Design, Fine Tuning, and the Multiverse

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`[0:00]` Okay, so there are three topics that I'm... My title has three parts, and I'm going to start with design. And Sam is partly responsible for having me talk about this, but I think I mentioned the idea to him, and he said yes.

Phil Hill also, a number of years ago, said, wouldn't you nice if you talked about this? And then I should say that I'm a mathematician rather than a physicist, so I'm not really expert on this, and that I owe a certain amount to talks by Robert Mann, who came to UBC last term and talked about this topic.
So let me start off with the first word part of this topic, which is design. And this is from a book by William Paley written in 1802, and he's arguing for the existence of God.
And this is a very well-known passage. Let me just read it out. I'm going to read out a slightly longer version than you've got on the screen. In crossing a heath, suppose I pitched my foot against a stone and asked how the stone came to me there.
I might possibly answer that for anything I knew to the contrary, it had lain there forever. Nor would it perhaps be very easy to show the absurdity of the answer. But suppose I'd found a watch upon the ground, and it should be inquired how the watch happened to be in that place.
`[1:22]` I should hardly think of the answer I had before given, that for anything I knew, the watch might have always been there. There must have existed at some time, at some place or other, an artificer or artificers, who formed the watch for the purposes for which we find it actually to answer, who comprehended its construction and designed its use.

Every indication of contrivance, every manifestation of design which existed in the watch, exists in the world's works of nature, with the difference on the side of nature of being greater or more, and that in a degree which exceeds all computation.
So, first of all, we can admire the ruling prose of Paley. Nowadays, you know, we are sparse in our prose and don't use five words when two would do.
But people in the 19th century had no such restrictions. So this book, William Paley, Natural Theology or Evidences of the Existence and Attributes of the Deity, collected from the appearances of nature, written in 1802.
And so basically, Paley is saying, if we see animals, frog, for example, we look at all the way the frog is adapted to its environment, we are led to believe that there must have been somebody who designed the frog.
`[2:46]` And that's why it's called the argument design. And the argument, if you take a step back from the argument, the design argument is inductive.

It proceeds from the existence of apparently designed objects, animals or frogs, to the existence of a designer. As with other inductive arguments, it can never give complete certainty, but nevertheless, it can be a strong argument.
Now, surprisingly, for people like William, like Richard Dawkins, the argument in the form that I've given it, as given by Paley, is actually relatively modern in the history of Christianity, I think really dating from the 17th century.
Older arguments for the existence of God, such as the five arguments of Aquinas, do not include the argument of design. So we might ask, why is the argument from design relatively recent?
So, let me give you a parable. You may recognize this. This is Highclere Castle, which is the fictional place where the, I don't know, my brain has gone blank.
`[3:55]` Downton Abbey. Downton Abbey is. It's done. So the parable is, imagine that you were bought, you were born, born in Downton Abbey as a member of the family.

So, as a young child, you probably imagine that everybody is like you. Everybody lives in a house with 60 bedrooms and 20 cooks and 40 maidservants.
Then, of course, as you grow older, you would realize that your position is exceptional. So, my parable is, perhaps the universe is a bit like that.
And, to go back to frogs, in classical and medieval times, the belief was that small animals like frogs just arise spontaneously from mud, from pre-refaction of mud.
And, it was only when people began to examine nature, scientists and the 17th, natural philosophers, they would have been called then, in the 17th to 18th century, that they found that spontaneous generation doesn't occur and they began to understand how complicated frogs were and how, you know, there is actually something to be explained here.
[5:07] So, as long as people imagine frogs or other animals to be unremarkable, they would not see any evidence for design. And, it was only when they discovered all the ways that a frog is adapted to its environment and is special that they began to see that there was something which had to be explained.

And so, we see, have this book, Paley, written in 1802, after a period of work by natural philosophers, as they would call then, on biology and so forth, pointing out all the ways in which animals are designed and adapted to their environments.
and Paley could go on for, you know, hundreds of pages on this kind of thing. His books were widely read in the first part of the 19th century.
In fact, evidences was prescribed that his compulsory reading for undergraduates at Cambridge in the 1830s when Charles Darwin was an undergraduate there.
And Charles Darwin admired Paley's book. There was an awful lot of natural, you know, of biology in it. And initially, I think he was convinced by Paley's arguments.
[6:19] But of course, we know that Darwin really gave the deaf knell to Paley's arguments in his 1859 book, Origin of Species.

He ended the classical argument of design, as given by Paley and others, by providing a scientific explanation of how apparent design in animals could arise by natural selection.
Now, when you see what, you know, initially, first of all, Paley's argument and then Darwin's rebuffal, the first instinct of Christians or Christians to reply to that might be a sort of defensive move.
Oh, okay, they would say. You've explained how once life starts, evolution can create frogs and design things. But you haven't yet explained how life starts.
So, that's a natural defensive move, but it's, in fact, a disaster. And it's a disaster because of what Christians, apologists, have called the God of the gaps argument.
[7:24] And here is a quote from Bonhoeffer which sort of emphasises the bad tactics in such arguments.

So, he says, if, in fact, the frontiers of knowledge are being pushed back, pushed further and further back, and that is bound to be the case, then God is being pushed back with them and is therefore continually in retreat.
We are to find God in what we know, not in what we don't know. So, in particular, in biology, although there is no firm explanation of the, of how life came into being, scientists are finding some sort of vaguely plausible pathways.
And I think to say, you know, science can never explain how life arose from inorganic materials would definitely be a bad move for Christian apologists.
So, one has to be careful about the argument for design because of exactly the warning that Bonhoeffer gives here. And many other Christians have also given the same argument.
[8:29] So, in fact, the term God of the gaps, atheists like Dawkins may say that, you know, this is an atheist argument. In fact, it's Christians who invented the term God of the gaps, not atheists, but to criticize a certain kind of Christian apologetic argument.

So, that is what I had to say about design. Now, let's go on to fine-tuning. So, now, looking around the room, most of you are of a sort of generation similar to mine, so I'm sure you will all know what this object is.
If I was talking to a younger audience, you might not know. But, so we have a radio and we have a little dial on it, and as you all know from the days when one used to tune radios, and in fact some of them still do, you know, you want to get the station, CBC2 or something, you twiddle the dial, you

hear ssss, and then when you get it right, almost right, you get something with a lot of hissing, you twiddle it a bit more, and when you've tuned it correctly, you get the station.
So, this is the concept of tuning, that if some dial is slightly off, you get nothing, if some dial is exactly right, you get what you want. And, there's going to be a certain amount of science in this talk, so I again have to introduce scientific notation for large numbers, probably familiar to many of you, but here if not, so 10 to the, with a little six above it, is one followed by six zeros, million.
10 to the 32 is one followed by 32 zeros, and you can see that there's a, there are lots of good reasons for writing it like that rather than like that, because if you read numbers like that, they take up a lot of the page, and then you have to count carefully the number of zeros.
[10:24] And then for small numbers, 10 to the minus 32 is just one over 10 to the 32. So we're going to be using scientific notation like that a lot in the talk to come, because there are going to be a lot of very big or very small numbers.

Now, I want to talk about the current state of physics. And there are two theories which explain nearly all physics, in particular, all the physics that we can do experiments with.
The first of these theories is General Relativity, produced by Einstein in 1915. And that extends Newton's mechanics to very heavy or very fast objects.
And you've probably all heard of relativity and Einstein. What you may not have heard of is the other theory, which is called now the Standard Model. You may feel this is like unimaginative terminology by physicists, but that's what they call it.
and it was produced by many people over a period of about 50 years from 1960 to 2010. And it extends quantum mechanics to give an accurate account of very small objects.
[11:32] And let me tell you that there are four fundamental forces that we meet in nature. Two of them will be familiar to you, and two of them will not be familiar to you.

And the two which are not familiar are not familiar to you because they only work at the scales of atoms and cells. So the first force is gravity, which we all know.
And here I have the relative strengths of these forces. So gravity is incredibly weak compared with the next force, which is electromagnetism. Then there is a force slightly unimaginatively called the weak force, and there's another force which physicists call the strong force.
And the strong force fortunately is weak, is stronger than the weak force. So these... LAUGHTER
And in fact it's the strongest of all the forces. And you might also notice that though the strong force is stronger than electromagnetism, compared with some of these other numbers, it's only about 100 times stronger than electromagnetism.
And that, actually, that ratio is, the relative strength of the strong force and electromagnetism is important. So, continuing with my description of physics, here is a picture of the atom as it was introduced to me at high school.
[12:52] And this is called the Rutherford atom. So, here's the carbon atom. It consists of six protons and six neutrons in a nucleus, and then electrons which are sort of drawn as orbiting it, though they don't, it's not quite like the solar system because the electron orbits are actually sort of smeared out.

But let's not go into that aspect of things. So, we still believe in carbon atoms being like that, but the standard model has now given us a more detailed description of what's going on with the protons and neutrons.
So, here is a picture, many of these slides I stole from the internet as you probably will guess. And here is a picture of the standard model. And I'll explain a little bit about it.
But before I do that, let me just say that when you see this as a description of all the matter that we have, there's an apocryphal quote from King Alfonso of Castile from the 13th century.
The system of epicycles, which was rather complicated, was being explained to him. And he said, if the Lord Almighty had consulted me before embarking on creation, thus, I should have recommended something simpler.
[14:06] Something simpler. There's no evidence he actually said it, but it's a wonderful quote.
And you may feel when you see the standard model here that similarly, couldn't things have been a bit simpler?

So, let me just, the colours give you, these are the various fundamental particles. So, we have here, I think this pronounced quarks rather than quarks.

There are six kinds of quark. Then we have familiar electrons here, and then some neutrinos here, which we're not going to be discussing in this talk. And the fundamental particles come in three columns, each column heavier than the previous column.
And in fact, as far as pretty much all the matter that we're concerned with in the universe, everything is in the first column and the second two columns are irrelevant. So, why are those second two columns there?
Nobody knows. And then we have some, we have some things called gauge bosons, which I'm not going to say anything about. And then there's something called the Higgs boson. And if you were following at all science news, you will have seen that the Higgs boson is the final part of the standard model.
[15:18] It was discovered a few years ago in the particle accelerators at CERN, and there was a lot of excitement about it and bad journalism calling it the God particle. The Higgs boson has no more to do with God than the electron has, and no less to do with God than the electron.

So, this is the standard model. And these quarks make up protons and neutrons. So, here is the picture of a proton and a neutron.
Each of these is made up of three quarks, and they're made up of the simplest lightest quarks, the up and the down quarks. Again, you may wonder about the terminology of physicists.
Up and down has no actual meaning. They're just sort of metaphorical terms. So, a proton is made up of two up quarks and one down quark, and a neutron is made up of two down quarks and one up quark.
And the up quarks have charge plus two thirds and the down quark has charge minus one third.
[16:29] And quarks always come around in threes in, in, in, in, in, for reasons which I won't go into. Not sure.

Not sure. Now, the standard model, I showed you all those particles in standard model. There are about 19 numbers which arise in the standard model.
Physicists would call these three parameters. That is, the numbers which could, in theory, take any value. And these numbers include the relative strengths of the forces and the masses of the particles.
If you go back to the picture here, in type which is almost certainly too small for you to see, there are the various masses of these particles written here.
And those numbers, they've been measured, but there's no explanation of why those masses are what they are rather than something else. And particularly important for these, for this talk, are the strength of the strong force compared with electromagnetism, which you saw, it's about 137 times stronger than electromagnetism, and the masses of the up and the down quarks.
[17:48] And let me just say, if we go back to the Rutherford atom for a moment, when I learnt about the atom, the natural question is, well, here we have six protons stuck together in a nucleus, how come they stay together?

And the first thought might be, well, gravity is holding them together, but gravity is 10 to the 39 times weaker than electromagnetism. There's no way that the gravitational attraction between the protons and neutrons could hold these things in the nucleus together.
And the answer is it's a strong force which is holding together the protons and the neutrons in the nucleus. scientists ask the question, why are these numbers what they are?
And we'll be thinking about that in a theological level later, but at the scientific level we have three answers. The first is that's just how these numbers are and that's all there is to say.
The second possibility is the current theory of physics are not final. There is some deeper theory which explains why all the masses of the quarks are whatever they are and everything else.
[19:09] So there's a possibility of possibility two and then the multiverse is a third possible explanation which I'll be coming to towards the end of the talk. And so now we haven't said anything yet about fine tuning.

So I'm going to give you two stories of fine tuning and the first one is what's called the Hoyle resonance. So this is Sir Fred Hoyle as a young man.
It looks like he's at a Knoxbridge college but it's not clear. And there are 92 elements, chemical elements, which are found in nature.
And the two lightest hydrogen and helium were made a few minutes after the Big Bang. But all the rest of the elements were formed by nuclear fusion inside large stars.

So in the early universe, that is when the universe was a few hundred million years old, stars began to form. Some of those early stars were very large. And inside the stars, nuclear fusion occurred, which means elements banging together and create heavy elements.
[20:20] stars. These early stars were large and had short lifetimes of only a few million years. They exploded in supernova, scattering the dust and things out, which then condensed into second and third generation stars.

So all the matter in this room was once in a star and was created in a star. So that's how the elements were formed.
And in the 1950s, Fred Hoyle was working on nuclear fusion in stars, trying to work out how carbon and oxygen would form. So physicists knew enough how to do a calculation.
At this point, a hydrogen bomb already existed, which is where hydrogen atoms fuse together to create helium and produce a huge amount of energy. So quite a lot was known about fusion, but fusion of more complicated elements was less well understood.
So two helium atoms make an element called beryllium with eight protons and neutrons combined, four neutrons and four protons, and that's denoted beryllium eight.
[21:37] Then add another helium to beryllium and you get carbon, and add another helium still to carbon and you get oxygen. So these processes were going on in stars and Hoyle was trying to work out how things would work.

So what he found is that unless the carbon and oxygen nucleus is, don't worry exactly what a resonance is, it's a bit like the dinging of a bell, but I can't give you any more detail on that, but unless these atoms have the right resonances, these reactions won't work.
So Hoyle was led to predict that carbon must have a resonance level close to 7.65 NEV, never mind what MEVs are, and this was then, I mean, this is actually what a scientist's dream about.
He made a prediction on theoretical grounds, persuaded some experimentalists to measure the resonance, and they found the resonance, as he predicted, more or less. So if this carbon resonance were not there, or were different, a bit different, then little carbon would form, so there wouldn't be any life or humans because, you know, we're made out of carbon.
And one also needs an oxygen resonance to be right to, or you get too much or too little carbon or oxygen. So Hoyle was an atheist or agnostic, but here he is in 1982.
[23:01] I've always been intrigued by the remarkable relation of the 7.65 MEV energy level in carbon to the 7.12 MEV1 in oxygen. If you wanted to produce carbon and oxygen in roughly equal quantities, these are the levels you would have to fix, and your fixing would have to be just where those two levels actually are.

Another put-up job? I'm inclined to think so. Now, what did he mean by that? It's not really clear, but as I said, he was an agnostic, but he's saying these resonance levels are a put-up job.
Do we have a British translation of put-up job? So, if a shop is burgled, and perhaps inside job would be another way of putting it.
But it's slightly different from inside job, but I think that's the sort of a, you know, something's not what it seems to be. Yeah. And you say someone robbed the place, and we don't know how it happened, but it was the inside where prison did it, and they're covering them themselves.
Yeah, yeah. You know, there are signs of a forcible entry from outside, but they look a little suspicious when you look at it carefully. Yeah. So I think that's what he meant roughly by a put-up job.
[24:20] But, you know, a put-up job has to be done by somebody. So, anyway, that's Hoyle in 1982. Now, when Hoyle was working, we couldn't, it's rather complicated to calculate these resonance levels from the fundamental constants of the standard model, but it has been done.

And one finds that if the strong force were about 1% stronger, there'd be lots of carbon and almost no oxygen. And if the strong force were about 1% weaker, there'd be almost no carbon and lots of oxygen.
So we saw that ratio of 137 between the strong force and electron magnetism. If that ratio were 1 in 110 or 150, we couldn't be here.
And here's a second example of fine-tuning, and I have to say these are the two best examples. Back to the proton and the neutron, here is the proton made from two up quarks and one down quark, and the neutron made from two down quarks and one up quark.

And the six quarks have masses in terms of the masses of the electron. The up quark is four and a half times the mass of the electron, the down 9.4 times. Then the other quarks have really strange names, including strange quark, charm quark, top and bottom quark.
[25:52] And the bottom quark you see is incredibly heavy compared with the other ones. Again, these numbers measured experimentally, but no one has any explanation of why these numbers are what they are.

Now, if the down quark were three times heavier, then neutrons would decay into protons. Remember, the carbon consists of six protons and six neutrons.
If the down quark were three times heavier, all the neutrons inside the carbon atom would decay into protons. The atom would then fly apart and the only element would be hydrogen.
So we'd have a hydrogen-only universe, and that's not a very exciting universe. If the up quark were six times heavier, then protons would decay into neutrons.
So, in fact, there wouldn't be any atoms at all. If you had a hydrogen atom, the proton would decay into a neutron, and you just have neutrons floating around, and again, no chemistry of any kind, no elements as we understand them, no life or people.
[26:59] So, again, you see these numbers. If the up quarks and the down quarks didn't have masses roughly what they are, we couldn't be here. So, there are a certain number of papers in what I'm calling here fantasy physics, which is working out what the world would be like if the constants of nature were different from what they are.

There aren't a huge number of those papers because it's not of huge practical use to know what these things are, but it's also quite complicated to make a little change in the constants, and to try and work out everything that would follow from that could be rather hard.
But what one finds roughly speaking is that most choices of constants give rise to various kinds of disaster, at least from the point of view of life, such as the neutron-only world, when nothing interesting would ever happen in the neutron-only world.
Only very special, and this is where the word fine-tuning comes in, fine-tuned choices of the constants lead to an interesting world with chemistry and the possibility of life.
So what we see from all this is that the argument from design comes back now, not now in terms of things like frogs which we find in the universe, but in terms of the fundamental laws of nature.
[28:31] So the argument of design is coming back, but in a much stronger form than it was before. So now let's look at explanations from a theological level.

Look at the three scientific explanations and what one would be inclined to say about it from a philosophical or theological point of view. So that's just how it is.
So in this picture there's just one universe and the constants could have been anything, but of all the possible choices of constants, it just so happened that the choice of constants produced in the one and only universe the possibility of life.
Well, for a theist, that's more or less perhaps what one might expect, but if you're an atheist, it raises some awkward questions. It's not a proof of the existence of God, it's an inductive argument, but it could be enough to make an atheist feel a little uncomfortable.
The second explanation, an unknown theory explains it. Well, of course, one can't say what an unknown theory might do, but the general expectation among physicists now is that they're not going to find a theory which will explain all these 19 parameters in the standard model.
[29:47] And even if an unknown theory does explain it, again, this would be the question, why is it then that the only universe just happens to be the one that things work out so nicely?

And then the third explanation, which is quite popular among many physicists, is the multiverse. universe. And so let me tell you a bit about what the multiverse is. So let me say that before I go on to the multiverse, I'll explain why people talk about the multiverse.
The word universe is ambiguous, is very ambiguous. It's used in all sorts of different ways. Sometimes it's used to mean everything exists. So God is something which exists, so God is part of the universe.
Or it may mean the space-time continuum that we're in as far as it can be. But what cosmologists and astronomers mean by the universe is actually rather bad terminology.
It's what we might better call the observable universe, which means everything that we can see. And because light travels not at an infinite speed, but at 300,000 kilometers a second, we can only see, and the universe is only 14 billion years old, we can only see so far.

[30:58] And what we can see is what physicists and astronomers call the universe. So looking for something to describe something beyond the universe, they have come across this term, the multiverse.

So up to this point in this talk, I've told you about what general relativity and standard model are saying. And these are well accepted and extremely well experimentally verified theories.
theories. Because the two theories aren't compatible and don't describe everything, there is a search for a theory which can unite those two.
And there are various sort of conjectured bits of physics which are beyond the standard model, and you may meet terms like supersymmetry, string theory, and the multiverse.
And all this physics is at this point not experimentally confirmed and is speculative. A point which is not always brought out in newspaper articles where there's a tendency by journalists to latch on to the new thing and make it more solid than it is.
[32:09] So several different lines of evidence indicate that the observable universe was compressed into an extremely small space at the beginning of time, at the beginning of the universe. This is called the Big Bang and it occurred about 13.8 billion years ago.

Now, although it's not essential, I think I should try and correct here, a common misapprehension, which is that before, 13.8 billion years ago, there was empty space and then there was a sort of explosion of everything.
So if you look at the Big Bang theory on TV, that's more or less the picture that the TV, the beginning of the TV show is showing. So this is not what physicists think happened.
What do they think happened? something harder to explain. And so I should say something about what I'm calling active space is my terminology.
So our everyday way of thinking about space, which perhaps follows Newton, is that space is just sort of an empty thing which is passive. Space without anything in it is just nothing.
[33:18] space. But in both the physics theories, relativity, and the standard model, space with no matter in it is still active in various ways. So empty space still contains, it's the sort of behavior of space which produces gravitation in general relativity, and in quantum mechanics in the standard model, even a bit of empty space, what are called virtual particles, are continually jumping into and jumping out of existence at a very, very rapid rate.

So stuff is going on even in space which is completely empty. And here is a sort of picture, I mean, all one can do at the non-mathematical level is to sort of use, and perhaps even for mathematicians too, to make some metaphors.
So here is a sort of picture of one of the ways that physicists may think about space. This is an Escher drawing, I think. We think of space as being these objects connected by rods, and if the rods get longer, the bits of space get further apart, and if the rods get shorter, the bits of space compress together.
And here is a slide which may be not very visible, saying how the universe expands. I stole it from the web, and it's more about the expansion of galaxies in the later universe, but it also applies to the early universe.
And this is the picture of baking bread with raisins in it. So you have a loaf with raisins. As the loaf bakes, it gets bigger, the raisins get further apart.
[35:08] So the picture is the raisins are the sort of bits of matter in the universe. space. And what is happening, first of all, at the expansion of galaxies is space is being created between the galaxies, so the galaxies are moving further apart.

And similarly, if we go back to the Big Bang, all the universe that we have, the space is getting smaller and smaller and smaller and smaller. So everything that we have, all the universe is compressed into a tiny region, but there's nothing outside it.
so what happens at the Big Bang, if you were trying to do a TV thing, which they do it honestly, what you'd show would be, I suppose, a completely white screen representing an extraordinarily high temperature and then gradually cooling as the universe aged.
And so in the beginning of the Big Bang, everything was compressed together at incredibly high temperature and pressure. And then as space expanded, the density of matter got less, the temperature got less, and we finally get to the world as we know it now.
So there's something called cosmic inflation. And this is the hypothesis that the universe underwent a period of extraordinarily rapid expansion very early.

[36:30] So when the universe was about 10 to the minus 32 seconds old, which is not very old at all, there was a period of about one ten-thousandth of its lifetime, 10 to the minus 36 seconds, in which the universe grew by an astonishingly big factor of 10 to the 26.

And this concept was suggested in about 79 or 80 to explain the uniformity of the cosmic microwave background. I should say that one of the strongest evidences for the Big Bang is what's called the cosmic microwave background.
This is the sort of universe was very hot. As it expanded, it got cooler, and the radiation left from that cooling is the cosmic microwave background.
It gives us the earliest view that we have of the universe as it was at about 400,000 years. And it's astonishingly uniform, and physicists were puzzled by why it's so uniform.
And one of the explanations, the best one really, is this concept of cosmic inflation. So there was a period very, very early in the universe when it grew by an extraordinary amount.
[37:44] So here is a sort of, again, I stole it from the web. Maybe we don't, so something happens at the Big Bang, and then there's an astonishingly rapid period of expansion there, and then the rest of the universe, the history of the remaining 13.708 billion years follows.

So here is the hypothesis for the physicists have. Space carries with it properties which determine the constants in the standard model.
So back to this picture, the Escher cubical grid. You might imagine that there's one kind of space which has got a cubical grid, and another which has got a sort of, you know, diagonal rods in it is two.
So you've got more than one possible kind of space. And before inflation, the universe was at very high temperature, and all the little different possible kinds of space were all mixed up.
And in the inflationary era, which was this period of extraordinarily rapid expansion, the little bit of space that we're now in had its properties kind of frozen during the very rapid expansion.
[39:01] And that little bit of space that we're in with the properties fixed expanded to a size far larger than the observable universe that we're in.

So here is, again, a sort of picture of what we can imagine happening. So imagine that before inflation occurs, all our matter is in this little region here.
direction of these arrows is supposed to represent different kinds of space. And in some sense, different kinds of space like to be next to each other.
But in the very, very high temperature early universe, there's enough sort of thermal energy around that everything is randomized. Then in the inflation era, this little bit of space expands, and we found ourselves in a region where all the bits of space around us here are like us.
if we went an incredibly long distance over in that direction, we'd find other bits of space looking like that, and so on. So that's what physicists are proposing, and as I said, or I didn't say rather, but the slide said, this is called by people the level two multiverse.
[40:14] So here's the multiverse hypothesis. The whole universe, or multiverse, contains many regions, some very large, like our own region, each with its own value of the fundamental constants.

And those values of the fundamental constants are chosen in some ways randomly by different kinds of space. Most parts of the multiverse will be unsuitable for life. We'll be in the neutron-only universe, or the proton universe, or universe where carbon and oxygen don't form, or whatever.
But of course, we have to be living in a part of the universe which is suitable for life, because otherwise we wouldn't be here. So this is the multiverse explanation of fine-tuning.
And no one really knows, but according to some theories, there are about 10 to the 500 different types of space. That would probably be enough to explain the coincidences that we find in fine-tuning.
So this is the multiverse explanation for fine-tuning. So in favour of the – but as I said, nothing has been proved, this is all speculation.
[41:29] So in favour of the multiverse, one could say that it arises naturally from a number of current theories in physics, and it gives an explanation of fine-tuning by what people would call anthropic or selection effects.

In other words, we have to be in an area where, you know, oxygen and carbon exists. So it's not surprising that the constants of nature are such as to allow the formation of oxygen and carbon.
against the multiverse hypothesis is, first of all, it relies on speculative physics of various kinds.
There's no established mechanism for the inflation.

People have hypothesised the inflation. There's some experimental evidence, observational evidence that it exists, but there's no explanation of why inflation starts or actually also getting it to stop is a problem.
And there's no experimental evidence, in favour of the multiverse, or observational evidence in favour of it. So what I've told you about is the level two multiverse.
[42:36] Physicists actually talk about a number of different level multiverses, and let me just quickly say a little bit about the other levels. So the level one multiverse is just parts of the universe with the same physical constants as us, but too far away to be seen.

Level three multiverse is to do with what's called the mini-world theory of quantum mechanics, which I'm not competent to talk about. And there are even more extravagant multiverses which I've put in fainter and fainter type to indicate that my view of their merits.
The level four multiverse, Mach-Tegmark, every mathematical object also has real existence. And if you think about what that means, it's really not even clear if it makes any kind of sense.
that. And the level five multiverse is that we live in a computer simulation. So these increasingly daft ideas I'm not going to talk about.
People do it from learning five, I do it. So Elon Musk apparently believes that we're living in a computer simulation.
[43:43] And one of the unfortunate things about God and the world is that if you're a billionaire, people take you really seriously. More or less every word that you drop is a pearl of wisdom.

So here are three Christian physicists. Don Page, I think, doesn't like the level two multiverse, but I think he's a many worlds person.
George Ellis, I heard him at a conference say the multiverse is not science and never will be. So he's very anti-multiverse. Robert Mann, who talked at UBC earlier this year, is somewhat against the multiverse, but in a slightly more ambiguous position there.
So Christian physicists have all kinds of different views on this topic. And what about the future? So the first thing is there's not likely to be any confirmation from astronomy.
The other bits of the universe, places where the constants are different, are just too far away to be seen and will always be so.
[45:02] The only way that the situation is likely to change is by progressing theoretical models such as string theory. could either add support for the theory or take it away.

So multiverse doesn't completely rely on string theory but it gets strength from string theory. And two theories in physics, supersymmetry and string theory, which are supposed to go beyond the current standard model, are both in a bit of difficulty because people aren't finding the kind of observational or experimental confirmation of them that they would like to be finding.
That is for supersymmetry and string theory relies on supersymmetry. So here we are at the end of my talk and here's my quick summary of what I've told you.
So fine tuning arguments bring back the possibility of the argument from design but now not expressed in terms of biological design of animals but expressed in terms of the fundamental laws of nature.
The multiverse provides an alternative scientific explanation but one which is far from being confirmed scientifically at this point. And sort of sitting on the fence, we may be rather enthusiastic about the fine-tuning argument for the existence of God but we have to keep in mind the pitfalls of God of the gaps type arguments.
[46:28] So that's it.