

**Introduction:**

Tape:

*Let me tell you about my annus mirabilis - my year of wonders.*

*It was 1665. I was 22 and a student at Cambridge University. But the Great Plague sent many into self-isolation so I left Cambridge for my home in Lincolnshire brimming with knowledge...*

John Dickson:

We're listening to a short video from the University of Cambridge, which they released at the height of the Covid pandemic lockdowns in Britain back in 2020. English mathematician and physicist Isaac Newton was in self-isolation himself during the Great bubonic plagues of the 1660s.

Tape:

*During this time I developed my theories on calculus, the chromatic composition of white light and the mathematics of force and gravitation ... Does it reach as high as the moon?*

John Dickson:

Newton's gravitation equation now forms part of a standard education for first-year physics students. But one of the initial objections to the Newtonian model of gravitation is that it says nothing at all about *how* the force of gravitation comes about. It just explains that the force is there.

Newton had a question to answer: *why* does a planet orbit the Sun in roughly the same plane and in the same direction? Newton's answer? Because that's the way God made the universe.

*"This most elegant system of the sun, planets, and comets could not have arisen without the design and dominion of an intelligent and powerful being," wrote Newton.*

*"And if the fixed stars are the centres of similar systems, they will all be constructed according to a similar design and subject to the dominion of the One ... And so that the system of the fixed stars will not fall upon one another as a result of their gravity, he has placed them at immense distances from one another."*

This answer was not good enough for fellow mathematician and scientist Gottfried Wilhelm Leibniz. In his *Philosophical Essays*, he wrote, “*For to have recourse to the decision of the author of nature is not sufficiently philosophical when there is a way of assigning proximate causes.*”

This isn’t because Leibniz did not believe in God. He did. But, for Leibniz, one who trusts in God should expect to find no gaps in nature. *We must keep seeking.*

If there is a gap in the scientific account, we don’t need to attribute it to God. Rather, we might assume that our scientific task is probably not yet finished.

That’s what Andrew Briggs, one of my guests on today’s show, says too. And he happens to be a leading scientist in quantum mechanics and nanomaterials - an area in which most would say there are still plenty of gaps in our knowledge!

Our other guest, Ard Louis, has just published new and compelling research that points to a beautiful symmetry in nature. He’s a celebrated theoretical physicist who believes that the elegance of the natural world and its seemingly rational order gives him *more* confidence that God is indeed behind it.

Neither of these scientists at the top of their fields feels the need to prove that God exists. But both say that they will *keep seeking* after the big questions of the world, in full expectation that there are answers to be found. And those answers will be beautiful.

### **Part 1**

**JD:** *Can you first begin by telling me about your work here in the Department of Materials?*

**AB:** I am the inaugural holder of the statutory chair in nanomaterials at the University of Oxford. And Nanomaterials is just a sort of long classical word for what Anglo-Saxon would be, small stuff.

John Dickson:

That’s Andrew Briggs, inaugural Chair of Nanomaterials at the University of Oxford. He’s an experimentalist, which basically means he’s a hands-on scientist. He’s got a particular interest in incorporating materials and techniques for quantum technologies in practical devices. He has more than 650 publications, with over 28,000 citations.

Andrew Briggs:

And what we do is we take very small objects that are so small that you can measure and control the individual quantum states. So a typical experiment for us might be to take one molecule - you can't get much smaller stuff than one molecule - and attach two wires to it and then attach that to a device and then measure how electricity flows through the molecule one electron at a time. And when you get this small and you are looking at such delicate effects, the disruptions that you'd get from thermal agitation become significant. So we cool it down and we cool it down to within about a 50th of a degree above absolute zero, so colder than anywhere in outer space. And it is just amazing that it's possible for us to understand and to study materials on this tiny scale and with these tiny energy levels and so on and whole new phenomena open up, which are completely different from anything that we experience.

So at this scale, you have an effect called quantum superposition, which essentially means that an atom can be both here and there at the same time in a way that it's no good trying to relate it to everyday experience because we don't experience that every day. But we can routinely observe and study such effects in the laboratory.

**Tape:** *Marvel Studios' Ant-Man and The Wasp: Quantumania:*

<https://www.youtube.com/watch?v=ZINFpri-Y40>

John Dickson:

That's a clip from the new Marvel Studio's blockbuster, *Ant-Man and the Wasp: Quantumania*, which is coming to cinemas in 2023.

The Ant-Man superhero franchise even has a quantum physicist consultant, as superhero movies attempt to incorporate scientific detail into their stories. Perhaps it's because real science is becoming increasingly, well, like science fiction.

The fact is quantum physics *is* pretty strange. Like what Professor Briggs was talking about: Quantum superposition is like being in two places at once. Quantum entanglement gets even stranger - when particles link up no matter how far apart they are in space.

There is a bit of a race to harness such phenomena into a quantum computer, which according to scientists could help address climate change and food scarcity... or just completely break the internet.

At the moment, despite hundreds of millions of dollars of investment, quantum computers still barely function. And they have become mythical in our popular culture, with movies portraying them as near-magical devices that can bend the laws of physics and reality itself.

To get us away from comic book heroes, here's what one of my favourite literary writers Marilynne Robinson wrote recently:

"With one brilliant advance after another, science burst out of the constraints of rationalism and found itself in the terrain of quantum theory, which everyone says no one understands, but which is very robust and has been put to all sorts of practical uses"

It may be the case that no one yet understands what's really going on with quantum physics, but Professor Briggs says it's still mathematically explicable. It's not *that* spooky.

**JD:** *When it does these things, is it still obeying, or obeying would be the wrong word, but is it still mathematically explicable?*

**AB:** It is, absolutely. And in fact, to a large extent, you need mathematics in order to be able to describe these things. So you can try and make analogies of quantum superposition and an even weirder phenomenon called quantum entanglement. But after a bit, the sort of life-sized analogies run out of usefulness. And then it becomes actually much more helpful to write the equations on the whiteboard and try to explain the equations because mathematics becomes a very, very powerful language for talking about these things.

**JD:** And I hate to jump straight to the application, but what are the applications? Is it as simple as making small stuff very helpful?

**AB:** Well, the applications of nanotechnology are manifold. In fact, we are enjoying them almost every day of our lives. But, specifically, the quantum technologies that this kind of science opens up, are now beginning to find real applications in things like sensing. So we can make senses that are so sensitive to a change in a gravitational field that if there's something different underground, you can be sensitive to that. The sort of poster boy of the, uh, quantum technologies will be a quantum computer. And already people are making progress towards building fully scalable quantum computers. Little quantum computers are working. And one day we may get really significant quantum computers operational, and they will be able to undertake computational tasks that are just simply never gonna be feasible for a conventional supercomputer.

**JD:** *And so machine learning becomes important here.*

**AB:** It does - machine learning is all around us. At its best. Machine learning is bringing fantastic benefits. So for example, in medical diagnosis, screening, medical scans and so on, the machines are just brilliant at it. For some time in the lab, we have been

developing machine learning for quantum technologies. And the reason for that is that the quantum states that you want to use for the quantum technologies for quantum computing are very delicate and they're very hard to achieve. And in the devices that support them, humans can tune the devices up, but it takes humans a long time to do it. And then after a bit, they fall out of tuning. So you've gotta retune them again and so on. And all of that is very difficult to scale because, you know, that's alright from one to five qubits but by the time you get to millions of them, you can't have millions of humans each tuning a qubit. Fortunately, that won't be necessary because the techniques that we've developed in our lab and are now being widely used are very effective at tuning these devices faster and better than humans can. So this is another example of an area where I think the benefits of machine learning are huge and certainly, the effectiveness has been now rather robustly demonstrated.

John Dickson:

In Andrew's line of research, he is so busy with the practical applications of science that he doesn't have much time for the religion vs science debate, despite claiming the Christian faith for himself.

Andrew Briggs:

I've just come from the Lambeth conference, which is a gathering which happens normally every 10 years of Anglican bishops from around the world. And we had a whole session on science on the final Saturday morning of the conference. And we had 560 bishops all in the same room. You know, tables of six or eight of them discussing science. I'm just now looking at the feedback from those tables. The idea of conflict is scarcely relevant in the majority world. They've got much more important issues to address, you know, how can science help with issues like physical and mental healthcare? How can it help with vaccine hesitancy and vaccine inequity? How can it address issues of water security and food security? These are very important practical questions for them. I would say, you know, that it's also gonna be important in the uses of things like AI and machine learning.

So I think by and large, the debate has moved on.

John Dickson:

Science, says Professor Briggs, has theistic assumptions built into it. Science proceeds on the supposition that nature is uniform; that it is intelligible. *"When we investigate the world, we don't assume it to be like random scribbles on a scrap of paper,"* Briggs says.

*“In fact,” he goes further and says “we can rephrase the statement ‘nature is intelligible’ as saying, ‘it is as if nature were the result of an intelligent act.’”*

Faith, says Briggs, is required for science. Not necessarily a faith in God – but at least a faith that there are answers to be found for the questions that science posits. We’re so used to this that we forget how strange it is. We live in a comprehensible universe.

Albert Einstein once commented that this is the spookiest thing of all: Einstein: “We are in the position of a little child entering a huge library filled with books in many languages. The child knows someone must have written those books”. And again: “One may say the eternal mystery of the world is its comprehensibility”.

Andrew Briggs:

Many, many people have observed that ... one of the most famous quantum physicists to recognize that was Max Plank who said that over the entrance to the temple of science is written “you must have faith”. And you can't do science without faith. Actually, you can't live your life without faith. It's just not possible. Some people don't recognize that. So you are quite right that in order to science, you've got to have an underpinning belief that there is something to be understood. And you've got to have also the confidence that somehow if you take the right bite-size problem, you will be able to make progress on it. One of the responsibilities of a professor is to help guide doctoral students to a problem that's about the right size. That it's not so trivial that it's, nobody's gonna be interested in it, but not so hard that they won't make any progress on it. You've got to have that confidence. And to some extent, in an academic career, it's a confidence that you learn and gain through experience.

It proves to be well-founded. It does indeed prove to be the case that there is some order in the universe. It does obey some equations. We can identify problems that, you know, at the start, we don't understand, but, after some diligent work, sometimes we can make progress and understand the better.

So all of those things have been empirically verified. It's also a matter of historical observation that, as we say, the kind of curiosity about the material world that eventually became science flourished in the context in which they were asking these big questions. But it is a complex story, and it never helps to pretend that a complex story is simplistic. It is of course, perfectly possible for someone who does not have faith in an underpinning God to do excellent science. That's a matter of empirical observation.

John Dickson:

Yes, of course, there are magnificent scientists who don't believe in God. And even *those* scientists might say that their research reveals beautiful, extraordinary things about the world. But Andrew says they're missing something.

Andrew Briggs:

So there's one picture which I've been enjoying, which has got five galaxies in it. One of them, the light started out about 30 million years ago and has been on its way that long. Long before the first humans. And then there are four other galaxies in the same picture. I think they're about seven times further away. So something over 200 million years the light has taken to reach us. And, you know, a sort of average galaxy like ours, the Milky Way has got about a hundred billion stars in it. For those of us who are privileged to know the creator of it all, there's this, there's this extra degree of pleasure and enjoyment.

John Dickson:

One of Andrew's scientific heroes is James Clerk Maxwell, a 19th-century physicist whose work rivals Newton and Einstein in importance, though sadly not in renown.

**JD:** *So I want you to introduce my listeners to Maxwell. They may have never heard of him, which I know is a scientific outrage, but let's pretend people have never heard of him. Why is he so important?*

**AB:** Oh, he was an amazing figure. He was someone whose influence on our lives was just as great as other people who are much better known, like Charles Darwin and so on. You're not really comparing like with like, because they were in different fields, but you know, all the electricity we use, all the electronic technologies, all the digital technologies are all designed based on Maxwell's equations, hugely influential figure. He grew up in Galloway in Scotland in a house called Glen Lair. His dad made all his clothes for him, which must have looked a bit odd. His school chum's nickname for him was 'Dafty', but he wasn't! In his teens, he wrote a paper on elliptic curves, double ellipsoids that you can draw. He was too young to present it to the Royal Society of Edinburgh, so a friend of his dad's presented it there instead.

He contributed to many, many fields of physics that were going on at the same time; heat viscosity of gases, and thermodynamics. He took the first colour photograph ever. He developed a way of visualizing stresses that continued to be used, you know, right up until modern digital computers would do the job for you.



But one of the things that he did was to bring together what was known about electricity and magnetism. And he eventually brought it together into - well, the way he wrote it down was more complicated, but you can write it now in modern notation, the equivalent equations as four equations, and they're known as Maxwell's equations.

John Dickson:

Maxwell's theory of electromagnetism, which shows that light was electromagnetic radiation, won him the label "Father of Light". You can even buy t-shirts that read '*And God said ... 'Maxwell's equations' ... and there was light.*' Very cool!

His work formed the basis of Einstein's later theory of general relativity.

Maxwell had a strong Christian faith but also had reservations about how that faith should play out in his scientific work. He declined several invitations to join the Victoria Institute, which was founded in 1865 by a group of London evangelicals as, essentially, an anti-evolution organisation, speaking out against Darwin in particular.

In some of his personal correspondence, Maxwell wrote about his reasons for his refusal to join the institution, which included a reluctance to link the particulars of shifting scientific thought with biblical interpretation. He wrote:

*"I think that the results which each man arrives at in his attempts to harmonize his science with his Christianity ought not to be regarded as having any significance except to the man himself and to him only for a time and should not receive the stamp of a society."*

Despite these reservations, Maxwell didn't think it was necessary to divorce theology from science or vice versa:

*"It is the particular function of physical science," he wrote, "to lead us to the confines of the incomprehensible and to bid us behold and receive it in faith, till such time as the mystery shall open."*

*"I think Christians whose minds are scientific are bound to study science that their view of the glory of God may be as extensive as their being is capable of."*

Andrew Briggs:

He was the inaugural professor. He was the first Cavendish professor at the Cavendish Laboratory at Cambridge. And he was responsible for the design of the laboratories. And on the entrance, there's an inscription. It's actually quite hard to read because it's in a rather ornate gothic script. And even if you can work out what the script is, it's in Latin. When I went to be a graduate student at the Cavendish Laboratory, it had by then



outgrown the original buildings in Free School lane in Cambridge and had moved to new and much, much larger buildings on the West Cambridge side. And I, as a rather sort of precocious first-year graduate student, talked to the head of departments Sir Brian Pitard and said that I thought it would be wonderful if we could have the inscription.

And there was a blank panel over the entrance to the lab. I said it'd go very well there. And now that not so many physicists read Latin every day. It might be wise to have it in English. And the inscription is a verse from the Psalms. It's Psalm 111 verse two. And in the Coverdale translation, which they chose, it is *"The works of the Lord are great, sought out of all them that have pleasure therein"*.

And I love that as a sort of motto for the science that's done in that laboratory or any other laboratory. It's saying that what scientists are doing is finding out how God makes the world work. And if you like, you know, it's great fun. It's great pleasure in doing it.

**JD:** *I want to quote you to yourself and then ask you to maybe expound on the thought because it's a dense and beautiful sentence. 'Dear naturalism' - here you are, you are questioning, you know, the worldview that many people have nowadays. 'Dear naturalism, it is impossible to know for sure that the physical world is the whole of what is. And furthermore, there is plenty of reason to suppose that it is not, for the whole world gestures onwards beyond itself.'*

**AB:** I think that's right. I think that the deeper that I go into science, and I think many of my colleagues should find this too, the more I find it fascinating in itself. It's beautiful, it's wonderful in itself, but also the more I find it calls us to something beyond itself. One way of thinking that we use in *'It Keeps Me Seeking'* is to think of this whole world as a house. And we live in the house and we are curious people. So we want to find out all about the house. We measure the rooms. If you're a material scientist like me, you want to find out what they're made of. What are the floors made of, and what are the walls made of? What's the ceiling made of? How does it all work?

You might have a friend with you who's a social scientist who might say "how are the different rooms used - which rooms are more for people to get together in and which rooms are more for people to be private in?" You might want to find out how the wiring works, how the plumbing works, especially if it goes wrong. You might want to find out how it works and try and fix it. And you can imagine that you could go on and on with great profit and great enjoyment, learning more and more about the house until one day you notice that the house has got windows.

You can look out through the windows, you can even open the windows and let the warm breezes come in and the scents from the garden come in. And the windows are

sort of as you were calling you to a world that's beyond the house. And so, I dunno whether you find that helpful as a metaphor, but the way that you can spend all your life just studying the material world - the subject of my professional career - or you can, if you want to respond, see how that calls you to something beyond itself and open the windows to a whole realm of existence that it needs a different kind of description, a different kind of enjoyment, a different kind of engagement from the material world that is so effectively studied by science.

John Dickson:

For Andrew, science is the study of how God makes the world work. That's what James Clerk Maxwell thought, too. Sure, there are plenty of scientists who don't think that's what they're doing. But, to those of the Christian faith, that's what they're doing even if they don't acknowledge it.

Just as it says over that door to the Cavendish Laboratory at Cambridge: *"The works of the Lord are great, studied by everybody who has pleasure in them"*.

After the break, we'll meet another scientist driven by faith-filled curiosity to seek answers about our world.

## **Part 2**

**JD:** Now in the *New York Times* article about your work, I think even in the headline, it was something like 'A New Law of Nature'. Have you, Ard Louie discovered a new Law of nature?

**AL:** Well, this is a little, first of all, that quote didn't come from me!

John Dickson:

That's Professor Ard Louis, a theoretical physicist at Oxford University. Ard is particularly interested in biological physics - the behaviour of systems from single-molecule machines to organisms, ecosystems and evolution. It's a pretty wide field!

His team has recently published some really important research that Ard has been working on for ten years.

It seeks to answer the question: why does evolution favour symmetry?

Ard Louis:

But I do think that what we're finding you know, I should also be very cautious. So we've made these discoveries. I've been working on this for at least 10 years. Well, it took me 10 years before I published it because it was a bit of a different way of thinking about things. And I was nervous that I was wrong. And there are lots of ways that you can fool yourself. And so I spent a long time and several PhD students of work trying to make sure that I dotted all my I's and crossed all my T's.

It wasn't so much I was worried about what other people would say I was worried about whether I was wrong. Because it's a rather grand claim. And I think it will still take probably, you know, a good while before we can say for sure this is different, this is a new law about how evolution works, but I'm, of course, I'm the originator of it, so I'm confident enough that it's gonna go that way, but I could be wrong.

**JD:** *A lot of people are saying very pleasant things about it.*

**AL:** People are very excited about it. So I've got a lot of very positive.

**Jd:** *Whether it is a new law or not, maybe there'll be mathematical formulae that explain this, but you're really talking about the tendency of nature that explores the symmetrical.*

**AL:** Yeah. I think part of this is a physicist's instinct. So when you look at biology typically it's taught a little bit like stamp collecting. Here are a lot of different things that you just see. There are patterns, the ideas that are just all contingent. You know, if you run the tape of life, you get something pretty different again. In physics, we tend to want to find laws that bring things together. And a classic example would be, you know, you have the laws of pressure and volume, right? If I decrease the volume, the pressure goes up and vice versa. So before we understood that law, we just had lots of complicated things we didn't quite understand. Once you had that kind of supervening law, it made things a lot easier to understand. So the question is, does biology also have these kinds of emergent phenomena that once you understand them, life will make be lot easier to understand, a lot less of the kind of all details and more the basic principles?

**JD:** *Yes. The cliché is that biologists are all into complexity and randomness and physicists are, you know, pattern-seeking machines, right?*

John Dickson:

Ard's research suggests that nature plays favourites, and prefers the elegance of simplicity.

We see that theory around us all the time: from the repeating patterns of snowflakes or flower petals, or the right and left halves of ... elephants or humans - symmetry is everywhere in nature.

It's also hiding in the very structures of proteins and RNA, too.

There is, of course, also *asymmetry* in nature.

But Ard's research suggests that symmetry turns up too often to be random. Something mathematically elegant is going on behind the scenes.

So, let's wind back and let Ard fully explain how he came to this research.

Ard Louis:

So I'm a professor of theoretical physics. So physics is split between people that do experiments, that have labs and people that do theories. Basically, people that write equations or use computers. And I'm on that second side. So my lab is my desk benefit, pen and paper, and blackboard.

**JD:** *Yes. Calculators and calculators and mental arithmetic and all that.*

John Dickson:

We spoke to Ard Louis way back in season 1. It was an episode titled 'Rational Universe', and it went into detail about evolution and Christianity.

We're not going to do that here. But I do want to acknowledge (again) that some of my listeners (and co-workers!) don't think evolution is wholly compatible with Christian belief. So - 'irritation warning' - the next few minutes assume the reality of evolution at a fundamental level.

**JD:** *Now, in the work I want to discuss, you are assuming evolution. Now, most of my listeners will be assuming evolution, but some of them won't be assuming evolution. So can you tell me just very briefly, um, what is evolution as you understand it, and why do you assume it in your work?*

**AL:** Yeah, so it's actually, there's no short answer to that question because evolution can mean many things to different people. It can mean something about natural history. So the earth is old and a long time ago, you know, organisms were simpler and then more complicated animals came around, dinosaurs came, did that out. And eventually, we appear that's natural history. Then your evolution is like, the Darwinian evolution is trying to explain how that change over time happened. And the most common explanation there is that there are mutations that generate a new variation. And then if

that new variation is fitter, it will eventually dominate the population. So that's the kind of evolution that I'm looking at. But the reason I'm saying there are actually three ways is because evolution is often also used as a kind of philosophical way of thinking about the world.

The idea that a man is the product of a process that did not have him in mind (that's the words of a famous biologist George Simpson), that's that kind of evolutionism I might call it. And I think a lot of the worry that people, Christians and fact non-Christians often have with evolution is that kind of philosophical interpretation, which I think is incorrect.

John Dickson:

George Simpson, by the way, was an American paleontologist, who wrote a book called *The Meaning of Evolution* in 1949. In it, he discussed the philosophical implications of the acceptance of the evolutionary theory. In that book, he wrote that "Man is the product of a random and purposeless process that never had him in mind."

Ard has written quite a bit about his scepticism toward using evolution as a 'worldview' in this way. He is all for evolution as a *mechanism* and as natural history, but he is adamant that none of that means that human beings are random and have no purpose.

Ard Louis:

And so I'm actually interested in the question of how mutations generate new phenotypes. And we've seen that obviously in the pandemic, right? The covid, so the covid pandemic, the virus was constantly mutating and changing, and when it changed, it would do slightly different things. So the mutations are random, but when it does is highly non-random when it makes you ill.. So So I'm interested in that process. So how does that technical process which we see at this micro level and we think probably explain the change over time?

**JD:** *So there are really two parts of evolution in this sense. There are mutations. And then there's the selection of the mutations for fitness. So is this entirely random?*

**AL:** Well, this is a good question. So to first order, the mutations are random. The second order, they're not, there are certain mutations that are more likely to happen than others, but those differences are not that large. And traditionally, people have also tended to think that the things that mutations throw up are also random. And that's one of the reasons why I think people often also have difficulty with evolution.

**JD:** *So every possibility is generated but nature just selects the fittest one.*

**AL:** That's right. Yeah. That's how they think about it. Yeah. And so evolution is a two-step process. There are these mutations that generate new phenotypes, which is a fancy word for the properties of the organism. So, you know, your children might be taller than you by some mutation. That would be a new phenotype, if they're a taller phenotype, for example. And then the idea would be if you see a population getting taller over time, that's because taller is fitter. It really means that taller people have more children who then pass those genes on. And the idea traditionally has been that the first step just generates a kind of fuel, but that fuel's not structured. Yes. And so I'm actually suspicious of that idea, and I'm trying to study that first step in evolution.

**JD:** *Your saying randomness isn't as random as it used to be?*

**AL:** Exactly. So one of the things where you're thinking about this is what is evolution really doing when it randomly mutates those genes? Well, remember that you are not your DNA. So just because the genes are random doesn't mean that the outcomes of those random processes are random.

Let me give you a very simple biological example that can help explain this. So if you look outside in my garden, you'll see various trees I have a walnut tree and a birch tree, and they have very different shapes. Now, interestingly, that walnut tree shape is not encoded in like a blueprint in its DNA. There's not like a little shape of the tree, put a leaf here, put a branch there.

Instead, the tree has an algorithm that basically makes, leaves a certain probability, and branches a certain probability. And if you run that algorithm, then you get that shape that comes out. The birch tree has a slightly different algorithm, which gives it a kind of more flowing birch shape. And so there's no, there's no blueprint in DNA. It's actually an algorithm, an algorithm is a fancy word for a computational program that's being run.

And so now imagine that there is a mutation to the algorithm. Okay? You might, it might be that actually, a small mutation to the algorithm changes you from walnut shape to burst shape really quickly. Or it may be that's really hard to go from walnut shape to bird shape. And so to understand that you shouldn't look at the shape of the trees, but rather try to understand the algorithms. Like a simple change with the algorithm is, for example, now double this process makes something twice as big, right? That's one little line change and a huge outcome. If I randomly change that program, I might see very big changes happening in certain directions and very small changes happening in other directions. So what I'm saying is the mutations are random, but the outcomes are highly non-random. And the big question then is if that's true, in what direction are they not random? That's the question I'm thinking about.

**JD:** *Explain symmetry. I mean, I, I know what symmetry is. I have two arms and two legs, right? So I'm symmetrical. My left foot is slightly bigger than my right. So maybe I'm not as symmetrical as I would like to be. But what do you mean by symmetry? Is it symmetry at the level of the algorithm or something else?*

**AL:** That's a good question. So actually, our idea that we've been developing over the last few years is that if you think about these algorithms, if you think about mutations at the genes really effectively being mutations of the algorithms, then what's gonna happen is if you need to evolve some kind of new phenotype, let's say the walnut tree needs to change into a more birch like shape because the weather changes or the climate changes, then what's gonna happen is it's gonna randomly tweak that algorithm. And the first algorithm that it finds that does the job roughly okay is the one that's going to pick.

Now let's think about symmetry. So on my right here in my kitchen, you, you can see in the tiles on my floor, and they're regularly placed. So if I say to you, come please tile my kitchen, it's much easier for you to say, take this pattern and repeat it ten times. That's a short description. I could also tell my kitchen with every tile in a slightly different place "Okay. I'd have to like to give you a blueprint of every tile". That's a lot of information I need to give you. Now imagine that I am just randomly making tile assembly programs to assemble the tiles in my kitchen. I'm much more likely to find a simple program because there are a few lines to describe that than a long complicated program. So that's the argument. If I randomly search in the space of tiling algorithms, to tell me how to tile my floor, I'm much more likely to find a symmetric way of doing it than a non-symmetric one. So we've looked, for example, at lots of properties in nature and seen that huge amounts of symmetry are there. And the question is, why is that symmetry there? We're saying, well, it's just there because it's easy to find.

**JD:** *So symmetry is easier than non-symmetry. Simple as that. One of your students you were telling me is working on leaves. Does this apply to leaves?*

**AL:** It does in a slightly more complicated way. For example, I mean this is ... maybe I shouldn't say this, I don't wanna be scooped yet, but, we've known for a little while that leaves in the evolutionary history are more likely to revert back to simpler leaves and to more complicated leaves. So you've been studying a model of how leaves form and basically just saying "let's just mutate that model". So we're now taking mutations of the leaf model. And what we see is the exact same pattern of reversions, but we're likely to go from a complicated shape with lots of wobbles on it to a simpler shape. And so that, we're getting something very close to what we see in nature. And that tells us that probably the reason why you're seeing that pattern in nature is nature's random mutating of the algorithms.



**JD:** *You've started to work on one of Richard Dawkins's fun things. Biomorphs - little stick creatures that he thought, you know, could illustrate how evolution works. Can you tell us first what he was doing with that and where your work might intersect with what he was saying?*

**AL:** Yeah, so Richard Dawkins has a very lovely book called *The Blind Watchmaker*, where he tries to show the power of natural selection. In that book, he has a model called Biomorphs. It's a kind of model for how animals develop. So you change the genes, and you get differently-shaped animals. And so in his book, he shows that you know, if you've natural selection and you make a bunch of random animals, you wanna make a beetle shape, you picked the one that looks close to the beetle, then you randomize that one again, you picked the best one, you randomize those ones, you keep taking that selection. Eventually, you will get to something like a beetle shape.

John Dickson:

Here's a little clip with Richard Dawkins explaining his biomorph computer program back in 1991 for the BBC. It's basically a program that features simple shapes representing plants or animals which can be 'bred' by clicking on them.

### [YouTube - Richard Dawkins](#)

**AL:** So it's a nice example of how natural selection might work. But what we've shown is that in that model, I don't think he realised this, if I just randomly mutate them, certain shapes are a million times more likely to appear than others.

And so what we've shown is that the shapes that are more likely to appear are also much more likely to be selected. So they may not be the fittest ones, like not, it's actually the ones that appear the most frequently, which are also the more symmetric ones, simpler ones, those are the ones that are more likely to appear. So although he didn't realize that his model is a lot richer than he anticipated, and it's kind of fun because he's kind of see, there's a long argument in biology between what people call structuralist people who say there's some kind of structure to the way nature evolves and adaptation is people that think that natural selection adaptation explains everything. He's typically seen as the arch-adaptationist. But I think actually if you look more carefully at this particular, that by watchmaker book, he's much more nuanced.

**JD:** *You're going to eventually show him your work?*

**AL:** Yes, and I hope he'll like it. He called biomorphs his most important scientific discovery. And I think it probably is. And I think hopefully we're gonna show that there are much more surprising, exciting than he may have thought.

**JD:** *Except you'll be coming from the perspective of a sort of deep structuralist.*

**AL:** Exactly. Yeah. So coming from the opposite side of this model than he's traditionally seen as, when I went into the paper, I thought this would be very fun cause I would show, I would use his model to show the opposite of what he is famous for. But then actually as I, as I kind of reread his work and understood it a little better, I think he, he's actually a more complicated thinker than he's often caricatured to be.

John Dickson:

I love Ard's respect for Richard Dawkins. You often hear very negative things about him ... not just in Christian circles, but also in mainstream intellectual circles. But Ard reminds us, Dawkins is first and foremost a proper scientist who has had some important things to say about the natural world.

I almost knocked him off his bike when we were living in Oxford for 5 months. I was backing out of the driveway and saw this cyclist have to make a radical turn out of my way. He looked at me like "What are you doing!" I looked sheepishly at him. And thought of the headline: Christian historian targets atheist scientist! Anyway, I'm glad I didn't hit him.

But what Ard Louis is saying is that his research on symmetry actually works well with - and can explain - some of Dawkins' own work. The difference is: Ard is pretty sure none of this points away from the reality of a Creator behind it all.

**JD:** *Now I have to ask you, maybe this is too philosophical. Why is simplicity favoured?*

**AL:** Well, that's a very good question. So the actual formal justification for why we should pick simple arguments over complicated arguments. So Occam's Razor the American saying. Occam, we think was that fellow American college here. So there's a local hero.

He famously said that we shouldn't, you should not multiply entities without necessity. That you go all the way back to Aristotle, all the way through history. People have said that simple theories are better than complicated ones. The idea being if you've got two explanations, pick the simple ones more likely to be true. It's a very common philosophical move to make. It's actually fascinatingly hard to formally justify. So why is it true? Well, it seems to have worked well in science, but that doesn't explain yet why it's true. So another great philosopher Richard Swinburne here in Oxford has a book on simplicity where he basically says, "look, it's just basic. Okay? I don't need to argue for it".

However, and I say this argument is the best general argument for why it might hold in the kind of big picture of philosophical arguments ... what I'm arguing here is that if you think about natural processes that are generated by algorithms, which many of the natural processes we see in nature are not just the evolutionary ones, but many other things around us have that quality to them, then because if you randomly pick algorithms you're much more likely to find a simple one than a complicated one, you're therefore much more likely to see simple things than complicated things. That's my stab at why it might therefore be good to use simple explanations, but I think the measures are more likely to happen.

**JD:** *If I had a box of numbers, It'd be much easier for me to just randomly throw them than for me to form a pattern - so the pattern is simpler but harder.*

**AL:** That's an excellent question. So I'll illustrate what you've just done with two monkey thesis. Okay. So the first monkey theorem is the infinite monkey theorem that you've probably heard of. You put a bunch of monkeys on typewriters, you wait long enough. Will they type the works of Shakespeare? The answer is yes, but you have to wait extraordinary long. So let's say I've got a typewriter with 50 keys on it, and I want to type some phrase like "good morning John Dickson". Then the first letter is G it's a one in 50 chance, the second letter is O, and that's another one in 50 chance all the way to the end. Maybe it's 15 letters. The probability of getting that right is one over 50 at the power to the power 15. Cause I gotta get correct the correct key 15 times in a row.

So when you're throwing your numbers on the ground, it's a bit like Randy typing on a typewriter. The probability that you'll see a nice pattern there is very small.

### [YouTube - 'The Simpsons'](#)

John Dickson:

If you haven't already guessed, that's a clip from The Simpsons - which is apparently still going, by the way! I think I only watched about 20 seasons, but it's up to 34 seasons! Something to aspire to here at Undeceptions!

Ard Louis:

But what if instead of the monkeys typing on a typewriter, they are typing into a computer program, and you see the outputs of this computer program, you don't know what they're typing and they're just randomly typing? They might accidentally type print 0 1 500 times - just 21 digits long - a small probability. But they might make that and you'll suddenly see zero and zero, zero and length a thousand strings very nicely ordered. So if you are looking at the output of monkeys typing onto a typewriter, then

every string of a certain length will be equal. If they're typing into a computer program, there are some simple programs that can generate long outputs and you'll see these, and they typically ordered outputs, right?

So print zero one many times on pies which is a very famous number because pie is very, looks very, if you just look at the dishes of pie, it looks random, but I can write you an algorithm, right? That describes pie in just a few lines. So you would see the monkey differ, often pie would come out, right? And so if you look at those patterns of the monkeys typing onto a computer program, you're gonna see these biases towards simplicity.

So what I'm saying is many things in our world are not just like random numbers thrown on the ground. They're something that comes out of some process. So the tree comes from an algorithm process. Evolution is an algorithm process. Our minds are using algorithm processes, and many things in nature are the algorithm processes. And therefore, if that is the case, if the processor is algorithmic, then a bias to a simplicity will naturally emerge. And if you're looking at the results of such processes, then using Occum's razor is a good idea.

John Dickson:

You may have heard sceptics of evolution say that there just hasn't been enough time to get such complex things like humans and all that exists in nature today with the random process of evolution. The space is just too big, there are too many possibilities and not enough billions of years.

Ard says, well ... actually, the evolutionary process is not really random. And the field of options is hugely narrowed by nature's preference for simple symmetrical solutions.

I find it fascinating that Ard's breakthrough does two things at once: it *strengthens evolution* (by explaining why it has worked at such high speed, relatively speaking) AND it points to the non-random elegance that is going on at a fundamental level behind evolution.

It is surprising but it shouldn't be. Contrary to the expectations of some, science and theism are peas in a pod. Intellectually speaking, they both depend on orderliness. People often say that the more sciences discover, the more theism has to retreat. But the opposite is true. It's precisely because the universe displays rational order, from the particle to the cosmos, that so many people are convinced the whole thing comes from a Beautiful Mind.

Science could only undermine the classical arguments for God if it stopped uncovering the deep rational order of the universe. But, then, that would undermine Science itself, since the premise of science is that the universe is rationally explicable. Any scientific argument against God would backfire.

So, it seems that science and theism are intimately tethered. The more order there is in the universe, the more science can progress AND the more plausible God seems. I'll get out of my pulpit now, and hop back into Ard's kitchen ...

Ard Louis:

So one of the interesting outputs of this theory is that it's that although there are many, many possibilities, these simple possibilities are quite easy to find. Yeah. So actually we've looked at one very specific example, which is RNA. So you probably remember this from vaguely from school.. So you, the three main molecules in your body that, that are proteins, which kind of do all the work, they turn the sugar into energy. For example, there's DNA that stores information how on to make proteins. And there's RNA, which part of it does, it takes copies from the DNA and turns them into proteins. But some RNAs actually do the same job as proteins. So they can do, they can, they can actually help catalyze reactions, for example. So we looked at those kinds of RNAs, RNAs that do work in nature, and we discovered that, although there are many, many, many ways of making them fold with the shapes, the shapes that you see in nature are a tiny, tiny fraction of all the possible ones. So just for fun, I picked pro Rs of length 126 for a study.

Now, why 126? Well, there are four. They're made of four different nucleotides. So it's four to the power 126 different possible strings. So that's, turns out that if you made every RNA of length 126, it would weigh more than the observable universe, everything that we can see. So ignore the dark matter, but everything else, it would weigh more than that. Okay. So, I like that. That's, it's the first one that's larger than the universe. So that's an unsearchable space. Okay. You nature cannot have ever made all of those RNAs yet. We see certain RNAs of that long period again and again and again as far as you can tell independently. And we did a study of categorizing them, although there's a very large number of sequences, we think there's about a trillion different possible shapes they can take. But nature only uses 68 of that trillion.

And we can find all 68 of them in about a million random samples, which is tiny. So the point is, although space is huge, and it would take longer than the age of the universe, the universe isn't even big enough to search that space. Yet I can search just a million of them and find every shape that nature uses. And, my theories basically make that kind of prediction as well as this tells the sceptical arguments that say the space is too big, it's unsearchable. This is definitely a very big pushback against that argument.

**JD:** *And then the flip side, I guess is to the atheist naturalist who really, uh, depends on everything just being completely random and every possibility having been found. And we just happen to have found this there. Do you feel there's anything theological? I mean, I know it's not your concern in your work, but do you think there's any theological pushback to that? Because really you're saying it's almost like there's a computer program.*

**AL:** So these natural theological arguments are always difficult. And there's a good reason why theologians have been suspicious of them. You know think of Newman one of our greatest theologians in the 19th century, or Bart, right? They are pretty, they're probably maybe over the top in their pushback against it. Alex McGrath here has been trying to revitalize this argument. And actually, interestingly, someone like Richard Dawkins or other atheists of that ilk are also natural theologians, which, and what I mean is they look at the natural world and they say, this tells us something about who we are or how we should live. So my first pushback to all that is to say I'm also somewhat of a sceptic for natural theology. And in the evolutionary story, I can give you two ways of running it.

So the one is the radical contingency argument, the idea that you know, if you run the tape of life again, something completely different would happen. And the other one is the argument that if you run the tape of life again, something very similar to what we see would happen. So my scientific arguments are on that second side, not on the first one. But actually, if you're a Christian, Christian or a theist, you might say, "well, the nice thing about that contingency argument is God only has to do a little tweak, and he controls the outcome of evolution because everything just can, can hinge on this ... you don't have to have God intervening at various times. You can just tweak it and then something like this could happen". And that's really, that's really amenable if you have certain views on divine action.

On the other hand, if you believe that there's a pattern to the world, and you know, the person who actually got me interested in evolution is a Cambridge paleontologist called Simon Conway-Morris, who talks a lot about convergent evolution. And convergent evolution is completely fascinating. You know, we have a camera eye, and so does an octopus and we evolved completely independently. So we see the same patterns appearing again and again and again in nature which suggests that there are deep structures that are channelling us in certain ways. And Simon says something like humans are inevitable. And he says, this is much more amenable to theism. Because if God were to create the world and want there to emerge from that world creatures that would be able to interact with him, then being able to have something like human intelligence appear is a very important part of that.



John Dickson:

Just quickly, we went a little further with convergence the last time I spoke with Professor Louis, back in Season 1. Links in show notes for that ep. Plus, we will link to an interview my mates at the Centre for Public Christianity did with Simon Conway Morris on convergence.

Ard Louis:

So the idea would be, you know, I'll take a step even further back, if God created the world, God created the world all in one go. And so I've got Lego blocks here for my kids. I can make them a train and they'll be very pleased. But if I could make Lego blocks that I put into a box and I shake it, and out comes a fully formed train because of the patterns, the shaking makes you a train, that would be infinitely cooler. I would also be very rich. But the idea is that, if you believe that life has been, has changed over, over kind of geological history, then that if you believe that God is behind that and God is doing something like that shaking of the train, and then it does feel to me like these deep structure arguments suggest that that tells us about how God is creating something like ourselves to make us inevitable.

I have to say that those arguments are difficult. Right. So that's why I push the other one as well to show you could run them both as natural theological arguments. And my first take is obvious to say, well ... both to my atheistic friends and to my Christian friends, we should be more cautious about trying to extract meaning about our lives from these biological arguments.

**JD:** *Do you separate your Christian life from your scientific life?*

**AL:** No. I think the world is a big circle in which everything else fits and science is part of that circle. So there are really fundamental facts about the way the, the fact that there is an orderly world or world that's under that's intelligible. This, I think only makes sense if you believe there's an intelligence behind the world.

I think the history of science has had deep theological roots for those very reasons. So I like to remind myself of that. I also think that part of my calling on earth at this time is to discover things about the world. So I think those are ways that I feel that my faith connects up. And probably it's true that I, because of my Christian background, but also because I'm a physicist, am much less likely to believe that evolution is just kind of one damn thing after another and much more likely to believe there can be, there are going to be beautiful patterns. So I think it's much more likely to be beautiful. And that isn't a Christian instinct perhaps. But having said that, many of my atheist colleagues also believe that the world is beautiful and use that as a guide to truth.



The idea that the world is beautiful is very common among scientists. Scientists are often motivated by this. There's been some interesting sociological work on this recently that showed that in fact, it correlates, very strongly with how successful scientists are, and how much they're driven by aesthetic kinds of drives. So I don't want to call that a Christian motivation because many, many non-Christians have it. I do think it's justification, it's origins are much more naturally derived in a Christian framework than they are in an atheistic framework.

### **Five Minute Jesus**

Let's press pause. I've got a 5 minute Jesus for you. You might be thinking that the life and influence of Jesus have little relevance to science. As a 1st-century Galilean, of course, he had nothing direct to say about the study of the natural world.

But I think it is arguable Jesus had a massive indirect influence on the development of science. Put simply it is widely acknowledged that the Judeo-Christian way of thinking about the world provided the conditions, the necessary conditions, for the passionate study of the natural world and therefore what would become a science. But I think it is arguable Jesus had a massive indirect influence on the development of science. And Jesus is the reason the Judeo-Christian worldview became the dominant view in the West.

There are three conditions to be in place to provide this soil out of which natural science grows. And Jesus taught all three, and his followers took these notions wherever they went.

First, the creation must be viewed as orderly, rational, and imbued with wisdom and elegance. That is not the Pagan view. Pagan religion from Babylonia to Egypt to Gaul to England in antiquity insisted on a capricious, unruly world. This makes science unthinkable. Science depends on mathematical elegance and rational order built into the structure of the physical universe. To be clear they were Pagan exceptions. The high philosophers like Plato, Aristotle, and Plotinus, had all moved toward an intellectual conviction that there was one reality, one great mind, behind the universe, and so the physical universe is rationally explicable. We can easily accept that these philosophers, especially Aristotle, were beginning to study the natural world, as a rational pursuit. My point, however, is that the Jews had already believed this, and operated on this assumption for centuries before the great Greek philosophers, and it was this Jewish view that Jesus passed on to his disciples, and his disciples passed on to the Pagan world.

But there is another condition that fostered the scientific project, and this was less obvious even among the great Greek minds. It is the belief that the world is not only rational, and therefore explicable, but that it is also profoundly good.

It is widely acknowledged in the literature of the history of science that all of the first scientists, Kepler, Copernicus, Galileo, Newton, and so on, saw their scientific work as worship. Because a good God had produced a good creation, the study of that creation was an act of devotion.

You may remember back in episode 9 when we interviewed Sarah Stonebraker, a historian of modern science. It was her study of the very first scientists of the modern era that began to lead her out of atheism toward Christianity. She couldn't get past the fact that these great intellects all thought they were doing something worshipful. Their science was inspired by their faith. And there can be no doubt that Jesus was indirectly responsible for inspiring countless millions to love the good creation, the gift of a father who makes the sunshine on the righteous and the unrighteous, as he said, and who decks out the lilies of the field in their splendour.

There is a third condition that inspired modern science, and this has been argued forcefully by the historian of science Peter Harrison, a Professor at Oxford and now at the University of Queensland. In order for modern science to take off people had to believe that they themselves were fallen, fragile, and prone to rational self-deception. Why is this so necessary? Because if we trust our rational capacities too much we will be content merely to observe the world and make rational judgments about why things are the way they are. We won't stop to test our rational thoughts.

This is what prevented ancient Greek science from going too far down the road toward empirical science. The Greeks firmly believed that the logos or rationality built into the universe was the same logos that was built into our brains. We had the capacity rationally to intuit why things are the way they are.

This led to all sorts of crazy but rational speculations about the world. An example Edwin Judge, the famous classical historian from Macquarie university, gives is that the Greeks very logically believed that male semen was produced in the brain, for the obvious reason that the brain (which they had observed) was the only internal material in the body that was the same colour as semen.

The Greeks did loads of this sort of science. They backed themselves and their intellectual prowess, their ability to rationalise the world. But what really got modern science going was a belief, inspired by Christianity, and Augustinian theology in

particular, that even our minds are corrupted by sin. Peter Harrison points out that there was a great revival of Augustinian thought in the Middle Ages. Augustine of Hippo had really just systematised the teaching of Jesus, that every one of us is evil, to use a word he often employed in the gospels. “If you who are evil know how to give good gifts,” said Jesus, “how much more will your father give good gifts”.

Harrison has shown how this idea really began to trouble the intellectuals of the Middle Ages. They had made so much progress in rational philosophy. They had studied ancient classical literature. They codified logic, rhetoric, observational astronomy, and much more. But they began to fear that all their speculations could be flawed given they were descendants of fallen Adam. The solution was to test their rational theories about the world. Only real-world testing could compensate for our propensity to get things wrong. And so was born the experiment. You'll have to read Harrison's book, 'The Fall of Adam and the Rise of Science', to get the details, but it is pretty clear that this is how early modern scientists expressed their empirical work.

So, it's true that Jesus didn't talk about science directly. But his indirect gift to the world, quite apart from his death and resurrection for our eternal forgiveness, was a worldview marked by a belief in the rationality of the universe, a conviction about the goodness of creation, and a realism about the limits of our rational abilities.

You can press play now.