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Q&A Roger Penrose

Impossible thoughts

As he publishes his collected works — six volumes comprising more than 5,000 pages — the mathematical physicist muses on 50 years of groundbreaking research in general relativity, quantum mechanics, cosmology, geometry and consciousness.

Your *Collected Works* includes a diverse range of papers. Is there a theme?
Most of them involve a particular point of view on how to unify space-time structure with quantum mechanics. I believe that quantum mechanics is not the whole story. On some scales, the rules of quantum mechanics have to be violated. There has to be some other ingredient that, I suspect, has to do with gravity.

You are currently working on a book called *Fashion, Faith and Fantasy*. What it is about?
I rashly suggested that title for three lectures I gave at Princeton University in 2003. 'Fashion' refers mainly to string theory, which has many merits but is not believable. I don't see how you can make sense of all those extra dimensions. 'Faith' refers to quantum mechanics. It's a wonderful theory and works beautifully, but is self-inconsistent — in my view, when you make a measurement, you violate the Schrödinger equation. At some scale in the Universe, quantum mechanics will have to be replaced by a better theory.

And 'fantasy'?
That's largely directed at cosmic inflation, in which the Universe is supposed to have expanded by an enormous factor just after the Big Bang. I've always been against this — it can only work if you start off in a very special state. In my recent book *Cycles of Time*, I propose my own fantastical scheme that the entire history of the Universe is just one stage in a succession. What we think of as the Big Bang is not the beginning. It's the continuation of the remote future of a previous aeon.

Roger Penrose: Collected Works
Oxford University Press: 2010. 5,104 pp. $1,250

How might we know if that is true?
The cosmic microwave background — the radiation left over from the Big Bang — would reveal evidence of events taking place in the aeon before ours, mainly encounters between supermassive black holes. When galaxies collide, their central black holes may spiral around and swallow each other up, causing an enormous burst of gravitational radiation. Such a burst from late in the previous aeon would leave its mark as circles around which the temperature is anomalously uniform. My colleague Vahe Gurzadyan sees tentative signs of them [see go.nature.com/Lbwiou].

What does mathematics have to say about consciousness?
In my 1989 book *The Emperor's New Mind*, I said that computers will not achieve any conscious understanding. Gödel's theorem tells us that mathematical insights fall outside any formal procedure, so understanding is not a computational process. Something else is going on. I have reason to believe it may involve the limits of quantum mechanics. Microtubules [tiny structures in cells] are the best candidate in the brain for where this might happen, as they are so small, but quantum mechanics would have to work on a huge scale to operate there.

NATURE.COM
Lee Smolin's review of *Cycles of Time*:
go.nature.com/sgvbcn

How was your work on impossible objects taken up by the artist M. C. Escher?
When I was a graduate student at the University of Cambridge, I went to a mathematics conference in Amsterdam. One lecturer had a strange picture of birds, Escher's *Day and Night*. I decided to try something new and produced the tribar, an impossible triangle. My father also produced an impossible staircase, which goes round and round. We wrote a paper and sent a copy to Escher, crediting him. He developed the ideas into two prints: *Ascending and Descending*, with monks going around an impossible staircase; and *Waterfall*, which incorporates the tribar.

Did you meet him?
I visited Escher once. I had some angular wooden tiles, all the same shape, which I gave to him to see whether he could cover a plane without any gaps or overlaps. One of the last pictures he produced shows the arrangement using ghost shapes. Later, after both Escher and my father died, I produced the first never-repeating pair of tile shapes [Penrose tiles]. It was a shame they didn't live longer because I'm sure Escher would have done something wonderful with them, and my father would have got a great kick out of it.

Was your father a major influence?
Yes. He was a human-genetics professor at University College London and studied the inheritance of mental disease. He was interested in the question of consciousness, too. He'd cut things out of wood and make puzzles for children, and was interested in games, chess in particular. I took no interest in chess myself, but my younger brother became British champion ten times. My older brother went on to become a highly respected mathematical physicist. To my father, science was very much like a game.

Yet you were a slow learner as a child?
At school in Ontario during the Second World War, I once got moved down a class because I couldn't do mental arithmetic. I was slower than the others. Then one teacher said, "You can have as long as you like to do the tests." Given time, I did extremely well. That's always been true of me. It takes me a long time to think things through. Luckily I can get away with little sleep. I compensate by working into the night. ■

INTERVIEW BY JASCHA HOFFMAN

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