The following are corrections and post-publication comments.

page vii. Preface

Many professional philosophers will hate this book, because it presents only one view of a wide range of problems that they have spent many years dissecting. As only one of many instances of this, one could mention my account of explanation and understanding in Section 2.1. Such problems arise in any book that attempts to summarize an entire field, but they are particularly stark in the case of philosophy, where extensive analysis tends to clarify problems but not to solve them. May I urge those who might find it easy to criticize this account to devote their energies to producing a better book that is still comprehensible to a general audience. They will find it hard, if only because they will have to abandon the specialized philosophical vocabulary that the subject has accumulated, for good internal reasons.

page 8. The need for faith in science

One sometimes reads statements that science is similar to religion in the sense that the former depends on a quasi-religious faith in the regularity of the natural world, without which it would be pointless to seek laws that govern it. This is fundamentally misconceived. There certainly are many scientists, particularly in physics, who have such beliefs, but scientists and science are not the same thing. Popper would rightly regard the existence of regularity as something that needs constant testing, not as a matter of faith. In the end, scientific laws are tested by different people, in different contexts and over long times.
periods of time. Many beautiful theories have been abandoned because they failed such tests – a possibility that would be entertained by few theologians. In the 1950s Fred Hoyle famously advocated that the universe was homogeneous in both space and time, but within twenty years the Big Bang theory was firmly established and physicists adjusted their expectations. At present physicists are constantly looking for evidence that the fundamental constants have not in fact had the same values throughout the lifetime of the universe, and many would be very excited to find such evidence. At a more practical level, the hope that computational advances would lead to ever more accurate weather forecasts had to be revised when it was discovered that weather systems can be chaotic, and therefore unpredictable in principle. We do not know where the search for regularity will lead, and do not need to have a prior commitment to the type of knowledge that will be possible.

page 14/15. Criticisms of Copernicus by Riccioli
In 1651 the Jesuit astronomer Giovanni Riccioli published a systematic scientific criticism of the Copernican theory, with the title ‘Almagestum Novum’. Parts of this were translated into English in 2010 by C M Graney. Riccioli showed that there were substantial problems with the Copernican world-view, in particular with its apparent implication that the stars must all be vastly bigger than the sun. The point was that the failure to observe any parallax in the positions of the fixed stars implied a very large lower bound on their distances. The further fact that the stars appeared to have discs with measurable angular diameters then led by routine calculations to the conclusion that their actual diameters must be huge. This problem was eventually resolved by the demonstration that the apparent discs of the stars were artifacts resulting from the optics of the telescope used. This underscores my comments on pages 14 and 15 that the acceptance of Copernicus by 1660 was based on a general judgement that the inadequacies of the earlier theory outweighed those of the new theory rather than on pure logic.

page 20. God as law-giver

Discussions relating law, philosophy and religion are sometimes confused because the word ‘law’ can refer both to a codification of ethical or other societal norms and to discussions about the nature of the universe.

The belief that the world could be understood mathematically, and in particular by means of geometry, was developed by the Greeks, long before the advent of Christianity. The idea that knowledge of the world can be attained by reasoning from one’s perceptions, and that the universe itself was governed
by reason, were central tenets of Stoicism in the third century BC. This was a well-established philosophy that had a major influence before and during the Roman Empire until it was suppressed by the Emperor Justinian I in the sixth century as incompatible with Christianity. In fact they have several common aspects philosophically.

On the legal side it should be noted that the Babylonian Code of Hammurabi (c. 1700BC) predates the Old Testament. Even older legal codes are known to have existed. To take a particular case, the doctrine of ‘an eye for an eye’ appears three times in the Old Testament, but it had already appeared in the Code of Hammurabi. The contrary doctrine about loving your enemies was emphasized by Jesus and Paul, but it had already been formulated by the Stoics and was a part of Buddhist and Hindu doctrine.

### page 20. Cultural impacts of printing

The advent of the printing press had many consequences. The cost of producing individual books dropped dramatically and the total number of books being published increased correspondingly. The literacy rate increased and the possibility of ordinary people reading the Bible for themselves made them less dependent on the priesthood to interpret its significance for them. Printers and others quickly realized the existence of a large market for occult material. One should also mention that the many editions of Malleus Maleficarum that appeared after its publication in 1486 were certainly influential in encouraging the persecution of witches. The public exposure of these ideas would eventually allow them to be discredited, but this process is still incomplete in many parts of the world.

More positive consequences of printing were the standardization and preservation of knowledge. When scribes copied books, they made occasional errors, which were then copied by their successors, who introduced further errors. Sometimes they added comments of their own. Nobody knew what these changes were, so over hundreds of years the content of a book slowly drifted away from that of the original. With the advent of printing thousands of people, often in different countries, could know that they were all reading the same text, and errors in one edition could be collected and removed from later editions. In addition the fate of printed texts was not tied to the preservation of individual copies; catastrophic events such as fires and even wars lost their capacity for destroying knowledge.

Many of the early printed works were of classical texts, starting with the Bible.

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The voyages of discovery in the fifteenth and sixteenth century were among many developments that proved the necessity of going beyond what had previously been known. Two of the pioneers in this respect were Mercator and Ortelius, who started the production of printed world and regional maps from about 1570. These improved on the maps in Ptolemy’s ‘Geographia’ in several ways. The new maps contained representations of parts of the world that Ptolemy knew nothing about. The copies of maps produced by scribes had been even less faithful than was the case for text, and over several generations the quality deteriorated markedly. Maps printed from an engraving were all the same as each other, so users could send comments to the printer and the maps could be corrected or augmented in later editions. Many of the new maps contained major errors, but they started an incremental process that led to the extremely reliable and detailed maps that we now take for granted. The first steps were important not only for their own sake, but for the self-reliance that they encouraged in the growing community of scholars. Early in the seventeenth century Francis Bacon advocated the steady accumulation of knowledge via observations (or experiments) as the basis of a new scientific method. The ideas in his ‘Novum Organum’ had considerable influence in the early years of the Royal Society.

Similar developments in botany happened a few decades earlier. This subject had suffered in the same way as map-making from the serious degradation of images produced by successive generations of copyists. In 1544, the Italian physician Matteoli published a commentary on Dioscorides’ classical treatise on herbal remedies. Several later editions were corrected and expanded following feedback from readers. The books were illustrated with many woodcut drawings and were sold very widely. They formed the basis of a systematic body of public knowledge in botany over succeeding centuries.

The advent of printing tipped the balance between secrecy and openness with regard to technical and scientific knowledge, although this took more than two centuries to be worked out in full. In late medieval times the guilds had encouraged secrecy as the only way of protecting their status in the absence of a developed system of copyright and patents. Since scribes produced single copies of books at the request of wealthy patrons, they tended not to be known beyond a small circle and to be categorized along with artisans. Printing allowed some individuals to establish personal reputations by publishing a variety of technical manuals. As well as obtaining immediate profits from the sales, we have seen that they were sometimes able to place themselves at the centre of small industries producing a series of further volumes on the same subjects. In other cases they used their reputations to promote related business interests or to obtain prestigious appointments with wealthy patrons. The growth of open

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publication was very beneficial to science, but it owed as much to self-interest as it did to altruism. Of course, this remains true today.

page 20. Political impacts of printing

My account overemphasizes the reaction of the Catholic Church to the advent of printing. The following expands on what I wrote in the book.

Around 1520 Martin Luther’s ideas were propagated by a series of pamphlets that were quickly reprinted throughout Germany and in many other European cities. The inability of the established authorities to stop this process caused them consternation. The pamphlets enabled his protests to gain publicity and support far more rapidly than he could have otherwise. Five years after he is said to have nailed his 95 theses onto the door of Wittenberg Church, Luther had published the first German vernacular translation of the New Testament, and the German revolution against the corrupt authoritarianism of the Catholic Church was irreversible. Luther was well aware of the important role that the existence of printing presses played in the dissemination of his revolutionary ideas, as were contemporary commentators.

William Tyndale’s publication of his English translation of the New Testament in 1525-26 was regarded as so dangerous that he had to smuggle it into England from a variety of European cities before his eventual capture and execution. However, after the break with Rome, Henry VIII and then his successors approved, explicitly or tacitly, the publication of a series of English Bibles, culminating in the King’s James Authorized Bible in 1611.

The impact of the printing press and its threat to the established order cannot be overemphasized. By the second half of the sixteenth century many European countries were restricting the freedom to print material without permission. Unfortunately for them, the restrictions could often be evaded by smuggling copies produced on presses in places where attitudes were less restrictive. In England the Licensing Act of 1662 aimed to prevent the printing of ‘seditious, treasonable and unlicensed books and pamphlets’ and was enforced for some decades with substantial fines or even imprisonment. Attitudes did not weaken until late in the seventeenth century, and most censorship ceased in England after the Statute of Anne in 1710.

page 20. Another Perspective on the Scientific Revolution

The Scientific Revolution was merely a part of a much more fundamental cul-
tural, political and commercial revolution that took place in Europe during the sixteenth and seventeenth century. As this period progressed, intellectual and commercial activity benefited from the fragmented nature of Europe, which was composed of a large number of quasi-autonomous states. These promoted individualism at a cultural level, as well as financial support for the many merchant venturers. They prevented any single body from stifling dissent, particularly after the introduction of printing. The end of the Thirty Years War in 1648 marked the start of a new era, in which the power of the Catholic Church was seriously diminished.

If it is difficult to explain why the Scientific Revolution happened in Europe, explaining why it did not happen in China is just as hard. The country is so vast that it is hard to avoid crude generalizations when making the attempt. One might point to the fact that the organization of society became increasingly centralized and bureaucratic during the sixteenth century; success in the formalized civil service examinations was the natural route into the ruling elite for those who could afford the education. When a massive Chinese fleet led by Zheng He made seven voyages going as far as Africa between 1405 and 1433, these were intended to enhance the status of China and of the Emperor Zhu Di, who had ordered the expeditions, more than to explore or colonize foreign lands. They stopped abruptly after the death of the Emperor and a few years later of Zheng He. Subsequently foreign trade was based on the export of silk, porcelain and, later, tea from a very small number of ports in foreign-owned ships. During the seventeenth century the Ming Emperors and their courts were increasingly preoccupied with famines, natural disasters and internal rebellions, which culminated in the collapse of the dynasty in the middle of the century. Although the Manchurian Ch’ing dynasty Emperors were much more vigorous, their main priority was to establish and maintain control over a vast country. The empire developed a cash-based, market economy, but it was very hierarchical and reinstated the civil service examinations of the Ming dynasty. All the above developments discouraged those with the intellectual capacity from taking an interest in the growing Scientific Revolution in Europe, which they regarded as an inferior civilization.

In England the claims of Charles I to ‘the divine right of kings’ led to a civil war and eventually to his execution in 1649. The Puritanism of the subsequent Commonwealth, led by Oliver Cromwell, did not appeal to the English either, and the Parliament agreed after his death to restore the monarchy under Charles II in 1660. A patron of the arts and sciences, Charles re-opened the theatres, gave the Royal Society its Charter and encouraged a more relaxed, even libertine, social atmosphere. He supported the Anglican Church and the rights of Parliament, but tried, with very limited success, to promote religious toleration; his own Catholic leanings no doubt influenced his attitudes on this
matter. Quakers, in particular, suffered substantial persecution between the middle of the seventeenth century and the passing of the Toleration Act of 1689. This Act did not, however, benefit Catholics. Nevertheless, dissent did not evaporate and the following decades saw a steadily growing belief in people’s right to express their views in public. After the Restoration, coffee houses became the centres of debates about a wide range of religious and political issues. The first of these was opened in Oxford around 1650 and they rapidly became popular in London. We are very fortunate that Samuel Pepys kept a daily dairy throughout the 1660s. The diary gives a vivid picture of life in London during that period for a fairly wealthy government official who had many high level connections. Pepys was among the many people of all persuasions who went to the coffee houses to hear the latest local and foreign news, to engage in discussions and to read the many pamphlets and newspapers that were available there. The coffee houses spread far beyond London during the 1660s. Eventually the Anglican Royalist faction, who had long believed that they were a threat to the stability of the kingdom, were able to get the Government to issue a proclamation suppressing them in December 1675. The public outrage at this action was so great that the proclamation had to be withdrawn almost immediately. This was by no means the end of a complex tale of political and religious conflict, but the century ended with a constitutional monarchy in place and the idea of a public sphere of free discourse deeply embedded in English culture.

page 22. Paper

The manufacture of paper was important for the Scientific Revolution because of its use in printing. It provides another example of the West’s reliance on inventions emanating from China many centuries earlier. Early media for writing/accounting included clay tablets (the ancient Near East), papyrus (Egypt) and parchment, the stretched and treated skins of animals. Paper first appeared in China in the second century BC. It was used for many things other than writing, for example clothing, wallpaper, toilet paper and even armour. The technology for making paper only reached Europe, via Asia, in the twelfth century. Prior to the invention of the printing press woodblock prints of religious and other images, including playing cards, were produced in some quantity because they could be appreciated by everyone.

page 22. Glass technology.

The history of glass manufacture is fascinating. This developed rapidly after
50BC with the invention of glass-blowing, possibly in Roman Phoenicia. Some of the earliest Roman glass vessels, produced in the decades following this, are of exceptional artistic quality. A wide variety of decorative glass was manufactured over the next few centuries throughout the Eastern Mediterranean, while glass lamps with elaborate Arabic inscriptions were produced early in the Islamic world. They were usually translucent or highly coloured and opaque, but did not have the transparency needed for optical instruments. Chinese T’ang porcelain used glass glazes, but the technique of glass blowing percolated to China from the Mediterranean area very slowly.

The main barrier facing the manufacture of optical glass was the difficulty of controlling the very high temperatures needed in the furnaces. Glass magnifying lenses were mentioned by Roger Bacon in 1268, but rock crystal (i.e. naturally occurring quartz) lenses were made much earlier. The Neo-Assyrian Nimrud lens dates from around 750 BC according to the British Museum, but several even older examples have been found in Crete and elsewhere. The Visby (Viking) lenses dating from the 11th century are of extremely high optical quality. The use to which these rock crystal lenses were put is not known, but it is difficult to understand why the Visby lenses would have been manufactured to such high optical tolerances if they were not intended for use as magnifying glasses, possibly for the manufacture of their extremely intricate jewellery. The invention of spectacles is often attributed to Alessandro di Spina of Florence around 1280, but they may have been used elsewhere before that. It should be mentioned that optics was studied by the Islamic scientist Alhazen, also called Ibn al-Haytham (965 – c. 1040). Several of his treatises, including his ‘Book of Optics’, were very influential in the West.

Glass technology improved throughout the second millennium, but The Hall of Mirrors at Versailles provides ample evidence that large mirrors were still very high status objects at the end of the seventeenth century. At that time the Republic of Venice had a monopoly on the technology needed for its manufacture. The mass production of high quality glass had to wait until the nineteenth century, and a large expanse of glass is now a key design feature of most high status corporate and public buildings.

**Page 44. Dummett and pluralism**

On page 44 of WBM I wrote that

> Pluralism, as defended in this book, does not imply anything about how the world is in itself. Rather it is the claim that we, as human beings, need multiple, context-dependent, viewpoints in order to understand the world as best we can.
Michael Dummett, recently deceased, drew similar conclusions to those in the second sentence of this quotation in his book ‘Truth and Reality’, which is couched in the forbidding language of a philosopher committed to linguistic analysis as the foundation of philosophy.

For our knowledge of our world has layers, too; some descriptions of it, though of course framed in concepts that we grasp, owe less to our uninstructed experience than do others. Does ‘our world’ contain sounds, or does it contain only sound waves? Colours or only light of different wave-lengths? We express propositions by means of words whose senses are given to greater or lesser extent by reference to our perceptual experience; these sentences determine the criteria whereby the various propositions are judged to be true or not true. When these criteria are satisfied, we rightly judge them to be true; but we cannot harmonize our judgements. Descriptions employing concepts given in very different ways appear to compete: they describe the same occurrences; but the descriptions stand at different levels. We are tempted to treat some of these descriptions as saying how thing really are; but the temptation must be resisted.

My quoting Dummett favourably does not imply that I agree with the conclusions that he draws from this passage. Dummett argues that all finite beings have limits to their differing conceptions of the world based on their physical natures, sense organs and conceptual capacities; he also believes that the world as it is in itself must make sense, and the only being to whom it could make sense as a whole is God. The present author does not find the second part of this argument compelling: the world could exist while not being fully comprehensible. Dummett rejects this because it would leave ‘a jumble of different worlds, our own and those of other creatures, which cannot be coherently related to each other’. This is too strong: it would leave a jumble of different descriptions of the world which might overlap to some extent, and the degree of overlap might increase as time passes. But that is already true of our own, human, attempts to understand the world, without invoking other creatures.

Dummett writes that it makes no sense to speak of the world unless it is ‘apprehended by some mind, yet not in any particular way or from any one perspective’. His deduction of the necessary existence of God is reminiscent of arguments of Thomas Aquinas in Summa Theologica. Even if one were to accept Dummett’s argument it would have the same weakness as the cosmological design argument for the existence of God. Namely the all-encompassing

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3The quotations in this section are taken from pages 100-102 of Michael Dummett, Truth and Reality, Oxford Univ. Press, 2006, which is a modified version of his 1996 Gifford Lectures.
God called into being by such arguments need not have any relationship with any particular religion (Catholicism in Dummett’s case), nor any aspect that one might call intrinsic goodness, nor even any interest in the human species.

**page 46. Calculation versus explanation.**

The following example of Gregor Nickel provides a neat example of the difference between mechanical calculation and explanation, in spite of its extremely limited nature. If one uses a pocket calculator one finds that

\[
1111 \times 1111 = 1234321
\]

but this does not explain the form of the coefficients of the product; the result might be a mere coincidence, and on its own does not help one to evaluate the product when the string of four ones is replaced by a longer string. On the other hand the pattern of the long multiplication

\[
\begin{array}{cccc}
1 & 1 & 1 & 1 \\
\times & 1 & 1 & 1 \\
\hline
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
\hline
1 & 2 & 3 & 4 & 3 & 2 & 1
\end{array}
\]

provides the required explanation and enables one to predict that

\[
111111111 \times 111111111 = 12345678987654321
\]

without doing the calculation. This is commonplace with calculations carried out by highly sophisticated computer programs. They may provide predictions that are verified to high accuracy, but if one changes the parameters slightly the whole calculation has to be repeated.

**page 47. Understanding versus explanation.**

Philosophical discussions of explanation and understanding often get bogged down in issues relating to truth and false beliefs. My own starts from definitions of the two terms. If one follows this approach, one must be very careful to use the words in accordance with the definitions, rather than with all the associations that they carry in different contexts. In the book I provided numerous examples to show that my use of the word ‘explanation’ is reasonable.
Even if this is not accepted, it is surely the case that if one considers that the
use of the word is only permissible if it accords with some ontological truth,
one is setting the bar for a successful analysis at an unrealistically high level.
Once one has succumbed to the temptation of defining the meaning of a few
words, it is hard to stop. Explanation and understanding lead inexorably to
belief, knowledge and then truth. One then finds oneself trying to distinguish
between different meanings of each word and whether they should be under-
stood as primarily individual, social or absolute. One even has to ask whether
the subtle gradations between near-synonyms can be analyzed in logic terms,
as a philosopher would like, or whether they may often be a matter of custom.
It is best not to pursue this line of thought, because it has no end.
There is a strong temptation to distinguish between false explanations, such
as those of alchemy, which are often considered not to be explanations at all,
and those that are true, such as those of quantum chemistry. There are good
reasons for resisting this. Newtonian physics was regarded as fundamentally
true throughout the nineteenth century but now it is seen to be an approxi-
mation to general relativity and quantum theory. Each of these three theories
makes totally different ontological claims. Their unification may or may not
involve string theory, but one can predict that it will initiate yet another major
ontological shift, even if its mathematical content contains that of the earlier
theories in some limiting sense.

page 52. The Arrow of time.

The following could be inserted after the second paragraph.

There are several mathematically rigorous models that appear to exhibit an
arrow of time in spite of the fact that the underlying physical laws are invariant
under reversal of the direction of the time variable. One starts by assuming
that the model is in a very special state at time zero and calculates its state,
or possibly the state of some part of it that is of particular interest, at a later
time by using the equations that define the model. In some cases one finds
that there is a new equation that is compatible with the calculated states and
that this equation is not invariant under time reversal. Time has apparently
acquired a direction for no apparent reason!

There are several comments to be made here. If one calculates the state at
negative times one would find exactly the same phenomenon. The arrow of
time is in fact away from that of the special state at time zero for positive
times and negative times. Secondly one has to explain why one chooses to
assign the special state at time zero an important status. It might well be
simple and attractive, but that is almost the same thing as saying that it is
highly untypical of the states that that the system could be in. Is it legitimate to ask why the universe can described rather well by a solution of Einstein’s equations that has a singularity at a particular time, which we call the past? Or should scientists content themselves with describing what the universe is like, as they always used to?

Finally there is the phenomenon of Poincaré recurrences. In some of these models, if one waits an unimaginably long time, the state eventually returns to its original state, or something very close to it. Once again the special apparently irreversible behaviour is no more than the comment that if one is close to a very special state, either before or after its occurrence, that special state allows one to assign a direction to time, namely the direction away from the time at which the special state occurs. If one is half way between two occurrences of the special state, this is no possible.

page 55. Emergence and reality

If one vigorously shakes a closed glass bottle containing a small amount of soapy water, the result is a bottle filled with a foam of soap bubbles. Since there is nothing in the soap or water molecules that refers directly to foams, one might say that they are an emergent phenomenon. Such a foam is stable over a period of a few minutes, but eventually it collapses back into a soapy liquid at the bottom of the bottle. We are only aware of the phenomenon because the time scale for the collapse is long enough. If one looks in detail at the foam, it becomes obvious that every repetition of the experiment produces a foam with an entirely different pattern of bubbles. The foam only exists by virtue of our ignoring these differences and identifying certain common features that they possess. We need to do this because we are not able to keep in mind the details of each foam, although we can remember the generalities.

The question to be asked here is whether foams exist in themselves. Against this proposition one could argue that we use the word to express a notion that we have constructed by abstracting certain common features of a series of events that have no permanence. The abstractions are necessary because our minds have certain capacities and limitations. If our memories were far better and our eyesight much sharper, we might identify each foam as an individual. This what we usually do for people, but almost never do for ants.

One cannot decide whether emergent entities such as foams should be regarded as ‘real’ without distinguishing between the ontological and epistemological interpretations of the word. Plato posed the ontological question in his parable of the cave. His conclusion, that the material world is an imperfect copy of an ideal world and for that reason not worthy of serious study, is no longer
acceptable. Kant cast serious doubt on our ability to appreciate the world in itself, and argued that one has to be content with knowledge of the world as mediated by our a priori capacities.

The epistemological question is easier to address. We refer to something as real if it is impossible to discuss some aspect of our experiences without using the relevant term. This should be fleshed out with some examples. Nineteenth century chemists were justified in doubting the reality of atoms because they considered the supporting evidence inadequate. While it is still logically possible to take such an attitude, it cuts one off from a vast range of science that has led to much of what characterizes modern civilization. The reality of God is questionable because a substantial minority of educated people find it possible to live their lives without the concept. Our experience of the colour green is real in spite of the fact that we only see it because of the particular formation of our visual systems. The scientific study of light and neurology has enriched our understanding of colour vision but does not invalidate it. Human intentions and goals are real, in spite of the fact that physics has no use for the concepts, because we could not organize our lives, or even conduct most conversations, without them.

Of course, it is possible to argue that God is real even if some people are not aware of him. It is equally possible to argue that he is not real even though millions of people do believe in him. The same applies to beliefs about whether the world was flat at various times in the past. These disputes cannot be settled by logic, but one can describe the consensus at any time and the evidence in support of it. We can, and should, alter our beliefs about the nature of the real world in the light of evidence. But we cannot move beyond the need to have beliefs, which may always be wrong even if they conform well to some aspect of the observed world.

page 65. Conway and Kochen on free will

In 2009 John Conway and Simon Kochen wrote a paper entitled ‘The Strong Free Will Theorem’, in which they stated

Some readers may object to our use of the term ‘free will’ to describe the indeterminism of particle responses. Our provocative ascription of free will to elementary particles is deliberate, since our theorem asserts that if experimenters have a certain freedom, then particles have exactly the same kind of freedom. Indeed, it is natural to suppose that this latter freedom is the ultimate explanation of our
With such eminent authors, it hardly needs stating that the theorem proved in the paper is completely rigorous, but it need not refer to freedom or free will. What they actually proved could equally well be summarized in the following way, which, admittedly, does not compel one’s attention so much.

If a certain type of measurement on spin 1 particles repeatedly produces results that are not consistent with the quantities concerned existing before the measurements are made, then the behaviour of the particles cannot be governed by deterministic laws.

To those who fully accept the paradoxical nature of quantum theory this comes as no surprise, but it provides another nail in the coffin of those who still yearn for some hidden variable explanation of quantum effects. It would be interesting to know the authors views about connections between their theorem and the currently fashionable multiple parallel universe accounts of quantum theory. The word deterministic should not be interpreted as the opposite of random; indeed the authors emphasize that randomness plays no role in their proof. Events are said to be deterministic in character if (and only if) there exists a function that can predict them from other events that happened earlier, in the sense of Einstein’s theory of relativity.

The authors state the theorem in terms of the experimenter’s free choice of measurements to be made, and interpret the result in terms of the similar freedom of the spin 1 particles. The notion of ‘free will’ is very hard to pin down; if it means, as the authors seem to assume, the capacity to make choices for which there is no subjective or objective reason or explanation, this is not obviously something to be valued. When people make choices, ‘free’ or otherwise, they are never aware of the extremely complicated processes going on in their brains. The explanations of these processes might involve chaotic classical laws or the theory of emergent phenomena, rather than quantum mechanics. Dressing a mathematical theorem up in the language of free will is inviting it to be quoted by people who have a non-scientific agenda and who may interpret free will in a way that the authors are less than happy about.

page 68. Kantianism

References to Kantianism and neo-Kantianism can be very confusing, because they refer to such a wide range of different beliefs. In this book I refer to Kant to

suggest that one should focus more on epistemology (what we can know) than on ontology (what may ultimately be the case). In addition I follow Slingerland and others in emphasizing that human beings have inborn cognitive abilities and limitations and that our way of looking at reality depends on these to a much greater extent than we normally realize. Our cognitive structures are heavily influenced by our possession of reasonably good vision, but Kant was wrong to think that they forced us to accept the specifics of Euclidean geometry.

**page 70. On human behaviour**

If it is accepted that human consciousness evolved and that it is a function of the particular type of brain that we have, then there need be no difficulty in accepting that our mental capacities and limitations depend on the course of that evolution. We do not have any real understanding of human consciousness, but many scientists have no doubt that this is a matter of unraveling the brain mechanisms involved.

On the other hand some religious people believe that human consciousness is linked to our immaterial souls and not amenable to any scientific analysis. Roger Penrose does not accept such religious arguments, but still believes that computer programs cannot exhibit genuine understanding. Unlike ourselves (he claims) their internal construction is algorithmic and therefore must be subject to the provable limits on all Turing machines. He has supported the idea of Stuart Hameroff that our ability to transcend such limitations is due due to quantum gravity effects in the microtubules inside our brains. Almost every aspect of this idea has been criticised by others and after twenty years no scientific evidence in support of it has been forthcoming. Nor is it as obvious as he thinks that we can transcend the limitations of Turing machines.

The idea that, if one accepted the theory of evolution, human behaviour might be the next subject to come under scrutiny was was clear to Darwin and to his opponents, who considered that this was not acceptable for beings who, unlike animals, were created in God’s image. Progress in developing the idea was slow. Margaret Mead became famous for her study of the people of Samoa, and her conclusion that adolescent discontent and sexual repression during were products of Western culture; this fitted the blank slate theory. However, a later study by Derek Freeman argued that she had been misled by the people she was studying; they quickly understood what she was interested in finding and obligingly made up stories that fitted. The arguments between anthropologists about this issue have been ferocious, to the extent that it is hard for an outsider to come to any conclusions. Desmond Morris came to fame in 1967 with his book ‘The Naked Ape’, which compared and contrasted human behaviour...
with that of other animals; this was regarded as shocking at the time, although it would not raise many eyebrows today. Jane Goodall has had greater influence, because her lifetime study of chimpanzees in Tanzania was recorded in so much detail that it set new standards in the field. She discovered similarities between human and chimpanzee societies that were undeniable and, in particular, completely demolished that idea that we were uniquely aggressive towards other members of our own species. There was initially a lot of opposition to her ideas, because the scientific consensus at that time did not permit the idea that individual animals could have personalities, distinctive long term behaviour patterns that affected their status in their groups.

page 71. Musical ability

One might also mention that humans have a unique capacity to generate complex musical pieces, and that many children with learning difficulties respond very positively to musical stimulation. Recent research involving fMRI shows that there are profound connections between the development of language and the appreciate of melodies; see Diana Deutsch, Scientific American, Mind, July/August, 2010.

page 71. The dangers of polarization

The conflict between the supporters of the blank slate theory and those favouring reductionist approaches to brain function is a typical example of the human tendency to polarize issues. The reductive method works well in logic, mathematics and physics, but it is much less appropriate when dealing with human social interactions. The human brain is obviously a biological entity with capacities and limits that can be probed scientifically. Equally obviously the huge variety of cultures that have existed, and still do, cannot each be explained in evolutionary terms. All scientists can hope for is to understand why a variety of cultures is possible for us, but not for other animals. Both approaches to our mental capacities have value, and which one prefers must depend on what aspect of human behaviour one finds most interesting. In the next section I will discuss Popper’s ‘Three Worlds’ theory, which fully recognizes the reality and importance of the cultural side of human activity.

page 72. Traditional labels in philosophy

Philosophers love to classify beliefs according to names that usually end in ‘ism’. In the book I have tried to avoid this, in the hope that it would thus
be more digestible to a general audience. The beliefs discussed in this section revolve around the existence of abstract entities. One cannot decide whether one believes this or not until one has settled on the meaning of the term ‘abstract entities’.

One may interpret the term to mean a non-spatiotemporal entity that does not operate causally on the natural world, and whose existence does not depend in any way on the existence of human beings. In this case Platonists (also called realists or idealists) believe in the existence of abstract entities while fictionalists do not; there are also nominalists, conceptualists and other categories and subcategories. Some of these distinguish between abstract entities and universals such as methane. David Corfield is very critical of this type of analysis, regarding it as a manifestation of many philosophers’ obsession with ontology to the exclusion of other considerations, such as the historical context. See his book Towards a Philosophy of Real Mathematics, Camb. Univ. Press, 2003. Anyone who wishes to penetrate more deeply into this subject could do worse than consult the online Stanford Encyclopedia of Philosophy.

One may also regard abstract entities as emanations or constructs of our minds. Popper regards abstract entities as real and as creations of society, rather than being purely mental and individual. He assumes that they are capable of being communicated, even if this has not yet happened, and that they may change, or develop, as time passes. From this point of view the difficulty in accommodating all abstract entities into a single theory is a particular case of the difficulty of analyzing natural language, generally agreed to be a human construct embedded in time.

page 76. The disembodied mind?

When Descartes wrote his famous sentence ‘cogito ergo sum’, he was encouraging the view that the rational mind could be disengaged from the body and the world in which it resides. Both are radically false. Anyone who has known someone suffering from hyperthyroidism is well aware that proper mental functioning is vitally dependent on the state of the endocrine system. At the other end of the scale, many of our most valued attributes are direct gifts of our cultural backgrounds. Even revolutionary breakthroughs happen in a social context, and have no impact unless they are fed back into society. The deepest insights of figures such as Euclid, Descartes, Newton, Kant and Kuhn have needed substantial revisions under the tireless examination of later generations of scholars. The physical, mental and social are so deeply entangled that one cannot understand the progress of science without taking all three

\[5^\text{many other illnesses could be named}\]
into account. This is what Popper encapsulates in his three worlds theory.

page 76. World 3 entities

Popper emphasized the differences between World 3 and the Platonic world. The first is dependent on human civilization for its existence and the entities in it have some degree of location in time. They could not have existed a million years ago and may not at some time in the future. Moreover they may change or develop as time passes. The situation in terms of their location in space is more complicated. Some, such as the law or a well known mathematical theorem, are spread over much of our planet. Newton’s laws of motion have been approximately valid throughout the history of the universe, but in spite of that they remain our description of observed regularities, and even we do not think that their form reflects the processes that make them good approximations. In other cases, such as individual works of art, the World 1 aspect is a material object, but the World 3 aspect, the significance of the object, is spread over all those who have been affected by it.

The difference between World 1 and World 3 objects may be illustrated by an example in Michael Jubien’s book ‘Possibility’ (OUP, 2009), where Popper is not mentioned. A statue made from unfired clay is a World 1 object as a lump of clay but a World 3 object as a statue. If one squeezes the statue into a ball-shaped lump, it is modified as a World 1 object but totally annihilated as a World 3 object, because its cultural significance is lost. Both methods of referring to it are equally valid, and which is used must depend on the context.

page 76. Moral obligations

I was stimulated to write this by reading the booklet by L. N. Trefethen, Trefethen’s Index Cards, Forty years of notes about People, Words and Mathematics, World Scientific, 2011.

A materialist might claim that moral obligations do not exist, because they cannot be described in terms of particles and fields, even indirectly. In spite of this, some scientists believe that such things may one day be explicable as emergent phenomena. At the other extreme, a religious person would describe them as social consequences of our knowledge of good and evil, which emanates from God. An evolutionist might consider that they are consequences of our being cooperative, social animals that possess sophisticated languages. Although he rejected evolutionary theory for most of his life, Popper would have classified them as social constructs, inhabiting his World 3. Moral philosophers do not anguish about existence, and distinguish between moral obligations that
we acquire passively as members of society and those that arise explicitly as the result of speech acts, such as marriage vows. Moral obligations can be investigated in detail by means of interviews, surveys and fictitious examples. This is hardly compatible with their non-existence!

page 77. The status of Popper’s three worlds.

Although it would be bizarre to deny the reality of cultural entities or subjective psychological states, this does not force one to regard Popper’s three Worlds as equally real. Popper might have believed this, but it is equally plausible to regard the allocation of all existing entities to one of three categories as conventional, and perhaps more useful in some cases than others. It seems reasonable to allocate ‘natural kinds’ (a philosophical term whose scope and even validity is much discussed) such as water, gold, electrons, stars and even electromagnetic fields to World 1. However, the situation with respect to biological species is much more murky. Before the Darwinian revolution each species was indeed considered to be a natural kind, immutable and created by God, but now we see that the boundaries between species are sometimes obscure even at a fixed time and that they become meaningless when viewed over periods of many millions of years. The fact that a single object might be considered as lying in two different Worlds, depending on one’s frame of mind, again suggests that the division between the Worlds is conventional. More whimsically one should suspect any theory that involves assigning the number three a fundamental role in the nature of reality.

page 79. Mathematical idealism

In his book ‘Thinking about Mathematics’ Stewart Shapiro describes some of the many different philosophical attitudes towards mathematics. The closest that he gets to Popper’s World 3 (there is no reference to Popper in the index) is in Chapter 2, where he describes idealism as the belief that mathematical objects exist, but that they depend on the human mind. This ignores the social aspect of the subject, which has only grown because of the communications between, and critical analysis by, a community of mathematicians over more than two thousand years. If one wishes to use this word, idealism does not imply that mathematics is a part of the mental fabric shared by all human beings. It can just as easily be interpreted as implying that the current body of mathematics is a part of the social environment appreciated by some human beings who have relevant mental capacities. One might say the same about most other products of our culture, such as Western orchestral music. Shapiro
states that

[idealists need to square their] picture of mathematical objects and mathematical knowledge with the full realm of mathematics as practised. There are infinitely many natural numbers, and even more real numbers than natural numbers. The idealist must square our knowledge of natural and real numbers with the apparent finitude of the mind.

The uncompromising, and question-begging, ‘There are infinitely many’ tries to force a Platonic view of infinite objects on the reader; an idealist would say that we have a limited and fallible concept of infinity which can lead to unintuitive consequences in spite of being very useful in many situations. The problem described in the final sentence is no worse for idealists than it is for realists. The former have a vague understanding of the concept of infinity that becomes clearer as the result of collective efforts to eliminate inconsistencies; the latter believe that their vague but finite understanding relates to an external entity in a manner that they cannot explain but nevertheless call knowledge.

page 79. Bishop’s philosophy of mathematics

I mentioned Errett Bishop in passing on pages 87 and 143 of WBM. His 1967 book ‘Foundations of Constructivist Mathematics’ was not written in philosophical language and was directed at mathematicians. He hoped to convert them to his cause, but largely failed, in spite of his proposed scheme being much closer to conventional mathematics than Brouwer’s intuitionism, and even, from one point of view, a part of conventional mathematics.

It is possible to explain the issues involved without going deeply into formal logic. The statement ‘all kangaroos have tails’ may be written formally as

$$\forall x. x \in K \rightarrow P(x)$$

This formula is unpacked as follows.

<table>
<thead>
<tr>
<th>formula</th>
<th>translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\forall x$</td>
<td>for all $x$</td>
</tr>
<tr>
<td>$x \in K$</td>
<td>$x$ lies in the set $K$ of all kangaroos</td>
</tr>
<tr>
<td>$\Rightarrow$</td>
<td>implies</td>
</tr>
<tr>
<td>$P(x)$</td>
<td>the proposition that $x$ has a tail is valid.</td>
</tr>
</tbody>
</table>

In standard mathematics $\exists x. P(x)$ is interpreted as ‘there exists $x$ such that $P(x)$’, but it can be formally defined, subject to the law of the excluded middle, as a short-hand for $\sim(\forall x. \sim P(x))$, where $\sim$ means ‘not’. 20
Bishop’s scheme involves abandoning \( \exists \) and using instead a more restrictive condition, \( \exists_c \), and one might call constructive existence. Following Bishop, one is only allowed to write \( \exists_c x. P(x) \) if one knows a procedure for constructing an \( x \) with the property \( P(x) \). The statement \( \exists_c x. P(x) \) implies that \( \exists x. P(x) \), but the two notions are not equivalent.

It is at this point that philosophy intrudes. Bishop considered that a statement using \( \exists \) is vacuous in the sense that it provides no information that human beings can use. Another point of view is that any statement involving \( \forall \) and \( \exists \) remains true if one deletes the subscript, so the new scheme simply forces one to work harder to obtain the same result. An intermediate position is to agree that many, if not all, mathematicians benefit from knowing whether the entities that they study are algorithmically accessible, and using Bishop’s scheme forces one to pay attention to such issues.

The rejection of Bishop’s scheme was often tied to the belief that he was trying to force people to reject the law of the excluded middle, which mathematicians were not willing to do. However, at a formal level his scheme does not reject it, but simply does not use it. It is astonishing how much of standard mathematics Bishop managed to recover, sometimes with minor modifications, without referring to the law of the excluded middle, contrary to the general view that almost nothing worthwhile could survive without it.

A Platonist criticism of the scheme is that it confuses existence and knowledge of existence; existence is timeless, but knowledge of existence changes with time. This is, of course, accepted by anyone who regards mathematics as a human pursuit that can be described using the language of Popper’s World 3. A related problem arises in quantum theory, where the dominant position is that we can only talk meaningfully about our knowledge, and that the nature of the atomic level world in itself is beyond comprehension in classical terms. Roger Penrose, on the other hand, is convinced that there must be something deeply wrong with quantum theory, because it does not conform to his Platonist standards.

page 80. Frege’s three world theory

At the top of page 80 I suggested that Penrose had modified Popper’s three world theory, but it is much more likely that he was following the logician Gottlob Frege, who introduced this terminology in 1918. Frege’s third world is similar to the Platonic world of Penrose, although Frege did not refer to Plato or mathematics at that time. It is fundamentally different from Popper’s World 3, although both were considered by the respective authors to be real, in different senses of that word.
Goodstein’s theorem is an example of a ‘true’ theorem about ordinary integers that cannot be proved using only the standard rules of Peano arithmetic. It asserts that if one starts from any natural number $n_1$ and applies a simple algorithm to generate $n_2$, $n_3$, $n_3$, etc., then the sequence will eventually terminate at 0. In practice the number of steps needed to terminate grows wildly as the starting point increases. The ‘proof’ that the sequence always terminates depends on the use of very large ordinal numbers.

From a constructive point of view one does not need to assert that the theorem is false, but only that no constructive proof of its truth has been produced, or can be produced. A constructivist could take the view that the (infinite) ordinal numbers involved in proving the theorem are symbols rather than real entities. A strict finitist could even take the view that the natural numbers involved in checking the theorem in a particular case might not be real entities either, because they could have more digits (base ten) than there are atoms in the universe.

Let $G(n)$ denote the number of steps that it takes for the Goodstein sequence starting at $n$ to terminate. It has been asserted that a Turing machine could be programmed to compute $G(n)$ successively for every $n$. This assumes that the Goodstein theorem is true, and bears little relationship with anything that an actual computer could do: Turing machines are not computers but abstract idealizations that are supposed to have unlimited memories and to be able to continue calculating for ever. Discussions about them are theoretical and at some point have limited significance.

The modernist transformation of mathematics

In retrospect I should have written a lot more about the process by which (pure) mathematics came to be disconnected from its applications to the physical world. This was far from straightforward, a modernist transformation in the words of Jeremy Gray, perhaps even a revolution, which unfolded so slowly that the main actors could not have realized where they were going. By 1930 Euclidean geometry, Newtonian mechanics and absolute time had all lost their status as necessary truths, as the results of mathematical and physical discoveries by Riemann, Einstein, Heisenberg, Schrödinger and many others. Calculus and complex numbers had been put on a firm footing, hyperbolic and

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Fortunately this is the subject of the impressive monograph ‘Jeremy Gray, Plato’s Ghost, Princeton University Press, 2008’.
other geometries had been discovered, and the axiomatic method had led to the development of a wealth of previously unsuspected new fields, such as group theory and formal logic. The remaining problems were to clarify the status of the natural numbers and of mathematical reasoning itself. Gray documents in detail the vigorous and often public disagreements about what might constitute progress on this subject, with many of the most eminent mathematicians clearly feeling that the issues were far from settled. Like a good crime novel, the denouement came suddenly, with the discoveries of Gödel early in the 1930s. His devastating contribution was to prove that the consistency of arithmetic, until then regarded as the most fundamental truth of all, could never be proved. Mathematicians might still believe that it was consistent, but that would be an act of faith.

In retrospect one can see that his work brought this phase in the history of mathematics to an end. Formal logic, which had been seen by many as the solution of the problems, gradually became an area of applied mathematics, of more interest to computer scientists than to most pure mathematicians. Curiously, mathematics itself was hardly affected by the foundational catastrophe. The subject continued to grow ever faster and achieved heights not dreamed of at the start of the twentieth century.

**page 97- Section 3.3. Manin on Platonism.**

The distinguished mathematician Yuri Manin has written about Platonism in the following terms in Notices Amer. Math. Soc. 56, no. 10 (2009) 1268-1274. The whole interview by Mikhail Gromov deserves to be read, but here is a quotation.

I am an emotional Platonist (not a rational one: there are no rational arguments in favor of Platonism). Somehow or other, for me mathematical research is a discovery, not an invention.

In Notices AMS 57, no. 2 (2010) 239-243 Manin further wrote the following.

I will call such an attitude *emotional Platonism* in order to stress that (in my view) it is intellectually indefensible, but not to the least degree invalidated by this fact, since our emotions happily resist rational arguments.

I do not agree that one can *happily* retain a belief that one knows to be rationally indefensible, although it is a matter of observation that many people do behave in this manner. At the very least one should feel some disquiet

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7Note, however, that Manin used the word ‘attitude’ not ‘belief’. 
about such a situation. Allowing one’s emotions or instincts to be the arbiters of one’s beliefs is commonplace, but that does not make it desirable. They can be changed if there is good reason to do so.

The following anecdote conveys a little of the emotional appeal of Platonism. In October 2010 I was trying to obtain an optimal bound on the long term decay rate of a one-parameter semigroup assuming only a certain integral condition; the details do not matter for the following. By 4 October, after much effort, I had proved a nice but not very original theorem of the required type. The next afternoon I tried a different method and found a shorter argument that gave a slightly worse result by a much more direct method. I saw the possibility that I might be able to improve the technique used, but guessed that it would be messy and did nothing further that day. The following morning I decided to use half an hour waiting for my train to reconsider what I had done the previous day, and almost immediately was able to write out a proof of the optimal bound in a few lines.

Many mathematicians have such experiences, and a widely accepted explanation is that the earlier work got the relevant facts back into my memory from when I had last thought about them in other contexts. Sleep then gave my unconscious mind the opportunity to rearrange the ingredients in various ways, or possibly just to loosen my attachment to a particular line of reasoning, leading to success in achieving my goal.

Forgetting the psychology, surely the final and very simple result must have been true before I discovered it? If not, how could I have done so? This ‘argument’ is very attractive emotionally, but would apply equally to many human activities. The possibility that Shakespeare might write Macbeth, using exactly the words that he did, existed before he actually wrote it, but possibilities are very ephemeral entities, and the use of the word existence when referring to a possibility seems to have almost no content. The rules for creating proofs in mathematics are highly constrained, with the result that different mathematicians who inspect a proof can usually agree whether or not it obeys them. Occasionally a logical contradiction is obtained within a field. Usually this is the result of a simple mistake, but very rarely a genuine paradox is discovered. On such an occasion a re-examination of the axioms of the subject may be needed. This happened repeatedly in set theory and logic early in the twentieth century. One may regard the actual, rather than the potential, existence of a proof as the criterion for truth in a subject that no longer considers agreement with some feature of the external world to be relevant. As a result of people’s efforts the body of humanly known mathematics has increased steadily, and that is what matters.
In section 3.5 I stated that large parts of Euclidean geometry would hardly be affected by the absence of the notion of infinity. This digression illustrates this by reference to Archimedes’ calculation of π in his booklet ‘Measurement of a Circle’, written in the third century BC. Surviving versions of this booklet have suffered from substantial revisions by unknown hands.

In his own era Archimedes was more famous as an engineer, inventor and astronomer than as a mathematician. He was, in fact, one of the great mathematicians of antiquity, but he lived at a time when almost nobody was equipped to understand his achievements. Some of his work, particularly that in the so-called Archimedes palimpsest, only survives as the result of a series of bizarre accidents. His ‘Measurement of a Circle’ does not attempt to obtain an exact value of π, which we now know to be impossible, but it does obtain the rigorous upper and lower bounds

\[
3 \frac{10}{71} < \pi < 3 \frac{1}{7}
\]

by a method that can evidently be extended indefinitely to yield more and more accurate bounds. We would now call his method an algorithm, in honour of the much later Persian mathematician, Al-Khwarizmi.

Archimedes obtains upper and lower bounds on π, or more properly on the perimeter of a circle, by considering two regular polygons with \(3 \cdot 2^n\) sides, one with vertices on the chosen circle and the other, larger, one touching the circle at the midpoint of each edge. The result for each \(n\) is used to obtain a better result for \(n + 1\) by means of a geometrical argument; Archimedes’ argument amounts to considering polygons with 6, 12, 24, 48 and 96 edges, but his method can evidently be continued to larger values of \(n\). The inductive steps eventually reduce to calculating square roots. Once again square roots cannot be calculated exactly, but Archimedes uses an unknown method – which has been much discussed – that enables him to write down accurate upper and lower bounds, both of which are rational, to square roots. In modern terms this is roughly analogous to rounding up or rounding down a calculation with decimals, depending on the requirements of the situation.

It is very hard to find fault with Archimedes’ method. Today, 2300 years later, we have much more powerful methods of computation based on the use of decimal expansions (or expansions base 2 inside computers) rather than fractions. We also have much more efficient, i.e. more rapidly convergent, algorithms for calculating π. The most important difference is that we have amalgamated arithmetic and geometry by an argument that relies on a rigorous definition of the real number system. The classical Greeks were well aware of a problem that, in our terms, amounts to the fact that numbers such as \(\sqrt{2}\) are not rational, but they managed to deal with this by regarding geometry,
which deals with measurement, and arithmetic, which deals with counting, as separate fields. For us \( \pi \) is defined by one of a number of formulae, whose convergence depends on our notion of the real number system, but classical Greek mathematicians considered that they were trying to find the length of a geometrically defined curve. This conceptual difference makes it very easy to misinterpret some of their arguments, because of the different meanings that we assign to the entities involved. There is, in addition, always the danger of crediting people such as Archimedes with understanding ideas that seem obvious with the benefit of a vastly more mature perspective.

**Page 115- Section 3.6. Gromov on brain function.**

In December 2009 the celebrated mathematician Misha Gromov wrote an essay entitled ‘Structures, Learning and Ergosystems’ in which he distinguished between the part of our brain processes of which we are conscious, and which he called the egomind, and the rest, which he called the ergobrain. Gromov provides a number of examples of animal and human behaviour to support his argument that the ergobrain operates on a long time scale and specializes in the recognition and creation of complex structures, or patterns. The egomind uses mundane methods for analysing immediate problems. Unfortunately the working of the ergobrain is largely invisible to the egomind, but he conjectures that mathematicians have more ability to use its powers than most people, even though the two operate autonomously.

*Rare* mental abilities could not have been evolutionary selected for and structurally complex features (be they anatomical or mental) cannot come about by accident. It follows that the hidden mental power of everybody’s (ergo)brain, not only of [the mathematical genius] Ramanujan’s brain, must be orders of magnitude greater than that of the (ego)mind. (Gromov, page 30.)

See ‘Why Beliefs Matter’, pages 66, 67, where somewhat similar comments of Hume are quoted. If one accepts these ideas, which have something in common with ‘Why Beliefs Matter’, page 117, then it is hardly surprising if ideas coming to the egomind from the ergobrain appear to be perceptions of an external reality – the Platonic world.

Gromov’s distinction between the ergobrain and the egomind reminds one of the difference between skills, often learned almost instinctively as a child, and factual knowledge, which one can often analyze rationally. In cognitive neuroscience the corresponding terms are procedural (or implicit) memory and declarative memory. Gromov seems to be focussing on the differences between procedural and declarative memory, each of which is very complex.
Declarative memory includes semantic and episodic memory, and is closer to our conscious awareness than procedural memory. In spite of this, we have no awareness of the mechanisms by which we recall facts such as a person’s name, a process that can take several minutes as one gets older.

The skill of catching a ball is an example of procedural memory. It depends on learning how to move the muscles in one’s arm and hand, depending on the visual stimuli provided by the approaching ball. The variety of speeds and directions of approach of the ball imply that this is not a simple matter. The process surely does not involve an unconscious knowledge of Newton’s laws of motion, even though the motion of the ball ‘obeys’ Newton’s laws. The person involved is not consciously aware of the actual rules followed by his brain.

Procedural memory may be learned or hard-wired or some combination of the two. The complexities of vision are well known and show that what we see is constructed, in some sense, from a variety of different features of the two-dimensional images on the retinas. However, one should not be led to suppose that this is necessarily the result of a learning process in the ergobrain. Many herbivores have to be able to run with the herd, and must therefore see clearly within a few hours of birth – otherwise they would be eaten by their predators – so their visual systems must be more or less completely hard-wired. The extent to which they are hard-wired in humans is not known. Uniquely among animals, we have an ability to acquire sophisticated new languages, and start to lose it from the age of eight if it is not used by then. This is an indication that the language instinct is hard-wired even though individual languages have to be learned.

page 150. Astronomy and creationism

Hoyle’s ideas on intelligent design are contested by some other scientists, as described on pages 163 and 211, but there are more basic theological issues arising from astronomy that are not often mentioned. Before explaining these, we need to describe the historical context in which they arose.

Disagreements between philosophers supporting an atomic theory and those believing that the nature of space forced matter to be infinitely divisible go back to classical Greece and were still being debated in the seventeenth century, but the subject only started to develop scientifically in the nineteenth century. Many chemists, starting with Dalton, came to believe in the existence of atoms during that century because of their enormous explanatory power, but others, including the very influential Ernest Mach, regarded them as no more than useful calculational fictions. General agreement about their existence came in the early years of the twentieth century with the advent of ingenious physical experiments that enabled the sizes of atoms to be settled.
Early in the nineteenth century Fraunhofer and Secchi started the study of the absorption spectra of the sun and other stars. They were able to identify the absorption lines with those of elements known in the laboratory, with the exception of an element that was called helium; this was not identified on the earth until 1895. These studies established that the sun and the stars were entities of a similar type, and that most of them were composed predominately of hydrogen, with helium as the second major component. None of the above was regarded as religiously controversial.

It had been known since the first observations by Galileo in 1610 that the Milky Way was composed of a vast number of individual, but very faint, stars. However, a number of attempts to measure the distances to individual stars failed because telescopes were not capable of making measurements with the required precision. During the nineteenth century telescope technology developed to the point at which it became possible to measure the stellar parallaxes of a few dozen of the closest stars, and hence to determine their distance and the scale of the Galaxy. The eventual conclusion was that the Galaxy is about a hundred thousand light years in diameter and that it contains about a quarter of a trillion separate stars. In the 1920s observations of novae in other galaxies, starting with the Andromeda galaxy, led to the realization that our Galaxy was only one of many, and that the Universe was vastly bigger than had previously been realized. The Hubble space telescope has provided extraordinarily detailed images of many of these galaxies.

These results are difficult to reconcile with the Biblical story that the world was created in 4004 BC (or some such time). One attempt is to argue that the speed of light was vastly greater a few thousand years ago, and this made it possible for light to traverse the enormous distances from the stars within the Galaxy during the few thousand years since 4004 BC. The problem with this is that absorption spectra of distant stars within the Galaxy do not show any changes in the fundamental constants of nature. Whatever its interpretation, the phenomenon of red shifts is not relevant within the Galaxy. The obvious remaining ways of avoiding this problem, if one is determined to do so, are to deny that the Galaxy is the size computed by astronomers or to argue that the light that we interpret as coming from the stars was actually created in 4004 BC, at the same time as the universe. While the scientific consensus, built upon a mass of evidence that has been examined by thousands of people over many decades, may, in a purely logical sense, be totally wrong, there is no evidence that it is actually wrong. Defending creationism involves arguments that become more and more contrived unless one regards belief in a creation event in 4004 BC as inviolable.

These considerations, and many others, undermine young Earth creationism for most people who think about the subject. Unfortunately few religious
moderates bother to confront the creationists, who constitute a substantial proportion of Christians in the USA; their influence in the UK may well increase if some of the so-called ‘faith schools’ come under creationist control, as some people claim is happening. However, the astronomical facts also pose a problem for mainstream theistic religion, by revealing how insignificant our planet is in the overall scheme of the Universe. Hoyle’s arguments for design, even if it is accepted, leads only to a severe form of deism, and provides no support for Christianity or any other particular religion. Nor does it suggest how the existence of the human species could have any significance at the scale of the Universe.

page 157. Loop Quantum Cosmology

A paper of Ashtekar and Sloan published in 2010 strengthens the case for taking loop quantum gravity (QLG) seriously, by providing an explanation for the existence of a period of inflation in the very early universe. Earlier accounts of inflation have shown that it explains observed facts about the early universe well, although it itself remained completely mysterious.

The Ashtekar-Sloan paper uses a modification of a very special, highly symmetric solution of Einstein’s equations called the FLRW space-time. It is derived using quantum loop gravity and depends on solving a system of differential equations involving only four parameters. It also depends on choosing a few fundamental constants, but also a particular classical potential. Subject to these choices, the authors show that the probability of a period of inflation is very close to 100%, using a standard method of calculating probabilities. The authors accept that they have not completely solved the problem of inflation because, without the assumed potential, the model does not behave as required.

Some members of the string theory community regard the whole approach as oversimplified to the point of absurdity, and even claim that by ignoring most of the complexities of particle physics it is stepping backwards from any serious engagement with an extremely hard problem. Only time will tell.

page 158. The LHC

At the start of 2012 observations by two independent experiments at the LHC suggest that the Higgs boson may have a mass of about 125 GeV/c$^2$. No sign of supersymmetry has yet been seen, but if the Higgs boson mass is right, this increases the chance of observing evidence of supersymmetry.
At the start of the nineteenth century mathematicians regarded Euclidean geometry as a straightforward description of the real world. There had been many attempts to prove the parallel postulate, the least obvious of Euclid’s axioms, but all had failed. Kant, in particular, made a serious, but as it proved wholly misguided, effort to show that our knowledge of Euclidean geometry was a consequence of certain philosophical arguments.

During the nineteenth century the logical possibility of non-Euclidean geometries, in which the parallel postulate of Euclid were not true, came to the attention of mathematicians. Shortly before 1870 Riemann and then Beltrami showed that one could contemplate a wide variety of logically consistent geometries with any chosen number of dimensions, and that these geometrical structures could be regarded as existing in their own right, without reference to Euclidean space. As the century progressed, projective geometry allowed mathematicians to study geometrical structures in which points ‘at infinity’ could be examined as easily as finite points and in which the very notion of point suddenly seemed to be a mere matter of convention.

All of these ideas were unsettling enough, but a much more radical change was to come. In 1905 Einstein created his theory of special relativity, in which Newtonian mechanics was abandoned as the correct description of bodies moving at very high speeds. Minkowski soon presented Einstein’s theory in a much more geometrical manner, as a four-dimensional ‘space-time’ whose geometry was non-Euclidean. The separation of space and time, previously unquestioned, was now regarded as a fundamental mistake, understandable because in most circumstances it was a good approximation. In the 1920s the Kaluza-Klein theory sought to unify general relativity and electromagnetic theory within a five-dimensional space-time. Gradually more and more exotic theories were proposed in which the dimension of space-time became a negotiable issue.

In the 1970s (super)string theory came into existence and after some time it was agreed that it indicated that space-time was ten or possibly eleven-dimensional. For a time it was considered that the great merit of the theory was the ‘fact’ that the equations had a unique solution, but gradually it was realized that this was far from being the case. The current situation, described in Section 4.5, is that string theory is widely regarded as not being capable of predicting the values of the fundamental constants. A substantial number of theoretical physicists now add a number of extra parameters into the theory, to distinguish between the various solutions, each solution corresponding to a different universe. This effectively raises the dimension of their theory even further.

To sum up. Two centuries ago geometers considered that they were study-
ing the physical world and that Euclidean geometry provided the correct description. Now there is a profusion of mathematically possible geometries of different dimensions, some based on exotic symmetry groups and others non-commutative. Physicists invent ever more in the hope that one of them might provide the correct description of the physical world as they now see it. There is little evidence that any of them is right, because of the enormous energies that would be needed to devise proper experimental tests, so the studies are based on mathematical coherence rather than experiment.

The developments in geometry described above do not appear to be converging to a simple theory. The geometrical approach has been remarkably successful in incorporating more and more aspects of fundamental physics, but only by making the mathematical model steadily more complicated. (It also involves more sophisticated mathematics as time passes, but that is quite a different matter.) The standard model works extra-ordinarily well, but it is not elegant, and efforts to go beyond it have not yet born fruit. Generations of physicists have tried to find a ‘Theory of Everything’, and may yet succeed, but if it were simple they would surely have succeeded some time ago.

page 163. Platonism and time

I should have mentioned that the tendency to assign mathematical theories physical reality is by no means new. Aristotle’s notion that the planets were embedded in transparent crystal spheres was refined into a mathematical model by Ptolemy and was the orthodox belief until after Copernicus. More profoundly the remarkable consistency between various ways of measuring time, which steadily increased as clock mechanisms became more sophisticated, confirmed people’s belief that there was a thing called absolute time, which the clocks were measuring. Newton, in particular, was completely committed to the absolute character of space and time, separately. Einstein’s special and general theories therefore came as a tremendous shock. His twins paradox is not a paradox in the logical sense, but an observed fact that shows that there is no universal time. Since Einstein and the development of quantum theory, many theoretical physicists have tended to regard mathematical models as the final reality.

All the above leaves unanswered the question of why we, like Newton but unlike Einstein, regard time as flowing, and even what this proposition means. It seems to be a statement about the physical world, but physics itself does not recognize it.

pages 166, 167. Quantum computation
The problem with quantum computation is not finding an acceptable philosophical interpretation of quantum theory, nor altering the mathematical basis of the subject. The surprising fact is that the mathematical theory devised in the 1920s has survived every experimental test in spite of its many profoundly counter-intuitive predictions. Certainly research into quantum computation has stimulated a number of new technical developments in quantum theory, such as the elaboration of the notion of quantum information. But the main problems are experimental. Physicists need to produce an array of a few hundred atoms (or more strictly two-level systems, also called qubits) that can interact with each other to produce what is called quantum entanglement, while at the same time not interacting with the external environment except in certain strictly controlled ways. In the classical domain this has proved relatively easy, even for systems involved billions of bits, but doing the same at a quantum level is an enormous challenge. Some physicists doubt that it will ever prove possible, but those working in the field are, unsurprisingly, optimistic. There is steady progress, but the desired goal is not yet on the horizon.

page 170. Sagittarius A*.

Sagittarius A* is a bright and compact radio source near the centre of the Galaxy. It was discovered in 1974, and the evidence that it is a black hole with a mass approximately 4 million times as great as our sun became overwhelming during the period 1998-2008. The mass was calculated by applying Kepler’s laws to half a dozen stars that orbited it with periods of only a few years. It is difficult to measure its diameter accurately because of obscuring material, but it seems to be smaller than the size of the Earth’s orbit around our sun. This combination of facts leaves little choice but to identify it as a black hole, perhaps the only black hole to be identified with this degree of certainty.

page 185. Platonism, Religion and Evolution.

The influence of Platonism on religious attitudes has been particularly obvious in disputes about Darwin’s theory of evolution. If one believes that every species of animal is associated with a ‘natural form’ which limits the degree of variation of individuals of that species, then one is bound to reject Darwin’s theory. Darwin was at pains to try to emphasize that the borderlines between species vary over time in a continuous manner, and that it was pointless to try to define precise boundaries. As a result of Darwin’s insights, it is now considered that classifications of species, such as those of the eighteenth century
botanist Linnaeus, should be taken as a partial record of how evolution has proceeded. The extent to which Platonism, or the somewhat more general essentialism, is embedded in Genesis could be argued, but one also needs to ask whether Genesis itself should be read literally or in its historical context.

**page 187. The Templeton Prize**

In April 2011, Martin Rees, ex-President of the Royal Society, was awarded the Templeton Prize in spite of the acknowledgement on their web site that he has no religious belief. His acceptance statement is typically non-confrontational on this issue, declaring “As regards my own ‘philosophy’, I continue to be inspired by the music, liturgy and architectural tradition of the Anglican Church in which I was brought up.” However, he did admit his scepticism about dogma and lack of religious belief in an interview with the New Statesman on 23 April 2011. His reluctance to get involved in the science-religion wars was presumably a reason for his winning the award. Unsurprisingly his acceptance has provoked strong criticisms from those who see religion as an outmoded form of belief. It is more difficult to see why those who are religious should celebrate the award, because Rees has said little to encourage them; he is an advocate of the multiverse theory, one of whose ‘merits’ is that it renders God unnecessary.

**page 191. Ritual Practices**

Although I stressed that religion involved much more than a set of theological propositions, I was quite surprised that Martin Rees considers himself as a member of the Anglican Church in spite of having no interests in its core beliefs. He stated ‘I grew up in the traditions of the Anglican Church and those are the customs of my tribe’. Nor does he appear to be alone. The Anglican version of Christianity is unusual in allowing you to join without assenting to any particular beliefs, but whether that is a merit is an another question.

**page 191. Transcendental experiences**

These are also called mystical or spiritual experiences. I have not discussed them in the book, because they are so variable and private in nature. Those who have them often decide not to tell anyone else about them, either from the start or after a few attempts to communicate them to others have resulted in incomprehension, or even worse.
An attempt to understand such experiences was made by Sir Alister Hardy, who set up a Research Institute at Oxford in 1969; it was transferred to Lampeter in Wales in 2000[8]. The huge range of experiences recorded in confidential surveys defies easy classification. Some people regarded them as confirming their religious belief while others had no settled beliefs, either before or after. Although it is possible to ‘explain’ them as ‘no more then’ the results of unusual unconscious mental processes, one must recognize that the experiences have transformed the lives of some of those who have had them. Some regarded them as emanating from their inner beings, but others thought that the source lay outside themselves, in some dimension of being that one cannot normally contact.

page 192. What is Catholicism?

In this chapter I make many references to ‘Catholics’. I should have taken the opportunity to distinguish between the Catholic Church as a body of more than billion worshippers, and some of the doctrines promulgated by a rigid Church hierarchy. Two successive highly conservative Popes have steered the Church away from meaningful ecumenical dialogues even with other branches of Christianity, let alone with other faiths. Fertility statistics indicate that millions of sincere European Catholics, even in Italy, ignore the Church’s prohibition on contraception, although they mostly avoid doing so too openly. In some other parts of the world the prohibition has increased poverty and misery. Even the definition of Catholic is open to discussion, In Spain, to choose just one example, about three quarters of the population identify themselves as Catholic, but church attendance is around 15% and still falling. The present trends are no doubt related to the Church’s close relationship with the Franco regime.

page 196, Ethics, paragraph 2. The Papal visit to the UK in 2010.

During his visit to the UK in 2010 Pope Benedict voiced his ‘concern at the increasing marginalisation of religion, particularly of Christianity’, and the belief of some that ‘the voice of religion should be silenced, or at least relegated to the purely private sphere’. It has long been the view of the Catholic Church that secularism, liberalism and relativism are closely associated, and that all

are opposed to the truth as they see it. Benedict considers that objective moral principles emanate from God, and said during his visit that religious people must promote ‘dialogue between faith and religion at every level of national life’. In another speech he said that ‘the exclusion of God, religion and virtue from public life leads ultimately to a truncated vision of man and of society’. This position has attractions, in that religion provides a context for contemplating the deepest questions about life, our values, sorrows and hopes. On the other hand it is not easy to determine what the objective principles are. His speech was very modest in this respect, and sits uneasily with many of his earlier and more dogmatic edicts. His values are certainly not the same as those supported by his own Church during the Second Vatican Council, let alone those of other ‘defective’ churches and religions. Benedict is undisturbed by this, because he takes a long view, and has no interest in adapting his message to short-term social consensus.

As evidence for the pernicious effects of secularism, Benedict related the lack of an ethical basis for the financial industry to the recent financial crisis and recession. These events were indeed consequences of the materialistic attitudes of bankers and of investors who demanded unsustainably rapid returns on their investments. Western governments deliberately chose to relax the regulatory frameworks of the financial industry in the belief that uninhibited capitalism would lead to the greatest benefit for all.

There is, however, a difference between materialism and secularism. The American governments concerned were led by Presidents all of whom professed sincere religious beliefs. The same applied in the UK. Its Prime Minister, Tony Blair, was openly religious and was warmly welcomed into the Catholic Church shortly after his term of office ended. The Chancellor, Gordon Brown, was more reticent about his religious belief, but it did matter to him. It appears that the religious convictions of these leaders were irrelevant when it came to facing up to the problems of managing the economic issues.

The simplistic comments of the Pope can be contrasted with an impressive lecture of the Archbishop of Canterbury on the same subject in March 2009, which we discuss in a new subsection attached to page 233.

page 195. On -isms.

I might justifiably be accused here of not distinguishing here between evangelicalism, evangelism, fundamentalism, creationism and various other -isms. Unfortunately they do not have sharp boundaries and the distinctions are sometimes academic (in the bad sense of the term).
By the middle of 2010 there were repeated allegations that Barack Obama is a Muslim; he is actually a practising Christian. One is impelled to ask whether some people in the USA repeat this myth for political reasons, or whether there is a racist element to them.

More on slavery.

The Pope referred to slavery in a speech in September 2010 in the following terms.

Without the corrective supplied by religion, though, reason too can fall prey to distortions, when it is manipulated by ideology, or applied in a partial way that fails to take full account of the dignity of the person. Such misuse of reason, after all, was what gave rise to the slave trade in the first place and to many other social evils.

The Catholic Encyclopedia provides some support for his position. It emphasizes that

in 1462, Pius II declared slavery to be “a great crime” (magnum scelus); that, in 1537, Paul III forbade the enslavement of the Indians; that Urban VIII forbade it in 1639, and Benedict XIV in 1741; that Pius VII demanded of the Congress of Vienna, in 1815, the suppression of the slave trade and Gregory XVI condemned it in 1839; that, in the Bull of Canonization of the Jesuit Peter Claver, one of the most illustrious adversaries of slavery, Pius IX branded the “supreme villainy” (summum nefas) of the slave traders. Everyone knows of the beautiful letter which Leo XIII, in 1888, addressed to the Brazilian bishops, exhorting them to banish from their country the remnants of slavery—a letter to which the bishops responded with their most energetic efforts, and some generous slave-owners by freeing their slaves in a body, as in the first ages of the Church.

In spite of these proclamations, Spain, almost entirely Catholic, was one of the main participants in the slave trade.

Incest and related matters
This is flogging an (almost) dead horse, but apparently it is still necessary. Strong evidence for the genetic advantages of avoiding incest exists, and the psychological mechanisms which govern the avoidance mechanisms are rapidly becoming clear. Both together explain why incest is almost universally regarded as wrong, but they do not prove that it is wrong, unless one assumes, either that the well-being of the human species is one measure of good or that God regards incest as in itself immoral.

It should be remarked that people have a strong preference for favouring their family and then their friends over complete strangers. Convincing reasons, both genetic and social, for these attitudes exist. In spite of this, Christians argue that it is morally right to love every human being equally, as Christ taught.

Many people consider that carrying out experiments on foetuses a few days old is morally evil, in spite of the facts that no inborn attitudes towards this could possibly exist; the existence and structure of such foetuses was not suspected until fairly recently. Other people consider that there is a stronger utilitarian argument in favour of allowing such experiments under controlled conditions. There can be no easy answer to such questions.

**page 199. Sociobiology**

In 1975 Edward Wilson published his book ‘Sociobiology: The New Synthesis’, proclaiming a revolution in the understanding of social behaviour by using Darwinian analysis. There was a very strong reaction against the merits of this idea, in particular by Stephen Jay Gould. Partly as a result of this, the term ‘sociobiology’ became less popular and ‘evolutionary psychology’ more so. The basic idea of the latter subject is not controversial; indeed it is expounded in Section 2.6 of this book, where it is argued that human beings have innate mental capacities that control our behaviour to some extent. The problem is to avoid making excessive claims for the subject, based on wishful thinking and story telling. Evolutionary approaches to incest avoidance, altruism, family bonds, gender stereotyping, religious belief, etc. become scientifically meaningful when systematic evidence that the behaviour really is universal over time and society can be marshalled. Finding a role for genes is bound to be difficult, if not impossible, because of the extraordinary variability of many social customs and the fact that they can change dramatically within a single lifetime.

**page 200. Mary Warnock**
In her closely argued book ‘Dishonest to God’, published in 2010, the noted moral philosopher and life peer Mary Warnock discusses the relationship between morality, law, religion and spirituality. Her book is informed by her detailed knowledge of many major debates in the House of Lords about life and death issues. Although some people have condemned her position on euthanasia (often without bothering to find out what it is), and might consider her a humanist, she refuses to label herself as belonging to some particular -ism. She grounds morality not in the declarations of religious authorities but in our nature as human beings, free to exercise our imagination. This might be regarded as a biological explanation of morality, but she presents it using cultural rather than scientific language.

We positively need morality to alleviate the predicament that we are all in together. We cannot make things perfect (though we can have visions of perfection) but we can at least determine not to make things worse. This, it seems to me, is the basis of our admiration for the human virtues of courage, honour, truthfulness, loyalty and above all, love, pity, kindliness and whatever is the opposite of arrogance and self-importance. It is imagination that enables us to aspire to a world in which such virtues prevail. And it is our human capacity to recognise such virtues that is the foundation of morality. [Dishonest to God, page 121.]

This declaration does not provide an instant resolution of the many disagreements between groups about what is morally right. Even in a country whose traditions are as long-standing as those of the UK, the last fifty years have seen profound changes in attitudes relating to contraception, marriage, abortion, euthanasia and gay rights, and many do not regard all of these changes positively. Nor is it obvious that other parts of the world are moving in the same direction. It is, however, reasonable to agree with Mary Warnock’s belief that there is more hope of obtaining agreement with moral judgements based on the above fairly universal virtues than with edicts based on pronouncements about the sanctity of life, whose implications are supposed to be unarguable.

Many of the virtues that Mary Warnock described are related to the notion of empathy, deeply embedded in our natures as intelligent social animals. Professor Simon Baron-Cohen has emphasized that empathy is scientifically measurable and varies from person to person; as always happens, it is partly genetic and partly environmental. He considers that thinking in such terms is much more productive than classifying people as ‘evil’, an emotionally loaded term that means very different things to different people.

In his Easter Sunday homily on 24 April 2011, Cardinal Keith O’Brien made the following comments about gay rights – without directly mentioning the words.
Recently, various Christians in our Society were marginalised and prevented from acting in accordance with their beliefs because they were not willing to endorse a particular lifestyle.’ He went on to emphasize that Christians ‘have that right to equality which so many others cry out for’. This closely echoes comments made by Pope Benedict to the Catholic Bishops of England and Wales on 1 February 2010. The issue here is the conflict between the rights of a proportion of Christians and of the gay community. The latter might legitimately respond by turning the question around: should people running B&Bs have the right to refuse to accept Catholics, or any other group whose lifestyle happens to be repugnant to them? (Racial discrimination of this type was un Concealed in the UK during a good part of the twentieth century.) Countries such as the UK, in which there are many communities with different lifestyles and beliefs, can only thrive if there is a firm distinction between what people believe or like and what the law allows. If people consider the rights of others as well as their own, which involves one aspect of empathy, they are more likely to come to balanced conclusions about what should be legal.

page 202, Section 5.2. Hawking on atheism

Stephen Hawking should be added to the list of atheistic physicists; see his book ‘The Grand Design’, co-authored with Leonard Mlodinow. The following passage has been widely criticized by religious leaders for its theological naivety, and I will not repeat their objections to his notion of God.

Because there is a law such as gravity, the universe can and will create itself from nothing. Spontaneous creation is the reason there is something rather than nothing, why the universe exists, why we exist. It is not necessary to invoke God to light the blue touch paper and set the universe going.

The passage reveals Hawking’s belief that laws have priority over physical reality. He does not accept that laws are (usually approximate) descriptions of the way the world behaves. Instead he adopts the Platonic view that the laws exist in their own right and that they not only control the universe, but are capable of calling it into existence. As usual with Platonists, the mechanism by which a law, which is a set of mathematical equations, can possess such astonishing powers is left totally unclear.

Hawking also espouses M-theory, a hypothetical eleven-dimensional unification of several different mathematical models of fundamental physics proposed by Edward Witten in 1995. It has attracted enormous support among string theorists, but it has to be said that at present this is entirely based on its structural attractiveness. There is no experimental evidence for its correctness, and there
Hawking conjectures that M-theory may never be comprehensible as a unified mathematical theory, and suggests that physicists may need to develop the philosophical concept of model-dependent realities to cope with this situation. This is far too pessimistic. Physicists could easily have taken the same attitude towards quantum theory in the early part of the twentieth century. They did not and were eventually rewarded with an elegant theory that was described using mathematics of an entirely unexpected type.

**page 205. John Gray on myth**

In September 2011 the philosopher John Gray gave a radio talk on the BBC service about the status of myth and of belief in religion. He claimed that many people, but particularly atheists, were persistently failing to understand this. This critique accepts fully his contention that myth can play an important role in expressing ideas that are not easy to explain by other means, and that their literal truth may be irrelevant, just as it is in novels.

However, he goes too far in stating that religion is not about beliefs. They are far from being the only component, but they are vital, and not just for ‘religious fundamentalists and ignorant rationalists who think that the myths we live by are literal truths’. Thus Rowan Williams, who takes myths as a fundamental aspect of religion, can say (WBM p. 230) ‘I have never managed to see...’ and Pope Benedict (WBM p. 234) can assert that ‘Hell really exists...’.

He also goes too far in stating that science isn’t the attempt to frame true beliefs, in spite of the fact that many of our theories in physics are approximations with limited validity, and destined to be superseded by more fundamental theories in due course. One may safely take the following to be true statements. The world is round and it moves around the sun, which is one of billions of stars in our galaxy. The moon shines by reflected light and it is a normal physical body of the same type as the earth and other planets. Human beings have existed on this world for much longer than ten thousand years and were preceded by many other species over a period of at least six hundred million years. The rocks that make up the surface layers of the world occur in different strata that were laid down by geological processes over billions of years. Visible light is a mixture of light with different frequencies and can propagate through a vacuum. Sounds have different pitches because sound is composed of vibrations of the air with different frequencies of oscillation. It cannot propagate through a vacuum. There is a profound connection between electricity and magnetism, which can be described mathematically and without which most of our present machines could not function. One could continue more or less
indeed with statements that all informed people now believe, and should believe, as a result of scientific endeavours. That is not to say that we will eventually understand all aspects of the functioning of the universe; I join him in doubting this.

**page 211. The multiverse and religious faith**

The doubts of physicists about the reality of the multiverse are often connected with their religious belief. One of the doubters, John Polkinghorne, became an Anglican priest in later life. George Ellis has put forward several detailed arguments against the idea, and is an active Quaker. This might be used by some as a basis for doubts about their objectivity, but it is equally possible to argue that people with a wider background can more readily distinguish between a theoretical construct relying on shaky mathematics and the reality of which it may be a partial representation. I, personally, find Ellis’s scientific arguments convincing, even though I do not share his religious belief. The following quotation is taken from “The multiverse, ultimate causation and God”, a lecture of Ellis given in Cambridge, England on 6 Nov. 2007.

The multiverse idea is not provable either by observation, or as an implication of well established physics. It may be true, but cannot be shown to be true by observation or experiment. However it does have great explanatory power: it does provide an empirically based rationalization for fine tuning, developing from known physical principles.
Here one must distinguish between explanation and prediction. Successful scientific theories make predictions, which can then be tested. The multiverse theory can’t make any predictions because it can explain anything at all.
Any theory that is so flexible is not testable because almost any observation can be accommodated.

**page 215. Catholic attitude towards intelligent aliens**

In spite of what is written here, astronomers at the Vatican Observatory are searching for evidence of intelligent life elsewhere in the universe, in the hope that they may learn more about the nature of God. It is perfectly possible that a theology encompassing alien intelligences could be developed, but the status of Christ would be profoundly affected.
page 219. Neoplatonism today

I missed the opportunity to compare the description of God’s nature by Rowan Williams and Paul Tillich with Neoplatonism, described on page 75. Perhaps this is so obvious that it hardly needs mentioning, but other Christian theologians seem to believe that God does exist, in some sense. For example, Keith Ward seems to want to prove the existence of God by a Platonic argument based on the existence of possibilities, see page 224, but he then jumps without any explanation to a God whose loving nature would not be recognizable to a Neoplatonist.

page 225. The status of possible entities

A perusal of Michael Jubien’s book ‘Possibility’ (OUP, 2009) demonstrates the disagreements of academic philosophers about the status of possible entities and many related matters. Fictional entities, such as Sherlock Holmes, are even harder to accommodate into traditional philosophical categories, because they appear to have properties in spite of the fact that it is a part of the understanding of both author and reader that they do not exist in the material sense. The three worlds of Popper are rich enough to resolve such issues. Physical entities exist in World 1 while possible and fictional entities exist in his World 3 of cultural constructs. If one accepts this analysis then fictional characters would not exist if we did not (which seems perfectly reasonable), but nor would possible entities (which takes more getting used to).

When an animal stares intently in some direction, it may be assessing the possibility that a predator is lurking there. This awareness of a possibility is best regarded as lying in World 2, as a mental entity, even though animals may be able to communicate their anxiety by specific signals, because non-human animals have no significant culture. It seems likely that reflections about possible alternative worlds or courses that history might have taken depend on the presence of a developed language.

Should a study of possibilities (if such an enterprise is worthwhile) be based on trying to find a common core behind the wide range of uses of the word in normal language? Should one only consider possibilities that are consistent with our best current understanding of science, or is logical consistency the only criterion for accepting something as a possibility? The answer to this question determines whether one should entertain the possible existence of a substance with the same properties as water but a different chemical formula – one of the favourite topics of philosophers.
The Catholic Church combines reticence about Catholic involvement in exorcism with actual support. The chief exorcist at the Vatican, Father Gabriele Amorth, claims to have carried out about 70,000 exorcisms, according to interviews with the press and books that he has written; he, at least, is firmly committed to the existence of Satan. The Church maintains a network of exorcists around the world, but it is rarely mentioned in public.

Human beings sometimes perpetrate acts on each other that seem incomprehensible when described in print. The Nazi Holocaust comes to mind immediately, but brutal murders and torture by small groups and by individuals are just as difficult to understand. Historically such acts and even the people perpetrating them are simply called evil, but this does not help either to understand or to prevent them.

One can try to explain such behaviour on an individual level. A lack of empathy for one’s fellow beings might be the result of genetic or developmental abnormalities in the brain, perhaps reinforced by inadequate parenting or worse. Simon Baron-Cohen has provided some scientific support for this idea in his book ‘Zero degrees of empathy: a new theory of human cruelty’, published in 2011.

Appalling cruelty can also be induced by a social atmosphere in which normal ethical standards seem to have been abandoned. One cannot dismiss such extreme cases as the orgies of violence in Roman Arenas, actively enjoyed by the audiences for centuries, because there are many present day examples. Some are associated with murderous hostility between different religious sects while others have more to do with the maintenance of political power. In wars soldiers are expected to obey orders without question, and then often come to regard ‘the enemy’ as subhuman; it is then only a short step to killing civilians outside the battlefield. At a more mundane level, excessive pressures on the staff in some hospitals and nursing homes for the elderly can gradually make lower and lower standards of care seem unavoidable, and then acceptable. If nobody in authority feels able to stop the decline, it can continue to the point at which a national scandal erupts.

Calling such events evil and punishing those involved does not provide a long term solution of the problems. This must come from a recognition that human beings form habits and succumb to social pressures too easily, and that the solution must be to set up social structures that that make such events less likely. A succession of public enquiries into individual scandals is not likely to
work if it does not take account of this general issue. The reason that this does not happen is the perceived expense of addressing the issues at a fundamental level. This perception is mistaken, because the long term cost of dysfunctional social behaviour is even greater.

**page 233. On vulnerability**

The following is a new final subsection of Section 5.5.

In March 2009 the Archbishop of Canterbury gave an impressive lecture about the lessons to be learned from the financial crisis that had engulfed large parts of the Western world in the previous year. It probed the failures of leaders in all walks of life (including, one should say, the Anglican Church and its Commissioners, responsible for its investment strategy) to anticipate the consequences of the behaviour of the financial market. Rather than blaming secularists, he declared that ‘this was not just about greed’. He suggested that

> economic justice arrives when everyone recognises some kind of shared vulnerability and limitation in a world of limits and processes (psychological as well as material) that cannot be bypassed. We are delivered or converted not simply by resolving in a vacuum to be less greedy, but by understanding what it is to live as an organism which grows and changes and thus is involved in risk. We change because our minds or mindsets are changed and steered away from certain powerful but toxic myths.

His tone was thoughtful and non-doctrinaire. It focused on how religion and particularly Christianity can help people to cope with social evil rather than on whether God is ultimately responsible for it.

> It is not for believers to join in the search for scapegoats, because there will always be, for the religious self, an awareness of complicity in social evil. Nor it it for believers to make light of the real suffering that goes with economic uncertainty and loss.

I have selected a few passages out of a complex and sensitive argument, which deserves to be read in full, and is available on Rowan Williams’ official web pages. I agree with so much of his lecture that it might seem ungenerous to pick on details, but there is a background assumption in his lecture that he would regard as fundamental while I regard it as irrelevant. Consider the following fairly typical passage in his lecture.
As we have noted more than once already, the perspective of faith understands human beings as part of creation – not wholly in control, though gifted with capacities that allow real and significant powers over the environment, bound to material reality and unable to escape material need. Living in faith is living in awareness of this created and limited identity without resentment or fantasy.

It is not surprising that the Archbishop of Canterbury identifies a certain frame of mind as Christian, but the passage could be changed as follows without any loss of substance.

A mature perspective understands human beings as part of a contingent reality – not wholly in control, though possessing capacities that allow real and significant powers over the environment, dependent on material reality and unable to escape material need. Maturity involves living in awareness of these limitations without resentment or fantasy.

It appears that religion is little more than window dressing at this level. Thoughtful people can share the same values whether or not they are Christian and whether or not they are religious.

The Christian religion and science are antagonistic to the extent that scientists try to achieve complete mastery of the laws of nature and forget that their consequences are anything but controllable. From a purely materialistic point of view death is the final failure of science to control matter. From that of a Christian it is a prelude to the final transformation. There is no rational process for deciding which is right.

page 233, 234. On Hell

It has been suggested that I pay too much attention to the notion of Hell, since there are few references to it in the Bible or in daily Christian worship. It would be nice if this were so, but try typing hell+christian into Google News. The onus lies with Christian theologians to make their attitude towards this important subject clear, rather than avoid it with apparent embarrassment. It appears to an outsider that they wish that the issue would go away, because the official doctrine poses ethical problems about God that they cannot answer.

page 237. The conservatism of Pope Benedict
The authoritarian attitudes of Pope Benedict XVI contrast strongly with his early liberalism, and have contributed greatly to the storm of criticism of him for his role in covering up the child abuse scandal in the Catholic Church. Many faithful Catholics in Ireland, Belgium, Germany and other countries are aghast at the behaviour of their own priests. Some civil authorities have come to believe that the Church is more concerned with protecting its own status than with the accountability of its priests under the law. Had Benedict pursued the reforms of the Second Vatican Council, and addressed the abuse much more vigorously in the past, the world would have been a very different place.

The preceding paragraph was written before the publication of the Cloyne report in Ireland led the Taoiseach (Prime Minister), Enda Kenny, to accuse the Vatican in Parliament on 20 July 2011 of actively impeding the progress of their latest investigation into child abuse. The uncompromising nature of his criticism has to be read to be appreciated; see the Taoiseach’s speech. The speech particularly criticized Bishop Magee of Cloyne, once a close advisor to three popes. Magee’s status may be gauged from the fact that Pope John Paul II requested that Magee be given the cassock that he (the Pope) had worn on the last occasion before he died. The Vatican took the criticism so seriously that it recalled its nuncio, Archbishop Leanza, on 25 July 2011.

The lesson that I draw from this is that the Roman Catholic Church is capable of serious corruption just like all other organizations, with no hotline to God that ensures that its declarations should be accepted uncritically. It would like its members to think that it is morally pure by its nature, but this is simply not the case. Whether it is better or worse on average than other organizations must be a matter of historical record combined with value judgements, about which opinions will differ.

page 238, end of first paragraph. The assassination of Salmaan Taseer

On 4 January 2011 the Governor of the Punjab in Pakistan was assassinated by one of his own bodyguards for opposing the death sentence on Asia Noreen, a Pakistani Christian woman who had been convicted for blasphemy. Adrian Hamilton wrote the following comments on the issues involved in the Independent newspaper on 6 January.

The danger of presenting Taseer’s killing as a simple issue of fundamentalism against liberalism and even secularism is that it ignores that the struggle is about power as much as belief. Assassination is still an abominable act but also an effective means of challenging power structures and frightening people into passivity. Religion
may make it more difficult for ordinary citizens openly to oppose the men of violence, but it’s not necessarily the cause in itself. The real issue is the almost universal assault on pluralism within countries.

He goes on to list examples of mass discrimination or even violence within religions and in non-Islamic countries, and ends by pointing out that some corrupt civilian (does he mean secular?) states are just as unpleasant as those that are fundamentalist.

One has also heard claims that some religious leaders deliberately promote fundamentalist attitudes within their followers in order to shore up their own power, but it is probably unwise to name any such here.

**page 236/7, bullet point 2**

The comment about strengthening social structures within which the better sides of our nature dominate is of fundamental importance. The grotesque evils of Nazi Germany were not caused by Germans being intrinsically evil, but were a consequence of a strong inclination of people everywhere to accept social conventions and the dictates of authority, however unreasonable those are. Many psychological experiments have shown that most people everywhere can be persuaded to carry out unacceptably cruel acts if they are repeatedly led to believe that this is required and that those in authority take full responsibility.

Our willingness to obey social conventions is what makes civilization possible; if it were possible to educate us out of it, chaos would ensue. All we can try to do is to create cultures and legal structures that prevent the worst outcomes, so far as that is possible. The desired state is sometimes called democracy, but the word has been misused so much one cannot rely on it any longer.