

| GEORGE ELLIS |

TOP THREE AWARDS

- Templeton Prize, 2004
- Star of South Africa Medal, 1999
- Fellowship of Royal Society (London), 2007

DEFINING MOMENT

Deciding to write *The Large-Scale Structure of Space-Time* with Stephen Hawking.

WHAT PEOPLE DO NOT KNOW

I have won trophies for both flying (the Stanley Damp Trophy) and gliding (Cape Gliding Club).



THE DOWN-TO-EARTH COSMOLOGIST

For somebody who has spent much of his time thinking about the structure of the universe, Professor George Ellis is remarkably down-to-earth. Over the past half-century his work has not only probed the nature of space-time, but his knowledge of mathematics has helped solve crises facing South Africa, such as providing housing for the poor.

A Professor (now emeritus) at the University of Cape Town (UCT), Ellis is one of South Africa's most distinguished scientists. He has co-written a bestselling book on general relativity theory with Stephen Hawking, whom he met at Cambridge as a research student. A deep thinker, he has won great prizes for his work on the interplay between science and religion. A big-hearted man, he has given much of his winnings to charity.

He has been instrumental in building up cosmology and applied mathematics in South Africa. This has had a direct impact on the country's ability to attract great astronomy projects such as the Square Kilometre Array radio telescope. Now in his 70s, he remains a defender of science and an influential international voice in debates about the philosophy of science.

EARLY YEARS, CAMBRIDGE AND APARTHEID

Ellis was born in Johannesburg in 1939 to socially conscientious parents: His father was a newspaper editor, and his mother helped found the Black Sash anti-apartheid movement. He went to boarding school in KwaZulu-Natal, where he matriculated with top marks for science. After matriculating he joined his parents who had moved to Cape Town, where he enrolled for a degree at UCT.

At university Ellis started out studying architecture, since a career counselor at his school had suggested he studied a subject that combined art and science. But he quickly realised that he did not have the visual imagination needed to make architecture his career. After a year he switched to major in physics and mathematics. Varsity was not just academics for Ellis, however. A sporty student, he represented the university in fencing, rowing and flying, and spent much time climbing.

After graduating from UCT with his BSc in physics (with honours and distinction) in 1960, Ellis went to Cambridge in the United Kingdom to embark on a doctoral degree. He once more started out on a dual track, combining mathematics and philosophy – as well as some intercollegiate rowing for his college, St John.

Ellis' choice of subjects at Cambridge was influenced by a book he had read before leaving South Africa by Sir Arthur Eddington, a British astronomer and physicist born in the 19th century. "The stuff of the world is mind-stuff," Eddington had written in his book *The Nature of the Physical World*. He argued that we, as observers of the world, cannot be separated from our interpretation of what we observe. This struck a chord with Ellis, and influenced his choice to study relativity theory at Cambridge.

Ellis got his PhD from Cambridge in 1964 aged only 25 years. For the next ten years he would be based mostly at Cambridge, but with stints at the Enrico Fermi Institute in Chicago and the University of Texas, both in the USA, and the University of Hamburg in Germany. At Cambridge, Ellis worked with Stephen Hawking, a fellow postdoc at the time. In a move that would help propel Ellis' career forward, the two wrote a book together: *The Large-Scale Structure of Space-Time*, published by Cambridge University Press in 1973. The book was called "a masterpiece, written by sure hands" by the journal *Science*, and by late 2015 it had attracted nearly 10 000 citations and had been translated into Russian and Chinese.

Ellis returned to Cape Town in 1974. He did so partly for personal reasons (his mother was there and he missed walking on his beloved Table Mountain) and partly because he wanted to "do something on the social scene" in South Africa. Ellis took up a professorship in applied mathematics at his alma mater at the height of apartheid. The move influenced his research direction profoundly. "I think if I had stayed in Cambridge I would probably have done more distinguished work in relativity and gravitation. But I wouldn't have broadened out the way I have done. I am very happy to have done that," he says.

As head of applied mathematics Ellis had a lot of freedom to choose what he wanted to research. In his inaugural lecture on 11 September 1974 at

UCT, Ellis stated: "There is no such subject as applied mathematics". Rather, he said, it is an 'attitude' of numerically investigating issues using mathematical techniques. He soon began working on real-world problems such as providing low-income housing for the poor. His 1976 book *Squatters of the Western Cape* written with colleagues from UCT and the South African Institute of Race Relations and his book with David Dewar on *Low-Income Housing Policy* ended up infuriating the Minister of Community Development, but also influencing housing policies in the country.

Ellis took a firm stance against the apartheid regime. He joined the Quaker Service Fund and the Institute of Race Relations. He took part in protests against government laws, and although he never did anything illegal the security police kept tabs on him. He noticed this especially when he got involved in a project that looked at ways to improve peoples' lives in black 'homelands' using appropriate technology. The closest he got to being 'in trouble' with apartheid authorities was when he publicly argued that the security agencies had intentionally stoked the violence that followed Nelson Mandela's release. "That could have been dangerous," he says.

SCIENCE, RELIGION AND TESTABILITY

Ellis remained in his professorial post at UCT until retiring in 2004, whereupon he took up an emeritus position. In addition to his work on cosmology he has spent a lot of time thinking about the philosophy of science and the relationship between science and religion. In 1996, he published a book with Nancey Murphy, an American Professor of Christian philosophy that discusses the 'moral nature' of the universe. He has also written about the concepts of free will and causation. He believes that all science is done with an assumed philosophical basis – whether the scientist him or herself wants to acknowledge it or not.

One of the central tenets of Ellis' own philosophy is that all systems – even humans – are more than simply the sum of their parts. He doesn't believe that systems can be understood by understanding each of their smallest constituents. Other forces, such as intentions, thoughts, and social conventions, influence systems 'from the top down'. This puts him at odds with others who argue, based on recent breakthroughs in molecular biology

among other things, that humans are basically just machines without a purpose driving them.

Thinking of humans just as a collection of atoms and cells can never explain what humans do, or why they do it, he wrote in the journal *Nature* in 2005. "There is no physics theory that explains the nature of, or even the existence of, football matches, teapots, or jumbo-jet aircraft. [...] Even if we had a satisfactory fundamental physics 'theory of everything' this situation would remain unchanged: physics would still fail to explain the outcomes of human purpose, and so would provide an incomplete description of the real world around us." (*Nature*, Vol 435, 9 June 2005, p.743).

In 2004, Ellis was awarded the Templeton Prize, which rewards academics whose research affirms life's spiritual dimension. The prize is given out every year, and was at that time the largest annual research award in the world – bigger even than the Nobel Prizes given out by the Royal Swedish Academy of Sciences. In the year that Ellis won the award it was valued at £795 000 or more than US \$1.4 million. He accepted it from the hands of Prince Philip, Queen Elizabeth II's consort, at a ceremony in Buckingham Palace. Specifically, he received it for his work balancing the rationality of evidence-based science with faith and hope, a view that the prize-givers judged had been influenced by his experiences during South Africa's political transformation.

Ellis put half the prize money into a trust that will be paid to UCT after his death. The other half he gave away; R1 million to the Association for Education Transformation, which provides extracurricular teaching to disadvantaged students in Cape Town.

More recently, Ellis has been engaging in what some call "the battle for the heart and soul of physics". Some aspects of physics are pushing up against the boundaries of what is testable in the real world. For instance, some proponents of string theory say that although the theory may not ever be testable, it should be accepted as solid physics as it is the only theory that is capable of unifying all the fundamental forces in physics – electromagnetism, the weak and strong interactions, and gravity.

"These guys have been saying that 'our theories are so good that we don't have to test them'," Ellis says. But to do so would, to his mind, be tantamount to science taking a step backwards by a thousand years. "The whole point of the experimental method was that you had to test things," he says.

In the December 2014 edition of *Nature*, Ellis and a colleague, Joe Silk, wrote about the problem of exempting speculative theories from experimental verification as a major threat to science. Especially at the same time as politicians and others were questioning key scientific results in topics from climate change to evolution. The testability of science, they wrote, is its only defence against such attacks. (*Nature*, 18 – 25 Dec 2014, Vol 516, pp. 321-323) The article received a great deal of attention, and fuelled a global debate on the issue.

A CLASS ACT

Ellis is living proof that world-class science can come from South Africa.

In addition to his accolades, he has shown that a theoretical science degree can be utilised for the good of society and humanity. The work on low-income housing in the Western Cape in the 1970s was just the beginning. Since then, he has worked on education, especially the mathematics curriculum, and has provided advice for national science policymakers. He has co-edited a book on substance abuse and neuroscience, published by UCT Press in 2010. In 2009, then UCT Chancellor Graca Machel capped him for an honorary philosophy degree, calling him "one of the most distinguished scholars, past or present, this country has produced".

He considers his important legacy as having built up cosmology and astronomy in South Africa. He is proud that many of the people who run departments in these fields across the country went through his department at UCT. He has supported efforts to get astronomy facilities built in the country. Instruments such as the Southern African Large Telescope based in Sutherland and the Square Kilometre Array radio telescope, an international mega-array of dishes that will have its centre in the South African Karoo, were both made possible partly due to the intellectual capacity Ellis

has helped to build in the country. He believes such large-scale, expensive projects are necessary to keep up the scientific morale of the country. "People always ask why should one do these things in a country like South Africa." To him the answer is the same as the one Winston Churchill supposedly gave

when he was asked during the Second World War why he wasn't cutting funding for the arts to boost the war effort. According to legend Churchill replied: "Then, what are we fighting for?" (The veracity of this has been called into question, but it's a good quote nonetheless.)

"This is the same," says Ellis. "The purpose of having these facilities is to show that Africans and South Africans can achieve scientifically at a world-class level. It's really important for the country to be able to say that it isn't a backwater."