Numberphile Podcast Transcript
Episode: A Chance at Immortality - with Marcus Du Sautoy
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Mathematical greatness can strike at any time - even on the train between Oxford and London.

Marcus is the Simonyi Professor for the Public Understanding of Science at Oxford University

Marcus' author page on Amazon

I is a Strange Loop - book

I is a Strange Loop - performance on YouTube

With thanks to MSRI

Podcast by Brady Haran

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[Gentle Piano Music]

Brady Haran [BH]: Today's guest is Marcus Du Sautoy. A successful mathematician based at Oxford, Marcus is more widely known for his public communication. BBC TV shows, an assortment of books, and in more recent times even in music and theater. I met Marcus at his home shortly after he'd popped some bread in the oven.

[Gentle piano music]

BH: Am I going to have your undivided attention or is your brain really on the sourdough bread baking in the oven? [laughs]

Marcus Du Sautoy [MS] No, no, no [stutters] the bread is quite good at looking after itself. So I won't be going…

BH: Alright.

MS: Suddenly saying, bread's dough power sour.

BH: The most important question is, how do I pronounce your surname? And where does it come from? 'Cause it's quite, to me it's quite an exotic name but you seem very… English to me.

MS: [laughs] Yeah, it has origins in France. And… funnily enough I used to apologize for how I pronounce it, 'cause we pronounce it du Sautoy [De-So-Toy] and I thought that must've been anglicized because when I go to France, you know, they say Monsieur Du-So-Twa [exaggerated accent]. And then a professor in Oxford at French, oh but when did your family actually come to England? And I said well, 1745, 'cause actually it was Catholic family helping the Scots fight the English. So they came over with Bonnie Prince Charlie to Scotland and then this Pierre Francois Du Sautoy got caught and was made a prisoner of war in Basingstoke, too many roundabouts and he couldn't find his way out [laughs]. But he explained, well, you know, the French Revolution they changed so many things. They tried to change the names of the days of the week, the weights and measures, time, and they actually changed pronunciation. So, people will know French is for the king, le roi [current pronunciation], but actually it used to be le roi [roy] and you could tell whether somebody was a revolutionary or not if they said le roi, they were Ancien Régime, or le roi and they weren't a revolutionary. So Du-So-Twa was du Sautoy. So actually I now do not apologize for the way I

pronounce my name. It is actually an old French pronunciation.

BH: And give me it… du Sautoy?

MS: du Sautoy.

BH: du Sautoy. I mean that's so long ago, do you sort of identify with any kind of French heritage-ness or is it just a quirk of history now? Or do you feel something about it?

MS: Well weirdly, we're sitting in my office at home making this recording and next to me I have a portrait of a Pierre Francois du Sautoy. So it's very interesting… you know, there's a kind of mathematical element to this, because of course every generation you sort of got two parents, four grandparents, eight great grandparents and so, you know, that one name du Sautoy comes from a very sort of singular branch of this huge tree, yet, because of this name and it being taken down I do strangely picked up on something. I have a sort of feeling of connection to this one person. But why him as opposed to the many other powers of two people that I've descended from? But I think, you know, it's quite a kind of romantic story, you know, he was caught, made a prisoner of war, stayed here, he probably avoided being… having his head chopped off. There are no du Sautoys in France anymore. Just this kind of band of us in the UK. Weirdly if you Googled du Sautoy, you'll get a lot of maths, but you'll also get some Bond movies. Not that I've been in a Bond movie.

BH: No? [chuckles]

MS: But one of our other relatives Carmen du Sautoy was an actress with the RSC and she actually appeared as a Bond Girl in one of the Bond movies, so you'll also see some pictures of her as a Bond Girl.

BH: Oh, wow, there you go. I have Googled you. I obviously haven't Googled

deep enough. I have not come across that yet.

MS: [laughs]

BH: Have you gone back to France and found some… hole or cottage that they were from or something or…?

MS: Well, I'm really hoping for a chateau rather than a cottage because I'm really hoping for the reinstatement of the monarchy [laughs] in France and then I'll be able to reclaim this… this chateau because they were quite an aristocratic family. Which is why they probably got wiped out during the revolution so… but I'm not holding my breathe on that one.

BH: Alright, well then let's go to your childhood then, like after all this sort of highfalutin aristocracy and what not. What was your childhood like? What was… where were you born? Where are you form?

MS: Well I was born in London but we moved out within a couple of years to Oxfordshire and so I really grew up, you know, not too far away from where I now, you know, work. Which is the University of Oxford, and that's probably significant because I spent a lot of my time doing music for example. That was one of my big passions and I would go up to Oxford a lot. Play in the Oxford Youth Orchestra, and so I've always sort of had a connection to Oxford through my music and I think seeing all the students and how much fun they were having I think that sort of helped kind of set my sights on… yeah I thought that looks a really fun place to hang out and be a student and to think. But I just went to normal comprehensive school in my town, so kind of nothing fancy there. But that said, you know, I had fantastic teachers and I do credit one teacher in particular, Mr. Bailson, who sort of picked me out at the end of a class and I thought I was in trouble and but then he sort of took me around the back of the maths block and I thought I'm really in trouble now but then he said well I think you should find out what maths is really about. And he recommended a few

books to me. One was called The Language of Mathematics and that was really intriguing because at the time I was really interested in learning languages. I thought that's what I wanted to do was… 'cause my mum had been the Foreign Office and I sort of thought that was kind of a fun… actually I thought she was a spy, frankly.

BH: [laughs]

MS: She gave us this image that she was basically double-oh-eight or something.

BH: Do you know for sure that she wasn't?

MS: Well, no, exactly, of course!

BH: [laughs]

MS: You know, that's a fantastic cover, but [chuckles] I was finding languages really frustrating because there were so many irregular verbs. There's a lot of learning you had to do. I really didn't have a very good memory and so that's why mathematics particularly appealed to me because you can reconstruct from first principles, and I loved that. Everything made logical sense so you didn't have to just remember things. And then this book, and I still have it, it's up on my shelf here, the one we bought after my teacher recommended it. It revealed, you know, the power of mathematics as a language to describe the universe and that's when I started to…

BH: Maths wasn't your passion at this point, but you were obviously good at it because Mr. Bailson had seen this?

MS: Yeah. Well that was what was interesting. I actually had a chance to… I did a radio program for BBC Radio 4 which is called Top of the Class and it's a

chance for you to go back to your old school and spend some time with a teacher. You choose a teacher that inspired you and I asked him at the time. Why did you pick me out? I mean did you do this sort of on a regular basis, you know, just if I throw a dart enough times one will hit the bullseye? [chuckles] And he said, no, no, I didn't do it with anybody else. I said so why did you pick me? 'Cause I wasn't that… particular fantastic at that point. And said, I could see you were responding to abstract thought. And I just knew this would be a wonderful place for you to spend your life. And so right he was. I mean I just… loved this… this… the imaginative side of being a mathematician. And that's what's interesting as well 'cause one of the other books he recommended and has been very important throughout my whole life has been A Mathematicians Apology by G. H. Hardy. And in that book he describes what it's like to be a mathematician. And he continually compares it to a creative artist rather than being a kind of useful scientist. And through my time at school what I loved doing was playing music, being artistic, I loved doing theater. These were my passions and…. but I still wanted something which was kind of scientific in nature which was exact, precise. I think I was a quite an insecure teenager and I think I'd like the security of mathematics. It's one thing, you know, I've done quite a lot of work on A Curious Incident of the Dog in the Nighttime, I did some work with the theater production version of it and Mark Haddon and I have done events together. And I think it's very clever that Mark Haddon… it's about a kid with Asperger's but why does he love mathematics in that book? Because… he just enjoys the security of knowing that something's gonna happen a particular way and it will happen the same way again. Whilst people are very unpredictable and so there's a security that mathematics provides and I think that also appealed to me. But… I think this book A Mathematician's Apology coming back to that. It showed me that mathematics was the perfect bridge between the creative world of the arts where you can use your imagination, make worlds that don't exist but are consistent and weird things happen in them but still being a world of science as well.

BH: How gradual or violent a process was Mr. Bailson's intervention from this

dream of… that seemed to involve language and music to becoming a mathematician? Was it overnight or was it a gradual drift?

MS: I think as soon as a teacher takes interest in you and sort of gives you that sort of positive feeling, you wanna respond to that. So I think that was a very key moment and I wouldn't say it was overnight but gradually as I learnt more and, you know another really important thing that was… that I feel was very lucky in my trajectory was that at school we did something called SMP mathematics. School Mathematics Project it was called. And this was an educational kind of experiment which in retrospective probably failed because many people got completely lost in it. But the idea was let's show our students at school real mathematics. So this course showed us the ideas of topology. It showed us the axioms of group theory. It showed us set theory and that just… really excited me and I think I was lucky to have a teacher who understood the mathematics and I've talked retrospectively with a lot of teachers who taught that course and they said well the… you know it was a great course but the trouble was that most of the maths teachers, they didn't have a maths degree. They didn't understand it themselves, and so it sort of basically failed because… you really… those very deep ideas need somebody with a lot of depth in the understanding to be able to teach it.

BH: So many people I've spoken to, on this podcast actually, have talked about when they got to university mathematics was completely different to what they expected but it sounds like for you it wasn't. You had been given…

MS: I had completely the opposite and in fact it had a slightly bad effect because the first year, you know, they were teaching us all these axioms of group theory, topology, and I said I've seen all of this already and actually I spent far too much time doing theater and music and slightly flunked my first year because I thought, oh, I know everything that's in the lectures, we've already done this at school [chuckles] you know, I realized you still have to do some hard work [laughs] to learn this stuff. But yeah you're right, I actually I think I was

lucky to see some real maths. And you know what I feel that's one of my missions as a kind of communicator of the excitement of mathematics. I really want to try and show people the real mathematics. The big stories and I think that's what I responded to, rather than all the just grammar and kind of the… the scales and arpeggios, you know, play some real music. I was lucky that my teacher and my course at school played some real mathematics to me and you know I heard the Beethoven, I heard the Mozart, I didn't just have to play scales all the time. And I think that's what we're missing. We're not being brave enough.

BH: So when you're at high school and presumably you're applying to do mathematics at university, that you've decided that's your thing. What were you thinking your career was gonna be? What did you think you were gonna be when you grew up and you finished university as a school boy?

MS: A mathematician. I really already had identified that I wanted to spend my life telling stories in this language. I had a few role models. One of them was Christopher Zeeman. He'd done the Christmas Lectures in 1978, and I was very lucky that my dad managed to get me a ticket to one of the lectures and we watched the rest on telly. It was the first time, Christmas Lectures, I mean, started by Faraday in 1825, it was the first time they'd ever risked doing it on maths because what on earth going to show people? You can't blow things up.

BH: So for people in America for example, these Christmas Lectures run by the Royal Institution is this sort of once a year, real national profile showcase of a science and some famous scientist does like a grand lecture that gets show on TV and everything.

MS: That's right and so kind of series of lectures, five lectures. They're broadcast on television at Christmas, amazing kind of exposure but this was the first time they'd ever been done on maths. And Christopher Zeeman is one of our greatest… I mean he's not died now but he was one of greatest mathematicians.

He solved one version of the Poincaré Conjecture for I think dimension six. And so this was a real practicing mathematician who spent his time that Christmas talking to kids. And I thought, you know, I said I want to be him when I grow up, that's amazing, he seems to be really enjoying…

BH: You did become him when you grew up!

MS: I know [laughs] weirdly I did because I…

BH: Yeah, [laughs].

MS: I actually got invited in 2006.

BH: Yeah.

MS: To give these lectures myself and I ended the lectures saying to the kids sitting there, you know what? I was like you sitting in the audience in 1978, and here I am up here, you know, living my dream, doing mathematics, telling people these mathematical stories and I hope that one day one of you will be up here saying, I went to the lectures that Marcus du Sautoy did in 2006.

BH: Did you find like a screenshot or a still of you in the audience?

MS: [laughs]

BH: In the Zeeman lecture? You've never found one?

MS: I've never found.

BH: No?

MS: No.

BH: Alright [laughs].

MS: And hopefully nobody else will because I was a horribly spotty [laughs] teenager at that stage.

BH: [laughs] You said that at high school you already knew you wanted to be a mathematician, did you properly know what a mathematician was? Like if you went to spoke to that boy now would it be a naive, his perception? Or do you think you pretty much had it nailed?

MS: No, I think, you see that book, A Mathematician's Apology, really… is a fantastic description of… I mean a lot of people criticize that book and I've been very critical… it's opening really puts anyone off trying to communicate maths to the general public 'cause it says, you know, he writes, it is a melancholy experience for a professional mathematician to find himself writing about mathematics. The job of a mathematician is to prove theorems, not to talk about them. So he's basically saying, nobody should try and do what I'm doing. But I think it was a very good description and I think that it gave me a very good idea about what it was I wanted to do. And it's interesting 'cause at Sixth Form I went to… so my school didn't have a Sixth Form and so we all went to a Sixth Form College which fed the comprehensives in the area into it. So it was like a massive like school about eight hundred seventeen and eighteen year olds, it was amazing. It was almost like a transition to university. But I remember my maths teacher there saying, ooh maths rather difficult, pretty difficult to get into Oxford. Why don't you do engineering? You'll probably get in, you know, there's much better opportunities for jobs and I said, that I do not want to be an engineer. I don't want to get my hands dirty in kind of [laughs] messy stuff. I love just the purity of this subject and I was already tending towards kind of the more abstract end, what one would call pure mathematics.

BH: That sounds quite grown-up. Quite a mature attitude for someone of that

age to not be thinking, oh I want to drive a Ferrari or play for Arsenal or something. I want to like you know, I want to do these esoteric things and proofs.

GS: I was an incredibly nerdy kid at school. And, you know, I loved sort of the idea [chuckles] not doing things in the normal. You know I saw my mates were getting into punk rock, I was getting into Wagner and you know, I loved going to six hour Wagner operas.

BH: Right. [laughs]

GS: In Oxford at the theater there, so yeah.

BH: [laughs] Alright.

GS: It's now that I'm sort of living my teenage… you know I go with my kids to Glastonbury and like… but that was not me as a kid.

BH: What was… you went to Oxford University, did you, as an undergraduate?

GS: Yeah.

BH: What was that like then? You said the first year was… you didn't do that well your first year you said?

GS: [laughs] Well, you know I have a lot of other interests other than just mathematics which, you know, helped me do my mathematics actually because you can't do maths all the time and you need the sort of down time. So doing the music, doing the theater actually often helps my mathematics so it was wonderful just being in an environment where so many theater productions, so many orchestras playing and so I spent a lot of time with that. I was very lucky to go to Wharton College, which had a lot of other state school, so you know,

people's impressions of Oxford is rather a kind of posh stuffy place, but actually there's people from all spectrums of life and I actually was lucky to be in a College which was very much people like me who came from state schools and… it was a very political time. It was 1980s. There was a lot of reaction to Margaret Thatcher here so I got very… mixed up it sort of left-wing politics and stuff. But it was a joy because, you know, we were doing fantastically exciting mathematics, especially towards the end of the course but also just, you know, it's where I kind of cut my teeth doing other things as well.

BH: So, it sounds like, you know, there was lots of distractions for you but you did quite well as a undergraduate, didn't you? Like you kind of got back on track and…?

GS: I got back on track and it was, you know, I realized actually my dream is to become a mathematician, I need to do my doctorate. I need, if I'm gonna get to that place I need to do really well on my finals. So, at some point I just gave up everything and burned hard on mathematics and did well enough to get my grant to do a doctorate. And that's actually mathematics really started. 'Cause even up to that point you're still really learning the scales and arpeggios, even at university. I think we only started to see… seeing real mathematics almost in my last year, a little bit, but it's that transition and it's a massive transition from undergraduate mathematics to graduate mathematics. You know, suddenly the problems aren't solvable in an hour, with the material that you've been given. [chuckles] You know every problem up to that point is manageable. And suddenly your supervisor's saying read this, read that, they're totally un… I didn't understand any of these papers I was given. I had to learn to read in a different way not step by step which is you know a kind of school and university mathematics. It was about getting a an overall impression of what is this paper talking about and then going into the details when needed. I learnt a completely different way of reading mathematics and then again dealing with the uncertainty of your supervisor giving you a problem that they don't know how to answer and it may not even have a recognizable navigable answer. That, you

know, as a now mathematician supervising other PhD students, I spend a lot of my time actually as a psychologist, not a mathematician. Managing, dealing with the uncertainty of going into the unknown, that is very very unsettling and a real transitionary stage. But that's when I really started to buzz because suddenly I was reading… real mathematics for the first time. You know, in that first year I did my own first contribution to mathematics and that was just such a buzz to realize, oh my gosh! Nobody has ever thought this before and it's now something that with my proof will be there forever and that is one of the just… joys of mathematics, you know? The other sciences are very evolutionary in nature. A theory will survive for a bit but then new insights will me it falls away. Mathematics has a, you know, robustness about it because of proofs so I know that the things that I've proved will last til the end of time. And in fact G. H. Hardy talks about that in A Mathematicians Apology, he says immortality is a bit of a fancy word but mathematicians probably have the best chance of achieving it.

BH: You make me want to be a mathematician.

GS: [laughs]

BH: So [laughs] Youtube videos don't quite have that permanence I don't think. Obviously towards the end of your undergraduate and then starting as a graduate, you have to specialize in a subject. Can you give me just the very very brief outline of what you specialized in? And more importantly why you specialized in that, of all things?

GS: Yeah so… it goes back to something I learnt at school was which was… I mean I'm actually a group theorist so this is a language that was developed first of all by this rather romantic historical figure, Évariste Galois, killed in a duel at the age of twenty over love and revolutionary politics in France at the beginning of the 19th century. Yet already he'd developed this language which became group theory and it's the language I write on my yellow pads which my office

here is kind of piled with them. So this is trying to understand symmetry and what symmetries are possible. So the ancient Greeks for example proved that the platonic solids, there are five of them, you can't make a sixth one, these are the shapes that make a dice, but I'm looking at sort of symmetries in like higher dimensions. What dice are possible in higher dimension spaces. My other passion is number theory. So I find that by combining very different ways of looking at things you can make extraordinary progress. So I actually use a tool which is used for trying to understand prime numbers. Something called a zeta function. But I… this is trying to understand a wild, you know these wild numbers, the Primes, which we don't understand any patterns to them. But I'm using the same tool but to look at what symmetries might be possible. And using that kind of set of glasses from number theory to look at a completely different area in group theory. Yeah it's interesting, I don't know what that seed that was sown at school… may be the reason that I ended up doing that.

BH: Was it do you think you just have like, you know, an innate interest in that subject or was it did you have a particularly inspirational lectures who drew you into it again or…?

GS: Well… you know what I think it comes back again to that passion for languages. Because I think mathematicians divide into two types. The ones that view mathematics very pictorial and they're very good at just drawing diagrams or pictures. Roger Penrose, my colleague in Oxford, you know. Twister theory comes out of his just ability to kind of crystallize in diagrammatic form complex thought. Whilst I'm somebody who likes to change things into language, so I'm very linguistic in the way I do my maths and I follow the rules of that language to make insights. Rather something which doesn't sound linguistic at all. Symmetry is about geometry, isn't it? Isn't it about pictures, about patterns? But this was the great power that this language had, it threw away those and so you don't get distracted by what the thing looks like. And you're gonna understand it's structure and make things in dimensions that you can't even see, so I think… you know, why I… felt happy in this world was I think partly because I love

manipulating language and seeing what the consequences of that are.

BH: You did a PhD, obviously.

GS: We call it a DPhil, interestingly in Oxford.

BH: Ah.

GS: Yeah, we're sort of unique in that and we're a bit nerdy about saying I didn't do a PhD [exaggerated stuffy accent] I have a DPhil, [chuckles] but it's the same thing.

BH: Okay, you did a DPhil. Doing this seems like a traumatic experience for many people I speak to and this… apparently there's this time in the middle where everything falls away from under you and you think you're not doing it right. Was it a traumatic process for you or was it smooth sailing?

GS: No, not smooth sailing at all, and in a way… you know I think that's important. You know one of my favorite films is Good Will Hunting. Matt Damon is a janitor in a math department, there are these problems up on the blackboard and he just solves them really easily and professors come in next morning and go, oh my god. I think, you know, ultimately he doesn't become a mathematician in that film, because the maths is too easy. You know, there's no challenge, for him it's the women that are the challenge, he doesn't understand them at all, there's no algorithm. So for me I think, you know, it's important that things are difficult, and you have that really tough time and I did. But then there's something very exciting about maths where you can get a sudden surge of insight and understanding and things can happen very quickly and that happened to me. I find train journeys very conducive to mathematics and indeed my great insight happened on a train journey, not a very romantic one, it was back from London to Oxford but I think there's something about the way the landscape is going past you. It's sort of creates something… the speed of it… just

right for stimulating mathematics. And so I… I kind of had this just like oh my gosh I think I see how to do this thing and then it turned out to be a good breakthrough in this area. I got published in the top journal, The Annals of Mathematics, where Andrew Wiles has published Fermat's Last Theorem, it's our dream that Journal. So my doctorate was published there, and that really launched me.

BH: You remember that train journey very well, obviously? [chuckles]

GS: Yeah… I think, you know, I've got a few moments in my life of those moments of just extraordinary insight and you live off those 'cause most of the time you're wrestling and you're having a really hard time and nothing's working and so you hold on to those euphoric moments.

BH: Did you keep the ticket?

GS: [laughs] I didn't keep the ticket.

BH: [groans] No!

GS: No.

BH: Wouldn't that be great?

GS: Gosh, yeah.

BH: Have that framed on the wall. [laughs]

GS: [laughs]

BH: Do you find yourself now, if you're stuck on something mathematical, booking some unnecessary train journey in the hope of… rattling something

loose?

GS: [laughs] Yes… it's… I mean I certainly value those kind of spaces where you can kind of let yourself just… I mean it's funny 'cause I don't find… you now someone people find plane journeys quite good because it's kind of a space of thirteen hours and they're going to California or something from London, but I'm afraid I just use those to watch movies that I haven't watched for a while so… it's train journeys are the ones for me.

[gentle piano music]

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[gentle chimes]

GS: Well I think there's an important thing to learn here because I had, you know, this great theorem that I proved, it was in the Annals and I had to learn to deal with the downtime again. And I remember I spent some… a period of time in Israel at the Hebrew University and things weren't going really well and there were a lot of eyes on me at that point.

BH: Because you'd had this good…

GS: Yeah, yeah, you know, what's he gonna do next?

BH: Mhm.

GS: And I think there's something rather nice about being a PhD student, a DPhil student, is, nobody's looking at yet and so it's quite… and I always say you know enjoy this period, to my PhD students. It's space for you to experiment, play, and nobody's watching too much. But one of my professors that I worked with at the Hebrew University, he said, you got to learn this. That it's like a sine wave, but unless you've actually experience a sine wave actually oscillate you think oh my gosh there's a peak and then I'm down again and maybe it just stays down here and I'm done and… so it was really important to learn that there was going to be another up and once that happened it helps me now to always think, yeah okay… it's a sine wave, it's not a [chuckles] you know, a parabola where it's sort of just one height.

BH: Yeah.

GS: And so my journey was kind of like doing, I had a postdoc, a summer in Oxford then I spent some time at Hebrew University. Very important for me because that's where I met my wife, and so I got a very strong connection to the Hebrew University. I was spent some time in Cambridge where I did a lot of number theory with Professor Coates in Cambridge and then I came back to Oxford doing my mathematics. But, you know, already sort of early on I was… I had this wonderful thing from the Royal Society. It was called a University Research Fellowship, and it was kind of like a Post- postdoc. And most people would be going into a lectureship and the teaching starts to overwhelm you. This was a period of about ten years when I could carry on doing my research and I really made some major breakthroughs during that time. But one of the things that was really important was the Royal Society were encouraging us to actually not just do our research. They didn't want us teaching because it was meant to be timeout but when I wrote an article for the Times newspaper, actually about the Fields Medals. It was before Matt Damon made Field Medals famous because

they talk about them in Good Will Hunting. And I wanted to write an article just to tell people about my excitement about mathematics. Partly starting to think about that Christopher Zeeman who'd made the effort to talk to people. And I was worried what my community would think if I wrote this article. And I spent ages on it. It's a thousand words and it took me a month to write it. It was just… painful. I'm not a natural writer. And you know that sentence I quoted the beginning of Mathematician's Apology basically we were living under the specter of G. H. Hardy saying, do not talk about mathematics just do it. So I was really nervous that people were thinking I'm selling out or…

BH: Being a bit showy or like sort of…

GS: Being a bit showy or oh maybe got nothing else to say mathematically so he's talking about maths. You know…

BH: Hmm.

GS: So but then I got this… incredible feedback from the Royal Society. They were very… they looked after their Research Fellows and would come and visit me in Cambridge, make sure everything was already. And they said you know that article you wrote in Times? We think that's a really great idea, because we think it's really important that scientists talk to society about the importance of their work and don't just stay in the ivory tower. And that support from, you know, our scientific body, you know going back to Newton, was really important in thinking, okay yeah I think this is an important part of being an academic. Being a scientist, being a mathematician , is actually telling people about why we're doing things. Why it will be important. What impact it will have. And so that started me on this extra part of my career which is now become very important. Probably why I'm now probably talking to you is that realized that making mathematical discoveries is important but talking about them and telling other people is when they start to come alive. We do that in our seminars, in our journals, but actually if we do it more broadly people will realize why maths is so

important.

BH: Some people… particularly people outside the UK might not know this about Marcus but he's known to most people for being like, you know, a real face of mathematics, you know you're on lots of BBC TV shows and the radio. So you know, you're very omnipresent when it comes to mathematics and communicating mathematics. You're a real sort of champion of it. But that thing you were worried about when you were writing that Times article, that kind of snipeyness or jealousy in that… was that well founded? Do you still find that? Do you think people think, oh Marcus du Sautoy is just a… he's a TV guy. He's not a real mathematician or do you think people have kind of accepted you can be both?

GS: I was really encouraged by the feedback I got from my fellow mathematicians and a lot of them said, oh it's so important what you're doing and, you know, as time has gone on, I get so many people telling me, [scoffs] we have these things in England when you're applying to university you have to write a personal statement about why you want to do mathematics. And they said time and again people just write that they've read Music of the Primes and got so excited about the unsolved problem of prime numbers, the first sort of major book that I wrote. And that's… you know and I get that from PhD students, they say, oh you know the reason I'm here… one of my PhD students, he's now graduated, but he came and knocked on my door and he said I came to a talk you gave in New Zealand when I was at school and my dream was to come and work with you and here I am, I'm now done a degree. He's a Korean guy. Now I done a degree in Oxford and I want to be your PhD student. And that's so exciting and so the feedback's been, you know, incredibly positive.

BH: Do you feel a pressure to keep doing math research and publishing to keep like your street cred?

GS: I don't feel a pressure. I actually love doing it. I mean, it's hard juggling

all of these things but weirdly, you know, we've just been through, hopefully coming towards the end of coronavirus and lockdowns and things. That's given me space to actually revisit a couple of mathematical problems I've been working on and really made progress with them. Because it's tough doing mathematics. You have to kind of get into this rather Buddhist state of… meditation, not letting things crowd in and so lockdown for me has been wonderful in sort of re-exploring some challenges that I'd kind of left bubbling. So yeah, I think why am I communicating about mathematics? Because I love doing mathematics. So it's really important to me to carry on doing the thing I love doing along side telling people why it's such an important subject.

BH: You talked about the Fields Medal before which is famously given to young mathematicians. You have to be below forty don't you, to receive it?

GS: That's correct.

BH: And you also talked about how you hit a couple of home runs really early on, you know your PhD… your DPhil was published in the Annals of Mathematics. Have you still got it now? Do you think you're as good at mathematics now as you were when you were a younger man?

GS: I think there is something about youth which is helpful and that's a certain sort of ignorance and arrogance. I often compare it… one of my favorite Wagner operas is Siegfried and in Siegfried he's able to kill the dragon Fafnir because he doesn't know fear. And I think one of the troubles is that we begin to learn fear of big problems like the Riemann Hypothesis about prime numbers. And that can sometimes play us out of the game. We don't take the risks that a young person might do because they don't know they shouldn't be trying that or something.

BH: What is the risk? You mean the waste of time, or...

GS: Yes.

BH: What are you risking by taking on a big dragon?

GS: Yes, sort of waste of time, I think. That, you know, if everyone else has tried this, you know, what new am I bringing to this? But sometimes it's still things that we haven't tried. But mathematics has become very rich and complex that experience can actually be a helpful component so knowing about a lot of other areas that you can bring those insights to a problem is actually… means that having a bit of mathematical maturity I think it is still… very helpful. This weird thing about having to just dedicate yourself to something which many people think well why are you spending all your life doing that, it doesn't seem… you know, there seem to be only about ten people in the world that really understand what you're doing. So sometimes as you grow older just the indulgence of doing mathematics can be quite hard to deal with actually. So I think… dealing with that it is something a lot of people face, you know, there's a kind of slightly, I mean I talked a little bit about Asperger's before… and I think having that incredible focus and not really being interested in anything else is an extremely helpful trait for a mathematician. And in fact, you know, Simon Baron-Cohen who's one of the experts in autism and Asperger's, he did a piece of research recently looking at the correlation between very high mathematical ability, looking at those mathematicians who had won prizes and just seeing where they are on the autistic spectrum and seeing whether is that a superpower… you know… we've heard talk of that being a superpower… I think it is a really helpful superpower for a mathematician.

BH: I imagine you're also can have a bit less of that when you have to worry about sourdough bread and kids and all the different things that come with an older age.

GS: Yeah, exactly! A lot of my PhD students say, you know, I have a lot of respect for you now having, you know, suddenly started my life and trying to

keep doing mathematics with all the noise outside and I think being able to shut out the noise from all of the demands from your faculty, from your family, and that's… you know can be very annoying sometimes for your colleagues and your family if you… if you do that but it's really important.

[gentle piano music]

BH: As you said there's a bunch of yellow notepads around as at the moment. You said you've been getting back into a bit of mathematics just lately and I saw them strewn around your leather chair here. Are you tackling dragons at the moment or are you dealing with smaller things?

GS: I think it's really important to… to go for smaller things. 'Cause often the dragons you find the back way into attacking them not from head on. So I think anyone who solves the Riemann Hypothesis will probably not have been working on the Riemann Hypothesis. I bet they will be working on something that was… seemed unrelated and then suddenly they see a connection and they go oh my gosh this is the way forward. So I think it's really important. At the moment I'm just working on a very small example of something but I know that if I understand this one little example it will give me the insight into the whole theory. So I've picked an example which is rich enough to have the complexity but it still manageable where [chuckles] I can actually kind of write out the equations on my yellow note pads. So I think that's a strategy that I give my PhD students. Don't try and go for the big one in a first go. Just go for the example of it and see whether that has enough of the kind of richness that you see what's going on in general.

BH: One last thing about doing mathematics. How do you do mathematics? I always hear people like you say, I'm gonna sit down today and do maths. Like what does that actually… what does look like?

GS: [laughs]

BH: I can't… by not being a mathematician it's one of the hardest things for me to understand. You sit down with a black piece of paper and just start writing things and then adding things together? Or… what does doing math look like?

GS: Well I think that was one of the motivations for the second book I wrote which is Finding Moonshine, or in America it's called Symmetry just simply. And it is the story of symmetry but that's what my research is about. Trying to understand symmetry. It's the story from, you know, the first objects that people made, these dice through to classification of finite simple groups today and the things we're still doing. I kept a diary for 12 months when I wrote that book, which was my attempt to answer this question. You know, my parents would ask me that, my girlfriends, my…

BH: What are you doing all day?

GS: Yeah! What are you doing all day?

BH: Yeah.

GS: And it is a kind of slightly mysterious thing. So I kept that diary to sort of examine my own process about how I do things and actually if you do open the book then the yellow notepad's the flyleaf in the hardcover book. But I think there's a lot of playing going on. That's why, you know, people who play are good at mathematics. 'Cause you just need to try things out, try different avenues and to keep questioning things and that's really being able to ask good questions is almost more important than being able to come up with slick answers.

BH: Now a huge part of your job, and it is part of your job description, is public understanding of mathematics and outreach and doing slightly more out there things. You've written books and done TV shows and we'll link to all sorts of that sort of stuff but a thing I do want to talk to you about is theater and plays.

‘Cause that is a bit more unusual when it comes to outreach.

GS: Yeah.

BH: And what not. Tell me a bit about what you’ve been doing in this area, ‘cause it’s… it’s different.

GS: Yeah, as I said, you know, music and theater were always very important to me. But actually in a funny way they were always places I would escape when my mathematics was not going well. So when I was in Oxford I worked with a community theater. The Pegasus Theater in Oxford. And it would be where I escaped to when the maths wasn’t going well and when it was really going badly during my PhD and postdoc period I remember, I lost fantasied about running away with a theater company. I downloaded a application form to a theater… school in Paris several times…

BH: In what role? Where you like an actor or like were you…

GS: Yeah I liked different things. So I liked acting. I liked devising pieces. I did some directing as well. But there was a theater company I met whilst working in that community theater called Complicité and they were doing theater in a completely different way and it was quite a mathematical way. They would set up kind of theater exercises, which were essentially little algorithms, that they would then let run and see what would emerge from this and I really loved that, you know, they wouldn’t come with a script and then you’d learn your lines. Completely the opposite. The script, if it ever emerged, would be right at the end of the process and they would use this kind of experimenting. Using the theater stage as a kind of like almost a place to play, you know…

BH: Like one of your yellow notebooks?

GS: Exactly. You know my maths started going well and I went the

mathematical route but just shortly after I published Music of the Primes, which talks about the story of Ramanujan, this Indian mathematician who comes to G. H. Hardy 'cause he's got insights about prime numbers. But then this theater company contacts me and say, oh we're doing a play about Ramanujan and Hardy, would you come in and give us some of your insights about the story and what we want to do about the maths. Turned out to be this theater company that I always loved, Complicité, and they say, you probably don't know who we are. And I wrote back this such fanboy letter…

BH: Yeah [chuckles].

GS: I said, I know exactly! I've been fantasying about running away with you.

BH: I'll be there tomorrow.

GS: [chuckles] Yeah! So I was there tomorrow.

BH: Yeah?

GS: And actually they were quite surprised to find a mathematician who understood the language of theater and so I set all of these theater games for them to explore the maths that Ramanujan and Hardy…

BH: They must have've think, oh we've bitten more than we can chew with this guy! [laughs]

GS: Well, exactly. But the weird thing was that the guy who runs the company, Simon McBurney, he would just love this. That there was… and so he said, are you free tomorrow? I said, yes. And I kept on coming back. Eventually the producer said… when Simon asks you to come back tomorrow you've gotta say no 'cause he's gotta write a play and he's just getting obsessed. You know, he wants to know what a mock theta function is and this really is a bit too far for

him.

BH: [laughs]

GS: Anyway, so this reignited my passion for theater and out of that piece of work which became a play called Disappearing Number, I met another actress who actually had a mathematical and physics background. And we started working together about ten years ago. We started making this piece. One of my favorite writers is Borges. Argentinian short story writer. And he writes very interesting mathematical scientific kind of short stories. And one of them, the Library of Babel, is actually an exploration of what the possible shapes of the universe could be. It's actually [chuckles] a story about the the Poincaré Conjecture weirdly. This kind of inspired me, oh I'd love to make a piece of theater which explored the way a universe might be looped. In a way the universe… for the theater is the stage. That is your universe and then you can ask well, yeah but how… what's the rules of this universe? If you exit stage right, what happens? Well perhaps you enter stage left. And if you go through a trapdoor perhaps you drop in through the ceiling. And so I thought oh this is fun, you can make actually a torus out of this theater space and so it sort of began this journey and then we created a piece with two characters called X, I play X… you know if you're gonna write a play I better have a part of myself, so I'm X and Victoria Gould played Y, and we used this process of devising to create a piece which ultimately we did in many places but it eventually arrived at the Barbican. What an amazing dream for an actor, let alone one who started as a mathematician, to actually perform their play at the Barbican. And it got its name then which is now it's called I is a Strange Loop. And we've just released it on the Maths Institute, Oxford Institute, Youtube channel. So you can see it there. The most exciting thing for me is that we've also published the play. And it's published by Faber and Faber is… you know… it's where every playwright wants to be. It's where Beckett is published, it's where Tom Stoppard is published. It's a real dream to have the play sort of crystalized there. So that's been… you know as you say rather unusual way to communicate scientific

mathematical ideas. But that's been my passion. Not just to talk to the people who will come to a science festival or would naturally log on to a, you know, science Youtube channel like Numberphile. You know, great, it's important that we give them great material but I think the real challenge is getting to people who wouldn't naturally choose Numberphile or a science festival, but might got to the theater and then suddenly say oh my gosh. There's mathematics in this, but I didn't realize that was maths. The way a space is connected together. So I'm very exciting by using sort of a rather unexpected platforms to tell mathematical stories.

BH: Am I being anti-snobby by suggesting, are theater goers the sort of people who are ignorant of mathematics and the important of academic studies? It feels like this is like one area where there wouldn't be a desperate call for, c'mon we need to get these people educated.

GS: You'd be surprised and I think it plays to this still two cultures idea of either you're into the arts and the humanities or you're into kind of science. So I think you'll find quite a lot of people who perhaps enjoy the world of the theater still wearing their oh I'm rubbish at maths as a badge of honor. And what was very curious is the place we took this play to where we got the most extraordinary reception and we found our audience was India. So we took it to the Mumbai festival and we did a couple of performances there and it was extraordinary. People on their… feet whooping during the performance at seeing mathematics on the stage. And I think there was something interesting here because, yeah they are… there's a mathematical literacy in India because, you know, they value mathematics. You can't wear I'm useless in maths as a badge of honor. No parent would allow their kid to say that. Yet they still consider mathematics as something which is in the classroom or in the university and for them it was the shock of seeing mathematics in a completely different environment. They were just blown away by it. And I think that is true that you know audiences in… the UK are more used to seeing sort of ideas of science creeping into the theater. You think of Copenhagen, Michael Frayn's play

exploring Heisenberg's Uncertainly Principle or Tom Stoppard in Arcadia exploring chaos theory and fractals. So you know, we're a little bit more used to seeing science in the theater. For this Indian audience they were like totally blown away.

BH: What was it like for you as someone who for most of your life when you like write a math paper and that, there's probably a hundred people in the world who can even understand it, yet alone critique it to suddenly be putting yourself out there. Being reviewed by theater critics and your writing being… criticized by a whole new group of people who don't have to understand mathematics to say you're good or bad at it. What was that like for you?

GS: Well I always love new challenges… so for me, you know, I'm always looking for something else to challenge myself. So, you know, it was frightening but exciting as well and I think there's something which actually is a common thread throughout all of this because even though you might say I'm only talking to a hundred people at a conference… that is still a performance and I think, you know, we're all natural storytellers. We're all natural performers. You know the audience might be a bit smaller and might be a bit more esoteric of group theorists from around the world. But I didn't feel it was so different to now standing up on the stage of the Barbican, in the Pit Theater.

BH: But you're on really solid ground when you're giving a talk about group theory, 'cause you're one of the world's best group theorist.

GS: yeah [laughs]

BH: When you're acting, you're probably not in the hundred best actors in the world?

GS: No, no, and I think that was a… I wasn't very nervous about that. And… what was really exciting was to get feedback at then of a performance and

people… you know talking to people… and people going, what? You're actually a… professor of maths? I thought you were a professional actor. So that was really reassuring to, you know, I would have taken myself out of the play had it weakens… and got somebody else to perform it. You know it was fun devising it. It starts with some just physical movement by me. I do basically ruler and compass construction using my body of a hexagon in space and that requires some really very important skills of holding a point and moving and making sure the point that you're holding does not move with you. That sort of the thing that, you know, you learn in Lecoq, in this school in France. And so, you know, I have done a lot of theater, so it's not a completely new world to me. But it was… this wasn't just learning lines. This was a very physical part.

BH: Are you… what's next? Are you doing another one?

GS: Yeah. Well, I am. I've got real taste for this. So during lockdown I wrote a new book which I actually delivered early because my diary got gutted so I've written this new book called Thinking Better: The Art of the Shortcut. But then I delivered it two months early and my editor said, oh my gosh you authors you've been so productive during lockdown. You know, I've got so many books, it's gonna be a couple of months before I get back to you. So I actually spent that time writing a new play and this play is about my heroes in mathematics. André Weil, a French mathematician.

BH: French again. You and the French.

GS: Oh yeah, maybe it's… some resonance there.

BH: Yeah, yeah.

GS: Going back to… people might know him because he was one of the people who created Bourbaki. This fictional mathematician. You know, if you go into a maths library you see a lot of books by this guy Nicholas Bourbaki and

you think, wow that's the most productive guy out. But it turns out he's a fictional mathematician created by this French group to try and write under a pseudonym. So I use him as a kind of chorus figure in this play but then it's the story, rather extraordinary story of André Weil and his journey… the play starts in prison with André Weil in prison and you think why is this mathematician in prison? And in fact in prison he makes the most extraordinary mathematical discoveries. He proves a version of Riemann Hypothesis, not for primes but for counting solutions to equations. And so it's sort of the story of the breakthrough that he makes whilst in prison but also the journey of how he got to prison. And he's very obsessed with India and the Bhagavad Gita and he makes a trip to India. So I've actually used the Bhagavad Gita which is a dialogue between Krishna and Arjuna. Krishna the god, Arjuna is about to into battle, he's very nervous about the deaths that will ensue but Krishna explains to him his duty is to go into battle. Turns out that André Weil decides not to go into battle which is why he ends up being in prison, because he's deserted his army and it's kind of his journey. So I have a… I created this new character which is his cellmate who is kind of Krishna to his Arjuna. It's just a play on paper on the moment and in a couple weeks time I'm going into a studio working with four actors to take this from page to stage and if that goes well and it's working as a piece we're gonna pitch it to the Vaults Festival which is our kind of like festival here in London for Fringe Theater. So hopefully in the coming years you might get a chance to see this piece of theater.

BH: Do you type it or handwrite it?

GS: So this one I actually typed in.

BH: Okay.

GS: Yeah, not handwritten. My writing, when I'm writing books and I'm writing plays, I'll use my computer. When I'm doing maths I never use my computer. That's why all the yellow notepads around the office here. I have to

use the non-linear nature of a page.

BH: I have one last thing to ask or one last concern. And now this might be silly concern. You're talking about how… you know, finding mathematical breakthroughs and discoveries and proofs are like immortal. They're a chance at immortality. That really appeals to me. And you're lucky to be blessed to be one of the people capable of making such breakthroughs. And then I hear you spending about all this time you're spending writing books and plays and giving talks and doing all this outreach which is really valuable. I feel like you're eating into the hours you have to solve the Riemann Hypothesis or make the next big discovery, like how do you reconcile your passion for these other things and outreach and that and the finite number of hours you have to do another great mathematical thing?

GS: Because… the great breakthroughs are very often done on the downtime and the time not looking the problem. And often, you know, I've always used these kind of other activities to help me come back to a problem and see things from a kind of new perspective. So, you know, that was always when I did theater as a PhD student, it helped me. I got stuck and there was no point sitting at my desk any further, I would just get deeply depressed. I needed to go and do something else and then when I came back it was like I was looking at the thing from a new angle. So for me these things… it's always been part of the journey of mathematical discovery.

BH: So this is like… this is part of your mathematics, is it?

GS: It is.

BH: Alright. Alright you can keep doing it then. Look I reckon you need to check on that sourdough bread. [laughs]

GS: Oh yeah? [laughs]

[gentle music]

BH: Well that's all for today, but if you'd like to see Marcus performing his play, see what you think, it's called I is a Strange Loop and it's been uploaded to Youtube where you can watch it for free. In the notes for today's show I'll also include links to Marcus' books, including the play and a few other bits and pieces. Thanks again to G-Research for supporting today's episode and to Numberphile's longtime supporter the Mathematical Sciences Research Institute. I'm Brady Haran and you've been listening to the Numberphile podcast.

[music fades out]