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*Can I begin by asking you about your background in astrophysics?*

I started by reading Mathematics here in Cambridge, and then moved to Oxford to do a doctorate and a couple of years' post-doctoral research in astrophysics. I had a wonderful supervisor, Dennis Sciama, who had been an inspiration lecturing me in Mathematics in Cambridge in such areas as General Relativity and so on, and cosmology. So I moved to study under him when he moved to Oxford. I was studying a rather specialised problem to do with galaxies and the later stages of galaxy evolution, the accretion of inter-galactic gas by our own galaxy in particular. That does have a relationship with cosmology. One of the problems that's still around today is to do with how much stuff there is in the universe – matter, energy and so on. That has moved on a lot in those years from just inter-galactic gas (which is kind of normal stuff) to more exotic kinds of things. But nevertheless that research had that cosmological import.

*You moved on from that area of science – cosmology and astrophysics, to become a minister in the Church of England, which seems a fairly strange thing to do.*

Well yes, perhaps especially after an interlude of fourteen years working in defence, working as a consultant to the UK Ministry of Defence, and doing operational research. I'd thought about ordination when I was still at Oxford. I had a very good Chaplain of my college in Oxford, who was helpful. But I thought I'd been in ivory towers rather a long time at that point and should go out into 'the world.' so to speak. So I did that job. I got married seven years into that, half-way into that period and again discussed ordination with my wife but then things plodded on. There were a number of factors in the end leading towards it, one of which was writing my first book that was called, 'Nothing but Atoms and Molecules.' Because I'd given talks to church groups on this sort of thing, on Science and Religion, if they realised you'd got a Science background, particularly with cosmology somewhere there, then people tend to ask for that. It was suggested by a friend of ours that I write a book on this. So I did in the end, and reading much more widely theologically at that point, was also very formative, as well as the book itself. There were some more personal things involved too. My wife and I found that we couldn't have children, and that was a traumatic thing to go through. She had an ectopic pregnancy, which nearly killed

her. It was extremely life-threatening. We had people praying for us that we'd have children, and that never happened in quite that way, anyway. But it was a factor, because it meant that when we were coming through that we were starting to ask where was God leading in all this, and what does this enable us to do that we wouldn't otherwise do. I think upping sticks and going off to theological college, and not having the worry of children and their education - it was freeing from that point of view. Then there were changes in my work that were coming along and I wasn't entirely happy with the way things were going. I asked myself, should I be doing the same kind of work in another company, working for the MOD doing the same kind of thing, or something radically different? Actually my wife and I spent a long time just praying about this, going on retreats and so on for about six months, and keeping this idea to ourselves. Then, interestingly, one or two people again were saying they could see me doing that, being at theological college. So there were a number of pointers. Then I started the ball rolling with the Rector of my church in London. He set in wheels the mechanisms of the Church of England, that grind rather slowly. But that was a good period too, still continuing to think and pray it through, before finally going before a selection conference, being selected, and ending up at Wycliffe Hall. There were so many confirming things during that period, when I first went to Wycliffe, and since. Indeed, it's been wonderfully life transforming to make that change of direction.

*Now you're at the Faraday Institute. You're working on the boundary of both science and faith issues...*

Well I am. How that came about is interesting too. One of the great things was that, even though I was rather elderly, the church paid for me to do a degree at Oxford in Theology, which I absolutely loved. It was incredibly intense. If you're forty-four and going to do a BA in Theology in two years, then followed by a diploma, it's incredibly intense, but it was just the right course for me. So there was, when it was reported back to my selection conference, which went to the Bishop and so on, that they could see me as a future theological educator, that was always somewhere in the background. But I did the normal church things and was ordained and was a curate in South Warwickshire, spent a wonderful period of seven months in Heidelberg in Germany, where I was Chaplain of the English Church, and then priest in charge of three churches in Buckinghamshire before coming here. I loved that ministry, the hands on ministry, and the being with people and the pastoral side of things and leading worship and so on. That was great. I was able, particularly during the period

in Germany, to do some academic work on the side. It was getting more difficult, really. I produced my second book while I was still a priest in charge of these three busy parishes in Buckinghamshire. But finding the time for that as well as the parish work was difficult. Then this opportunity came along which I heard was going to be advertised. I heard that on the grapevine, and agonised a lot about it actually, whether it could possibly be the right thing, since I'd barely been in the parish three years, and I felt it would be letting them down somewhat. But, eventually I saw my Bishop there. He said you just ought to go for this because it combines all your interests and so on, so I came and was interviewed and offered the job, so it was a tremendously exciting new thing. So there's part of me, the more pastoral and more liturgical side, if you like, that is much less to the fore now. It's not entirely absent, because I help out a little bit where we worship in Cambridge, and preach in College chapels and so on from time to time. So some of that is still around but the main focus now is academic, doing this job within the Faraday Institute, and running courses and continuing to do research. And speaking here, there, and everywhere about Science and Faith issues. So that's been great and I think a tremendous vision actually that Denis Alexander and Bob White (who were here already as Fellows of St Edmunds College) had for this Institute.

*Let's move on to the specific issue of cosmic fine-tuning. We hear quite a bit about cosmic fine-tuning. Can you explain in simple terms what it actually means?*

Essentially it relates to the Big Bang theory of the origin of the universe, which is very well established: the scientific theory of how the universe began in a gigantic fireball some 13.7 billion years ago, and that gets more and more accurate as time goes by. The fine-tuning relates to that, because it asks the question, 'What if things had been different?' What if the initial conditions of the universe had been slightly different right back at the Big Bang? If, say, the mean density of the original matter and energy had been different? The kind of stuff I was looking at way back when I was doing research myself, but now we know there's more to it than just ordinary matter. Whether that, were it slightly different, would make any difference to the way the universe evolved. Whether, if we tweaked the constants - the constants that determine how strong the various forces of nature are (the gravitational force, various atomic forces, electromagnetic forces) - if we tweaked those, if we changed those strengths or the masses of those particles, so if we altered the laws of physics in different ways, even by quite small amounts, how would the universe evolve? It's really very interesting that the moment you start to do this (and cosmologists were

doing this from towards the end of the time I was in astrophysics myself, end of the 70s really) playing games if you like with their cosmological models and tweaking these numbers and seeing what would happen. What was fascinating was that the universe would turn out completely different. Not only that, it would turn out completely lifeless and boring and dead, with nothing interesting happening in the universe at all. You've only got to tweak that mass energy by one part in 10 to the 60, at the very earliest time we can think about, the tiniest fraction of a second after the Big Bang when we have any kind of confidence in our laws of physics, and tweak that by 1 part in 10 to the 60, one with 60 noughts after it, change it either way, up or down, and the universe is lifeless, dead and boring. It either collapses too quickly before galaxies and stars can form and certainly planets and life, or it expands far too quickly for galaxies and stars and planets to evolve. So the universe is sitting on an absolute knife-edge when it comes to those kinds of initial conditions, and the same thing goes for the constants of physics. Perhaps not such incredibly accurate tweaking as 1 in 10 to the 60 but, nevertheless, if you change those laws you end up with a universe which doesn't produce the chemical elements that are needed to make life for example. I can give you one of the most famous examples of that if you like, and that's due to Fred Hoyle who was an atheist astrophysicist. (Interesting background to Fred Hoyle because originally he was opposed to the Big Bang because he thought that it meant that the universe had an origin. If it had an origin in time you might need a God to make it. Theologians are more blasé about that, but Hoyle, as an atheist, was really troubled by it, and he proposed the Steady State theory instead, which was eventually over-thrown, and the Big Bang reigns supreme.) But Hoyle did some really, really important work on how the chemical elements (of which stars, the planets and ultimately us) are made. He discovered that you need a very very fine balance of the forces of nature in order to make carbon inside stars, which is essential for life, and in order to make oxygen without destroying all the carbon in the process. So there were two seeming coincidences, necessary in order to get the materials for life. When Hoyle made that discovery, he was moved to remark that 'a super-intellect has monkeyed with physics and with all of chemistry and biology and that there are no blind forces worth speaking about in nature.' 'It's a put up job,' is the kind of way he expressed it. He was deeply impressed by this. Here you have an atheist, a man who called religion an illusion - he said that in books and on TV programmes in the '50s. Here was a man with that kind of background who talked about a super-intellect monkeying with physics. So the very interesting and exciting thing in many ways about this fine-tuning is that it's something that's come out of cosmology directly, and out of astrophysics and been

raised by cosmologists. It isn't theologians coming along with some kind of axe to grind, but it's coming directly out of the science, which I think is very interesting.

*I see a number of different objections being put forward to the fine-tuning argument. One of the simplest objections says, OK these numbers are highly improbable but any combination of numbers is highly improbable. The example is that you go into a car park, and you see a particular number plate. It is vastly improbable, and you go out and say, 'Wow that particular number plate was there.' But so what? There's nothing that needs explaining.*

Yes, I think that's right in one sense, that any particular combination of constants is highly improbable, but the combination that we actually see is highly significant. I think what you should be looking at is the number of combinations of constants and initial conditions that are significant in that way and giving rise to life, compared with the possible range of values of constants. If you do that sort of sum you get a probability of things turning out right which is more like zero actually. One of the of the early papers of Stephen Hawking literally put a figure of zero on this probability for things turning out just right for life. There is a very good explanation for why that should be, in terms of a theistic explanation. So if we go back to the kind of example you're suggesting: suppose I had a pack of cards here and just dealt them, I shuffled them, very carefully shuffled them. Then I dealt them, and it came out ace of clubs, 2, 3, 4, 5, 6, and 7 of clubs, then the same in diamonds, hearts, and spades. Well you could think, well the chances of that 1 in 10 to the power 60 actually. But if you knew beforehand that I was some kind of conjuror or magician, you'd think there's a better explanation for that than it's just a random deal. There are a number of ways in which the car park analogy fails because that car in particular is insignificant. Another analogy to go for is one that's due to a philosopher called John Leslie, who talks about me being in front of a firing squad. You've got twelve sharp shooters. They all line up and they fire and, lo and behold, you blink and you're alive. Do you shrug your shoulders and say I could only be alive if they all fired and missed? Do you put it down to some gigantic accident or do you say, there's a deeper explanation of this? They were ordered to fire over my head, or whatever it might be. This is contrived. Or maybe there are millions upon millions of firing squads dotted around the universe and the odd one or two of those things will go wrong for the firers and turn out right for me. And I'm in the right part of the universe.

*Another argument says that we have to be in a universe that's fine-tuned for life because if it wasn't we wouldn't be here to observe it. So the only kind of universe we could ever observe is a fine-tuned universe. Is that an explanation or is it dodging the bullet?*

It's certainly true that we couldn't be in a universe that was different in the kinds of ways I've been describing from this one. But that doesn't answer the question as to why this particular one exists with these particular parameters, and why we're here to observe it. So I think it's still related to the pack of cards or the firing squad. I wouldn't be here unless the parameters had turned out right. As I say, this has come out of cosmology, with cosmologists asking the kind of 'what if' question. Now a way of getting another sort of explanation I think, that would be better than the one you've just offered, is to say, maybe things couldn't be any different. Maybe these cosmologists are wrong in saying that the constants of physics could take on other values. Or the initial conditions could be different, or if they were different things would turn out vastly differently. Maybe there's only one self-consistent set of laws of physics. In which case, if a universe is going to exist, then it's going to be this one, or one with these same laws. So in that sense, life is inevitable. But that begs all kinds of questions. Stephen Hawking, looking for such a theory, raised the question, what breathes fire into the equations for there to be a universe to which they apply? So there's still that question: why does that universe exist? Martin Rees is the Astronomer Royal. He's here in Cambridge, where he's the Master of Trinity, and President of the Royal Society. He asked the same kind of question. The 'why is there anything at all?' question is one for philosophers and theologians, he says, not for scientists. But that answer would still also, leave you with a very very big surprise that if the only possible set of laws of physics that could be instantiated, that that set of laws would give rise to an interesting universe with stars and galaxies and life. But it also goes against the grain of the whole argument, the way it's been in cosmology really, of tweaking the numbers. People are looking for a unique theory, but time and again they've been driven away from that to realise that actually they're not getting much closer in the end. The more fundamental theories we get, we're still left with lots of free parameters that seem to need to be chosen.

*The most serious objection to the theistic explanation of fine-tuning is the multiverse idea: the idea that there is a huge number - perhaps even an infinite number - of universes with different physical parameters, different laws. At least some of them must strike lucky, and we just happen to be in one of those that struck lucky. I know*

*you've done some work on the probability of this, which tends to contradict what appears to be a very strong argument. Can you summarise what you have done?*

The idea of this is that if there was vast collection of universes in which (and this is a second 'if') the initial conditions in these universes, and the constants of physics were different, and chosen from the range of possible alternatives, that would give you a much higher probability of getting a universe with life. It's often said that if everything that can happen does happen somewhere sometime in some universe, if all possible universes are instantiated, then, of course, our universe will exist. But that idea does seem to me to be fraught with problems. Part of the reason I think it is not very probable is that it's very anti-occamite. Occam's razor is a principle that's used often in science to choose between competing theories, competing alternatives. You use the fewest number of parameters, the fewest number of entities that are compatible with explaining your data. You don't have an over complex theory if a simpler one will do. You need a more complex theory if you've got more things to explain that aren't embraced by the simpler theory, but simplicity and economy of explanation is a guide to truth in science. Certainly quite a large number of scientists, including Einstein, Paul Dirac, and even Newton, I think, some very famous scientists, have thought that. So simplicity is a virtue, and this breaks that in an incredibly dramatic way, the most dramatic way possible. So it's not a very simple explanation, but also it's fraught with a lot more difficulties than that. In the various ways that are conceived of these many universes existing it's the case that they are unobservable in principle. The only universe we can observe is this one. These other universes cannot be observed even in principle. Now, the most popular way of conceiving of these many universes these days is as some kind of island bubble universes within an overarching background space-time. So they're part of the same space-time, really they're part of the same universe. It's a slight misnomer, but they're so far apart and they're moving apart from each other faster than the speed of light, so there's no way there can be any communication between these universes. There's no way a signal from these other universes can reach us, so that we can know by observation that it's there. So from that point of view it seems highly speculative. Indeed, the physics on which these universes are based is also highly speculative. The latest version of this is a version which involves String Theory, which is really a theory about what the fundamental building blocks of matter are, which is highly contentious. It's a theory that applies to the first very tiny fraction of a second in the origin of the universe. We have no handle experimentally or observationally on that. So it's highly speculative physics. How can we ever know

we're in an infinite universe at all? We would never really generally be able to know that. It depends on some parameters of the overarching space-time being just right in order to get that kind of multiverse in the first place.

*So that doesn't actually solve the problem it just pushes it back a step?*

Exactly. I think that's right. Another question you would always have is, why does the multiverse give rise to life? There are some theologians and cosmologists who are happy with the idea of multiverses and of God creating multiverses, so it doesn't preclude God creating them. Arthur Peacocke, for example, who was very eminent in the science-religion field talked about the importance of whether it's a universe or a multiverse giving rise to cognising subjects of conscious, self-aware human beings. That's what's important. OK, God might make a multiverse if that is his aim, and just creating one universe wouldn't necessarily give that. So it doesn't preclude God. I think one of the arguments I find quite powerful, theologically, against it, I think I did put in my book, but also Keith Ward, a theologian has developed. He says God would only develop universes that were good to be created. So you can imagine a scenario which rather blithely talks about all possibilities existing, that there would be vastly more evil in some universes than they are in this one, unimaginable kinds of evil. It does seem that God would preclude those. There are philosophical kinds of problems to do with human identity. If we have multiple universes then we might get multiple copies of this conversation going on at the moment. If you get an infinite universe you get infinite repeatability, although the conversation would diverge at some point in the history of this universe. It would go on longer in some universes. This would be an incredibly, incredibly tiny fraction of the number of universes as a whole. But this whole idea starts to get you into perplexing problems and conundra, and there really is a problem about infinity in the first place. I think you need an infinite number to solve the problem, because if you've only got a finite number of universes and infinitely many possibilities you've left out most of the possibilities. If, though, there are infinitely many universes then that infinity can never be complete. You can always add to infinity. There's no a guarantee that you've ever included every possibility within infinity. This idea isn't just scientifically difficult and speculative, but philosophically, let alone theologically, does really start to hit quite serious conceptual problems.

*You have a background in cosmology and astrophysics; you've been a Christian minister. Do you personally find the cosmic fine-tuning argument persuasive?*

I do actually find it persuasive. I think as any form of natural theology, it's limited in what it tells you. I think the best explanation for this fine-tuning is the theistic one, that God did it, as opposed to an atheistic view in which there is no God; it's a multiverse or whatever. Curiously enough, someone like Richard Dawkins says, 'no I believe in a multiverse, that will explain it.' On the other hand, Richard Dawkins tells you that you should only believe things on the basis of evidence. Well, there's a massive contradiction there within the thought of Richard Dawkins! But, be that as it may, I find the argument persuasive. Not conclusive, not foolproof. No argument of this kind will be that. There are let-outs of course, like the multiverse. God doesn't force us to believe in him. Then, as I say, natural theology of this or any other kind only gets you so far. What does it say about God? Well, not all that much. I think God has to be pretty powerful. Adjectives to do with majesty and so on might apply to the creator of such a vast universe as we've got. But it doesn't get you to the personal God who reveals himself in Jesus Christ and who, actually most astonishingly of all becomes one of us, and becomes incarnate in Christ. Who lives a perfect human life, dies for us and rises again. That story is a different one. What astonishes me as a Christian minister, though, is that it's the same God doing both these things. The same God creating this vast universe out of many, many possible choices in the mind of God. God creates this particular universe with these parameters that are just right for us to come to existence in the universe, and that same God reveals himself to us as a human being, is born in lowly circumstances in an animal feeding trough and lives and suffers, suffers with us, alongside us and for us, so that problem of suffering we have at least gets some kind of address there within the story of the incarnation and the death and resurrection of Jesus.