As Devaney has put it, 'Small errors in computation which are introduced by round-off, may become magnified upon iteration. The results of numerical computation of an orbit, no matter how accurate, may bear no resemblance whatsoever with the real orbit' (Devaney 1989, 49). What he means here is that, even though we may think that we are 'following' the trajectory of a given air particle in Lorenz's system by modelling it by computer, the sensitive dependence of his equations, in conjunction with the errors induced by the fact that our computer is only accurate to twenty decimal places, means that we are not necessarily following the trajectory we thought we were. Indeed, it is possible to show in the logistic map that, after approximately seven iterations of two closely positioned iterates, the size of the deviation between the final positions will be of the same order as the initial precision of the iterates (Leiber 1998, endnote 6). This difficulty in the computer study of chaos was noted by Lorenz himself:

> In phase space a numerical solution ... [of chaotic equations] must be represented by a jumping particle, rather than a continuously moving particle. Moreover, if a digital computer is instructed to represent each number in its memory by a pre-assigned fixed number of bits, only certain discrete points in phase space will ever be occupied. (Lorenz 1963, 134)

Accordingly it is actually meaningless to claim that we are following the particular trajectory of a given particle in the Lorenz (or any other chaotic) system by using computer modelling. The consequences of this situation for qualitative modelling are not as bleak as they might appear, however, for our computer modelling still gives us points of genuine

[9] This was formally expressed by Devaney in relation to the quadratic map (Devaney 1989, 49).

trajectories resulting from some other possible starting points. For simple chaotic systems this can be precisely solved by the well-known Shadowing Lemma from number theory:

> For chaotic systems every computer calculated trajectory after a short time interval, or small number of computational steps, is 'false' because of the SD-property [sensitive dependence on initial conditions]. Nevertheless, it has (reliable) explanatory power because it astonishingly well approximates a 'true' trajectory of the same chaotic system for all times. That is to say that a computer calculated trajectory starting within an $\in$-neighborhood of a true trajectory for all times stays in that neighborhood, similar as the shadow of a wanderer always follows the latter. (Leiber 1998, 359)

Thus in simple chaotic systems, the computer calculated trajectory will closely mimic or shadow the behaviour of a point close to the one we thought we were studying and so our computer calculations do give true information about the system in question, just not the evolution of the system from the starting point we originally inputted![10]

The existence of this butterfly effect is not, however, the only feature of chaos in dissipative systems that is of interest. Indeed it is arguable that this sensitive dependence is so ubiquitous in physical systems that it hardly constitutes a feature restricted to chaotic systems. One feature that is of vital importance in the context of chaotic SDA is the presence of attractors in dissipative chaotic systems which act as constraints on the long-term behaviour of a given system to a finite number of options. Indeed Polkinghorne shows that he is considering the role of dissipative as opposed to conservative systems in his work by placing emphasis on the constraints imposed by these attractors on sensitive dependence (e.g. Polkinghorne 1989a, 123).

CHAOTIC ATTRACTORS

A necessary preliminary to any discussion of attractors is an understanding of the concept of phase space. The notion of 'space' as it is commonly understood refers to the three (or four if time is included) dimensions of our day-to-day existence. We all have an intuitive understanding of this kind of space in which lorries crash and people play cricket. To a mathematician, however, the concept of space is not so limited. Consider

[10] See also Smith (1998, 59–60). A similar problem exists in the computer – generated images of fractals such as the famous Mandelbrot set – essentially what is seen on the computer screen is a slice through an infinitely complex structure, and so the 'picture' is not truly an image of a fractal in all its complexity (Shenker 1994, 973).

something as commonplace as driving down the road in a car. In order to describe this situation physically we need to know the position of the car in three dimensions – its latitude, longitude, and height above sea level (let us call these values x, y and z). We also need to know the car's speed in each of these three directions – forward or backwards, whether it is turning right or left, and if it is travelling uphill or downhill (call the speed in each of x, y and z, V_x, V_y, V_z). These six quantities define the position and speed of the car at any particular time. Mathematically we can say that the car is described by a six-dimensional phase space in this model which is given by (x, y, z, V_x, V_y, V_z).[11] What this means is that in the physical system we are considering there are six variables which can take different values. Correspondingly, a similar modelling in phase space can be attempted for any physical system. Consider this time a slightly more detailed model of the car which takes into account the engine r.p.m. and the gear the car is in – of course there is a physical difference between one car travelling in first gear at twenty miles an hour, and another car travelling in second gear at the same speed. Our model would now occupy an eight-dimensional phase space: $(x, y, z, V_x, V_y, V_z, R, G)$ in which R and G are the variables for engine r.p.m. and gear respectively. The more information about the car we add to our model, the more dimensions in general we add to our phase space.[12]

Any particular journey we make in our car is represented by a unique trajectory in this eight-dimensional space. As time passes (and note that time is not one of the variables in our phase space) a trajectory is traced out as our position changes, as we travel at different speeds, and in different gears etc. There are an enormous number of potential phase space trajectories for our car – in fact there would be one for every possible journey on the face of the Earth. Some potential trajectories would, however, be *physically* impossible – those at which my clapped-out car travels faster than, say, one hundred miles per hour in any direction, or where I attempt to drive into a building or through a river. Furthermore a large proportion of physically possible potential trajectories would overlap and intersect where, for example, two different potential journeys contained a trip up the same road at the same speed in the same gear.

Leaving our car journeys aside, let us reconsider Lorenz's model of air convection. This is a three-dimensional phase space which contains

[11] For the sake of discussion, we assume V to be an independent quantity from the rate of change of position in each of x, y and z.

[12] For a helpful discussion of the relationship between real-world phenomena and phase space modelling see Jackson (1989, pp. 6, 10–12).

the movement of air particles. Like the car there are a huge number of potential trajectories in Lorenz's model, although this time there are no physical restrictions in the mathematics of the model on how fast the air particles can travel or where in phase space they can go. We have already stated that the mathematics of Lorenz's system is deterministic – recall William James' ontological description of determinism as 'those parts of the universe already laid down absolutely point and decree what the other parts shall be'.[13] The implication of this determinism is that *none of the possible trajectories in the phase space of Lorenz's model of air convection can cross or intersect with each other or themselves.* This is a crucial implication of deterministic models in phase space. If there are *any* joins between the potential trajectories then at the point of the join the entity in question can evolve from that intersection in two or more different ways and accordingly there is a choice for the future evolution of that particle, and its future is not 'decreed' as James' determinism requires.

Let us now turn to consider the notion of phase space attractors in chaos theory.[14] Consider the example of a pendulum comprised of a string tied to a weight and swung circularly: if we plot out the motion of the weight in two dimensions, we would obtain a spiral. As air resistance slows the pendulum to rest, the pendulum dissipates energy, the size of the oscillations decreases, and the trajectory closes in on an equilibrium point where the string is hanging vertically. There are of course a number of different potential trajectories which correspond to how hard we pushed and whether the initial swing was clockwise or anticlockwise. Each of them, however, terminates at the common point of this equilibrium or 'attractor' where the pendulum has come to rest. In this two-dimensional phase space, although not for the physical situation of the damped pendulum, there could theoretically also be closed loop cycles so that instead of approaching a single point as time increases, a given trajectory in phase space approaches a particular looping path in phase space.

Given that in a deterministic system trajectories in phase space cannot cross or interact, there can be two fundamentally different types of behaviour. In a closed conservative chaotic system which operates at a constant energy represented by Hamiltonian equations, Liouville's theorem applies. This states in effect that the volume in phase space of the possible trajectories is preserved as the system evolves with time. This

[13] See chapter 4 above.

[14] The following discussion owes a debt to Peter Smith's excellent lectures on the philosophy of chaos theory at Cambridge – see Smith (1998).

total volume can, of course, become more spread out and thus conservative systems can show sensitive dependence on initial conditions like that discussed above. However Liouville's theorem rules out the possibility of attractors in phase space since it is impossible for a given volume of trajectories to be 'pulled' towards an attractor without some squeezing of phase space and this requires a loss of energy from the system. Thus, in a conservative system, a given phase space trajectory is limited to a plane which contains other possible trajectories at that particular energy.

The situation is radically different for dispersive chaotic systems such as the damped pendulum in which energy loss from the system as time passes can lead to the shrinking of the potential trajectory volume in phase space. In these dissipative chaotic models attractors become commonplace.[15] The Lorenz equations are of this second, far more common, sort. Until Lorenz plotted the numerical solutions to his equations on a computer only three forms of attractors were known – the fixed point, limit cycle and torus. Lorenz discovered a fourth, the so-called 'strange' attractor.[16] The origins of the term 'strange' are unclear and it is most probably only used in the colloquial sense of meaning 'very unusual'.

The reason why these strange attractors are so fundamentally unlike anything previously studied is that they *combine* the two features of chaos theory we have already discussed – namely determinism and sensitive dependence on initial conditions – and yet still 'funnel' the trajectories to a particular point. The way this occurs is by a complex folding of phase space which curves trajectories in on each other, without letting them touch (recall the determinism) in an infinitely complex way. In the attractors in Lorenz's model the potential trajectories are focussed towards these strange attractors and as they get closer and closer to the attractor, they become more and more intricately wound up. At no point do the separate trajectories cross or join because the equations are deterministic, and the only place where they actually touch is at the infinite limit of the strange attractor itself.

This is where the link between chaos theory and 'fractals' arises. This object of infinite complexity is known as a fractal, a term coined by Benoit Mandelbrot from the Latin *fractus* (Mandelbrot 1983). Given the

[15] In a dissipative chaotic system, an attractor may be defined as a set of zero volume in phase space which is invariant under the action of the dynamical equations of motion and which is surrounded by a domain of non-zero volume such that any trajectory which originates within that domain converges asymptotically onto the attractor set (Bergé, Pomeau and Vidal 1984, 111).

[16] There are three essential features for an attractor in phase space: that it is invariant under the governing equations; that all trajectories from a nearby neighbourhood are attracted towards it; and finally that it is minimal – i.e. it is not possible to produce an 'attractor within an attractor' (Smith 1998, 13–14).

requirement that trajectories cannot ever intersect, but still diverge from each other, it is easy to see that the Lorenz attractors cannot have only three dimensions. In order to visualise this just imagine trying to draw sample trajectories onto a piece of paper without letting any of the lines intersect. In general, chaotic attractors have non-integral 'dimensions', which, of course, relies on a different notion of dimension to the standard Euclidean one. One way to assign a dimension to a particular fractal attractor in an n-dimensional phase space is to imagine covering the surface of the attractor with n-dimensional 'cubes' of a large size. After counting the number of these 'cubes' that it takes to cover the attractor, we reduce the length of the side of the 'cube' and count how many of these smaller 'cubes' are needed. In the infinite limit, where the length of the side of the 'cube' decreases to zero, we reach what is known as the Hausdorff–Besicovitch dimension D.[17]

Given the difficulties due to the extreme sensitive dependence on initial conditions described above, the difficulty with computer simulation, and the existence of these strange attractors, one might be forgiven for wondering whether dissipative chaotic models were of any use whatsoever. Returning to our example of the Lorenz model we can, however, see two different ways in which it could be used to study the behaviour of a dynamical system (in this case air convection):

1. As a very short-term model for predicting the precise behaviour of a trajectory in phase space given suitably accurate initial conditions; or
2. as a model describing the 'bulk' behaviour of the entire Lorenz system if the constants in the equations are altered and the behaviour of 'typical' trajectories established by the shadowing lemma studied under these different conditions.

It is in this second sense that most of the qualitative predictive power of the Lorenz equations (and in general any chaotic system) resides. What Lorenz himself did was to alter the values of the constants in his equations and see what qualitative differences this had on the typical evolution of his convection model. Given this, let us now turn to consider how chaos theory and SDA have been related.

CLAIMS FOR CHAOTIC SDA

Jason Colwell in a recent article has argued that chaos theory and providence are potentially linked. Providence, as he interprets it, is the concept of SDA without the suspension of the laws of nature and this he associates

[17] See Hilborn (1994, 407). An alternative to the Hausdorff–Besicovitch method for measuring attractor dimension can be found in Grassberger and Procaccia (1983).

with God acting as the 'determinant of fundamentally random events' (Colwell 2000, 134–5). Colwell develops two different potential mechanisms in support of this notion of providence – either, he argues, God might have developed a mechanism which generates randomness, or God could choose the outcome of otherwise random events. Stating that he prefers the second of these options, Colwell considers the possibility of God

> [choosing] the position of an electron at one time while preserving its probability density function through His pattern of choices over all time. The electron's position at that moment could influence the motion of one, then several air molecules. This would soon affect the flow of a tiny region of air. Amplified through chaos, this could cause a significant meteorological event after more time had elapsed. God, being omniscient, sees all the intricate workings of chaotic systems. He knows where tiny changes would have huge effects later on. This enables Him to act providentially in many situations to produce a desired result. (Colwell 2000, 135)

In comparison with the work of those theologians considered in chapter 5 above Colwell's model is relatively unsophisticated. He is essentially arguing for a notion of quantum SDA which itself triggers macroscopic chaotic events. Divine quantum manipulations are linked in his theory to sensitive dependence on initial conditions in chaos theory and act as 'triggers' for chaotic amplification. This is a common argument from proponents from quantum SDA, however it is unclear from his account whether he also asserts that God is active through chaotic processes as distinct from quantum ones. Moreover, his discussion of randomness appears to conflate notions of predictability and determinism. This latter criticism has also been levied by a large number of scientist-theologians against John Polkinghorne, whose model of chaotic SDA we now consider in detail.

Polkinghorne has made an enormous contribution to the debate over the interaction of science and theology.[18] However, his position on chaotic SDA has been widely dismissed on the grounds that chaos theory remains a deterministic theory and is thus *prima facie* not 'open' in any sense required for non-interventionist incompatibilist SDA. As we shall see, however, such conclusions about Polkinghorne's position are not as clear-cut

[18] It must be emphasised at this point that what follows is the present author's interpretation of Polkinghorne's argument and as such it has not received any explicit imprimatur from Polkinghorne himself. The discussion is both defensive of Polkinghorne's position in that it seeks to address those areas in which it has been arguably misinterpreted by its detractors and critical for other reasons.

as many have assumed. Moreover, it will be shown how Polkinghorne's theory of chaotic SDA actually relies on several questionable assumptions concerning the expression of deterministic elements of chaos theory in indeterministic systems and the realistic interpretation of the fractal basis of mathematical chaos.

Polkinghorne makes a convincing theological case for the existence of SDA based on a personal acting 'father' God, as opposed to a divine 'force' (Polkinghorne 1994a, 64). He strongly rejects any notion of God as a deistic 'absentee landlord' merely watching over creation, and accordingly critiques Maurice Wiles' subjective approach to divine action; in distinction he emphasises the role of continuing creation (*creatio continua*), which he treats as a synonym for the existence of SDA over the background of GDA (Polkinghorne 1989a, 40–1). He asserts that the nature of this SDA cannot be capricious or self-contradictory, and thus Polkinghorne concludes that SDA must take place in the 'grain' of created processes and must not be 'interventionist' (Polkinghorne 1994a). In this emphasis on non-interventionism in physical processes, Polkinghorne's position is closely allied with those theologians who have proposed forms of quantum SDA. Their positions are, as we have seen, based on an implicitly necessitarian interpretation of the laws of nature which permits the possibility of law violation.[19] Indeed similar grounds also lead Polkinghorne to reject interventionist conceptions of miraculous SDA.

A further theological element to Polkinghorne's understanding of SDA is that its operation should be continuous and not fitful. This continuity is not, however, to the extent of accepting what he terms the 'desperate remedy' of occasionalism (Polkinghorne 1994b, 19). Rejecting Austin Farrer's assertion that the 'causal joint' of divine action must remain unknown as an 'unintelligible kind of theological doublespeak' (Polkinghorne 1994b, 81–2), he asserts that in his opinion chaos theory presents a better candidate for this than quantum mechanics.[20]

The basis of Polkinghorne's thesis of chaotic divine action can be found in his interpretation of what it means to be truly critically-realist

[19] This is in distinction to the regularist position in which the notion of law violation is not theoretically possible – see chapter 3 above. It is also clear that Polkinghorne asserts a form of incompatibilist SDA – see chapter 2 above.

[20] Polkinghorne has written at some length on the reasons why he rejects a connection between SDA and quantum mechanics. He considers it unacceptably 'episodic' on the basis that measurements are relatively isolated events (Polkinghorne 1998b, 89). He also objects to the notion of a God who tinkers at the 'rickety roots of the cosmos' (Polkinghorne 1988, 58).

in interpreting epistemology:[21] 'Scientists are realists at heart and so they believe that what we can or cannot know is a reliable guide to what is actually the case' (Polkinghorne 1996b, 71). However this gut instinct realism has to be tempered, Polkinghorne emphasises, in that realism must be critical rather than naïve in order to address potential future changes as a result of scientific developments. Indeed Polkinghorne elsewhere characterises critical realism by an 'attempt to maximise the correlation between epistemological input and ontological belief' (Polkinghorne 1998a, 53). His approach thus appears to be an attempt to make the most detailed realistic claims about nature as far as is defensibly possible. It is in this context that Polkinghorne has developed his much-maligned epithet of 'epistemology models ontology' – or alternatively that 'what we know is a reliable guide to what is the case' (Polkinghorne 1994a, 68).

The meaning of this soubriquet is, of course, totally dependent on what interpretation of the word 'model' is intended. It is clear that Polkinghorne does not distinguish between mathematical and physical models – he asserts that there is 'an isomorphism (corresponding identity of structure) between mathematical patterns and physical patterns, which makes the former explanatory of the latter' (Polkinghorne 1991, 29). It appears that the notion of model which Polkinghorne applies in this context is actually relatively uncontentious, and is shared by many of those who critique him on this basis. Essentially the point which Polkinghorne appears to make through this epithet is that, for a critical realist, models in science are always an attempt at achieving the best fit possible with the actual nature of reality whilst bearing in mind that models must always be open to revision in the future.

While Polkinghorne's epithet is relatively uncontentious in itself (if a suitably rich interpretation of 'modelling' is permitted), the use to which it is employed by Polkinghorne has also led to its being widely criticised. Nancey Murphy, for example, essentially argues that Polkinghorne appears to have interpreted 'model' in an analogous sense to 'imply'. In order to evaluate her claim we must move on to consider the specific assertions Polkinghorne makes about chaos theory. He acknowledges that the mathematics of chaos theory are deterministic, and places great stress on the anti-Laplacian difficulties of prediction due to the sensitive

[21] Polkinghorne states that the critical realist position 'implies the possibility of gaining verisimilitudinous knowledge, which is reliable without claiming to be exhaustive' (Polkinghorne 1991, 41). A succinct description of Polkinghorne's approach to critical realism can be found in Polkinghorne (1998b, 16–17).

dependence on initial conditions. Polkinghorne is clearly correct in his assertion that

> unless one knows the initial circumstances with unlimited accuracy, one can only predict their behaviour a small way into the future with any confidence. Beyond that they are intrinsically unpredictable. (Polkinghorne 1991, 36)

However, as Wim Drees has perceptively noted, there are additional problems with Polkinghorne's epistemology models ontology position that arise from the fact that Polkinghorne elsewhere considers himself a realist. As we shall see, Polkinghorne gives himself considerable metaphysical freedom – notably he postulates certain things in connection with chaos theory and determinism. However there is a persuasive argument that this freedom cannot be easily combined with Polkinghorne's other claim, namely that he remains fundamentally critically realist about chaos theory (Drees 1995, 227).

As sensitive dependence is itself a direct result of the determinism of chaos theory, it is nevertheless clear that Polkinghorne accepts that the theory is deterministic. Moreover, he argues that this sensitive dependence is constrained by the regions of phase space known as strange attractors which he interprets as implying a 'limited range of possibilities' in the evolution of a chaotic system (Polkinghorne 1991, 36). Again, as we have seen in connection with out discussion of phase space, attractors only become 'strange' in connection with dissipative *deterministic* systems in which the potential trajectories cannot cross or interact. Indeed it is clear throughout his discussion that Polkinghorne considers exclusively the dissipative non-Hamiltonian form of chaotic systems in which the existence of strange attractors becomes a possibility. So, to this point in his argument it is clear that Polkinghorne has been reliant on various features of chaotic systems that arise solely because those systems are *deterministic*. One of the conclusions he reaches for similar reasons is that a 'real world' chaotic system cannot easily be isolated from its environment and consequently that chaos suggests a holism or interconnectedness of nature. The following short quotation succinctly illustrates his position as a result of these deterministic implications:

> The general picture resulting from these considerations [on chaos theory] is that of deterministic equations giving rise to random behaviour; of order and disorder interlacing each other; of unlimited complexity being generated by simple specification; of precise equations having unpredictable consequences. (Polkinghorne 1991, 37)

In this statement Polkinghorne's interpretation of the determinism in chaos theory is very standard, and is shared by virtually all scientist-theologians. The same can also be said of his associated claim that chaotic processes are widespread in nature.

Where the difficulty in assessing his theory arises is in connection with Polkinghorne's focus on the *epistemological* unpredictability of chaos theory. He conceives what he terms an 'ontological extrapolation' from chaos theory. Whilst Polkinghorne accepts that mathematical chaos is essentially deterministic, crucially he denies that real-world chaos is like this (Polkinghorne 1991, 39). At the root of his argument is an implicit distinction that runs through Polkinghorne's work between deterministic mathematical chaos and indeterministic real-world *chaotic-like* phenomena. Polkinghorne introduces this distinction by questioning why there should be any metaphysical priority of one set of assumptions over another:

> if apparently open behaviour is associated with underlying apparently deterministic equations, which is taken to have the greater ontological seriousness – the behaviour or the equations? Which is the approximation and which is the reality? It is conceivable that apparent determinism emerges at some lower levels without its being a characteristic of reality overall. (Polkinghorne 1991, 41)

This is a deceptively complex argument and it is vital that we appreciate the metaphysical moves Polkinghorne is making here. By his reference to 'apparently open' he presumably means open in an epistemological sense. His question of whether to interpret this as deterministic equations on the basis of 'ontological seriousness' is confusing, and in a sense unrelated to his assertion that 'apparent determinism emerges'. The central claim Polkinghorne makes is to question whether the mathematical representation of chaos is an approximation or reality – alternatively whether mathematical chaos is an emergent deterministic system from an indeterministic flexible reality. *The key point is that these associated claims limiting the scope of determinism in the real world are in essence a metaphysical postulate made by Polkinghorne.* This fact becomes clearer in the example of the challenge he considers between whether 'Newton was exactly right [i.e. mathematical chaos], and so all our problems are those of ignorance', or whether to make an ontological conjecture such that 'actual physical reality is subtle and supple in character; that physical process is open to the future [i.e. real-world chaotic phenomena]' (Polkinghorne 1994b, 25). Polkinghorne explicitly acknowledges that the most common

interpretation is that of accepting the equations at face value; but his interpretation is to view the equations of mathematical chaos as

> emergent-downward approximations to the true, supple, physical reality. The approximation involved is probably that of treating constituents as isolable . . . there is an essential holism built into the nature of chaotic dynamics. (Polkinghorne 1994b, 26)

Polkinghorne's use of the term 'emergent-downward' is very important. Essentially his position is that he *postulates that there is a pervasive indeterminism in the real world*. This real-world indeterminism is *modelled* by the deterministic mathematical chaos theory, but the determinism of mathematical chaos is *not applicable to this real-world chaos*. What Polkinghorne does is to turn the standard notion of ontological emergence on its head, and assert that as one moves down from this true supple indeterministic reality one eventually meets the deterministic equations of mathematical chaos. This metaphysical assertion that nature is inherently flexible *cannot* be caught by any simplistic critique on the basis that mathematical chaos theory is fundamentally deterministic. The choice between these two metaphysical interpretations of nature is one which Polkinghorne elsewhere likens to the decision between adhering to Heisenberg or Bohm's interpretation of quantum mechanics (Polkinghorne 1996b, 247). The analogy has arguably not been taken seriously enough – in relation to the quantum measurement problem there is, again, a question of which *postulates* about the nature of reality to accept. Polkinghorne's assertion is itself quite radical, namely that the real world contains pervasive indeterminacy despite the determinism of chaotic mathematics. Where his account runs into difficulties is in the justification for making this postulate of downward-emergent determinism. By means of an application of 'epistemology models ontology', Polkinghorne appears to argue that the sensitivity of mathematical chaotic systems implies real-world indeterminism. However, a better reading of his position is that this mathematical deterministic sensitivity is 'diagnostic' of the need for holistic treatment and of the existence of real-world systems as distinct from mathematical chaos being open in a sense suitable for SDA (cf. Polkinghorne 1997, 154).

Essentially what Polkinghorne's scheme amounts to is the claim that mathematical chaos theory does not fully represent reality. Implicit in his understanding is an assertion about the reality of real-world indeterministic chaotic phenomena that operate in nature over and above their mathematical representations. What he is essentially asserting is that the

mathematical models used to study chaos are only an approximation to this character.[22] There is, however, a partial circularity in this reasoning – essentially he argues:

1. mathematical chaos theory is deterministic;
2. mathematical chaos shows sensitive dependence on initial conditions and constraints due to the existence of strange attractors;
3. he then *postulates* that chaotic phenomena in the real world are indeterministic and the deterministic mathematical models we have are only downward-emergent approximations to this flexible reality;
4. this indeterministic and flexible reality distinct from mathematical chaos theory is a suitable locus for SDA.

The problem is that in step 2 the *only* reason that sensitive dependence and strange attractors exist is precisely because the mathematics of chaos theory are deterministic – recall the fact that trajectories in phase space cannot cross or join. Step 3, on the other hand, is a radical metaphysical *postulate* that Polkinghorne makes which cannot be effectively critiqued on the basis that the mathematics of chaos theory are deterministic; implicit in Polkinghorne's argument is a distinction between deterministic mathematical chaos and indeterministic real-world chaotic phenomena. However, given that in the real world the mathematical determinism is only a downward-emergent approximation to the true flexible nature of reality, then Polkinghorne needs to address why it is that the deterministic principles of mathematical chaos he identified in step 2 remain realistic features of this indeterministic reality. Alternatively, the question Polkinghorne's account faces is how it is that one can postulate that nature is fundamentally indeterministic and yet still justify the claim that it embodies two features of mathematical determinism (namely sensitive dependence and attractors) at the same time.

A second and potentially separable element of Polkinghorne's interpretation of chaotic SDA concerns a number of specific claims he makes about the nature of chaotic attractors. The first claim he makes about mathematical chaos is that different possible trajectories in phase space 'near' an attractor have equal energies:

> Since paths through a strange attractor differ in patterns of behaviour rather than in energy, these new principles would relate to the structure of future behaviour rather than to energy input. (Polkinghorne 1998b, 42)

Recalling Lorenz's discussion of sensitive dependence in chaos theory, what Polkinghorne is effectively claiming is that the nudge of a butterfly's

[22] Polkinghorne has put this point explicitly – he describes them as only approximately valid as limiting cases of this indeterministic real-world chaos (Polkinghorne 1998a, 64).

wing can be vanishingly small in a chaotic system and yet still have macroscopic consequences. This, he argues, opens up the possibility for two fundamentally different forms of causation – energetic and informational. The first is that which is a common part of any physicist's experience and involves interactions in a 'bottom-up' sense. The latter is the input of pattern formation which relates to the behaviour of the whole. It is crucial to appreciate that 'information' in this sense is not the same as 'information' stored on a piece of paper. The term is used in the sense of an ordering principle that operates *without any input of energy into a system*.[23] Polkinghorne writes that 'these higher-order principles act in a way corresponding to the input of information rather than energetic causation' (Polkinghorne 1994b, 77). The great advantage of the approach of information input understood as pattern organisation is, as we have already noted, that such assertions avoid potential interventions in the law of conservation of energy:[24]

> since the paths through the strange attractor all correspond to the same energy, we are not concerned with a new kind of energetic causality. The energy content is unaffected whatever happens. What is different for the different paths through phase space is the unfolding pattern of dynamical development they represent. The discriminating factor is the structure of their future history, which we can understand as corresponding to different inputs of information that specify its character (this way, not that way). (Polkinghorne 1998a, 62)

Indeed Polkinghorne goes as far as to argue that, 'As embodied beings, humans may be expected to act both energetically and informationally. As pure spirit, God might be expected to act solely through information input' (Polkinghorne 1998a, 63). Elsewhere Polkinghorne has been motivated by the assertion that God is not embodied in the universe to conclude that SDA is solely in the form of active information. Accordingly chaos theory in his view results from the interaction of top-down informational influences and familiar 'bottom-up' results of reductionist science. These top-down influences might also, Polkinghorne conjectures, help in the understanding of human action and free will despite the fact that both forms of action must, he argues, remain fundamentally different.

Polkinghorne's position has been widely criticised, and almost exclusively on the basis of a deterministic interpretation of chaos theory. The use of 'epistemology models ontology' is misplaced, his detractors have argued, since chaos theory is simply deterministic. However, as we have

[23] 'Information' used in this sense is close to its Latin root *informare* meaning to give form or shape to an entity.

[24] See further the discussion of Larmer's position in chapter 3 above.

seen above, Polkinghorne's position is not simply an application of his critical realist epithet, *but a fusion of deterministic and indeterministic interpretations of chaotic mathematics and an implicit postulate about the nature of physical reality*. The central novel feature in his work, aside from issues of determinism, is that of the potential role for active information in chaos theory. It is clear from Polkinghorne's other writing that he interprets the principle of conservation of mass/energy to be a fundamental feature of the physical universe, and one that is established by God's faithfulness as creator. Certainly Polkinghorne rejects any SDA which violates the conservation principle directly as interventionistic and against the faithful character of God. Chaos theory in his interpretation allows for the input of active information – essentially path decisions about which particular trajectory in phase space a particular system will follow – without any energy change whatsoever.

In more technical terms than Polkinghorne's treatment, what lies at the basis of his notion of active information input in chaotic SDA is a statement concerning the energy of various trajectories in a chaotic attractor. A strange attractor in phase space is, as we have seen, a region in which a large number of possible trajectories is focussed. However, *because the equations of mathematical chaos are deterministic*, none of the trajectories can cross or merge. Thus phase space has to be sufficiently folded to accommodate all of these possible trajectories. This infinitely tight folding is depicted by a fractal structure, and 'deep inside' the attractor itself, in the infinite limit, these trajectories become arbitrarily close. *It is at this point, and only at this point (the infinite limit), that Polkinghorne's notion of trajectory selection without input of energy becomes feasible.* This is a key implication of Polkinghorne's proposal, and one that has not been widely appreciated. Active information input relies again on the determinism of mathematical chaos to produce the required fractal structure in attractors, the required infinite limit of that structure, and the corresponding region in which energy differences between alternative possible trajectories tend to zero *in the infinite limit*. However, if Polkinghorne's indeterministic 'real-world' chaos truly exists, and the deterministic equations of mathematical chaos theory are actually a downward-emergent approximation to an indeterminate structure as Polkinghorne suggests, then *there is no* prima facie *reason to presume that possible trajectories in phase space will not cross or join as they do in an indeterministic situation*. If it is possible for trajectories to join, there is no reason to presuppose that the infinite complexity required for active information input by God is to be found in a chaotic attractor by virtue of the folding of phase space near an attractor. If this infinite

complexity is not present, then there is no point at which dissipative chaotic systems will have identical energies along their various possible trajectories, and the possibility of non-interventionist SDA by non-energetic active information input becomes impossible. The strength of this conclusion, of course, depends crucially on which elements of Polkinhorne's description of mathematical chaos theory can be taken to be realistic elements. As we noted above, there is a certain tension in Polkinghorne's work between a wide metaphysical freedom on the one hand, and claiming to remain within the orthodoxy of critical realism on the other.

It may well be possible to develop the notion of chaotic SDA without recourse to the distinction of an indeterminist ontology in the real world. If one considers the action of God in the infinite limit of a fractal attractor, where the energy required to swop between potential trajectories tends to zero, then it is still possible to assert that God chooses from amongst them. Whether such action in the infinite limit of a deterministic system is essentially interventionist is an unclear matter and one that we shall consider in more depth below. At the very least, it could be claimed that chaotic SDA by this means is an infinitely small intervention into nature, and one which will in principle remain undetectable by natural science.

Almost without exception published critiques of Polkinghorne's position focus on the deterministic nature of *mathematical* chaos theory in 'reaction' to Polkinghorne's claims about the indeterminacy of real-world chaos.[25] In one of the most sustained criticisms of Polkinghorne's position, Nancey Murphy places the basis of her position on a rejection of what she characterises as Polkinghorne's 'unpredictability to indeterminacy' link. The basis of Murphy's objection is that Polkinghorne's argument is not derived from a statement about the actual content of the world, but 'rather an argument from the character of our knowledge . . . to the character of the world' (Murphy 1995, 327). Murphy likens Polkinghorne's position to confusing modal qualifiers to the extent that the existence of unicorns is not entailed by the statement 'possibly there are unicorns'. In a related argument she criticises Polkinghorne's indeterministic interpretation:

So what chaos shows is not that there is a genuine indeterminacy in the universe, but rather that we have to make a more careful distinction between

[25] The most frequently cited response to Polkinghorne's position can be found in Robert Russell and Wesley Wildman's study of the logistic map and the philosophical consequences of chaos theory (Wildman and Russell 1997).

predictability (an epistemological concept) and causal determinism (an ontological concept). (Murphy 1995, 328)

This critique, as we have seen, does not appreciate the subtleties of Polkinghorne's argument. Polkinghorne's assertion that real-world chaos is indeterministic cannot be attacked by reiterating the deterministic basis of chaotic mathematics. A correct basis on which to critique this postulate would be to consider Polkinghorne's motivations for asserting it including features such as strange attractors and sensitive dependence which, as we have seen, exist as an uneasy fusion of the deterministic consequences of mathematical chaos onto an assertion of indeterminacy. Moreover, Polkinghorne is making some quite specific claims about the role of infinitely complex fractal attractors in dissipative chaotic systems.

Thomas Tracy similarly rejects chaos theory as it 'does not, by itself, generate the ontological openness that would be fruitful for theology [SDA]'. As Tracy continues, chaos theory is a realm in which 'The reign of causal determinism persists unbroken here; the non-linear equations describing chaotic systems fix exactly what each new state shall be, given the immediately preceding state' (Tracy 1995, 313). Tracy is equally dismissive of Polkinghorne's position, citing Murphy's claim that the application of a critical realist perspective to chaos theory is fallacious – he too claims that Polkinghorne makes an unacceptable link between unpredictability and indeterminacy. Philip Clayton also echoes Tracy's point with his assertion that 'The mathematics of chaos is completely deterministic ... Russell and Wildman provide an excellent model of the care needed today when speaking of God's bringing about changes in the natural world' (Clayton 1997, 207–8). Stephen Crain asserts a similar position focussing on problems with determinism in Polkinghorne's theology and ultimately grounds his belief that the causal nexus of SDA will remain elusive because of the transcendent nature of God (Crain 1997).

It is a pity that *all* the critiques of Polkinghorne's position have focussed on this aspect without appreciating that Polkinghorne's argument is itself dependent on the very determinism that they hold against him. Indeed, even Arthur Peacocke's position, which is based on the limitations in God's foreknowledge of indeterministic processes, also echoes the deterministic interpretation of chaos theory (Peacocke 1993, 154). Moreover, there are additional claims in Polkinghorne's metaphysics which concern the status of fractal attractors in chaos theory, and we now turn to consider these in some detail by considering another example of a physical system which behaves chaotically.

THE STATUS OF ACTIVE INFORMATION

Chemistry provides some of the best examples of chaos. Not only are there parallels between the dynamics of chemical reactions and chaos in populations modelled by the logistic map, but chemical chaos often arises from simple, well-defined rate laws which are in the form of differential equations. In general there are two conditions necessary (although neither is sufficient) to constitute chemical chaos. The first is the general chaotic condition of non-linearity – typically a reaction rate is dependent on the product of the concentration of two different species; the second feature commonly found in chaotic chemical systems is feedback, for example autocatalysis.[26] The combination of these two factors – positive feedback and non-linearity of reaction rates – can cause the concentrations of products of some reactions to oscillate in a chaotic manner. One famous example of chemical chaos is the Belousov–Zhabotinskii (B-Z) reaction. Boris Belousov noticed by chance that a certain mixture of chemicals (sulphuric acid, potassium bromate, cerium sulphate and malonic acid) produced unusual fluctuations in the concentration of bromide and cerium ions. He had a lot of difficulty convincing his colleagues that this was a genuine phenomenon because the accepted wisdom at the time was that all reactions eventually settled in an energetically favourable state. Anatol Zhabotinskii several years later heard of Belousov's work and was able to prove that the result was genuine (Zhabotinskii 1964). Although the chemical details of the reaction are complex and there is not yet universal agreement of the several different reaction steps involved, few people can deny that the B-Z reaction is spectacular. In a typical set-up the chemicals are mixed in a continuously stirred beaker which then begins a series of seemingly random colour oscillations of the mixture between red and blue or, in another variant of the reaction, from colourless to gold to blue and then back again.[27]

The precise details of the reaction do not concern us here, although it is important to note that the mechanism is highly complex and involves approximately eighteen steps and twenty-one different chemical species.[28] What is particularly important for our purposes is that, as

[26] Positive feedback can take place by means of one of the products of the reaction being fed back into the reaction in the next step. Alternatively, it occurs by means of thermal feedback in which the heat produced by the reaction accelerates the reaction (for example in combustion and oxidation reactions). For more details see Scott (1991 b, 16–17).

[27] For a typical 'recipe' to perform the reaction see Scott (1991 a, 111–12).

[28] The mechanism is described by Field, Körös and Noyes (1972), although there remains some debate as to its full details.

Scott has emphasised, there is indisputable evidence that this chemical system is chaotic (Scott 1991a, 113). The B-Z reaction can show period doubling (characteristic of chaos in the logistic map) and highly complex chaotic oscillations. Indeed, in general it has become widely accepted that chaos theory places important epistemological limitations on the extent of knowledge that can be gained about chemical reactions, as Scott concludes:

> Chemists, especially those who study the details of organic and inorganic biochemical reactions, need to shake off some of their traditional views and accept that, as in other areas of science, there are also limits to predictability in chemical dynamics. (Scott 1991a, 121)

It is clear that there are chaotic fractal attractors in the B-Z reaction and in many chemical reactions in general. Indeed, there have been several studies that have plotted pictures of the attractors in concentration phase-space for the B-Z reaction (e.g. Hudson and Mankin 1981). Given this, it would be reasonable to argue that: (1) many non-linear chemical systems which contain feedback are chaotic; and (2) chaos theory can be used to model chemical reactions as successfully as it can other physical situations.

It would be a reasonable question, then, to ask whether Polkinghorne's model of chaotic SDA by means of active information input can apply to chemical systems in nature. The technical implications of this claim are that God chooses from equal energy trajectories in the phase space generated from the concentrations of the various reactants without inputting any energy into the system. However, as we saw in the discussion above, these equal energy trajectories are only found in dissipative chaotic systems at the infinite limit of a particular attractor, and this is an attractor with infinite complexity – i.e. fractal geometry. The important point here is that there are significant problems with this proposal from a chemical point of view. *The chaotic modelling of chemical processes assumes an infinite complexity in the values of the concentration of the various reactants* and this simply cannot be the case in nature. It does not make any sense to suggest that a concentration of a particular chemical species in a reaction has anything other than a finite precision – in a given quantity of solvent there are only a certain number of molecules of any one species. It is simply meaningless to assert that, in order accurately to predict the concentration of a given species in a chaotic reaction at any point in the future, we must know it to infinite accuracy. In a given beaker of water there are only a finite number of indivisible atoms of any one particular type.

It would thus seem that there are two contradictory statements here: on the one hand the B-Z reaction shows many of the features of chaos; on the other hand any chaotic model which assumes that there exists an infinite fractal intricacy to attractors may not represent the physical world. This problem is not restricted to chemical chaos and applies to many different physical quantities. Consider, for example, the use of the logistic map to study chaos in the population numbers of a particular animal species (e.g. May 1991) – it makes no sense to claim that there are populations of fractions of animals in a given area.

This problem is central to the claim that God acts by means of active information input in chaos theory. The possibility of this form of chaotic SDA is dependent on the ontological existence of infinitely complex fractal attractors in which the energy differences between potential trajectories become zero. However there is good reason to assert that the existence of these infinitely complex regions of space is not a realistic part of chaos theory. Indeed, it would seem that God is prevented from acting in this manner in any chaotic chemical system, and many other physical systems by implication, because of the absence of the required equal energy trajectories. In actual fact, if God wished to act to determine the colour of the B-Z reaction, the only means open to him would be some form of quantum manipulation coupled with a chaotic amplification owing to sensitivity in the system which would produce the required colour change. Indeed, *it is possible that all Polkinghorne's examples of SDA by means of input of active information into chaos theory require a similar quantum chaos model.* We shall return to these issues in some depth below.

FRACTAL GEOMETRY, CHAOS AND ONTOLOGY

Benoit Mandelbrot, who has been widely dubbed the 'father of fractal geometry', has been keen to assert a direct consonance between fractal mathematics and natural forms.[29] His work has been widely cited, and there have been many subsequent attempts to link fractal geometry to natural forms.

Many mathematical structures have a form of underlying geometric regularity, known as scale invariance or self-similarity. If one examines

[29] Indeed Mandelbrot has written that 'scientists will . . . be surprised and delighted to find that not a few shapes they had to call grainy, hydralike, in between . . . wispy, wrinkled, and the like, can henceforth be approached in rigorous and vigorous quantitative fashion'. Mandelbrot cited in Jürgens, Peitgen and Saupe (1990, 47).

these objects at different scales and magnifications, one repeatedly encounters the same fundamental elements. There have been several technical studies of the precise nature of this fractal geometry which are unnecessary for our purposes, and we shall focus on this question of infinite fractal intricacy which corresponds to the notion of having an infinite amount of detail within a finite amount of space. It is a definition offered by Mandelbrot himself and is equivalent to his identification of a fractal as an object with higher dimensions than its topological dimension alone (Mandelbrot 1983, 361 f.). Mandelbrot elsewhere puts the relationship like this:

> they [fractals] have the same degree of irregularity on all scales. A fractal object looks the same when examined from far away or nearby – it is self-similar ... Nature provides many examples of fractals, for example, ferns, cauliflowers and broccoli, and many other plants, because each branch and twig is very like the whole. (Mandelbrot 1991, 123–4)

Mandelbrot's most famous example of a fractal was the coastline of the British Isles; his point is that it is possible to model the coastline by means of fractals 'within the scales of interest to the geographer'. From this Mandelbrot concludes that 'coastlines are fractal patterns' (Mandelbrot 1967). Yet it is unclear how the coastline of Britain could be anything like a fractal – it simply does not embody the necessary complexity. Indeed Mandelbrot focusses in his claim on one feature of fractal geometry (its self similarity), and totally ignores another (its similarity on all scales, no matter how fine). Indeed, it appears that the coastline of Britain can be modelled by a number of *pre*-fractal curves. These pre-fractals lack the infinite complexity of true fractals. Moreover, even if it is found technically that certain features of the coastline of Britain do scale regularly in a manner akin to mathematical fractals, there is little possibility that any single model could be developed for the coastline as a whole. The coastline of Cornwall appears rather different from that of the Western Scottish Isles, so it is highly unlikely that any given fractal scaling law will apply for the whole coast (Smith 1998, 32).

If Mandelbrot's example of fractals in nature had its flaws, then the misapplication of fractal mathematics to real objects surely finds its pinnacle in the work of Taylor, Micolich and Jonas. Their study of art in the late 1940s draws similarities between fractal mathematics and Pollock's famous drip paintings which were formed by dripping paint onto canvasses laid on the floor of the studio. As the authors themselves put it,

Here we describe an analysis of Pollock's paintings which shows, first, they are fractal, reflecting the fingerprint of nature, and, second, that the fractal dimensions increased through Pollock's career. (Taylor, Micolich and Jonas 1999)

Despite the fact that the authors even suggest using a measure of fractal dimension as a test of the authenticity of Pollock's disputed paintings, there is little in their analysis that suggests that Pollock's work could be radically reinterpreted as infinitely intricate. Consequently the extent to which fractals represent the 'fingerprint of nature' is highly questionable. Indeed, there is much gibberish talked about the physical application of infinitely complex fractal structures to nature. Peter Smith has put this point well:

Given a merely surface-descriptive appeal to fractals, where it is claimed that some natural phenomenon has a fractal-like look to it, we can agree that there may well be anomalous measurement behaviour at coarse scales. But we should be cautious about leaping to assert that some department of nature really has a fractal geometry. We always need to ask: won't a better surface description of nature in fact be provided by prefractals that lack the infinite excess detail? To which the answer seems invariably 'yes'. (Smith 1998, 33).

In a more critical account than Smith's, Orly Shenker has examined these issues in some detail (Shenker 1994). Shenker posits a distinction between what he identifies as temporal and spatial fractals: the former are those found in chaos theory and embedded in phase space; whilst the latter are claimed to represent natural objects such as ferns or cauliflowers. Shenker is not as critical of the use of fractal geometry in chaos theory which he interprets as a necessary, although unfortunate implication of the theory. The difficulty, as he interprets it, is that science is based on an atomistic paradigm which, if an object is fundamentally constructed from elementary particles, leads to a direct contradiction with the infinite intricacy of fractal species:

As the atomistic paradigm is otherwise invariably corroborated, the sole motivation for rejecting it in search of a 'physics of fractals' . . . is the prima facie resemblance of pictures. This resemblance itself [is] . . . superficial and misleading. It seems that the fact that a satisfactory non-atomistic interpretation was not offered, not even in the most general terms, is not without reason. (Shenker 1994, 979)

Indeed, according to Shenker, the over-enthusiastic embrace by many scientists of fractal geometry is due to the simple fact that in their enthusiasm they have forgotten many of the most basic lessons of scientific methodology (Shenker 1994, 980).

This consideration leads us on to the fact that chaos theory models the world in a fundamentally different manner to standard classical mechanics. In the latter assumptions are generally of a *simplifying* kind (such as the inelastic string, the perfect collision etc. . . .), in the fractal geometry of chaotic systems, however, the assumptions are of an increasing complexity. In order to predict the outcome of chemical reactions we need to know the concentration of the reagents to an infinite complexity. It would seem then that the nature of chaotic modelling is in fact quite different from Russell and Wildman's assertion that mathematical modelling always involves making simplifying assumptions (Wildman and Russell 1997, 77). Despite the claims of those such as Smith that we should not be overly concerned by this overrepresentation of reality, it appears at the very least that this is one sense in which chaos theory is fundamentally different to classical mechanics. Smith places reliance on the fact that, despite the infinite complexity of the underlying mathematics, a chaotic model's permitted bundle of phase space trajectories still maps realistically onto the actual natural set (Smith 1998, 44). However, given that claims for active information input in chaotic systems *rely on the realism of exactly this kind of infinite complexity*, the same distinction is not open to the proponent of chaotic SDA through active information. Of course the option is still open to assert as Polkinghorne does that the real natural world is ontologically indeterministic and that our deterministic mathematical models are downward-emergent approximations to this reality, but this is a separate claim to that concerning active information SDA.

DETERMINISM AND MATHEMATICAL CHAOS

Ostensibly it may appear strange to have left a detailed discussion of the relationship between determinism and mathematical chaos until this stage; however, as we have seen, there is much more to claims for chaotic SDA than simple appeals to indeterminism. The issue of the relationship between determinism and epistemological chaotic unpredictability has been widely studied,[30] and Wildman and Russell (1997) have presented a good summary of the various issues at stake here. Chaos is, they argue, totally distinguishable from randomness, is to be interpreted as a tertium quid and actually leads to a strengthening of assertions about the deterministic nature of reality. The key to their assertions can be seen in their reliance on the fact that a mathematical equation exists which governs chaotic phenomena. In connection with quantum theory they

[30] See, for example, Stone (1989) and Hobbs (1991).

note that 'The exact number of alpha decays each second, however, is random. Randomness here always means at least that no known equation determines this exact number, but it sometimes carries additional suggestions of metaphysical determinism' (Wildman and Russell 1997, 76). Although they note the difficulties in moving from randomness to indeterminism, it is a move they are happy to make in connection with quantum mechanics. Despite their other well-balanced discussions about the role of modelling in mathematics, this statement about the existence or non-existence of a defining equation appears absolutely fundamental to their subsequent claim that

> We can say without hesitation that chaos in nature gives no evidence of any metaphysical openness in nature. The fact that a natural dynamical system is open to its environment, which is sometimes described in terms of a whole/part causal relationship, does not entail metaphysical openness, for the entire environment may be causally determined. (Wildman and Russell 1997, 82)

This conclusion leads them to the assertion that in order to cause any SDA in classical chaotic systems, God would have to intervene in the pre-determined course of nature, by either breaking or suspending its natural causal sequences. The intervention of law-suspending miracles would differ only in that sensitive dependence permits these acts of interference or suspension to be at an extremely small scale, rendering them undetectable (Wildman and Russell 1997, 83).

It is a pity that this paper does not address Polkinghorne's thesis more explicitly. It is clear, however, that the authors reject Polkinghorne's epistemology models ontology link, yet they fail to address the force of Polkinghorne's proposal in two fundamental ways. Firstly, in response to the criticism of Russell and Wildman described above concerning the interventionistic nature of SDA in chaos, Polkinghorne would surely respond that his active information model solves this problem. As we have already seen, the option is open to Polkinghorne to argue that any intervention would in fact be vanishingly small in the infinite limit of a chaotic attractor. We have rejected this proposal on other grounds concerning the applicability of fractal geometry to nature, however Russell and Wildman do not mention this. Moreover, their critique totally fails to come to grips with Polkinghorne's second proposal – namely that the deterministic equations of chaos theory are downward-emergent *approximations* to a more flexible reality. Whilst we may disagree with Polkinghorne's motivation for asserting this downward-emergent determinism, the option is open to the theist to interpret the laws of nature in this manner.

Indeed, Wildman and Russell do appear to be open to this suggestion to a certain extent; in a discussion of the difficulties in determining whether a particular natural system exhibits chaotic properties, they note that

> Though the model might predict system behavior perfectly in situations of equilibrium or relatively simple periodicity, therefore, it is impossible to be sure that another, unknown model of the dynamical system (say, one that involves God as a causal factor) does not finally provide a better description of the system's behavior. Thus, there is a limit to how well the hypothesis of metaphysical determinism can be supported. (Wildman and Russell 1997, 86)

Maybe the situation for chaotic SDA is not as bleak as Russell and Wildman seem to indicate – indeed there are a number of influential physicists who believe, like Karl Popper considered in chapter 4 above, that chaos is indicative of flexibility in nature. There are essentially three different approaches to this argument in the literature.

The first is based on what could be termed the 'technological problems with prediction' approach and is most easily grasped by considering the Lorenz model once more. We have already encountered the problems raised by the sensitive dependence of the Lorenz system on initial conditions and the epistemological difficulties this raises. In actual fact if we wished to know one exact trajectory in the Lorenz system for an extended period of time the computational precision we would require to make that prediction accurately outstrips the number of sub-atomic particles in the known universe.

In this technological sense it is thus correct to say that there is no way *in principle* that we, or any other finite beings, could ever know the detailed future evolution of such a system. Here, the argument runs, we encounter a radically new kind of 'indeterminism' – that of computational difficulty in principle. However this is not the same as the sense in which we have been using indeterminism throughout this book – after all even given this limit in computation there are still presumably well-defined trajectories in phase space, even if we cannot know them. It is thus not clear by any means whether this really supports any conception of indeterminism in James' sense of open possibilities in nature. Indeed, it is not clear how we can uncritically accept Paul Davis' contention that:

> Those [physical systems] that are chaotic have severely limited predictability, and even one such system would rapidly exhaust the entire Universe's capacity to compute its behaviour. It seems, then, that the Universe is incapable of digitally computing the future behaviour of even a small part of itself, let alone all of itself . . . This conclusion is surely profound. It means that, even accepting a strictly deterministic account of nature, the future states of the Universe are in

some sense 'open' . . . it seems safe to conclude from the study of chaos that the future of the Universe is not irredeemably fixed. The final chapter of the great cosmic book has yet to be written. (Davies 1991, 220–1)

We must, as we have seen, be extremely careful not to conflate concepts of epistemological computability with ontological openness, and the vast majority of philosophical accounts of chaos theory assert that it is a paradigm deterministic model. Interestingly there is not, however, absolute unanimity in this regard.

The other two philosophical approaches towards an indeterministic interpretation of chaos theory are more philosophically interesting and rarely discussed in full detail. Both approaches are quite fundamental – neither draws a simplistic verificationalist distinction between 'real-world' and mathematical chaos. The basis for both schools of thought is a fundamental challenge to the core assumption in mainstream chaos theory that real numbers are the most basic specification of the state of a system. The basis of their claims for indeterminism is the identification of a purported logical incompatibility between ontological determinism and chaos theory (Jones 1991, 546).

Ilya Prigogine, whose work has been very influential on Polkinghorne's position, develops a dualistic complementarity between chaotic systems which are reliant on an external-time ordering, and those which are themselves based on an internal 'system time' (for example, Prigogine and Stengers 1984).[31] Joe Ford, on the other hand, relies on recent results of algorithmic complexity theory which, he argues, imply that no variable can ever be measured precisely: 'the number continuum is, strictly speaking, a fiction' (Ford 1983, 47). The most striking feature of Ford's reformulation of the number system is that all real physical variables are quantised, and consequently the infinite levels of precision required to make deterministic chaotic predictions in the standard theory of chaos fall away. Both of these approaches are currently not fully developed and the detailed theological implications of them remain to be thoroughly studied. At the very least, however, they illustrate John Earman's point that it is extraordinarily difficult to graft concepts of determinism unequivocally onto varied physical systems.

CHAOTIC SDA – A COHERENT APPROACH?

In summary the possibilities presented by chaotic SDA are quite complex. If we take a deterministic interpretation of chaos theory (and leave

[31] A detailed critical discussion of Prigogine's position can be found in Batterman (1991).

Polkinghorne's downward emergence aside) it appears that there is little possibility for non-interventionist SDA. The only point in the mathematical theory of dispersive chaotic systems that the zero energy input required for active information can be found is in the infinite limit of a strange attractor, and we have already seen in connection with chemical chaos why these may not ontologically exist. Yet despite this there are interesting technical reasons why we may claim that chaos theory is ontologically indeterminate and these serve to support Polkinghorne's interpretation. Polkinghorne's position may also derive further support from Earman's discussion of the fundamental difficulties surrounding determinism in classical physics, although it is unclear whether they would also support his active information approach.

Jeffrey Koperski's in *God, Chaos and the Quantum Dice* raises a further set of criticisms of chaotic SDA to those considered in this chapter (2000). Koperski questions closely whether nature is actually as chaotic as many informal descriptions imply. He emphasises that in many of the so-called examples of real-world chaos, such as fluctuations in the cycle of the beating human heart, chaos only exists as a minor background phenomenon and in no way implies whole-scale disorder. His main objection to chaotic SDA is thus largely a question of scale:

> For God to make effective use of chaos, it must influence the large-scale, dominant behaviour of a system. However, this is often not the case. To put it crudely, CQD [chaotic quantum determination] describes a causal pathway in which God could alter the arrangement of bubbles in the crest of a tsunami but not redirect its course. Presumably more is wanted from an account of divine agency. (Koperski 2000, 557)

Such issues can only raise more difficulties for theologians asserting chaotic SDA models, however it should be noted that there are still theoretical possibilities for chaotic SDA in relation to a future thermodynamically inspired theory such as that currently being developed by Prigogine and his colleagues.

In the next chapter we turn to consider the other main approach to incompatibilist SDA developed by Arthur Peacocke and, in the last chapter, whether there is any prospect for models of quantum chaos in connection with SDA.

CHAPTER EIGHT

Whole–part models of SDA

In previous chapters we have considered two principle facets of the current academic debate concerning SDA in nature: what we mean by a 'miracle'; and how quantum mechanics and chaos theory are claimed to support SDA. It is now time to consider a third limb to the debate, namely the claims made for SDA which arise from a methodology which is variously described as whole–part, top-down, or downwardly emergent. We have already seen a hint at this further approach in John Polkinghorne's concept of downward emergence as applied to the seemingly deterministic equations of chaos theory and classical mechanics. The question we must now address is whether there is another basis on which the world may be said to embody William James' notion of open possibilities. The basis of Polkinghorne's proposal is that at increasing levels of complexity in nature the essentially indeterministic fundamental processes of the world can be codified into pseudo-deterministic equations. The equations thus appear to us to be deterministic, whilst the underlying reality is not. A similar, multi-layered, emphasis on emergent reality lies at the core of Arthur Peacocke's enormous contribution to the debate on SDA. We shall now turn to consider his position in detail.

Arthur Peacocke has had a long and distinguished career both as a scientist and as a priest-scientist and has deservedly recently been awarded the Templeton Prize for Progress in Religion.[1] Peacocke's approach to many of the issues considered in this book is subtly different to several of the physical scientists we have already considered and is strongly rooted in a panentheist conception of the relationship between God and the world – the belief that the Being of God includes and penetrates

[1] The following short discussion will focus exclusively on Peacocke's contribution to the top-down model of SDA. It is important to note, however, that Peacocke's contribution to the SDA debate in general is extremely wide reaching – almost all of the scholars considered in this book despite their widely divergent views rely on one or other of Peacocke's works.

all-that-is but that God's being is more than it and is not exhausted by it (Peacocke 2001, 57).[2]

Peacocke bases his study of the relationship between science and theology on the methodology of critical realism which, he argues, can be applied to both science and theology. His emphasis is on the approach that theological concepts and models can, like those employed in science, also be open to revision in the light of new information. It is in this context that he is clear that he does not unconditionally accept any overriding authority of the church or scripture, and stresses that coherent belief must satisfy a general criterion of reasonableness, or inference to the best explanation. Although Peacocke places emphasis on the importance of intention in connection with SDA, he does not deny the possibility of a causal joint in principle (Peacocke 1984, 76). Rather, the role of intentional language is that it supplies the meanings of a given SDA by analogy with intentional descriptions of the action of human agents. In common with virtually all of the authors considered in this book, Peacocke places a great emphasis on the rationality of God and his role as a faithful sustainer of the world. It is this rationality, in tandem with our understanding of God's transcendence, which leads Peacocke to the conclusion that belief in SDAs which intervene in the world is belief in an incoherence in God's nature: 'It suggests an arbitrary and magic-making Agent far removed from the concept of the One who created and is creating the world that science reveals' (Peacocke 2001, 56). Moreover, Peacocke argues, God's actions are supremely personal and find expression in communication with humanity; yet, because God creates within the processes of his creation, SDA must be limited to the operation of natural laws. Peacocke is clear that he cannot conceive of how SDA might occur in a fully deterministic world, and that God cannot intervene in the workings of creation in an interventionist sense, a position which leads him to a rejection of John Polkinghorne's assertions concerning chaos theory. He also rejects the notion of intervention for several other reasons: because of the implied separation between God and the world; because it undermines the rationality and faithfulness of God; because there can never be adequate evidence to establish the truth of any claimed intervention (cf. Hume); and because it raises unacceptable problems of evil in connection with occasions when God did not suspend the laws of nature (Peacocke 1993, 141–3).

[2] Helpful discussions of panentheism can be found in Peacocke (2001, 138f.) and Clayton (1997).

Where Peacocke's theology differs from several of his colleagues in science and theology circles is in connection with the relationship between God and quantum indeterminacy. For, whilst it is an essential part of the position of those who advocate a mechanism of quantum SDA that God can 'see' behind the indeterminism and manipulate it to his own means, Peacocke holds that this same indeterminism must also be recognised by God for it to be truly indeterministic. As he puts it, 'God cannot know definitely the precise outcome of any quantum event because God can only know that which it is logically possible to know . . . Ontological indeterminacy at the quantum level precludes such precise knowledge for God to have' (Peacocke 1998, 368–9, footnote 31).[3] Peacocke's extension of indeterminacy to include God's knowledge of quantum events is a fundamentally metaphysical choice, and a potentially wise one given the extreme difficulties we have already identified in holding simultaneously that ontological indeterminacy exists as created by God and yet is modified by God. Indeed God in his view is so coherent that he cannot both support a truly indeterministic scheme and have knowledge of it at the same time: 'the future does not yet exist in any sense, not even for God' (Peacocke 1993, 131). Because of this self-limitation, Peacocke argues that God both 'takes risks' in his creation and suffers as a result.

Peacocke's statements concerning the kenotic limitation of divine omniscience in connection with indeterminism are to be placed in the wider context of his work on the multi-layered nature of the world. No doubt as a result of his biological training, Peacocke places a greater emphasis on the many different irreducible layers of reality in the world than any other scientist-theologian. The fundamental basis of his approach can be found in his philosophy of critical realism (Peacocke 1984, 35–6). He argues that because higher-level phenomena emerge as one progresses from the 'bottom' to the 'top', these phenomena must also be interpreted in a basically realist sense (Peacocke 1979, 116–19). There are different hierarchies in nature and more complex systems are essentially more than the sum of their parts. In other words, Peacocke argues, as a result of the emergentist properties of complex systems it is possible for them to have top-down causal efficacy on their more simple constituents.

[3] Peacocke correctly argues that quantum SDA remains fundamentally interventionist (cf. the discussion in chapter 6 above), that there are difficulties with probability in quantum theory if SDA is held to occur, and that God acts more fundamentally as he creates 'through the very processes' of evolution. Peacocke's argument against Russell's model of quantum SDA driven evolution could derive considerable support from Brandon (1996), who argues strongly against a deterministic hidden variables interpretation of evolutionary theory.

It is against the background of God's creation containing many different irreducible levels of reality that Peacocke develops his understanding of whole–part SDA:

> If God interacts with the world-system as a totality, then God, by affecting its overall state, could be envisaged as being able to exercise influence upon events in the myriad sublevels of existence of which it is made without abrogating the laws and regularities that specifically apply to them. Moreover, God would be doing this without intervening in the supposed gaps provided by the in-principle inherent unpredictabilities. (Peacocke 2001, 109)

The notion of a world-system which Peacocke uses in this context is an expression of the interconnectivity of all physical processes. The basis of his approach to SDA is that by means of God's omniscience it is possible for SDA on the whole world-system to be such that God is able to predict the intricate workings that he desires on lower levels. Accordingly lower-level SDA occurs through what Peacocke terms a 'trickle-down' effect as each level affects those below it. Of course, because God acts on the whole universe at once it is not possible for created beings to make detailed presumptions about the 'causal joint' of God's action. Indeed, on the categorisation of divine actions developed in chapter 2, Peacocke's approach is very close indeed to a strong form of general divine action (GDA).

Peacocke claims support for his model by analogy with the manner in which a non-dualist account of the human person supports the idea that states of the brain-as-a-whole have causal effects at the level of neurons and hence of human bodily action: 'God would then be regarded as exerting a continuous holistic constraint on the world-as-a-whole in a way akin to that whereby in our thinking we influence our bodies to implement our intentions' (Peacocke 1995, 146). Peacocke thus appears much closer to the single act approach to SDA, considered in chapter 2 above, than Polkinghorne. Indeed, he allies himself with Kaufman and Wiles, although he emphasises that he interprets SDA in a far richer and more continuing sense than either of these authors.

RELATIONSHIP WITH THE LAWS OF NATURE

Peacocke's model of the relationship between God and the world as a whole–part constraint on the free processes of nature is a helpful model of SDA. Yet there is a strong sense in which its strength – namely its generality – is also its weakness due to its lack of specificity. Peacocke

himself is the first to acknowledge this problem and he is clear that his approach requires supportive sample instances of whole–part causal action. Peacocke's notion of whole–part constraints by God on the world could derive some support in Polkinghorne's notion of downward emergence despite the fact that both authors are clearly arguing for quite different conceptions of SDA. Peacocke considers divine interaction with indeterministic events unnecessary and impossible as God is immanent to the whole of his creation (recall his emphasis on panentheism), while Polkinghorne asserts that his concept of top-down SDA operates in tandem with a pervasive indeterminism.[4]

Indeed Peacocke's whole–part model raises interesting issues in relation to the philosophy of laws of nature. A core assumption that pervades the theory is that part–whole reductionism must clearly fail – in other words it is not possible for a necessitarian understanding of physical laws to apply on all scales. Where the fundamental laws of nature may determine what events take place on lower levels, there cannot be a reductionist connection with those higher-level phenomena in which top-down guiding is claimed – a straight denial of the assumption that fundamental laws provide a complete explanation for all phenomena at all scales. As such Peacocke's model sits on the crossroads between emergence and reductionism and has interesting similarities with the assertion that the laws of nature form only a patchwork over natural phenomena.

There are many claims that phenomena are emergent throughout the sciences and in particular in relation to the philosophy of mind and biological organisation. A note of caution must be sounded, however, for as with quantum indeterminism, it is unacceptable simply to identify an emergent phenomenon and make broad claims that God's activity parallels it. Michael Silberstein and John McGeever (1999), for example, argue that there are particularly strong claims that quantum non-locality may constitute an ontologically emergent phenomenon, but as we have already seen non-local correlations can only serve to act as a limitation on the potential scope of quantum SDA. It is consequently clearly important to distinguish senses of epistemological and ontological emergence in physical processes. The former, in which emergence is produced by the structure of the model alone, is fundamentally different to the latter in which the claim is made that there are causal processes which are ontologically irreducible to any of the constituent parts, or any of the

[4] It is important to note, however, that Polkinghorne also emphasises that his model of chaotic SDA makes broadly holistic claims also.

relations between the parts. Any future study of SDA in natural processes must focus on this notion of ontological emergence.

The related argument, that the laws of nature form only a patchwork of explanation, has received detailed attention from Nancy Cartwright. She has emphasised in a number of articles that the mere assertion that a particular physical law is true is not the same as claiming that it holds universally and applies on all scales and in all domains:

> Do the laws of physics that are true of systems (literally true, we may imagine for the sake of argument) in the highly contrived environments of a laboratory or inside the housing of a modern technological device, do these laws carry across to systems, even systems of much the same kind, in different and less regulated settings. (Cartwright 1996, 316)

This principle may appear fairly uncontroversial – for example many physicists appreciate that the laws of quantum mechanics do not apply to large-scale entities. However Cartwright's assertion is in essence universal and applies even to those laws considered to work on all scales. After all, she argues, what is it that gives philosophers belief in the scope of application of a particular physical law? What successes there have been assert only that the law in question is valid in that particular domain, rather than universally. At the root of her approach is a similar questioning of metaphysical assumptions to those made by many protagonists of indeterminism over determinism. What she asserts is 'metaphysical nomological pluralism' – the doctrine that different sets of laws are applicable in different domains in nature, and that there is no systematic or uniform connection between these laws. What results is a patchwork coverage of natural phenomena, and one, it is logical to argue, that is potentially open to SDA. As Cartwright notes,

> some features of systems typically studied by physics may get into situations where their behaviour is not governed by the laws of physics at all. But that does not mean that they have no guide for their behaviour or only low-level phenomenological laws. They could fall under quite a different organized set of highly abstract principles. (Cartwright 1996, 322)

What such organisational principles are, and whether they preclude SDA, is a matter for metaphysical speculation. Interestingly the existence of this patchwork of laws need not, however, necessarily imply ontological emergence – Cartwright notes that the argument is not that these properties necessarily 'grow' out of another physical situation, merely that the nomologically unregulated properties of physical systems have existed all along and stand alongside, but not under, the realm of physics.

Despite the fact that Peacocke's approach, when combined with Cartwright's nomological pluralism, appears the most promising current theory of SDA, we must note two elements of caution. Firstly there is the difficulty that it is extraordinarily difficult to demarcate exactly where emergence, and/or physical events that occur outside the patchwork of laws, actually takes place. By their very nature it is not possible to study them directly. Secondly, as we noted in relation to quantum emergence, the fact that a system is not whole–part reducible, or falls outside the patchwork of laws, need not necessarily mean that it is open to the possibility of SDA.

Consequently, while Peacocke's model is currently the most detailed model of SDA we have, it still remains far from the theological requirements we identified in chapter 2 earlier. We have not so much provided support for the claim that God actually acts in the world, but rather made statements about the limits of the laws of nature and simply asserted that he does. As such the jury must remain out on whether this is ultimately a productive model of SDA, but as things currently stand it remains the best we have. In the next chapter we turn to consider what consequences this has for the theological claim that God acts in the world.

CHAPTER NINE

Is SDA really tenable?

Before we begin to examine the implications of the failure of so many attempts to articulate the nature of SDA, it may be helpful to summarise briefly the conclusions of the preceding pages. We have seen how central the assertion of SDA is to Christian theology and looked at several alternative approaches to how it may be related to the natural sciences. It was argued in chapter 2 that any coherent account of SDA must contain both intentional and causal modes of description, and that we cannot simply bypass the issue of the 'causal joint' in this regard.

We began in chapter 3 to look at the issue of when a particular SDA might be considered as an intervention in the autonomous workings of nature. It became clear that the issue of intervention in natural processes is highly contingent upon which interpretation of the laws of nature one admits, and the extent to which one asserts that the laws of nature are fundamentally statistical. In connection with the latter we also examined the relationship between SDA and determinism in some detail.

We then considered various attempts to elucidate the nature of this causal joint in connection with quantum and chaos theories. It was shown in chapter 6 that the possibilities for SDA in orthodox quantum theory are far more limited than many theologians have presumed, and in chapter 7 that the concept of SDA by information input into chaotic events relies on a fractal intricacy which may not be embodied by natural processes. In chapter 8 we concluded that Peacocke's model of whole–part SDA is in essence the only tenable philosophical approach that remains.

One remaining approach to SDA arises through combination of both chaos theory and quantum theory. Indeed recent theology and science scholarship has been widely supportive of quantum chaos and any potential it may have for SDA. In short, however, it is very difficult to see how quantum chaos could actually add any new possibilities for SDA unless it gives rise to the emergence of causally unrelated phenomena of the sort required by Peacocke's theory. Indeed, given that quantum SDA

is only possible on a regularitarian understanding of the laws of nature, there is no obvious advantage to be gained by chaotically amplifying quantum results as many theologians assert. Moreover the fact remains that we simply do not yet have a detailed theory of quantum chaos,[1] and unless we obtain a more detailed understanding of the quantum measurement process, it looks like such a theory is a long way off.

THE 'STATE OF THE ART' IN SDA

Would it be correct to argue on the basis of the forgoing critique that the prospects for supporting anything like the 'traditional understanding' of God's activity in the world are extremely bleak? To a large extent the answer to this question must be yes. *In fact it is no real exaggeration to state that contemporary theology is in crisis.* As we have seen, such a wide range of doctrine is dependent on a coherent account of God's action in the world, and we simply do not have anything other than bold assertions and a belief that SDA takes place.

We have already seen how many of the contemporary attempts to reconcile God's action with modern science founder on technicalities in the relevant physical theories. The theist has only the remaining option of adopting a broad regularity approach to the laws of nature (see chapter 3 above), with the result that any actions of God are simply subsumed into the wholly descriptive laws of nature. The flexibility of this approach is, as we have seen, also its inherent weakness – while God never acts against the laws of nature, it becomes extraordinarily difficult for any scientific prediction to be made whatsoever.

Of course this book is not the first to have reached a similar conclusion concerning the current state of science and theology scholarship, however it must be stressed here that this failure on the part of our detailed models of quantum and chaotic SDA should not lead us to a Farrer-like desperation on the causal joint issue. Indeed, if we are true critical realists about science, then we are simply unable to resort to metaphysical hand waving on these issues, and nor should we want to – the causal half of any justification of the possibility of SDA is surely dependent on us exploring and developing this question. While we are arguably in a

[1] It is important to distinguish true quantum chaos from 'quantum chaology' which is the analysis of quantum systems that have classically chaotic analogues. While such studies are extremely helpful, not least because they may shed light on the fundamentals of quantum theory, they are emphatically not the detailed theory that would be required before theologians could safely conjecture about quantum chaotic SDA.

position where we can evaluate and discuss the scholarly attempts to reconcile SDA and science, it is undoubtedly premature to conclude on the basis of the forgoing critique that there is simply no future hope for any understanding of God's role in guiding and directing nature.

So, can we really continue to assert that God is active in the physical world? The answer to that question must remain yes, but we should also note that much of the traditional account of God's activity cannot hold up against our modern understanding of science. The fact is that any intellectually honest theologian must appreciate that the wide-ranging demands of faith are simply not satisfied by the current state of the art of theological scholarship. However this does not mean that we should simply give up and assert that there will never be any basis for claiming God's activity in the world. What theologians need to do is to work ever harder to press on with these seemingly intractable problems and in the process become more scientifically aware. For it is only through a detailed understanding of the claims made by science, the assumptions behind the laws of nature, and the philosophy of determinism, that theology will continue to progress into the twenty-first century.

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