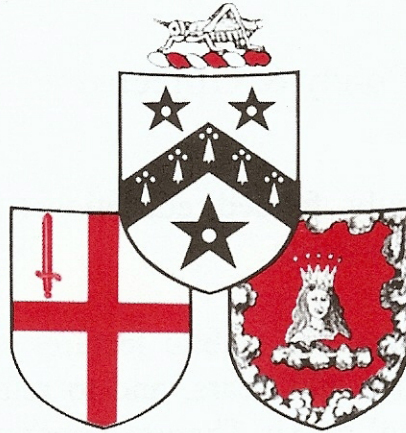


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Gresham Special Lecture

Science and Theology: Traffic Across the Frontier

delivered by

*The Revd. Dr John Polkinghorne F.R.S.
President, Queens' College, Cambridge*

at the Church of St. Lawrence Jewry-next-Guildhall, London EC2

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Science and Theology - Traffic across the Frontier

I am a passionate believer in the unity of knowledge - that we must seek to integrate our understanding of the richly complex and multi-layered world in which we live. Both science and theology explain aspects of the reality of that one world. In consequence I do not believe they contradict each other or are in conflict. Instead I believe they compliment and enhance each other and it is the thesis of how this might happen - how this is fruitful traffic across the frontier - which I wish to explain this evening.

I speak from within the western Christian tradition. That tradition's approach to the physical world has been characterised by a commitment to reality, a search for rationality, and an acknowledgement of contingency. It has been agreed, with some plausibility in my view, that just such an ideological setting was the necessary matrix for the development of modern science, thus making it intelligible why science first arose in Europe rather than say, China.

Theologically, the reality of the physical world and the value set upon investigating it, derive from the doctrine that it is God's creation. That world's rational structure, apprehended by science, is taken to be an expression of the Mind of the Creator. I shall return to that issue later. Theologically, the contingency of the world is a reflection of God's freedom to create whatever he wills. For science it implies the necessity of experiment and observation: we have to look and see how things actually are. A similar necessity is placed upon theology, with the implication, *inter alia*, that it must listen to what science has to say. The theologian cannot discourse on the doctrine of creation without condescending to pay attention to what is actually found written in the Book of Nature. In both disciplines, as their histories show, we must be prepared for surprises. Our power of rational prevision is strictly limited.

What then is the mutual relationship of science and theology? Each has its own decent degree of autonomy. We have every reason to believe that scientifically possible questions will prove to be scientifically answerable. In that sense, science requires no assistance from theology. To suppose the contrary would be fall into the error of the God of the gaps. Equally, theology is concerned with its own phenomena (in essence, the experience of the presence of God) and the understanding of these phenomena. Science, because of its self-defining limitation to a restricted class of generalisable, largely impersonal, occurrences (a restriction itself the very enabler of science's success) is in no position to endorse or deny the claims of religion. To suppose the contrary would be to fall into the error of scientism. Yet the two disciplines are not completely separable. There is an inescapable degree of interaction between their world-views, but one which is not symmetrical in form across the boundary. The asymmetry arises from the nature of theology. To be concerned with questions of God is to be concerned with the totality of all that is real. Necessarily, theology must take account of the deliverances of all the varieties of human inquiry whether they be those of science into the physical world, or aesthetics into beauty, or ethics into goodness, or its own 'particular' domain of revelatory encounter with the divine. I have written of theology that 'If it is to lay claim to its medieval title of the Queen of the Sciences that will not be because it is in a position to prescribe the answers to questions discussed by other disciplines. Rather it will be because it must avail itself of their answers in the conduct of its own inquiry, thereby setting them within the most profound context available. Theology's regal status lies in its commitment to seek the deepest possible level of understanding'.

What theology can do for science is to provide answers to those meta-questions which arise from science but which are not themselves scientific in character. The role of theology as providing the ultimate quenching of the thirst for an understanding through and through is one which has been particularly stressed in the tradition stemming from Thomas Aquinas. A twentieth century Thomist thinker, Bernard Lonergan, wrote of God as 'the unrestricted act of understanding, the eternal rapture glimpsed in every Archimedean cry of Eureka'.

What science can do for theology is to tell it what the physical world is actually like. In so doing it imposes conditions of consonance which the broader considerations of theology must respect. The doctrine of creation has to respond to the fact that the history of the universe is one of simplicity evolving into complexity over billions of years, rather than the springing-into-being of a ready-made world a few thousand years ago. That will surely encourage thought of a Creator who is patient and subtle in his operation. The need for consonance with the findings of science can be a healthy corrective for theology, whose persistent temptation is to indulge in ungrounded speculation.

I want to illustrate these general observations by giving two examples of meta-questions (theology's gifts to science) and three examples of the constraining demands of consonance (science's gifts to theology), taken largely from the experience of contemporary physics.

Let us take the meta-questions first. I begin with intelligibility. One of the most striking features of the physical world is its rational transparency to us. We have come to take it for granted that we can understand the universe, but it is surely a highly significant fact about it that this is the case. Einstein once said that the only incomprehensible thing about the universe is that it is comprehensible. He was referring to what Eugene Wigner, in a memorable phrase, called the 'unreasonable effectiveness of mathematics'. Time and again we have found that the physical theories which fit the facts are characterised in their formulation by the unmistakable quality of mathematical beauty. It is an actual *technique* in fundamental physics to seek theories endowed with mathematical economy and elegance, in the (historically justified) expectation that they will be ones which describe the way the world actually is. There is a marvellous congruence between the workings of our minds (the mathematical reason within it) and the workings of the physical world (the scientific reason without). Of course, up to a point the need to survive in the evolutionary struggle provides an explanation of why this is so. If our thoughts did not match in some degree the world around us we should all have perished. But that can only apply to the relation of everyday experience (the world of rocks and trees) to everyday thinking (counting and Euclidean geometry). Wigner was not talking about anything as banal as that. He had in mind such things as the counterintuitive quantum world, whose strangeness is made sense of in terms of highly abstract mathematical entities. It is hard to believe that the ability to conceive of quantum field theory is just a spin-off from evolutionary competition.

Science does not explain the mathematical intelligibility of the physical world, for it is part of science's founding faith that this is so. Of course, we can always decline to put the question, shrug our shoulders and say 'That's the way it is, and good luck for you mathematical chaps'. It goes against the grain for a scientist to be so intellectually supine. The meta-question of the unreasonable effectiveness of mathematics insists on being answered. A coherent and elegant explanation would lie in the theological claim that the reason within and the reason without are linked together by their common origin in the Rationality of the Creator. The physical universe seems shot through with signs of mind. That is indeed so, says the theist, for it is God's Mind that lies behind its

rational beauty. I do not offer this as a knockdown argument for theism - there are no such arguments, either for or against - but as a satisfying insight which finds a consistent place in a theistic view of the world.

Secondly, let us consider the Anthropic Principle. I shall not rehearse in detail the many considerations that have led people to the conclusion that a physical world which is fruitful in evolving complexity out of simplicity, to the degree that an almost homogeneous ball of energy becomes, after fifteen billion years, a home for self-conscious beings, such a universe is not in scientific terms 'any old world', but rather one which is very special in a finely-tuned balance of its law and circumstances. To get the flavour, consider the question of stars. A fruitful universe needs stars for two reasons. One is as a source of energy for life. Almost all our energy in Earth comes ultimately from the Sun. That means that one must arrange for steadily burning, long-life stars - main sequence stars as we call them. But these stars have a second purpose to do, which is to make the elements out of which living matter is ultimately to be formed. The big bang will only give you hydrogen and helium; all the rest has to be cooked up in the stellar nuclear furnaces. Every atom of carbon in your body was once inside a star. We are all made from the ashes of dead stars. So you have to be sure that stars will indeed make all the elements, in suitable abundance, and then that some will explode as supernovae at the end of their lives, so that the element they have made becomes available elsewhere and are not locked up useless in the cooking can of a dying star (and it turns out that only in that terminal explosion can you actually make the very heaviest elements). All that sounds complicated - and it is - and only the most subtle, delicate, finely-tuned balance between the fundamental forces of nature makes it possible at all. A fruitful universe is very special - one in a trillion you might say. Notice that we are referring in the Anthropic Principle, not to particular occurrences within cosmic history, but to those natural laws which are the necessary ground of all such occurrence. Firstly these laws contain certain parameters specifying the intrinsic strengths of the forces of nature. Secondly, the laws take particular forms - in our universe they are quantum mechanical and, more specifically, they appear to correspond to spontaneously broken gauge theories. Thirdly there are also certain givens about our universe itself (its size, for instance) which play an important part in determining its history. The Anthropic Principle suggests that quite small variations in any of these fundamental specifications of our world would have rendered it anthropically sterile. They would have condemned it to a boringly unproductive history.

If we accept this view, then a meta-question arises of why things are this way. That seems to me to be the interesting form of inquiry, stronger in intent than the 'Weak Anthropic Principle' (which simply observes that our presence in the universe necessarily imposes certain constraints of consistency, requiring its circumstances to be compatible with that fact), and not as scientifically pretentious as the 'Strong Anthropic Principle' (which purports to claim that the universe **must** be such that the observers arise within it. Instead one has what one might call the 'Moderate Anthropic Principle' which notes the contingent fruitfulness of the universes as being a fact of interest calling for an explanation. Of course, if things were not that way we would not be here to worry about them, but it does not seem enough just to say 'We are here because we are here' and leave it at that. Instead there is a hint of an amazing anti-Copernican revolution. We do not live at the centre of the universe, but it does look as though the very fabric of the cosmos has been given a character which is required if the emergence of beings like us is to be a possibility. There seems to be the chance of a revised and revived argument from design - not appealing to Paley's Cosmic Craftsman working within physical process (which process science explains in a way not requiring intervention by such a God of the gaps) - but appealing to a Cosmic Planner who has endowed his world with a potentiality implanted within the delicate balance of the laws of nature

themselves (which laws science cannot explain since it *assumes* them as the basis for its explanation of the process). In short, the claim would be that the universe is indeed not 'any old world' but the carefully calculated construct of its Creator. The 'Strong Anthropic Principle' is then seen to be an intuition teleological truth, but of a theological rather than scientific character.

It is necessary to consider a number of arguments advanced in rebuttal of such a claim:

(i) Perhaps there is in fact only one possible world; that it is an illusion that things could have been different. Perhaps the strengths of the fundamental forces have to be just what they are for reasons of consistency. [A more sophisticated version would say that there are different cosmic domains of symmetry breaking in which the force ratios take different values, but if there are enough such domains then one of them will be within anthropic limits, and that's where we live because we could not turn up anywhere else]. Such claims of a rational inevitability in the way things are have recently had some fluctuating degree of popularity among physicists. They spring from the difficulties encountered in fully reconciling quantum theory and general relativity, with the consequent speculation that there might essentially be only one way in which to do so. But even if that proves to be the case, we have already built in powerful tacit specifications of the worlds that we are prepared to talk about. They have to be quantum mechanical, contain Einsteinian gravity, and so on. I see no reason why among possible worlds there should not be a Newtonian world, made up of billiard ball atoms and with gravitational action-at-a-distance, or a world without gravity altogether and consisting of just electrons and photons. For sure, they would not be an anthropically fruitful worlds, but that's what we are discussing. I don't think the uniqueness argument stands up. Even if it did, it would surely be rather remarkable that the only possible universe was a fruitful one.

(ii) At the other extreme, perhaps there are lots and lots of different universes, each with its own law and circumstances and existing independently of each other. In that case, it would be no more surprising that *one* of them fulfilled the anthropic condition than it would be to find an almost spherical pebble if one had sorted over a million specimens in the first place. Once again it would be that particular universe that we live in because we could not turn up anywhere else. This 'portfolio of universes' approach has been quite popular in one way or another. It can be tricked out in various scientific-sounding ways (by *illegitimate* invocation of many-worlds quantum theory, or by speculations about vacuum fluctuations of ur-stuff, for instance) but it seems to me not to be a scientific proposal at all (for scientifically we only have adequate motivation to speak of this particular universe of our actual physical experience). Rather it is a metaphysical guess. Its interest lies in the fact that by making such guesses people indicate clearly that they feel there is really something calling for an explanation. To my mind a metaphysical speculation of equal coherence and greater economy is that there is just one universe, anthropically finely-tuned because it is the creation of a Creator who wills it to be capable of fruitful purpose. Again, I present that as a proffered insight, not a knockdown argument.

(iii) The most interesting counter-argument is that the Anthropic Principle is the fruit of limited imagination, for its questions of balance centre around the conditions necessary to ensure the eventual development of carbon-based life. Perhaps intelligence and self-consciousness could have totally different embodiments, not based on carbon chemistry - a thinking plasma maybe. Perhaps all universes (or a great many) are capable of producing their own idiosyncratic forms of 'life'?

Perhaps...But those who speak this way are drawing a very large intellectual blank cheque on an unknown account. The only form of intelligent and self-conscious life that we know about is carbon-based. When one considers the physical complexity of the human brain (far and away the most intricately interconnected physical system we have ever encountered), it is difficult not to believe that this degree of structure is necessary as the physical substrate sustaining self-consciousness, and it is very hard to believe that there are many radically different ways of realising naturally such a necessary complexity. Our knowledge of how brain and mind relate is so pitifully rudimentary that no one can be dogmatic about what is possible, but I regard it as wholly reasonable not to entertain seriously this ground for rebutting the claim of anthropic significance.

Having said all that, I do not doubt that some anthropic 'coincidences' which now seem special may be found to result from other deeper, linkages, (So-called inflationary cosmology - the primeval boiling of space - has already provided one possible example of how this might happen, in relation to the anthropic requirement that cosmic expansion and gravitational attraction must be very evenly balanced in a fruitful universe, which must neither become too dilute nor suffer too prompt collapse.) However, I think it is reasonable to expect that there will still be some things distinctly and minutely particular about a world capable of producing men and women. I therefore conclude that there is indeed a meta-question arising from Anthropic Principle considerations to which theism provides a persuasive (but not logically coercive) answer.

Let us now consider some constraints of consonance which science might seem to lay upon theological thought. We will start with (a) Origins. Perhaps no subject has given rise to more confusion in the inter-relationship of science and theology than the question of how things began. It has often erroneously been supposed that the Christian doctrine of creation is principally concerned with initiation, with the primary instant. To think that is to confuse Christianity with deism. The doctrine of creation is concerned, not just with what God did, but with what he is doing; its subject is ontological origin, not temporal beginnings. It seeks to answer Leibniz's great question; Why is there something rather than nothing? Its central assertion is that the physical world, at every instant of its existence, is held in being by the will of God. Two consequences follow. The first is that if physical cosmology delivers us a dateable moment when the universe as we know it spring forth from the Big bang, that is scientifically very interesting but theologically neutral. There never was a theological stake in preferring big bang cosmology to steady state cosmology. Secondly, and conversely, if physical cosmology were to abolish a dateable beginning for the world, no great theological upheaval would follow. Stephen Hawking, in his book 'A Brief History of Time', has proposed a highly speculative, but just conceivably correct, quantum cosmology in which the universe is a kind of fuzzy spacetime egg with no sharp beginning. He says 'If the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end; it would simply be. What place then for a creator?' It is theologically naive to give any other other answer than 'every place' - as the ordainer and sustainer of the spacetime egg. God is not a God of the Edges, with a vested interest in boundaries. In fact there is a contemporary current of thought in theology, particularly associated with the German theologian, Jürgen Moltmann, which stresses the gift of a genuine 'otherness' made by a loving Creator to his creation, and which would find very consonant physical realisation in a universe 'really completely self-contained'. If there are problems for Christian theology in cosmological thought they lie, not in questions of origins, but in the question of

(b) The End. Cosmologists not only peer into the past but they can also attempt to descry the future. On the grandest scale, cosmic history is a tug of war between two opposing principles: the explosion of the big bang, throwing matter apart, and the pull of

gravity, drawing matter together. They are very evenly balanced and we do not know which will win. Accordingly, we have to consider two alternative scenarios for the universe's future. If expansion wins, the galaxies will continue to fly apart for ever. Within themselves gravity will certainly win and they will condense into gigantic black holes, eventually decaying into low-grade radiation. That way lies cosmic death. The alternative scenario presents no more cheerful a prospect. If gravity wins, the present expansion will one day be halted and reversed. What began with the Big bang will end with the Big Crunch, as the universe falls back into a singular cosmic melting pot. That way lies collapse.

On the face of it, the ultimate prospects are bleak. What does that imply for theology's claim that there is a purpose at work in the world? Christian orthodoxy has never subscribed to an evolutionary optimism which expects a total fulfilment of divine will to be brought about within the flux of present physical process. If there is a true and lasting hope - and it is a deep human intuition that there is such an hope - then it can only rest in the eternal mercy and faithfulness of God himself. Christians believe that for themselves (for, after all, our bodies will decay on a time scale of tens of years) in their assertion of a destiny beyond death, and they can believe it as well for the whole universe (whose decay will be on a time scale of tens of billions of years). We need to embrace a cosmic hope as well as a personal hope, for it would be far too anthropocentric simply to regard this vast universe as being of concern to God only as the backdrop for a human drama which has just started after an overture lasting fifteen billion years. It is, of course, beyond our feeble powers of imagination to conceive what that act of cosmic redemption will be like, but if there is true hope it lies in God and not in physics.

Some of those unable to embrace a hope arising from casting oneself on divine faithfulness have engaged in ingenious speculation about whether there might nevertheless be some form of adequate fulfilment attainable within physical process. As cosmic circumstances change radically within the universe's evolving history, the embodiment of intelligence would have to adapt itself to what is going on. Carbon-based life would have to give way to successors which it had itself produced by conscious design. There might eventually indeed be 'thinking plasmas', engineered by their predecessors in the great chain of intelligent being. In this way, even within the chronologically finite history of a collapsing universe, there could be such rapidly accelerating processing of information that a kind of infinite 'psychological' history would be able to unfold. This kind of 'physical eschatology' has been pursued particularly by Freeman Dyson and Frank Tipler. Tipler exhibits great speculative ingenuity. Even to the point of supposing that as embodied intelligence approached its ultimate phase (which he calls Omega and equates with a kind of physical realisation of God) it could recover traces of our past lives and reconstitute isomorphic models of ourselves in a final act of 'resurrection'. It seems to me that it is an etiolated and abstract generalised hope that his fast-racing cosmic computers would fulfil. In contrast, the Christian hope is that nothing of individual and particular good is ever lost in the Lord, and that a future awaits us of unending exploration of the riches of divine reality.

(c) Chance and Necessity. As we survey the cosmic process which has carried the world from initial simplicity to present differentiated complexity at every stage the realisation of anthropic fruitfulness has depended upon an interplay of two opposing tendencies, which we can conveniently summarise in slogan form as 'chance' and 'necessity'. By chance is meant just happenstance, the way things come together in an essentially uncorrelated sequence of occurrences: a fluctuation produces a little more primeval matter here than there; a genetic mutation produces a new characteristic of animal life. Through such novel offerings of chance there came about the condensation

of the galaxies and the origin of new species. Yet, for those things to happen also requires the operation of lawful necessity to preserve and sift the novelty provided; gravity enhancing the matter fluctuation; evolutionary biology operating within a stable, and so effectively selective, environment.

Some have felt that the role assigned to chance subverts religious claims of a Purpose at work. After all, what will eventually happen is not foreseeable at the beginning. The universe is given something of the air of a game of cosmic roulette. With characteristic Gallic rhetoric, Jacques Monod, whose book 'Chance and Necessity' spoke of 'pure chance, absolutely free but blind, at the base of the stupendous edifice of evolution'. For him the role of chance turned cosmic history into a tale told by an idiot, full of sound and fury, signifying nothing.

At times one feels that Monod lost sight of the indispensable, complementary, role of necessity, with its implications of finely-tuned anthropic law. If one attempts a more even-handed evaluation of the interplay of chance and necessity, then an alternative metaphysical interpretation becomes possible which is, in my view, fully consonant with Christian theology.

The Christian God is both loving and faithful. The gift of the God of love to his creation will surely be freedom. He will prove to be no Cosmic Tyrant, holding all in tight control. Yet freedom by itself can only too readily degenerate into licence and chaos. The gift of the God of faithfulness will surely be reliability. He will prove to be no Cosmic Lord of Misrule. Yet reliability by itself can only too readily degenerate into an iron rigidity. We may expect the creation of the God who is both loving and faithful to display characteristics of both openness and regularity, such as are in fact reflected in the physical interplay of chance and necessity in the process of the world.

A doctrine of creation of this open yet regular kind can indeed be found in contemporary Christian theology, not only in the writings of Moltmann, but also in the work of the English theologian, W H Vanstone. He is motivated, not by acquaintance with the scientific story, but by profound meditation on the necessary precariousness and value of any act of creation by love. This leads him to write in 'Love's Endeavour, Love's Expense, 'If the creation is the work of love, then its shape cannot be predetermined by the Creator, nor its triumph foreknown; it is the realization of vision, but of vision which is discovered only through its own realization'. Such an account is perfectly consonant with the scientific insight of the realization of anthropic fruitfulness through the shuffling explorations of happenstance.

This understanding can afford us some help with what is for theology the most painful of its difficulties. I refer, of course, to the problem of evil. Some modest help with the question of moral evil (the chosen cruelties of humankind) is given by the so-called free-will defence. It asserts that a world of freely choosing beings is better than a world of perfectly programmed automata, however destructive some of those choices may be. Our instinctive recoil from coercive measures such as the castration of persistent sex offenders, shows us that we accord some force to this insight. However it leaves untouched the problem of physical evil (disease and disaster). I believe this needs what I have called the 'free-process defence', appealing to the divine gift of freedom to *all* of the creation, not just to human kind alone.

Austin Farrer once asked himself what was God's will in the Lisbon earthquake. His answer - hard but true - was that the elements of the Earth's crust should act in accordance with their nature. God wills neither the act of a murderer nor the incidence of a cancer; but he allows both to happen in a world to which he has granted the

freedom to be itself.

I am both a priest and a physicist. I want to hold these two sides of me together, without dishonesty and without compartmentalisation. I do not want to be a priest on Sundays and a physicist on Mondays. I believe that I can do that - not without some puzzlement, to be sure, - but with integrity and, I have tried to show, some mutual enlightenment. I do not believe the frontier between science and theology is one that must be heavily fortified on each side. Rather there is a pleasant and fruitful traffic across that open border