

## Numberphile Podcast Transcript

Episode: Why Did The Mathematician Cross The Road? with Roger Penrose

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Sir Roger Penrose is one of the biggest names in mathematics AND physics. Here he talks about sibling rivalry, Stephen Hawking, having ideas, and toilet paper.

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[gentle music]

Brady Haran [BH]: Sir Roger Penrose is a true giant of math and physics. Anyone who works in relativity, cosmology, and black holes will surely know his name. Dozens of important discoveries and principals bear the name Penrose. Some of the more beautiful and beguiling areas of mathematics are also his doing, such as Penrose Tiling. [music continues] His breadth of work and interesting life would be impossible to fit in a book yet alone this brief podcast.

[music fades out]

BH: Were you a prodigy? Would someone have seen you in school and thought, this boy's destined for greatness?

Roger Penrose [RP]: No. [pause] Well you see I was... often compared with my older brother when I was very young. Well, I should explain I was in England up to the age of seven. I had my eighth birthday in Canada. This was when the Second World War broke out and my parents decided to stay in Canada. They went off. War was looming rather at the stage. I have some memories of when I was in England. I sometime tell people this story, I don't know what you'll make of that. You see I never liked to eat spinach. This is something that has changed in when I got older I love spinach now. But in those days I just couldn't stand it. And you see we had a well off family and there was a nurse or somebody I think, I dunno, a cook... we had various people to look after us 'cause my father was very well off. The nurse or whoever it was had decided that I ought to eat my spinach, which was a sort of circular spot on the plate. And so I said no, no I don't want my spinach. So she said well alright eat half of it. I said... I think I said how about if I eat half of it? So she okay eat half of it, alright. So when she was out of the room I carefully made this circular patch into a semi-circular patch, of the same volume, and when she came back she said that's very good, thank you, and so she was quite completely satisfied. So if that gives you any hints, I don't know?

BH: You had two brothers and they were both quite capable boys, were they?

RP: Well you see they were more prodigious, or whatever the right word is, than I was. 'Cause Oliver, my older brother, was certainly a prodigy. When we were in Canada he went to a thing called the advancement class and that set him ahead two years and so he went into... he went immediately to high school when I guess he was ten. He was two years younger than the next youngest and he was second in the class. He was certainly a prodigy and he read all sorts of

things. It was very useful to me because he taught me quite a bit of physics when I was young. Just sort of basic things but I think I learned a lot from him. I learned a lot from my father certainly. He was a scientist but not a physicist. He was on the biological side. But he knew quite a bit of maths.

BH: Yeah?

RP: I learned mathematics from him. But physics I got a lot from Oliver, my older brother. My younger brother was a prodigy in a completely different way. He was very good at games and later on became the British Chess Champion a record ten times. [laughs] And he was really good already at the game of chess. He could beat me at pretty well all games. Not quite, but pretty well. I remember this game Scissors, Paper and Stone, you know this thing, and he used to wallop me at that game. I couldn't kind of understand how he could beat me at that game and it seemed to me it was a pure game of chance. And I wondered whether he was reading my mind or something. So I went and I got hold of a table, of log tables, and went opened the thing right in the middle and it had a code for what the numbers were which was stone, which was paper and all that.

BH: Yeah?

RP: And I had made the long strip of paper and I just followed that and I broke even. So this was a lesson to me. You know, that if I was doing randomly as I was trying to do that he was doing psychology on oh this and he was sort of predicting what I was thinking which is a little [laughs] bit unnerving but...

BH: Professor when you reflect on your upbringing and the fact you had this scientist father, you had an older brother who was exceptional, you had a younger brother who was exceptional, do you see that as shaping you in anyway? It made you into the professional you later became?

RP: Probably, in some ways. As I said I think I learnt things from my older

brother Oliver. I learned not to play chess from my younger brother.

BH: [chuckles]

RP: Which was useful. I could have wasted a lot of time on chess [chuckles]. And not to spend too much time on games. I think [laughs] that was probably educational.

BH: Was there a competitiveness though? Did you feel like... were you fueled to keep up with them?

RP: There was a competitiveness, I think yes. That's true. Certainly there was with my younger brother I felt. I think when it came to physical games, it was... I was a bit better. 'Cause of course [laughs] he was two years younger than I was. Like at badminton, which we used to play and things like that. But he didn't... he wasn't a mathematician. People like used to think, you know, chess and maths go together. Oliver was a good chess player but he wasn't as good as John. He became Cambridge University champion. He was that good.

BH: Right?

RP: But I was simply didn't... attempt to play chess. I was just... completely nothing I would try to do.

BH: So professor if I went back in a time machine and met the...

RP: [laughs]

BH: ...brothers Penrose, would I have guessed you were the least likely to sort of, you know, become this Knight of the Realm, Fellow of the Royal Society, acclaimed physicist and mathematician? Or would I have picked it?

RP: It depends. There was one person I remember who did... I think he regarded me as the dark sheep of the family. This was Oliver Strachey, who actually was a high up in... I didn't know anything about this... in what became the GCHQ, he ran it one time, but nobody knew anything about that.

BH: Yeah?

RP: It's all dead secret. But I think he spotted something... I dunno... I dunno what it was. But on the whole I think I was known for my brothers and not myself. But I did... I didn't do terribly well in school. I did get moved down a class when I was in high grade three.

BH: What you got demoted?

RP: I got demoted at school.

BH: Huh.

RP: Yes you see the teacher whom I didn't get on with at all, and she had shared what was called high grade two and low grade three and I was in low grade three and she considered I was too stupid for low grade three. Mainly because I couldn't keep up with her and the class with mental arithmetic. You know you add three, multiply by seven, subtract fifteen... whatever it was and you see and I'd get completely lost [chuckles] and then got going.

BH: Yeah?

RP: That sort of thing I was completely useless. And I was very slow, I was very very slow when I was young and she moved me down and then decided I was too good for, you know, high grade two and not good enough for...

BH: Right?

RP: She didn't know what to do with me.

BH: You're a bit stuck in the middle.

RP: I was stuck in between... in the crack between those two, in the narrow crack. But eventually she got rid of me by moving up to high grade three, just to get rid of me I think. And I got on better with the teacher and I did have a teacher later on, not grade three teacher, I forget if it was grade four, grade five, I don't remember what it was. Yes, it was something about skipping a grade which I think I did.

BH: Right?

RP: I remember now. But the teacher who I thought was very insightful, Mr. Stanet, and he had looked at my exam papers and realized that I did pretty well at the beginning and then sort of tapered off when I couldn't do anything... it's just that I was too slow.

BH: Right.

RP: And that allowed me a whole... it's supposed to be one period where you're supposed to the test in and then he allowed me to take the game... what was the play period after that and still keep going and sometimes the period after that as well.

BH: Hmm.

RP: Working away at the test and then I would do very well, I'd get in the high nineties. I think a quite lot of it was not being able to remember my tables and things like that. I had to work them out on my fingers or whatever it was, you see? I knew what I was doing but I just had to figure it out more from first

principles rather than remembering it.

BH: Professor, if I got into that same time machine and went back and spoke to the boy Roger Penrose and said what do you want to be when you grow up, what's the job you're aspiring to? What do you think he would have told me?

RP: At that time when I was in Canada as a school kid, it would have been a doctor.

BH: Right?

RP: Medical doctor. They had some vocational guidance, no I can't remember the right word. It was something where you had to score in two different ways and it met in the middle it was always on a doctor.

BH: Right.

RP: I think I did it twice. Yes, I did an IQ test too.

BH: Right.

RP: The first time I did pretty well and the second time my IQ had come down considerably.

BH: Right [chuckles]

RP: I think it was because you had to divide by something to get your IQ and as I got older...

BH: Did the idea of being a doctor appeal to you for the job that it was or just because it's what the test told you you should be?

RP: Partly what the test told me. Partly because secretly I was not going to a GP, a general practitioner, or something, which my mother thought. You see, she thought I would have a good bedside manner or something and I think my bedside manner would have been okay but I wouldn't have remembered the names of any of the [laughs] the drugs and I'd have gotten confused. It would have been completely hopeless.

BH: Right [chuckles]

RP: But what I secretly was going to do was to be a brain surgeon.

BH: Right?

RP: And I thought I would open them up and figure out how the blasted thing worked, you see, this was [laughs] which in a sense came back in a certain way later on in life.

BH: Yeah.

RP: I never followed the medical degree because as later on when I was back in England and we had to decide we were to do in the final two years, each of us individually had to go and see the headmaster, and he said what do you want to do in your final two years and I said I'd like to do biology, chemistry, and mathematics. I think it was chemistry and not physics because the chemistry teacher was more exciting than the physics teacher who was a bit old and...

BH: hmm.

RP: It became too much from him. The headmaster said, well, I'm afraid you can't do that. If you wanna do maths you can't do biology. If you wanna do biology you can't do maths I'm afraid, make your choice. [chuckles] So I said mathematics, physics and chemistry. And this was a big change in my life.



BH: Yeah?

RP: I said mathematics because I... I learned to love maths which was something I had a feel for even though I was extremely even before that. And I used to make polyhedra with my father and all sorts of things and I made a slide rule for working out the date and things like this.

BH: Professor if you were a little bit slow at mathematics like it was something that you would take you a long time, what was it that appealed to you about mathematics? What was it that you know that day sitting with the principal and when the principal saying okay, it's biology or mathematics, you chose mathematics? What was it that appealed?

RP: I just loved it. But it was partly, I remember three teachers and the teacher that I had at the end was one I got on best with and there was one point he said something and it was about differentiation and smoothness of curves or something and he said something which I said look that's not what you said isn't quite right. And he said well what... and I said no. Ah Yes! I said if you take  $Y = X$  to five-thirds or something it then has an inflection.

BH: Hmm.

RP: But it's second derivative doesn't manage it, the origin. And he didn't believe me and made me cross it out so I pointed it out and I said you can see X had just did that, beautifully, nod that way if you looked. [laughs] And uh...

BH: And what was it about that interaction that was special to you? Just you enjoyed calling out the teacher?

RP: I think I did yes. And you could see him pulling books out of the shelves and I think people would nudge me [whispers] look what he's doing [laughs]

BH: You've got him. You've got him!

RP: [laughs] yes and he finally found the same curve, you see, and he agreed with me, said well it goes to infinity at the origin. I said well I knew that [laughs].

BH: Professor can I just go back in time a little bit more to your school days, because obviously later in life one of the things you've become famously associated with is black holes and some of the more exotic things in space. As a boy growing up, I was obsessed with the ideas of black holes. They were like, they were amazing to me. But you wouldn't have had black holes when you were a boy as an inspiration, would you? The name black hole hadn't even been coined at that point, I imagine.

RP: Well that's true, well apparently it was Wheeler, I'm not sure. It was fairly in common practice by the time I got interested in. But I should go back in the history.

BH: Yeah.

RP: Because... well what stimulated me you see, there were other things earlier on going back particular... well people go back to Chandrasekhar who discovered that...

BH: Hmm.

RP: ...white dwarves if they were massive than a certain mass there was nothing to stop them. And then there were neutron stars and again you had this problem that there was nothing to stop them if they were too massive.

BH: Were you captured by the idea of these things as a boy? Like would you read books about space and look at the stars and be excited or was that not on

your radar yet?

RP: It was. Again you see my father was a big influence on me. And I remember when he decided, I told him that we were going to learn calculus the next day and he instantly took me away and he taught me calculus. He wanted to be the one to teach me and say how wonderful.

BH: Really? Because he wanted to give you a head start at school or just because he wanted to be the one to impart the knowledge on you?

RP: He wanted to be the one to impart the knowledge. It wasn't being a head start, no it wasn't that.

BH: Right.

RP: He just taught there was really beautiful about it and he wanted to convey this to me. And he did, and it was true.

BH: Yeah.

RP: And I picked up on it enough to realize how beautiful that was. But Chandrasekhar and the work that he'd done and all that was not known to me at that time.

BH: Hmm.

RP: Now you see my father had a telescope which incidentally I inherited but I can't ever get it to work because, you know, we have much better telescopes now.

BH: Do you still have it now?

RP: Yes. It's an old brass one.

BH: Yeah?

RP: I think I remember when he was just... I can't remember whether if it was married or courting mother and they were camping on a mountain because there was a total eclipse of the sun and he had this telescope and he seen the... it had a special lens for dark lens so you could look at the sun.

BH: Yes, good [laughs]

RP: And he and my mother saw the eclipse with this telescope.

BH: Yeah.

RP: And just when they finished looking at it, all the people came rushing up the mountain and they'd just missed it. [laughs]

BH: [laughs]

RP: And so but the same telescope much later, I remember him looking at Saturn and he showed me Saturn.

BH: Yeah?

RP: And I saw... and there was something very, you know, influential I would say about seeing Saturn.

BH: Yeah.

RP: It was seeing... I had seen pictures of the rings and all that and when you saw it in the telescope and there it was. The little speck of light in the sky and

suddenly you see it and it's really got the ring, it's there.

BH: Hmm.

RP: And you see it there yourself.

BH: Hmm.

RP: And this made a big impression on me.

BH: I think anyone who's looked at Saturn through a telescope never forgets the first time they see Saturn.

RP: That's right and it certainly had an effect on me.

BH: When did you make the transition from thinking oh well I guess I'll be a doctor to something else?

RP: That was... the walk up to see the headmaster.

BH: Right.

RP: Because up to that point I was still going to be a doctor.

BH: Right.

RP: I just had fallen in love with mathematics.

BH: So being forced to ditch biology in order to pursue mathematics is when the doctor thing went out the window?

RP: Down the tubes. Yes, I'm afraid.

BH: Yeah?

RP: And I went home and both my parents were furious.

BH: Really?

RP: I remember they were annoyed with me because one of my friends at that time who wanted to become a scientist and he wanted to do nuclear physics, he never did it as it turned out, [laughs] but he wanted to do nuclear physics, and at that time it was the worst crime in the world to do nuclear physics because my parents were both pacifists and the idea of nuclear bombs was the most dreadful thing you could think of.

BH: Yeah?

RP: So that was a bad thing, so if you did physics...

BH: When you were telling your parents, look I've decided to pursue mathematics and biology's gone out the window, as has being a doctor, what were you telling them? What did you say to your parents? Look, I think I'd rather I want to be a mathematician. I want to be a physicist. What was your like rationale to them?

RP: I didn't want to lose the maths. I didn't exactly want to be a mathematician at that time and you see there was a second phase of the same thing which happened later, because I did this mathematics, physics and chemistry and I did all those subjects from my what did we call, they were called different things in those days?

BH: Yeah.

RP: So they were called high school certificate.

BH: Yeah.

RP: That's what it is. And I did that and I did... mathematics, physics and chemistry.

BH: Hmm.

RP: I think my best paper was in mathematics. As far as I remember and then I sort of think I felt I would want to do maths. I wanted to do mathematics because I'd just grown to love the subject more and more as the time went on.

BH: Yeah.

RP: Then I proposed I would go and do mathematics as a degree, for a degree.

BH: Thinking what? That I'll be a math professor, or?

RP: To do mathematics, yes, I didn't know quite first sort of what I would do with it but I wanted to do maths.

BH: Yeah.

RP: I was proposing to do it at a University College which was my father's... he was a professor of human genetics at University College and there was an advantage there because you could go without paying. You... whether they paid the whole fees or just half of them I can't remember but because he was a professor there, there was some advantage. So I wanted to go to UC to do mathematics. And he was not happy about this at all. He said well if you're gonna do maths... you can do other things, you understand about physics and things like that and biology and he had the view that mathematicians were

people who just did mathematics were pretty odd people, they were just sort of focused in this direction and...

BH: Yeah?

RP: And he considered that... he didn't think that was a very good idea for me. I think it was in a way a compliment, because he thought I could do other things.

BH: Hmm

RP: And he thought you know these sort of odd people who were sort of separate from the world would do mathematics. So he did do something I must say was to his credit, he got one of his teachers. He was called Kesselman and he was a... as I learned later an extremely good teacher he was.

BH: Hmm.

RP: And he made up a test of whether it was six or twelve, I can't even remember whether it was six or twelve, very special problems.

BH: Hmm.

RP: They were not the things you would have come across. But not beyond my sort of knowledge...

BH: Yeah.

RP: capabilities at that stage, but unusual problems. There were certainly six, I think there may well have been twelve. And he said to me, he said look I got this set of problems, you may find that you can only do half of them, maybe only two of them, that's fine.



BH: Yeah.

RP: Do what you can. I worked away for the whole day and did the whole lot.

BH: Right.

RP: [laughs] And when he picked them up he was quite impressed by that.

BH: And what he would have said to you dad, this boy's gotta it?

RP: He's got it, yes. He did, say that, yes.

BH: And then your father kind of gave his blessing at that point, did he?  
When Kesselman told him, he's good, he's good?

RP: He gave in. Oh he didn't completely give in because he thought I ought to go to Cambridge. And that was a rather... not very good set... because I think I had done my first year already.

BH: Right.

RP: I think I was in second year... and he thought I should go to Cambridge. And so he wanted me to do the Cambridge scholarship exam. I can't remember quite when it was, maybe in my first year.

BH: Okay so then the money thing wouldn't have been an issue, 'cause you would have been on a scholarship?

RP: That's right.

BH: Yeah.

RP: I should explain that while my father was well to do before all this he'd given almost all of his money away. He gave it to charities and that sort of thing. He hated money.

BH: Right [chuckles]

RP: [laughs] And so he pretty well given it all away by then.

BH: Okay.

RP: He had a curious point of view he had on various things. But I can't quite remember, I think it must have been in my second year, when I did maths. I discovered a theorem which I believe is a still unknown.

BH: hmm.

RP: And I never published it. But I gave a seminar when I was in my second year as an undergraduate...

BH: Yeah?

RP: ...on this theorem. And my father attended or must have heard about it, yes.

BH: What was... without going into the detail what was it about? Is this Penrose's Forgotten Theorem?

RP: This is Penrose's Theorem which hasn't even been seen because it was never published.

BH: Oh this could be an exclusive!

RP: I never did it, yes. It was a theorem about conics.

BH: Yeah?

RP: It's not so hard to explain actually what it is, but I had learnt about various theorems from my geometry teacher who was a sort of an oddball. He was called T. L. Rand and he had his own way of doing it which was very sort of formal.

BH: Hmm.

RP: He went along so that the class didn't exist, more or less.

BH: Right.

RP: Everybody hated him except me, I loved his lectures [laughs] and I sort of picked up on various things, and so how to generalize them.

BH: Right.

RP: This theorem is a theorem about conics. Now a conic is like an ellipse or circle of ellipse, a hyperbola, but the only property you need is when they have double contact. So that's when they touch at two places, so you can image one of your conics, an ellipse like that and then another one inside it which touches here and touches here. And that is the condition.

BH: Hmm.

RP: Now imagine a cube, and I used to this cube with one blob at the top, three in the middle, and three and then one at the bottom so you have this. And you think of the way the vertices are connected with the other vertices. Now each

vertex of that cube represents one of these conics. If the two vertices are connected by a line, they have double contact. The theorem is if you've got your cube almost finished, except for one vertex, then three more lines you've gotta fit in and the last conics gonna be there... it exists. The last one exists. And that's a theorem. The point about it was you could specialize it in all sorts of way. You could make it a pair of lines, you could make it conical lines and three lines and always or various theorems like Pascal's Theorem, Brianchon's Theorem, Poncelet's Theorem with Triangle, Desargues' Theorem, Pappus's Theorem, all these theorem's you specialize in different ways and you put little symbols in the little blobs representing conics to say how they specialize and you get all these theorems out as special cases. It was one I was quite proud of this theorem.  
[chuckles]

BH: Why did you not publish it?

RP: Why did I not publish it... you're digging deep into something [laughs] with my personality which I'm not sure [laughs] what it is.

BH: Do you have lots of these unpublished things in a drawer do you?

RP: I have a few others, yes.

BH: Yeah?

RP: I did have one or two others.

BH: Why don't you publish these things?

RP: I kept meaning to... and other things kept getting in the way.

BH: Yeah.

RP: John Conway almost published it, I think he didn't because I think he died... he was going to write a book, I think you actually know, he was going to write a book on triangles. Do you know anything about that?

BH: I don't.

RP: No, his intention was to write a book. He was writing a book on triangles. And he wanted to put my theorem in it. And I explained it all to him. Why is that a book on triangles? Because you get triangle theorem's out of it.

BH: Hmm.

RP: And he was quite taken by my theorem and so he almost published my book... my theorem in his book. I have no idea how far...

BH: Let's get it out there sometime professor, when the pandemic's over I'll come and visit you and give you a piece of brown paper and you can explain it to me. Did you ever sit that scholarship exam?

RP: I did.

BH: Yeah?

RP: I'll tell you what happened. I did some of it. I did badly in one of them I know, because I had a cup of coffee at the beginning.

BH: Hmm.

RP: And in the middle of it I had a [scoffs] a real [laughs] need to go to the loo and it just distracted me completely.

BH: Yeah.

RP: And I messed up that paper, I know.

BH: So a cup of coffee stopped you being a Cambridge undergraduate?

RP: I don't know. I was relieved. I came just below...

BH: Literally you were relieved... [chuckles]

RP: [laughs] Yes, well I was relieved a bit at the end after the particular exam.

BH: Was your father disappointed, you didn't get into Cambridge then?

RP: Yeah! I was glad. I didn't want to go to Cambridge because I thought I'm wasting my time, I liked my... my course at University College. I thought that was... I did go to Cambridge afterwards [chuckles]. I went there to do research.

[gentle piano music]

BH: You obviously started merging your mathematics with physics very famously in many many famous ways, now... do you consider yourself a mathematician or a physicist?

RP: Well I have two ways of answering that question. The way I normally answer it, or well I'm not whether if it's still true because people say it's the other way. I say that if I'm with physicists, I'm a mathematician to them. If I'm with mathematicians, I'm a physicist to them. [chuckles]

BH: You're always the outsider?

RP: I'm considered that I was normally the outsider yes. I think that's true still to some degree that I'm sort of an outsider in that respect, yes.

BH: When you travel and you have to fill out that form saying what your occupation is...

RP: [laughs]

BH: What do you write?

RP: Mathematical Physicist, usually.

BH: What you write that on like your passport like custom form and stuff?  
[laughs]

RP: I forget where... well it depends what kind of space there is [laughs] for what...

BH: [laughs]

RP: For what you can put in there.

BH: Okay.

RP: I think I do tend to say mathematical physicist, yes.

BH: Obviously at university you're doing quite pure mathematics to start with. How do you start getting tugged towards physics?

RP: Well I should explain that in Britain mathematics degrees is not entirely pure mathematics. At my stage it had three parts to it. It was analysis, algebra, and geometry, applied mathematics. And applied mathematics was what people might call physics.

BH: Yeah.

RP: You learn about, you know, LeGrange's Equations and Newtonian Dynamics and electromagnetism. I'm not sure which of these things I learned at courses that I sat in on afterwards. Because when I did my undergraduate degree I specialized... at University College there's a slightly strange rule, it's a three year course, and the first two years were general. Everybody did the same thing.

BH: Hmm.

RP: And the final year you specialized.

BH: Yeah.

RP: And I did a paper on the first two years and I did a specialist paper... on the specialists' papers. And the specialists' subject I did was algebra and geometry and projective geometry.

BH: Right.

RP: So but I'd done applied mathematics and I had done analysis and I had done the algebra. My best paper was on algebra and not geometry.

BH: Right.

RP: Even though that was my specialist topic. Why wasn't it? Well, well I could see the paper, I could see how to do the problems, but how do you do a geometry problem? Well, you write an essay on it basically, you say, you know, it's a little bit of words... it's all words, you have to say this goes here and then why is this true because so and so implies so and so. And it's words like that. And I was slow, I was slow at writing. And I only got halfway through, I didn't finish the paper. Whereas with the algebra, you go you do this [gibberish] you



rattle through it. [laughs]

BH: Okay.

RP: And you don't have composed sentences, you just write down algebraic equations and that.

BH: Obviously a theme of your career has been incredible success and what not but another theme of your career and your life from what I'm hearing is things you didn't quite finish because you're a bit slow at them.

RP: Absolutely. Well that's... even though I'd speeded up enough to get through my school exams...

BH: Yeah?

RP: I was still slow.

BH: Yeah.

RP: And it had showed up when I was doing my geometry.

BH: Are you still slow?

RP: Yeah. I think so.

BH: Yeah. Or methodical? Is that a nicer way to say it?

RP: I'm not sure it's quite right. I think it's partly... this is probably more true that my thought processes are a little bit different from other people somehow. So if I hear... I have to translate it into my way of thinking. I don't know if that's it at all. There's something of that in it.

BH: Yeah.

RP: But I like to work things out for myself. I gain most from lectures and things like that when I can see the general idea. And then I go away and figure it out my own way. If it's a lecture course which is just following equations, I get lost. That doesn't help.

BH: Right.

RP: But if I can see the general idea and I can go back and go through it myself, then I can do it.

BH: You've got this own personal language you then convert into inside your brain, do you?

RP: I think there is a lot of that, in it, yes. And part of it... a lot of it is visual.

BH: Right.

RP: Many lectures in mathematics are not very visual. And I learnt this too, when I tried to do diagrams and things, often people had trouble, that's it. And I remember early on when people maybe suggested on my giving a popular talk, in the early days of this. And they said oh well, lots of pictures, lots of pictures, people like pictures to understand.

BH: Hmm.

RP: Then I thought, that's interesting, because when I talk to undergraduate mathematicians, they don't like the pictures. They like the equations and they wanna make sure they can do it that way.

BH: Okay.

RP: I dunno, some do and some don't.

BH: Professor, I spoke to a physicist friend of mine the other day who went to a lecture of yours in the last year or two and I said oh what was a Roger Penrose lecture like. And he said... it was pretty good, but the thing I remember most is he did the best drawings of any lecturer I've ever seen.

RP: [chuckles]

BH: He said your drawings were incredible!

RP: Right I guess that's also the artistic streak... strand in my family because...

BH: Yeah?

RP: I hadn't said this before, my father was a very good artist, actually.

BH: Right.

RP: But he was one of four brothers all of whom were. In fact his younger brother Roland became a big figure in, certainly in Britain, in the surrealist movement. He more or less founded the Institute for Contemporary Arts.

BH: Hmm.

RP: He was a good friend of Picasso and various of the people in the surrealist movement.

BH: Do you take pride in your drawings in lectures and books and things, or

to you is it just a means to an end and if people say you're good at it, well, that's nice?

RP: I do take pride in it. In fact I like to draw all the diagrams in my books.

BH: Yeah?

RP: Which I do. Early on I got somewhat talked out of it... browbeaten out of it to some extent.

BH: Yeah?

RP: And I would sketch them and then they were redrawn professionally. Later on I got to learn that correcting the professional drawings was more trouble than drawing it myself. You know, they wouldn't get it quite right. And I'd say look this line goes in front of that, not behind it. [chuckles] And drawing them as though neither of them sort of front or behind...

BH: There are whole websites dedicated to Roger Penrose drawings, now, so you're obviously doing something right.

RP: Well I don't know.

BH: When you look at the list of prizes and honors and things you've won over the year, it's quite a long list. [chuckles] So, can I ask is there anything that you have won, or anything that's been bestowed on you that meant more to you than the others? That was particularly, you know, you're particular proud of, if I can put it that way?

RP: I think there are a few. Well the thing that shook me first was I suppose when I got... the trouble is I forget all the names of these prizes.

BH: [laughs]

RP: I won't even try because my memory for names is...

BH: Oh, Professor I think in the industry that's called a humble brag now, when you say I can't even remember the names of my prizes. [laughs]

RP: [laughs] Oh dear, that's not so good. But I guess the thing was about the Knighthood, I think that... that was just strange and I don't quite know why I was given that.

BH: Who bestowed your Knighthood? Which member of the Royal Family did the sword?

RP: Well it would be the Queen who did.

BH: Oh you got the Queen?

RP: Yes, I had to... the thing that I remember worrying about. Was you had to lean, kneel on knee or not on the other and I get... one of the confusions I have in life is not remembering which is my left and which is my right.

BH: [laughs]

RP: In my mind it's the other way around. I was greatly relieved that they had a special chair that you can only do it one way. [laughs]

BH: okay, [laughs] And did the Queen say anything to you? Did she ask you anything about space-time curvature or black holes or?

RP: You're not allowed to say anything, but I didn't even remember that at the time.

BH: Yeah.

RP: I had more of conversation with the Queen, with the thing which did mean more to me I think, which was the Order of Merit.

BH: Right.

RP: Because there's only... it's limited to twenty-four or twenty-five people, whatever it is.

BH: That's a very exclusive club that you're part of it.

RP: That was a totally unexpected thing.

BH: What did you talk to the Queen about then?

RP: That I'm not allowed to say.

BH: Ooh.

RP: It was an interesting... I didn't know I was not allowed to say because she's... I learnt later from people that you're not supposed to say what the Queen says to you.

BH: Ahh. But you can just tell me. [laughs]

RP: [laughs]

BH: One thing I would like to ask you about because it's a personal fascination of mine was what was it like becoming a Fellow of the Royal Society and signing that famous charter book that Isaac Newton and Hawking and everyone else has

signed?

RP: That was nice. Well, he hadn't signed it by then.

BH: Oh yeah, you got in before him. [laughs] You mentioned to me your father was at your induction into the Royal Society which meant something to you.

RP: Yes, he was quite proud, very proud of having father and son and so he tried to track down how many other... there were quite a lot of them I should say, Fathers and Sons who were FRSs at the same time.

BH: Oh your father was an FRS was he?

RP: Yes, he was an FRS at that time, yes, that's true.

BH: I hope at that point your father leaned over and said to you, okay, you made the right decision going for mathematics. [chuckles]

RP: [laughs] well no he was proud of me. He definitely was proud of me.

[gentle bell music]

BH: Many of Professor Penrose's discoveries are linked with Stephen Hawking. In fact in the recent movie of Hawking's life, the Theory of Everything, he attends a lecture by Roger Penrose. This is shown as a pivotal point in Hawking's career. Penrose is later shown as an examiner for Hawking's PhD thesis.

[gentle chimes]

BH: I mean you obviously worked with Stephen Hawking a lot, he was... was

he a friend of yours?

RP: I got to know him... unlike what the film suggests. According to the film, [chuckles] there was a lecture given by me at I believe King's College London [pause] and it was on black holes and things and there was Stephen in the audience and there were sparks coming out of his head by being inspired by...

BH: [laughs] right.

RP: I did give a lecture on black holes, my theorem on black holes, in King's College London. Stephen Hawking was not present.

BH: Right.

RP: However, well J. L. Synge was present. He was a... I was very proud of that 'cause he was a geometer who was a relativist who had written a book... a geometrically oriented book which I got a lot from. I liked his book very much. So I liked his way of doing relativity. Anyway I gave this talk on black holes and why they had singularities in the general case and it wasn't just the symmetry and the fact that it was just dust and so on, but whatever matter you in and it could be very asymmetrical and it always produced singularities. And Dennis Sciama, who I had worked with a lot before and who had become Stephen Hawking's supervisor, Dennis Sciama heard of this talk and suggested I give a repeat.

BH: Right.

RP: The talk was given in 1964...

BH: Right.

RP: In December I think. And I gave a repeat in Cambridge in early 1965. And



Stephen Hawking was present at that talk.

BH: Oh okay.

RP: But the main thing was not so much... his being present at my talk but that he afterwards together with George Ellis and I believe Brandon Carter might have been there, I'm not sure about Brandon... but this was a more private little session where I explained the details or the techniques that I was using.

BH: Okay.

RP: And this was where I really got to know Stephen.

BH: Oh these little details don't matter for Hollywood movies, Professor.  
[laughs]

RP: [laughs]

BH: But was your relationship like with Stephen Hawking? What was he like? I mean you're in a select club that gets to have this kind of, not only a relationship with him, but an intellectual relationship with him?

RP: The film is partly correct in that I was one of the examiners for his PhD thesis.

BH: Right.

RP: Dennis Sciama, who was the supervisor, in those days the supervisor was supposed to be one of the examiners, so Dennis was one, I was one... and according to the film Kip Thorne was there too. I don't know why they put Kip on there because he wasn't there.

BH: Right.

RP: [laughs] He only had two, so I dunno why they wanted him.

BH: Yeah.

RP: But it was an interesting occasion because I'd read the thesis which had four parts and I remember I said I think in my... write up of the account that any two of them were good enough for a PhD.

BH: Oh right.

RP: I made a note of various mistakes that there were in the...

BH: yeah.

RP: In the main thing which was his main thing which was the final part which was the singularity theorem part. And in the interview... Stephen had found them all so... [laughs]

BH: He'd already picked them up?

RP: He's already picked them up... and I think it was he had made errors previously... it was interesting because he made errors of the first kind and errors of the second kind. Errors of the first kind which is when you correct them the theorem still works. Errors of the second kind is they wreck the theorem. [laughs]

BH: Okay.

RP: These were all errors of the first kind. Although they weren't technically quite correct, well you could correct them by planting the argument by slightly

improved argument.

BH: What was he actually like to work with though? Was he funny? Was he just like, you know, blindingly smart? Was he quite dry like?

RP: He certainly could be funny. He certainly was funny, yes.

BH: Yeah.

RP: I tend to think back, you see, the disease took a long time before it was hard for him to talk.

BH: Yeah.

RP: And then it got very difficult to talk and then he got his machine.

BH: Yeah.

RP: That was only after he had his tracheotomy and then he couldn't talk at all.

BH: Yeah.

RP: When he was in Switzerland he got pneumonia very badly and he almost died of it and they had to make a hole in his neck...

BH: Hmm.

RP: ...so he could breathe through it and then he couldn't talk at all. Then he got his machine and after that he spoke with his machine.

[gentle violin music]

BH: Can you tell me how you have an idea? Where you do it? Do you get it swimming in a lake? Standing in the shower? Out on a run? Sitting at your desk at work? Where do ideas come from? In dreams maybe?

RP: Well I can tell you two things which I don't get them in. You just mentioned two of them. One is in my office. When I say my office I don't mean my messy thing at home where I sit and do other things in... but I mean in my office at my university.

BH: Right.

RP: I don't think I've ever had a good idea in my office, wherever it's been.

BH: Right.

RP: In dreams... I've definitely never had a good idea in a dream. I've had ideas, which I said gosh that's a brilliant idea, in my dream.

BH: Yeah?

RP: I've had them where even I've woken up and I've thought that's a great idea, wow! This is the first time I've had a brilliant idea in a dream and I remember one it took me a full ten minutes when I realized how stupid it was. [laughs]

BH: So you wake up thinking you've solved the Riemann Hypothesis and then you watch it fall apart over the space of ten minutes?

RP: I've never done that one yet. [laughs]

BH: [laughs]

RP: No I have thought I, in a dream... but they've all been complete rubbish. Not just wrong, utter rubbish. [laughs]

BH: Where do you have your ideas? Can you think of any times or places where they've happened, like walking in the mountains, crossing a bridge?

RP: Yes. I'm sure I've had one crossing a bridge, but I can't remember when and where and what.

BH: [laughs]

RP: I've had it, I think in the mountains, yes, or walking... yes definitely.

BH: Yeah?

RP: Shaving I used to think was a good time to have... I dunno if you won't know about this but well I suppose you trim your beard sometimes...

BH: Yeah. I have shaved!

RP: There was a period when I tried to go a beard but it was a disaster.

BH: [laughs]

RP: But no shaving I used to think was a good time to... but I have not had a good idea shaving for a long time so...

BH: But you used to have good ideas shaving? Just...

RP: I did.

BH: Why?

RP: I guess it was just a relaxing moment, I don't know.

BH: Yeah.

RP: It's usually when you're thinking of something else and it clicks with something, you see, one idea on another topic and you think oh and you can see it and realize that there is something similar...

BH: Yeah.

RP: In another line of thinking. That is a big thing.

BH: Right.

RP: And it can be not quite the same. You see, that way of thinking about something reminds you of a way of thinking that you'd thought about something before and it was in a different problem maybe and that can be important, yes.

BH: Can you ever have ideas when you're with other people? Like interacting in a room and standing at a blackboard with a colleague or are you normally on your own?

RP: I cannot remember whether I've had a good idea in a party of something, I remember thinking that it's maybe a bit of alcohol that helped me in a party...

BH: [laughs]

RP: And I used to think when I got home and I'd actually had too much to drink and maybe this would give me a good idea. And then I started thinking about some problem and this had happened more than once... twice, at least

twice.

BH: Yeah?

RP: That I had found a mistake in what I had done when I was sober.

BH: Huh!

RP: So it wasn't that I had a good idea from beer... I was actually able to go through it more carefully and see it where I made a mistake.

BH: So you're doing your own peer review?

RP: Doing my own peer review. But I think there was this occasion which I know people often quote, where I was worrying about black hole problem, and I had developed certain techniques because this was a time when the quasars had been discovered and these were very luminous objects. Brighter than an entire galaxy, enormously far away because of the redshift and people used to argue is this a real redshift, is some funny physics, is it gravitational retrograde, really part of the universe expansion, is it anomalous motion, or all sorts of things. And they sort of concluded it really is a universe expanding so they really are that bright. And that bright... and that small. Why that small? How small? Well, because the brightness varies to a degree within a week or so, within a week, it means it's more than the solar system, because the time it would take the light to get across from here to Saturn, I can't remember but a long time and the time it would mean the thing was smaller than the solar system. And if it's smaller than the solar system it would mean you run in problems with general relativity.

BH: Okay.

RP: And so people were starting to worry about that and they brought up this old paper by this Wheeler who I worked with at one stage and he was rather

keen to look at this paper by Oppenheimer and Snyder where they had studied black hole... what we now call collapsed to a black hole but this was... the material was just dust which has no pressure. I mean it was just called dust, it was zero pressure material so nothing to stop it collapsing. Spherically symmetrical and so just focused itself into the middle and so the density would become infinite, the curvature would become infinite, you get a singularity in the middle. Is that real? Or is that just an artifact of the lack of pressure and of the fact that it was focused into the middle? So there were a couple of Russians who had seemed to have proved, this is Lifshitz and Khalatnikov who had seem to have proved that in a general case you wouldn't get singularities, things swish around and swirl out or something like that. And so that was a sort of common belief and so I dunno it didn't explain the quasars but maybe something did something like that, or I dunno. And so the question is, did you get these singular states where the curvatures become infinite? The densities become infinite? The equations simply give up. I started worrying about this problem. I looked vaguely at Lifshitz and Khalatnikov's paper and come to my conclusion that although I didn't realize... I didn't know there was a mistake in the paper which there was, I thought that the techniques they were using while clever they weren't the kinds of things that you could really get a proper proof that there was no singularity. So I thought the question was a bit open. And I had developed techniques from other things I was thinking about, looking at general relativity, not global... not solving equations. I wasn't good at solving equations. I could do it occasionally but that wasn't my skill. I could think about these things geometrically and look at how light waves behaved and how they focused and how boundaries of future sets and things, what they looked like.

BH: Hmm.

RP: And the kinds of singularities they had and the properties that they had. So I was getting quite familiar with that kind of thing but I had no characterization of what a collapsed to beyond point of no return, you see, when the collapse goes to a certain point there's nothing you can do about it. It's had it.



[chuckles] So what is that point, and how do you characterize in the way which doesn't depend on symmetry or solutions of equations or like that? So I hadn't gotten my mind around that exactly. And there was this occasion when I had a quite yarding it out conversations with people. Ivor Robinson who was a colleague of mine for quite some while, I had known him for a long time, and he had a way with words. He was English but he was working in Dallas, Texas where he spent most of his later life. Oh they all loved him because of his way with words and he was talking to me, I don't know what he was talking me about [chuckles] and we were walking along quite near to Birkbeck College where I worked at that time. And I came at a sort of crossroad, a side road, and as we crossed the road we was looking for traffic and the conversation stopped. Got to the other side of the road and he went on talking to me... talking talking and then he went off. And that was the end of my conversation with him. But then I had this strange feeling of elation. I thought, huh, something was good. Wasn't just the conversation, I was trying to think of the conversation was that it? No. It wasn't this then. Was it something I had for breakfast? I went through my life of all the things that had happened to me that day until I got up to crossing the road. And then it came back to me, that I had this thought of how to characterize a state which... a point of no return, which is what I called the Trapped Surface.

BH: Hmm.

RP: It was a rather local property but it was a global property of a surface. A two dimensional surface. That when it had this property, it was too late, it would had it and this was the end of it. So I went back to my office and I sort of sketched out a proof using the methods I'd thought of...

BH: Right.

RP: ... a singularity result. It needed improving. I had a version of it in the paper which I lectured about and was published in 1965 in Physical Letters.

BH: So that could become a new joke? Why did the mathematician cross the road? To better understand singularities. [laughs]

RP: [laughs] That's right. Well, yes that's right. So I don't know what of happened if I hadn't had this impetus to try and... I guess I try to think of why... what things in mind... I've tried to do this... at that time it was successful. Often... I have had thoughts in my mind and I've thought what is that strange feeling I have, where does that come from? And I just never've been able to trace it down.

[gentle violin music]

BH: Penrose Tiling is one of my favorite discoveries. This is a system of so called aperiodic tiling with amazingly just two shapes that'll perfectly tile an infinite plane. No gaps, no overlaps, but also in a way that never repeats. Now I've left out a few details but if you're listening to the Youtube version of this podcast, I'll show it on the screen right now. There are also plenty of other places where you can read about it and see examples. I'll include some links.

[bells chime]

BH: I won't ask you too much about Penrose Tiling 'cause it's quite detailed and it's quite a visual thing and this is not going to be a visual thing that we're making but well one of our listeners asked the question, does Roger Penrose have Penrose Tiling in his bathroom? Do you have Penrose Tiling anywhere in your house?

RP: No. Except in I suppose in, well some pages in books and...

BH: Yeah.

RP: Papers in my bedroom yes. [laughs] No.

BH: No, no Penrose... and another person asked me to ask you, what does he feel about the whole toilet paper debacle? Which was when a big American company used Penrose Tiling as a pattern on their toilet paper and there was legal action and all sorts of stuff kicked off? How do you recall that incident? Was that an amusing thing? Were you upset by it?

RP: Well it didn't mean that much to me, you see, I think we'd moved into our new house and I think we'd just gone in and there was a loo roll in there.

BH: What left by the previous owners?

RP: By the previous people. I think some people had rented the house and left the loo roll.

BH: yeah?

RP: And I don't think... I looked at it and I could see it very well. I dunno if I saw it as bad at that... or no was it something else? My eyesight was probably not very good. I just saw it was some pattern on it. I didn't even look very carefully. But my wife Vanessa had looked at it and she noticed that it seemed to be what people call a Penrose Tiling. So she said have you looked at that pattern? So I look carefully at it and I saw there was a big stretch of it and it wasn't completely right, there was places where it had cheated, and apart from that, yes, gosh! There was a person and he was making puzzles and things using, with my permission, making puzzles with my tilings and things like that, some quite nice ones. But... I don't think it was not very commercially successful because at that time the techniques for making these shapes was a bit... a bit expensive.

BH: Hmm.

RP: But anyway he took away from making these things and decided to sue

the company which made the toilet paper.

BH: Right.

RP: And I thought this was pretty dead loss but he decided to do it.

BH: You were quite arms length from it all?

RP: Yes, pretty well. But what he did want me to do was to find all the places where people had published articles with these tilings in them and who had written the articles... I forgot what it was. There was an article by Paul Steinhardt, I think, on quasicrystals, I can't think what it was not, [sighs] I'm just trying to remember, and he had used a tiling pattern, and you know, with permission and everything like that it was fine. But what my colleague who was making the puzzles wanted me to do was to get all these people to say that this pattern was done with my permission. You see, that it was my design and it was done with my permission. Which is what they all did. Perfectly bindingly did, and that was fine.

BH: Yeah?

RP: And so he decided to have a court case and he had these people up.  
And...

BH: Did he win?

RP: It was agreed out of court. There was an out of court settlement.

BH: Right.

RP: It was an amount of money which was incoming, which as far as I can tell more or less covered the costs that...

BH: Were you upset about it? Were you upset that a toilet paper company had put Penrose Tiling on their loo roll? Or did you not care?

RP: Quite honestly I didn't care too much.

BH: Yeah.

RP: I think I was a little bit upset... I can't really remember.

BH: Yeah.

RP: It wasn't a big thing for me. Because there are other people who had used the tilings on buildings.

BH: Yes! I've seen several buildings with Penrose Tiling on them.

RP: Some of them have had my permission and some haven't.

BH: Yeah.

RP: Some have asked me and some haven't.

BH: Do you feel that you own the tiling? I mean you kind of... did you find the tiling or did you invent the tiling?

RP: Discovered is the word.

BH: Discovered.

RP: There's a curious story about that, gosh, they're all sort of curious stories. Because I was just playing around with designs. And I had played around with

patterns which cover the plane and I'd seen a lot of Escher Patterns and I was very intrigued by how you could make birds and fish and you can do all sorts of clever things, and I liked the idea of patterns which maybe didn't repeat themselves and I had come across a letter with a logo from somebody who had written me a letter and it's been very long... never answered it for a long time and the logo had a pentagon, a regular pentagon, five sided shape with five ones just in it and one in the middle, so they're were six of them around, and little triangular gaps in the middle. So I looked at that as an escape from writing my letter, I wonder what would happen if you iterated this. You put this whole pattern inside on of the pentagons, you did it again and again and again, stretched it out, stretched it out, and made a big pattern. Now you've got lots of gaps here and I thought of a way of filling the gaps, in sort of a systematic way, and it made this pattern which I thought was rather attractive.

BH: Yeah.

RP: All sorts of almost repeatings and lines and things, well I thought it looked nice.

BH: Inspired by a letterhead?

RP: Inspired by a letterhead. By a logo. It was a logo, yes.

BH: Right.

RP: And so, I sent this to a friend of mine who was in hospital, a woman I knew quite well and she had an interest in mathematics. She was a having an operation and I thought this would cheer her up. And so I think it did. But somewhat later I looked at this pattern and I thought I wonder whether you could make a jigsaw puzzle out of this which would force that arrangement. Or this is a sort of idea... I sometimes have ideas which I give about fifty percent being true, fifty percent not. It's not that yes I have the confidence that Poincaré

seemed to have when he got on the bus [laughs] the famous story? Okay maybe it's true, maybe it's not, give it a good fifty percent chance and this was one of those.

BH: What was the thing that you thought fifty percent might be true?

RP: That you might force this arrangement by putting little knobs and notches to make it into a jigsaw puzzle.

BH: Right.

RP: With a finite number of pieces. So finally I came round to six pieces, each of the pentagons had... they just had to be three different versions of them. Depending on how many pentagons were around them and then there was a rhombus which had to be done the wrong way and star, a five pointed star and a half sort of three pointed tile star.

BH: Hmm.

RP: And each of those you had to put little things, and knobs and little holes in them. Slot them together, jigsaw puzzle-wise and you could only do it only in a non-repeating way. I was quite proud of that. I think this was when I just had my job at Oxford. I can't remember which the ordering was. Must have been just about then, that's right. Then I was at a gathering of some sort... in Oxford and I met Simon Kochen who is a mathematician, who is a good friend of John Conway's in Princeton. And Simon Kochen had been talking to me about a non-periodic design, started to say a jigsaw puzzle which originally had to have a... I dunno several thousand pieces, several thousand different shapes, and they would only tile non-periodically. And that Raphael Robinson had got this down to six, and he told me that Raphael Robinson was somebody... a mathematician who really'd like to get it right down to the smallest number. Some other people had got it down to about a hundred or something, Robinson had managed it,

down to about seventy. He got it to six. And I thought... I can do it with five. Because I knew, not with... his were all little square shapes with knobs and things... not with square shapes with these funny shapes in mine, I could get it down to five, because I knew there was a funny little puzzle knob and notch that you could only fit together with two pieces.

BH: Yeah.

RP: And you just glue those together, you have to do two of them to do it together. And then you could do it with five. And so I said I could do it with five. I then went home, fiddled around a bit, and I got it down to four. And I thought well that's pretty good I can live with four. It's got part of that... and I thought maybe is that the best I can do? And I fiddled around I got it down to two. And my main reaction was disappointment, which you may think is a strange reaction. I'm not quite sure why I was disappointed, I just thought this is just too damn easy. This is so simple! I think it was the kites and darts and then the rhombuses... that's so easy. Well... [mutters]

BH: Did it feel like a big deal? Did you think people are gonna love this? Or did you think...

RP: No.

BH: Did you think it was trivial?

RP: It's funny, I thought it was too easy.

BH: Yeah?

RP: That was my initial reaction.

BH: You thought someone must have already done it?



RP: Yeah! I don't know why I thought it... I'm not sure whether I thought somebody must have done it. That was part of it... maybe a nuisance you'd have to track down and see whether who would know. That sort of thing.

BH: Yeah.

RP: I was at a mathematical colloquium with the... this was in Exeter or something, I can't remember if it was that one or another one. And I knew John Conway and he was there too and asked me have you done anything interesting recently and I thought well I have done a little thing. So I showed him and he picked up on that and then went to have a session with Martin Gardener and Martin Gardner's article was based on the session that he'd had with John Conway. So they found out various properties that these infinite patterns would have.

BH: How do you feel when you see the Penrose Tiling used in some way, on a building or just in a beautiful way. Like do you look at it and feel like a warmth or an attachment or an ownership or an affection or... what does it do to you?

RP: I have various reactions. It depends... if they've done it well I feel pleased with it yes. If they've done it well and they've previously asked my permission and I've said yes than I feel very pleased with it. If they've done it well and they didn't mention it to me at all and they've just do it [laughs] I might be quite pleased with it but I feel, I wished they asked me first... [laughs]

BH: Yeah.

RP: Some of them do, some of... I had to hear about it and then some of them might do it in a way which I don't like very much, so I know there are some of those. Sort of the way I feel is they've wrecked it. Yes, I have had that view sometimes.

BH: You're not gonna name names of someone who's wrecked it? [laughs]

RP: Well I guess the one that I'm most proud of is, of course, there's, you know, a lot of hard work involved in that. Was the Transbay Center... what's it called now, it's got another name to it... in San Francisco.

BH: Right.

RP: I know the architect there and he's a very nice fellow.

BH: Hmm.

RP: And he got hold of me and he said, did you hear... I mean they sent, it was a quite curious reaction I'd had because I think they'd emailed me and I looked at the email and I had this sort of reaction I often have when people wanted to use my pattern I said oh well this somebody wants to make a cushion, you know, I have a lot of people who've asked, my aunt wants to make a cushion she'd like to use your pattern on the cushion, and she said okay and so I'd right back and said sure it's fine but just make sure she gets it right. [laughs]

BH: Right.

RP: The only thing I'm fussed about is if she gets it right [chuckles] and so I've the same reaction in this thing, I've said okay make sure you get it right and then I looked at it and they had the... I can't remember how much I could see of it but they'd done it by making big panels and they'd repeated the pattern on the panels and that I didn't like very much.

BH: Yeah. That kind of defeats the whole purpose of a Penrose Tiling.

RP: I did feel that rather.

BH: So they did a good job but you kind of wish they didn't do it with the panels.

[String plucking music]

BH: It's one of sort of the cliches of science and particularly mathematics that the best work is done by mathematicians when they're young, you know, and the Fields Medal's given to people who are under forty and it's considered like a young person's game. How do you feel about that, and how do you feel your brain works now compared to when you were twenty and thirty? Do you feel like you're still firing on all cylinders? Do you notice differences in the way you think now?

RP: I think there is some differences. I notice its the main difference when I was a graduate student. I think at the beginning I was all over the place. That is I was thinking about things sort of unconnected things.

BH: Hmm.

RP: Not necessarily on the problem I was working on. Not on the problem I was working on, I was drifting off on all sorts of other directions.

BH: Yeah.

RP: And I was trying to develop notations from tenses. A lot of that was doing that.

BH: Right.

RP: And there are like you think that this notation is sort of abstract ways which weren't all connected with the problem I was working on. So it was sort of

all over the place. Later on I think as I got... I got more focused and it got more into the physics. So I think it was when I was an undergraduate I was sort of interested in general relativity a lot and Dennis Sciama was trying to focus me much more into cosmology and general relativity and the steady state model which was a thing in those days and...

BH: Yeah?

RP: He got me interested in that.

BH: If you went forward in time, a thousand years, what was the first thing you'd ask or look up in a physics text book or ask a physics professor?

RP: It's a difficult problem for me you see, 'cause I could say with one hat on, I could say look we're so far away from it, we're not that close, I probably wouldn't understand a word they said. [clears throat]

BH: Right.

RP: I'd love to see that book it would probably take me... a whole ten years course to understand what the mathematics is, how on earth this explains anything.

BH: Do you think over, eighty-eight years... you've done a good job of work-life balance? Or do you have to be a workaholic and always be working to put these runs on the board?

RP: I could answer a question to say I've done eighty-eight years of good work and I've gone and watched the telly and maybe paint or grow pictures or do other things which might even entertain more than what I'm doing. I don't do that not because... I think people aren't paying me enough attention and therefore I've got to publicize myself and point out certain things that people

haven't noticed

BH: Do you watch TV shows? Do you watch Netflix? Do you watch the Cricket? Do you like... go to the movies?

RP: I don't have television. So I don't watch... I can watch somethings on Netflix. I would occasionally for something very special, yes I would. I have watched occasional ones.

BH: What's the last thing you watched on Netflix?

RP: I watched a movie which I really enjoyed, that was the one on Marie Curie. I really liked that movie.

BH: What else in like, you know, do you sometimes tickle with your brain thinking you would have like to have done, maybe, if it hadn't been the math and the physics?

RP: I think probably painting or something like that.

BH: Yeah.

RP: Even possibly music, now there's a funny one. [sighs] I wouldn't have probably been any good at it but I had a... colleague when I was with Christopher Strachey and the only group I had anything to do with computers seriously, and Colin Merton who was work colleague of mine he had a zither.

BH: Hmm.

RP: Which he had tuned nineteen to the octave. So I call that nineteen to the dozen. And that is the next good equal temperament scale. twelve is a very good number. So you can get the Pythagorean scale, it's a very good approximation

using twelve notes. The next good scale is nineteen. And you could compose music nineteen to the scale. And he then let me... gave me eventually this zither of his, which he tuned nineteen to the dozen. Which was a huge mistake because it absolutely went out of tune before you knew where you were. It didn't like being nineteen to the dozen.

BH: Right.

RP: How you returned it nineteen to a dozen I had no idea.

BH: Do you play any conventional musical instruments?

RP: Well I used to play the viola which also was a mistake, because I should have learnt the piano. No,... I enjoyed playing the piano and sort of improvising, but I only used to do it for fun. I never was really very good at it. So I never could read music well.

[gentle piano music]

BH: It's been a real spanner in the works Covid-19. Has it been a real spanner in your life, the pandemic?

RP: It's a spanner but I'm not sure whether it's a spanner which I've been opening... safes with. [laughs]

BH: Hmm.

RP: I mean it has changed... definitely. I'm not being... I had tours all over the place planned to go and pick up actually various prizes [laughs] and things too.

BH: Hmm. Hmm.

RP: Cambridge honorary degree [laughs] and three prizes. Yes.

BH: Yeah?

RP: But all are gone and I'll never return to many of them.

BH: But you want you've seen a silver lining to it, have you? Like has it helped you focus on your work?

RP: It's meant I've changed what I wanted to do. I had this... well there is this plan to write the Escher book and that's taken a breather I'm afraid for a while. No but I've had... sort of something else... I thought sort of vague unthought, not completely thought ideas out about the collapse of the wave function.

BH: Hmm.

RP: So I think it's gravity. It's how gravity interrelates with quantum mechanics, it's not quantum gravity. It's not you should quantize gravity, like what everybody else... you should gravitate quantum mechanics. It's the other way around. And there are a number of other people who want to do this. Limited but quite a few.

BH: Do you work long days? Do you like get up at the crack of dawn or do you sleep in and do you work til midnight? Or do you like...

RP: I work long days but they start quite late, they end... they tend to end at about two in the morning.

BH: Oh okay. What time do you get up then, like at about ten or something?

RP: I get up at about nine.

BH: Okay.

RP: You see by the time I've gone to sleep it's probably... it tends to be about two or often later unfortunately and then I wake myself up at about eight and then get myself up.

BH: Yeah?

RP: I'm a bit slow at doing all these things, so I don't get started until about eleven. [laughs]

BH: That's okay, if you're working til two in the morning I think eleven's okay to start.

RP: But I'm not real efficient and then I try to get my things working and then the emails that I've got sort of prompt, don't get to replying to them.

BH: Well thank you for replying to my email and thank you for so much of your time today. I will let you get back to you work. I see it's your birthday coming up soon so maybe I'll try and get this podcast ready for your birthday.

RP: Just in a couple of weeks, I forget when it is. I forgot what the date is, but yes.

BH: Do you enjoy your birthdays?

RP: I endure them. [chuckles]

[gentle violin music]

BH: Well as it happens this podcast is being released on the day of Professor Penrose's birthday, so I'll end by wishing him a good one, and thank you for all



his time. [gentle music fades in] I'm Brady Haran and you've been listening to the Numberphile podcast. Check our feed for more episodes and the podcast description for helpful links to all sorts of other material. The podcast is made possible by support from the Mathematical Sciences Research Institute in Berkeley, California and you can also support us on Patreon by going to [Patreon.com/numberphile](https://Patreon.com/numberphile). [music continues and then fades out].