Miracles and Science:
*The Long Shadow of David Hume**

By Ard Louis

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1. Introduction: Miracles as violations of the laws of nature

Unbelievable, isn't it, that there are still students at this university who believe in stories from the Bible, said Martin, an older colleague, at one of the formal dinners around which the traditional life of Oxford University revolves. But Martin, I answered, *their faith probably doesn't differ much from mine.* I can still see his face go pale while he nearly choked on his glass of St. Emilion Grand Cru Classé: *How can you believe in such things nowadays – Walking on water, a resurrection from the dead? Those are miracles, and aren't you a scientist?*

Oh, how interesting, say John and Ruth, a couple that I have just met at the end of a church service. *You are a scientist*. They look a bit unsure of what to say next and John blurts out, *I read recently that we still don't understand how birds can fly so many miles to the south and yet return to exactly the same place each summer. Scientists can't explain this; it is a miracle, don't you think?*

I never quite know what to say next in such conversations. Perhaps nine years of living in Britain have made me too sensitive to that most cardinal of English social sins – causing embarrassment. But there is more to it than that. Behind these statements lies a tangle of complex intellectual issues related to the definition and scope of science, the nature of God's action in the world, and the reliability and interpretation of the Bible. These have exercised many of greatest minds in history:

> *The debate between atheism and religious belief has gone on for centuries, and just about every aspect of it has been explored to the point where even philosophers seem bored with it. The outcome is stalemate.* [1]

So says my Oxford colleague Alister McGrath. Although these subtleties are well known to philosophers and historians of science, public discourse on science and religion often seems blissfully unaware of them.[2]

Everyone brings a set of presuppositions to the table. To make progress, these should first be brought out into the open. Without time for an honest conversation in which we can listen to each other in depth, I won't know exactly what Martin, John, or Ruth's presuppositions are. But, for the sake of this essay, I will be a bit presumptuous and venture a guess. My guess would be that, although both seem to be on opposite sides of a vast divide, they are in fact influenced by a similar perspective on science and miracles, one first laid down by the great sceptical Scottish philosopher David Hume, who wrote:

> *A miracle is a violation of the laws of nature, and as a firm and unalterable experience has established these laws, the proof against a miracle, from the very nature of the fact, is as entire as any argument from experience can possibly be imagined.* [3]

This language of "miracles as violations of the laws of nature" has framed the debate ever since. Martin, John and Ruth, perhaps without realizing it, are living under the long shadow of David Hume.

Martin may think that science is the only reliable route to gaining knowledge about the world, and that, since belief in miracles is obviously unscientific, such belief must *ipso facto* be false. John and Ruth may feel a similar tension between science and miracles, and are therefore encouraged by any natural process that seems inexplicable. Weakening the power of science would seem to strengthen the case for God acting in the world: If we know that today God miraculously steers a bird back to its original habitat after a long return flight to the south, then it is easier to believe that 2000 years ago he turned water into wine at a wedding in Cana.

Now, as a Christian scientist who believes in the miracles of the Bible, I take issue with both of the views above. But to explain this better, I need to first take a step back and answer two critical questions: What do I mean by science, and what does the Bible say about miracles?

2. Defining Science

The problem of deciding where to draw the lines around science has vexed generations of philosophers. Like many unsolved issues, it has been given its own name—"the demarcation problem." Although one can determine with some degree of consensus what the extremes of the science/non-science continuum are, exactly where the boundary lies is fuzzy. This doesn't mean, however, that we cannot recognize science when we see it[4], but rather that a watertight definition is difficult to create. The old fashioned idea (still taught in many schools) that scientific practice follows a well-defined linear process—first make an observation, then state a hypothesis, and then test that hypothesis—is certainly far too simple.

Science as a tapestry

Rather than attempt to come up with a careful and precise definition of science or scientific practice, I will instead resort to a favorite metaphor of mine. It originates with one of my former teachers at Cornell, the physicist David Mermin, who describes science as a "*tapestry*" woven together from many threads (experimental results, interpretations, explanations, etc.).[5] It is only when one examines the tapestry as a whole that it will (or will not) make a convincing pattern.

Creating scientific tapestries is a collective endeavor building on mutual trust and the communal experience of what kinds of arguments and evidence are likely to stand the test of time. In part because the skill of weaving reliable scientific tapestries relies on subtle judgements, a young scientist may work for years as an apprentice of older and more experienced practitioners before branching out on his own. In this process there are many parallels with the guilds of old. I am fond of this metaphor because it describes what I think I experience from the inside as a scientist. Moreover, it also emphasizes the importance of coherence and consistency when I weave together arguments and data to make an "inference to a best explanation."[6]

The strong communal element inherent in scientific practice has at times been seized upon by sociologists of science to argue that scientific knowledge is just one more type of human construct with no greater

claim on reality than any other form of knowledge. But scientists as a whole have reacted to this proposition in a negative way.[7] Although they agree that all kinds of economic, historical and social factors do play a role in the formation of scientific theories, they would argue that, in the long run, the scientific process does lead to reliable knowledge about the world.

The view of nature embraced by most scientists that I know could be described as critical realism. They are realists because they believe that there is a world out there that is independent of our making. The adjective "critical" is added because they recognize that extracting knowledge about that world is not always straightforward. Thus, the primary role of the collective nature of the scientific process is to provide a network of error-correcting mechanisms that prevent us from fooling ourselves. The continual testing against nature refines and filters out competing scientific theories, leading to advances in the strength and reliability of our scientific knowledge tapestries.

Although there are many commonalities in the ways that scientists in distinct fields assemble their tapestry arguments, there can also be subtle differences. These differences are foisted on us in part by the types of problems that each field attempts to address. For example, as a theoretical physicist I've been trained in a tradition of what the Nobel Laureate Eugene Wigner called "the unreasonable effectiveness of mathematics:"

> *The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning.*[8]

We believe, based on a history of spectacular success, that mathematical consistency among threads is a key indicator of strong tapestries.[9] These days, I spend much of my time interacting with biologists who tend to view my confidence in the ability of theoretical models to extract knowledge about the physical world with great suspicion.[10] I, on the other hand, am often instinctively sceptical of the huge error bars that can afflict their data.[11]

To a large degree, these cultural differences are forced on us by the kinds of questions we study. My reaction above arises because physics is self-limiting. As a community we simply don't deal with problems of the same level of complexity that biology does. If an experiment is too messy we will often define it away by declaring "that isn't physics," and move on. Similarly, molecular biologists can afford to be more selective about their data than medical scientists or psychologists can.[12]

But, despite these cultural differences, which can lead to heated and sometimes frustrating discussion, we do agree on a number of ground rules for defining what makes a tapestry strong. For example, what we either predict or measure should be repeatable. If I claim to see an effect in an experiment, someone else in a different lab should be able to reliably measure the same effect.[13] That simple requirement has many ramifications for the types of problems we are able to address

The limits of science

There are many questions that simply are not amenable to purely scientific analysis. A very lucid discussion of this issue can be found in the book The Limits of Science by Nobel Prize winner (and atheist) Sir Peter Medawar, who wrote:

> *That there is indeed a limit upon science is made very likely by the existence of questions that science cannot answer and that no conceivable advance of science would empower it to answer… It is not to science, therefore but to metaphysics, imaginative literature or religion that we must turn for answers to questions having to do with first and last things.*

and

> *Science is a great and glorious enterprise - the most successful, I argue, that human beings have ever engaged in. To reproach it for its inability to answer all the questions we should like to put to it is no more sensible than to reproach a railway locomotive for not flying or, in general, not performing any other operation for which it was not designed.*[14]

Science's great power derives from its self-imposed limits. It is wrong to ask it to pronounce on issues outside its jurisdiction. In fact, the most important decisions in life cannot be addressed solely by the scientific method, nor do people really live as if they can. In the words of Sir John Polkinghorne, former professor of Mathematical Physics at Cambridge and Anglican priest:

> *We are entitled to require a consistency between what people write in their studies and the way in which they live their lives. I submit that no-one lives as if science were enough. Our account of the world must be rich enough – have a thick enough texture and a sufficiently generous rationality – to contain the total spectrum of human meeting with reality.*

But just because we don't live life by the scientific method doesn't mean that the only alternative is irrationality. For example, if I were to decide to get married, a truly irrational approach would be to pick a random woman off the street. Instead, assuming I find a potentially willing partner, it is wise to go through a period of courtship during which we get to know each other. We may also ask for the opinion of wise friends. There are helpful counseling programs with compatibility lists, etc. that, in fact, often use knowledge that scientific techniques have extracted from our collective experience and wisdom. But at the end of the day I can't demand scientific certainty before deciding to marry someone. Nor is it wise to perform repeatable experiments! I need to make a volitional step because there are aspects of marriage that I can only see from the inside.[15]

Another example of a method used to obtain knowledge is the legal process which, although it is a tightly organized system, is not strictly scientific. Similarly, a historian will use a combination of evidence (e.g. manuscripts) and understanding about the thinking patterns of a particular era to make informed judgements about what happened in the past. Clearly, this big question of how to extract reliable

information about the world, how to separate fact from mere opinion, is indeed a very difficult and important one.

3. Miracles and the Bible

How can we then judge whether or not the miracles of the Bible are reliable? Since the word miracle has taken on so many different meanings, it is important to first examine the biblical language.

The New Testament predominantly uses three words for miracle:

- *teras*, a wonder
- *dunamis*, an act of power
- *semeion*, a sign

Sometimes it combines all three, as in Acts 2:22:

> *Men of Israel, listen to this: Jesus of Nazareth was a man accredited by God to you by miracles (dunamis), wonders (teras) and signs (semeion), which God did among you through him, as you yourselves know.*

The word *teras* (wonder) is almost always used together with one of the other words, emphasizing that the main point of biblical miracles is not to merely elicit amazement but rather to serve a higher theological purpose. For this reason, biblical miracles cannot be understood outside of the theological context within which they occur. They are not anomalous events. This principle provides a key to the proper assessment of their validity.

Nature is what God does

Miracles happen against a backdrop. In this context, it is illuminating to see how the Bible describes God's action in the natural world. For example in Psalm 104, that great poem about nature, we read,

> *He makes springs pour water into the ravines, it flows between the mountains*

The first part of this verse refers to God's direct action while the second part suggests that water flows through its own natural properties. Read the Psalm for yourself and notice how fluidly the point of view changes back and forth between what we might call the laws of nature and the direct action of God. Such dual descriptions can be found throughout the Bible. The New Testament is even more explicit:

> *The Son is the radiance of God's glory and the exact representation of his being, sustaining all things by his powerful word.* (Hebrews 1:3)

and

> *He is before all things, and in him all things hold together* (Col 1:17)

In other words, if God were to stop *sustaining all things by his powerful word,* the world would stop existing. That is why, when describing nature, the Bible so easily switches perspectives depending on whether it is emphasizing the regular behavior of natural phenomena, or their origin in God's providential sustenance. So, as St. Augustine might say,

> *Nature is what [God] does.*[16]

Augustine doesn't mean that nature is the same as God (pantheism), for, as he also argued, God operates outside of space and time. Nevertheless, and this is a very subtle point,[17] a case can be made for ascribing some independent causal power to the laws of nature. On the other hand, there is no room within a robust biblical theism for the opposite deistic notion that God started the world and then left it to run on its own, completely independently, because descriptions of God's continuous care for creation are found throughout Scripture:

> *Are not two sparrows sold for a penny? Yet not one of them will fall to the ground apart from the will of your Father. And even the very hairs of your head are all numbered*. (Matthew 10:29,30)

As Christian thinkers throughout the Middle Ages wrestled with the questions of miracles and God's action in the world, the following ideas emerged: if the regularities of nature are a manifestation of the sustenance of God then one would expect them to be trustworthy and consistent, rather than capricious. The regular behavior of nature could be viewed as the "customs of the Creator" as it were. Christians glorify God by studying these "laws of nature." A strong case can be made that such theological realizations helped pave the way for the rise of modern science.[18]

By the time the Royal Society of London, the world's first scientific society, was founded in 1660, Christian thinkers like the metaphysical poet John Donne, then dean of St. Paul's Cathedral in London, could write:

> *the ordinary things in Nature, would be greater miracles than the extraordinary, which we admire most, if they were done but once... only the daily doing takes off the admiration.*[19]

God of the gaps

A similar sentiment lies behind a famous exchange between those old adversaries, Gottfried Wilhelm Leibniz and Sir Isaac Newton. The latter noticed that the orbits of the planets did not appear to be stable when calculated over long periods, and postulated that the solar system needed occasional "reformation" by God. Leibniz objected that,

> *if God had to remedy the defects of His creation, this was surely to demean his craftsmanship.*[20]

In other words, the regular sustaining activity of God, as evidenced by natural laws, should be sufficient to explain the regular behaviour of the solar system, without the need for additional ad-hoc interventions. Making it right the first time is more glorious than having to fix it later.

In the same context, Leibniz also emphasised the theological nature of miracles:

> *And I hold, that when God works miracles, he does not do it in order to supply the wants of nature, but those of grace. Whoever thinks otherwise, must needs have a very mean notion of the wisdom and power of God*.[21]

A more modern version of Leibniz's general objection can be found in a famous statement by Charles Coulson, the first Oxford professor of Theoretical Chemistry who wrote,

> *When we come to the scientifically unknown, our correct policy is not to rejoice because we have found God; it is to become better scientists.*[22]

He popularized the phrase "God of the gaps" for those who, perhaps like John and Ruth, think that God is found primarily in the lacunas of our scientific understanding.

Two sorts of miracles

Science, as well as tools from historical disciplines, can be brought to bear on biblical miracles. For example they can be split into those that are examples of providential timing (type i miracles) and those that can only be viewed as directly violating physical cause-effect relationships (type ii miracles).

An example of a possible type i miracle would be the crossing of the river Jordan by the people of Israel:

> *Now the Jordan is at flood stage all during harvest. Yet as soon as the priests who carried the ark reached the Jordan and their feet touched the water's edge, the water from upstream stopped flowing. It piled up in a heap a great distance away, at a town called Adam in the vicinity of Zarethan, while the water flowing down to the Sea of the Arabah (the Salt Sea) was completely cut off. So the people crossed over opposite Jericho.* (Joshua 3:15,16)

Colin Humphreys, Cambridge professor of material science, has studied this miracle in great detail[23] and notes that the text supplies a number of unusual clues, including the fact that the water was blocked up a great distance away at a particular town. He has identified this with a location where the Jordan has been known to temporarily dam up when strong earthquakes cause mudslides (most recently in 1927). For many scientists, the fact that God is working through natural processes makes the miracle more palatable:

> *The scientist, even when he is a believer, is bound to try as far as possible to reduce miracles to regularities: the believer, even when he is a scientist, discovers miracles in the most familiar things*.[24]

Of course this doesn't take away from the fact that there was remarkable timing involved. Perhaps the attraction of this description comes in part because there is a direct corollary with the very common experience of "providential timing" of events, which believers attribute to God's working.[25]

There are also miracles in the Bible that defy description in terms of current science. Perhaps the most significant of these is the resurrection of Jesus Christ. If anything, science has strengthened the case for this not being a type i miracle. For example, in John 19:34 we read:

> *Instead, one of the soldiers pierced Jesus' side with a spear, bringing a sudden flow of blood and water.*

Modern medicine suggests that this is clear evidence that the pericardium, a membrane around the heart, was pierced, confirming that he was in fact dead. The more we know about the processes of decay that set in after death, the less likely it appears that Jesus could have risen from the dead by any natural means. Rather, science strengthens the case that if Jesus did indeed rise from the dead, the event must have occurred through a direct injection of supernatural power into the web of cause and effect that undergirds our physical world – it was a type ii miracle. Of course the resurrection is central to Christian teaching:

> *And if Christ has not been raised, our preaching is useless and so is your faith*. (I Corinthians 15:14)

Given that almost every great Christian thinker in history has emphasized the fact that miracles must be understood within the context of a theological purpose, perhaps one could invert this argument and say that it is not surprising that the central event in history would be miraculous.[26]

So where has this argument brought us? I have argued that the precise relationship between miracles and science has been the subject of a long and unresolved debate with strands reaching back to the early Church fathers. Theologians wrestle with questions that concern the differences between God's regular sustaining action and His special non-repeating actions, i.e. miracles, and how these fit in with redemptive purpose. There is a link to the question of demarcation in science, since within a robust biblical theism the regular working of God's action, the "customs of the Creator" (or natural laws) are, almost by design, amenable to scientific analysis. Biblical miracles, in contrast, are always linked to special theological purpose and are therefore, almost by definition, non-repeatable and a-scientific.

4. The decisive significance of worldviews

If Martin and I would have time to get this far in conversation, I'm sure we would have swiftly passed the red herring of natural science being the touchstone upon which to examine biblical miracles. But Martin could point out that Hume made a number of other arguments against miracles, namely:

- Witness testimony is often suspect.
- Stories get exaggerated in the retelling.
- Miracles are chiefly seen among ignorant and barbarous people.
- Rival religions also have miracle stories, so they cancel each other out.

These arguments are substantial, and I refer to footnote 3 for an introduction to the voluminous literature they have inspired. However, we can take a little stab at the first two objections. It is true that witness testimony cannot always be trusted and that stories change with time. But these are the same problems that face legal systems and historians. Nonetheless, we can employ the tools of these professions to examine biblical miracles. Take, for example, the resurrection of Jesus Christ. There is significant extra-biblical historical evidence that he indeed lived. Much has been written about the general trustworthiness of the Gospels. For example, there is much internal evidence, in both the style and content of the narratives, that the writers themselves were convinced that Jesus did indeed rise from the dead. Tradition holds that 11 of the 12 original apostles were martyred for this belief that turned a group of cowards into a people who "turned the world upside down." Although it is well beyond the scope of this essay, a very strong case for the plausibility of the resurrection can be made.[27] Similar analysis can be brought to bear on other miracle claims, including those of other religions. After all, every meaningful system of thought must be open to careful scrutiny.

But I suspect that often, underneath the surface, it is really the third argument that carries the most persuasive force. In part because history is littered with claims for the miraculous that seem bizarre, or smack of superstition, and in part because the incredible advances of modern science and technology inspire awe, we can intensely feel the attraction of identifying with the latter and not the former. This disposition is exemplified in the following quote by the theologian Rudolph Bultmann, a man famous for his attempts to de-mythologize the New Testament:

> *It is impossible to use electric light and the wireless and to avail ourselves of modern medical and surgical discoveries, and at the same time to believe in the New Testament world of spirits and miracles.*[28]

By getting rid of the miracle stories in the Bible, Bultmann and his followers hoped to make the Christian story more palatable to modern man. Although I recognize the emotional weight of this sentiment, I am not convinced that it is an intellectually coherent approach, mainly for reasons of self-consistency. If the New Testamentitself asserts, both directly and indirectly, that the historicity of the resurrection is foundational to Christianity, then it would seem to stand or fall by that fact. As a physicist, I have a natural penchant for wanting to see how an idea relates to more basic principles. And to analyze the validity of a quote like the one above, we must take a cold hard look at our fundamental presuppositions. In the words of John Polkinghorne:

> *If we are to understand the nature of reality, we have only two possible starting points: either the brute fact of the physical world or the brute fact of a divine will and purpose behind that physical world.*[29]

Where does each of those two fundamental starting points take us? When we use them to construct a worldview, what kind of sense does it make of experience, morality, truth, beauty, and our place in the world? These are not easy questions. There is so much mystery around us. Perhaps the best way to move forward would be to borrow Mermin's tapestry analogy and carefully investigate whether the different threads of historical evidence, philosophical consistency, and personal knowledge can be woven together into a worldview that is robust. In particular, does our tapestry posses those qualities of coherence and (surprising) fruitfulness that characterise the best scientific tapestries?

If I start from the brute facts of nature, I personally am unable to construct a tapestry that is both rigorous and rich enough to make sufficient sense of the world. By contrast, if I assume a divine will and purpose behind the world I believe that I can construct a much more compelling tapesty that incorporates all of the threads of human existence. Within that purposeful world, the case for Christianity is much more persuasive. To use a famous quote from C.S. Lewis:

> *I believe in Christianity as I believe that the Sun has risen-not only because I see it, but because by it, I see everything else.*[30]

It is the sum total of all those arguments that convinces me of the veracity of biblical miracles.

Nevertheless, I recognize that no matter how cogent, say, the historical evidence for the resurrection is, if I start from a different worldview, as Martin and Rudolph Bultmann do, then it will be virtually impossible to accept the existence of biblical miracles. (In the end I think this is what Hume is really saying). Miracles cannot be interpreted independently from the theological context in which they function. They are part of a package deal.

I don't know what Martin would make of all that. We would surely need more than one glass of wine to complete this discussion (but wouldn't it be fun?).

5. Conclusion

Finally, what would I say to John and Ruth? If they are like many Christians I know, they might feel a slight uneasiness with science, a subconscious fear fed by the pontifications of some popularizers who seem keen to equate science with atheism.[31] So perhaps I would first point out the obvious limits of science. But then I might tell the story of Leibniz and Newton's exchange, and point out that Newton was a good enough theologian not to turn the alleged instability of the planets into a God of the gaps argument. Similarly, if it is true that we don't yet understand how birds can navigate so accurately over large distances, then surely it would bring more glory to God to search for the mechanisms by which such remarkable feats are accomplished:

> *It is the glory of God to conceal a matter; to search out a matter is the glory of kings*.
>
> **Proverbs 25:2**

Perhaps because evolution has been a particularly favorite bludgeon of the science = atheism cabal, a Christian mini-industry has sprung up to debunk it. Unfortunately, this only feeds the public misperception that the core of the conflict between science and faith concerns scientific mechanism (evolution did or did not occur) rather than one of the philosophy and interpretation of science. God could, of course, have regularly used miracles to create throughout the time-span of natural history. He is free. But whether he did so in natural history is fundamentally a question of Biblical interpretation.[32] Surely it is even more glorious if God could design a physical system that creates itself through the regularities of his sustaining action. Like many of my Christian scientific colleagues who hold to a high view of Scripture, I believe the biblical text allows itself to be interpreted in this way, that sentient beings arose primarily through the ordinary "customs of the Creator," and that moreover it glorifies God to seek to understand these patterns.[33]

John and Ruth might then ask: if I emphasize the integrity of the regular action of God in sustaining the universe, and even in creating us, then why should miracles occur at all? Can they occur today? Rather than answer that theological question directly, let me resort to a musical analogy borrowed from Colin Humphreys. Suppose you are watching a pianist play a classical piece. You will notice that there are certain notes that he plays, and certain ones that he never does. The choice of notes is constrained because the music is being played in a particular key signature. But then, occasionally he may break this rule and play an unusual note. Musicians call these accidentals, and a composer can put them in wherever she likes (although if there are too many the music would sound strange). As Humphreys puts it,

> *If he is a great composer, the accidentals will never be used capriciously: they will always make better music. It is the accidentals which contribute to making the piece of music great. The analogy with how God operates is clear: God created and upholds the universe but, like the great composer, he is free to override his own rules. However, if he is a consistent God, it must make more sense than less for him to override his rules.*[34]

Notes

1. Alister McGrath, Dawkins' God: Genes, Memes and the Meaning of Life, (Blackwell, Oxford 2005) p 92.
2. A good example of this is Richard Dawkins, The God Delusion, (Bantam, London 2006)
3. David Hume, Enquiry Concerning Human Understanding and Concerning the Principles of Morals, (1748). Hume's argument has often been criticized for being self-referential. He at first presupposes that no reasonable person can believe that the laws of nature can be violated, and then concludes that miracles cannot occur because he defines them as violations of the laws of nature. Note that this analysis is not accepted by all commentators. Colin Brown, Miracles and the Critical Mind, (Paternoster, Exeter, 1984) provides a lucid overview of the debate. See also John Earman, Hume's Abject Failure. The Argument against Miracles (Oxford University Press, Oxford 2000) for a critical view, and Peter Harrison, "Miracles, Early Modern Science, and Rational Religion", Church History 75 (3) pp. 493-511 (2006) for an interesting historical perspective.
4. I am reminded of a famous quote by US Supreme Court judge Potter Stewart who, when asked to distinguish between art and pornography, noted that although it was hard to define: "I know it when I see it" (Jacobellis v. Ohio (1964)).
5. N. David Mermin, "The Golemization of Relativity", Physics Today **49,** 11–13 (1996)
6. Peter Lipton, Inference to the Best Explanation, (Routledge, London, 2004)
7. In the 1990's this tension between sociologists and the scientific community erupted into the so-called 'Science Wars'. For a good overview, see e.g. J. A. Labinger and H. Collins (eds), The One Culture? A Conversation about Science, (University of Chicago Press, Chicago, 2001).
8. Quote from Nobel Prize winner E. Wigner, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences", Communications in Pure and Applied Mathematics, vol. 13, No. I (February 1960).
9. An iconic example would be Paul Dirac's 1928 prediction of anti-matter, which he showed to be necessary to satisfy the mathematical consistency constraints imposed by combining quantum mechanics and special relativity for electrons. See P.A.M. Dirac, Proc. Roy. Soc. A, **117**, 610 (1928).
10. The cultural differences between more mathematically minded physical scientists and more empirically minded biological scientists are discussed by Evelyn Fox Keller, in a fascinating book: Making Sense of Life: Explaining Biological Development with Models, Metaphors, and Machines, Harvard University Press, Boston (2002).
11. Such instinctive reactions are what make interdisciplinary research so difficult. Clearly biology has been incredibly successful despite its differences with my scientific culture.
12. I also suggest that as the questions we ask become difficult (often the case for applied subjects like medicine), the tapestries, by necessity, become more fragile.
13. I realize that this is more subtle for historical sciences like geology and cosmology (we have, for example, only observed one universe). Nevertheless, even in these fields, parallel concepts apply.
14. P.B. Medawar, The Limits of Science, Oxford University Press, Oxford (1987).
15. There are interesting analogies here to making a religious commitment. Christians would argue that important aspects of the Christian life can only be understood and experienced from within a relationship with Christ. That is not to say that a step of faith is just a blind leap in the dark. It should be a decision that is informed by careful thinking and weighing of evidence. But it is more than just that.
16. Augustine, Literal Commentary on Genesis, c AD 391
17. See e.g. C. J. Collins, Science and Faith: Friends or Foes? (Crossway, Wheaton, 2003) ch 11.
18. See e.g. R. Hooykaas, *Religion and the Rise of Modern Science*, (Eerdmans, Grand Rapids,1972)
19. John Donne (Eighty Sermons, #22 published in 1640)
20. John Hedley Brooke, Science and Religion , CUP, Cambridge (1991), p147.
21. Leibniz, as quoted by C. Brown, Miracles and the Critical Mind, (Paternoster, Exeter, 1984)*, p 75.*
22. Charles Coulson, *Christianity in an Age of Science*, 25th Riddell Memorial Lecture Series, Oxford University Press, Oxford, (1953).
23. Colin Humphreys The Miracles of Exodus: A Scientist's Discovery of the Extraordinary Natural Causes of the Biblical Stories, (Harper Collins, San Francisco, 2003).
24. R. Hooykaas, *op cit*
25. One could argue that God must nevertheless employ divine action to set up the conditions necessary for a type i miracle to occur at the right time. In that sense both kinds of miracles may involve violations of normal physical cause-effect relations, but in type i this is more hidden. Note that I am not arguing that miracles break ultimate cause-effect relationships. Within a divine economy, they may make perfect causal sense. Language like "violation of physical cause-effect" reflects our limited access to the mind of God.

26. The Cambridge evolutionary biologist Simon Conway Morris notes: "*I am not surprised at those [NT miracles] reported, I am surprised that they are so few. What else would you expect when the Creator visits his Creation?*" Hulsean Sermon, Great St. Mary's Cambridge 26 Feb, (2006).
27. For a popular exposition I recommend the classic Who moved the Stone?, (Faber and Faber, London, 1975) written by a lawyer, Frank Morrison, who initially set out to disprove the resurrection. For a more sophisticated and modern discussion I recommend The Case for the Resurrection of Jesus, G. Habermas and M. Licona (Kregel, Grand Rapids, 2004) and The Resurrection of the Son of God, N.T. Wright (SPCK, London 2003).
28. R. Bultmann in Kerygma and Myth: A Theological Debate, ed. H. W. Bartsch, trans. R. H. Fuller (New York: Harper & Row, 1961), 5.
29. John Polkinghorne, Serious Talk: Science and Religion in Dialogue, (Harrisburg: Trinity Press International, 1995).
30. This quote comes from the essay "Theology as Poetry", in C.S. Lewis, *The weight of glory*, Harper Collins, San Francisco (2001)
31. Richard Dawkins would be a prime example. Of course he is entitled to his philosophical views and is welcome to popularize these. But I worry that when science is used to justify unbelief, or a host of other issues that it in fact has little to say about, the end result is even more anti-science feeling amongst the general public.
32. We don't have direct access to the mind of God. We therefore need special revelation to know when, for his own redemptive purposes, God performed miracles in the past. See e.g. E. Lucas, Can we believe Genesis today?, (IVP, Leicester 2001),
33. See e.g. D. R. Alexander, Rebuilding the Matrix: Science and Faith in the 21st Century, (Lion, Oxford, 2002); D.R. Falk, Coming to Peace with Science, (IVP, Downers Grove, 2004); F. S. Collins, The Language of God: A Scientist Presents Evidence for Belief, (Free Press, New York 2006). Note that these authors believe that God can still act miraculously today if he chooses to.
34. Quote from C. Humphreys, http://www.st-edmunds.cam.ac.uk/faraday/CIS/humphreys/Humphreys_lecture.htm. I realize that the question of *why* God does, or, more importantly, does not perform a miracle, is a particularly vexing one, especially when a miracle would alleviate innocent suffering. As critical (and interesting) as the relationship between miracles and theodicy is, it unfortunately falls outside the scope of the present essay.