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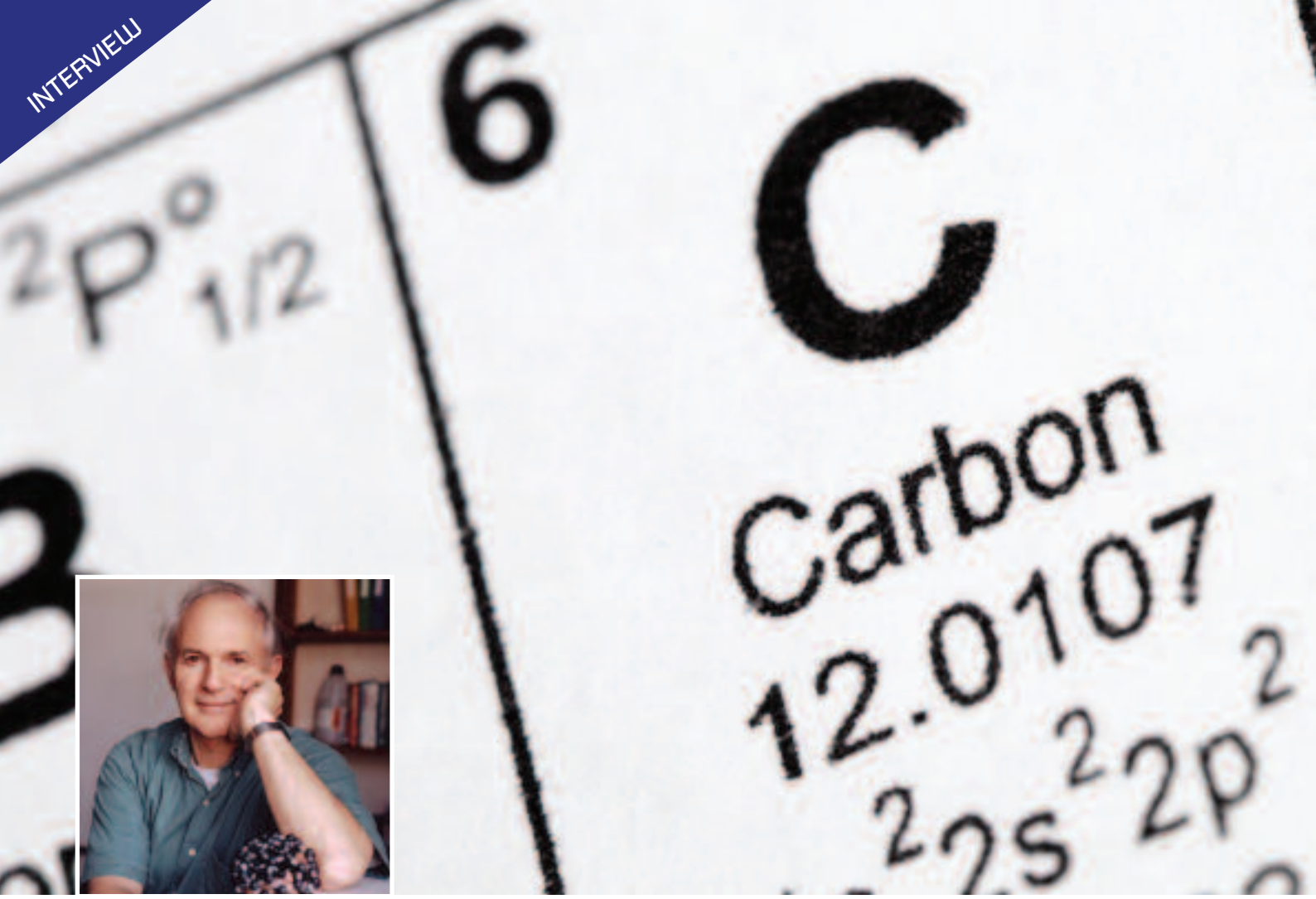


Nobel conversation

OTTILIA SAXL INTERVIEWS SIR HARRY KROTO, WHO RECEIVED THE NOBEL PRIZE FOR CHEMISTRY, IN 1996, ALONG WITH ROBERT CURL AND RICHARD SMALLEY FOR THE DISCOVERY OF CARBON C60, AN ENTIRELY NEW FORM OF CARBON WITH MANY INTRIGUING PROPERTIES. SIR HARRY IS CONVINCED THAT THE WORLD OF CIVIL ENGINEERING WILL CHANGE AS DEFECT-FREE STRUCTURES ARE CREATED ONCE LONG LENGTHS OF CARBON NANOTUBES HAVING A CONSISTENT DIAMETER CAN BE ROUTINELY SYNTHESIZED..

Apart from his research and other interests, Sir Harry has been active in enabling leading scientists to communicate with the public through the Vega Trust, and has more recently set up a new website, GeoSet, which offers a forum for young scientists to share their ideas and research, using video and powerpoint.

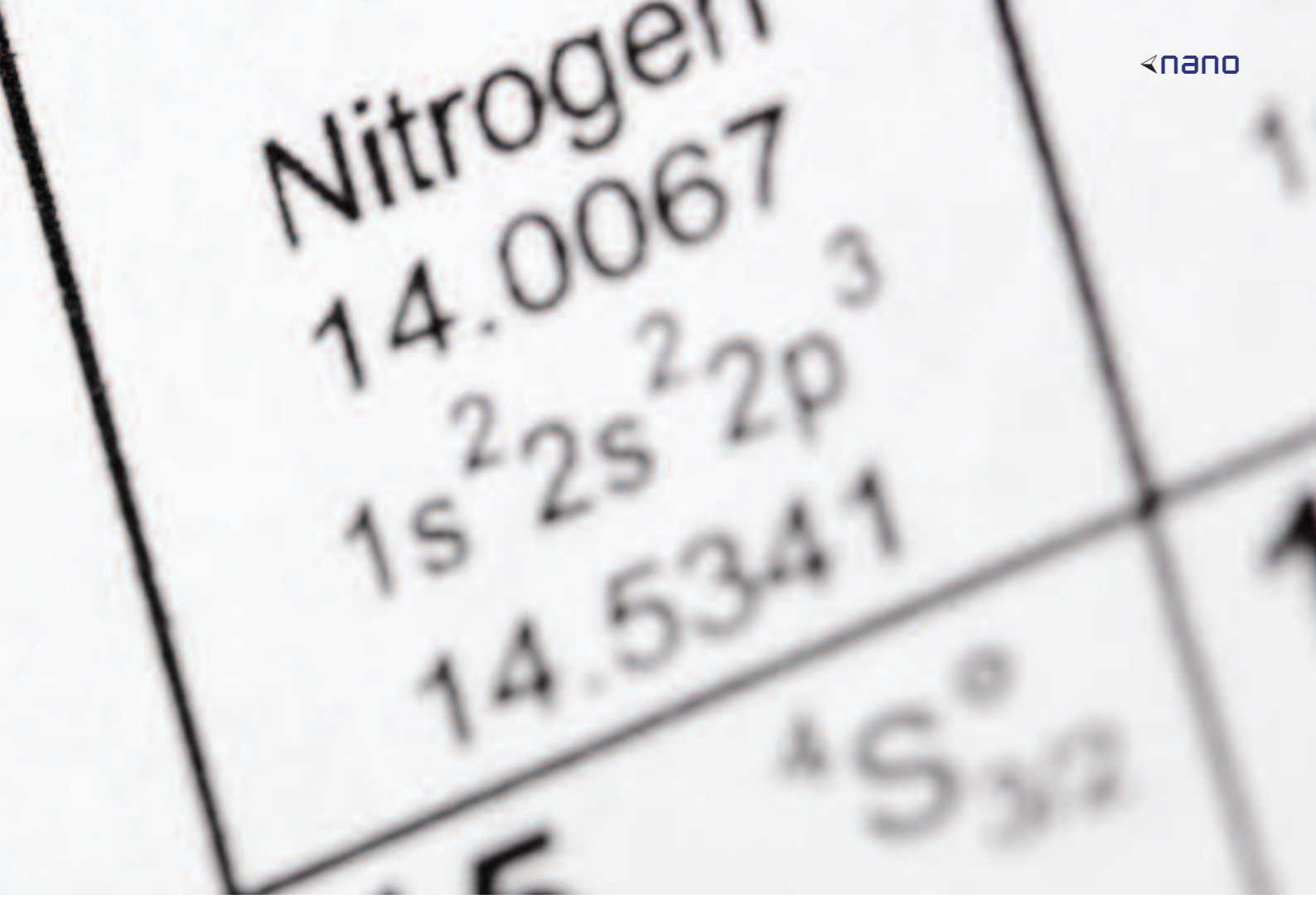
OS: What inspired you to become a chemist?

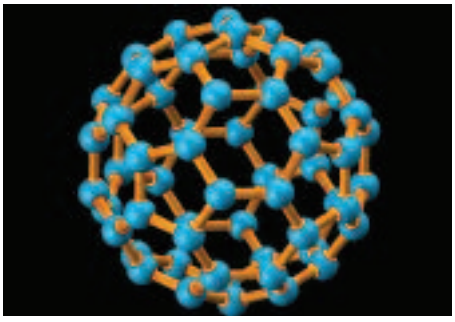
HK: Well, I was good at chemistry, but what I really wanted to be was a Wimbledon champion. I was good at art and graphics as well, but in the '50's there was no real future in these as a career. My father, who had been a refugee, ran a small family business, and was keen for me to join him. But both my chemistry teacher and my art teacher were very supportive of me continuing my studies, and it was my chemistry teacher, Harry Heaney, who encouraged me to go to Sheffield University. So I went to University and read chemistry (science was certainly one of the better options for getting a job!) where I became fascinated by quantum mechanics and spectroscopy. I also found that University was a way to continue my education and interests! – I played tennis for Sheffield, got involved in athletics and worked on the student magazine. I did so many things there that I wanted to stay on, and did so by taking a PhD in Spectroscopy. Essentially, University for me was a place I could do all the things I was interested in, so I gave it a try for 5 years.

In spite of winning the Nobel Prize for Chemistry as one of the discoverers of carbon C60, buckminster fullerene, Sir Harry Kroto bemoans missing out on a Wimbledon title, and still views the world of graphic design as where his real interests and talents lie!

A post-doc opportunity then opened up in Canada, so I moved there, and then I wanted to live in the States, so I went to work for a time in Bell Labs. After a while I wanted to get back to the UK, and came to Sussex. Coming home was certainly a shock – particularly a financial shock – my salary dropped from $14,000 a year to £1,400! But we survived.

OS: What were the highlights along the path that led to the discovery of Carbon C60?





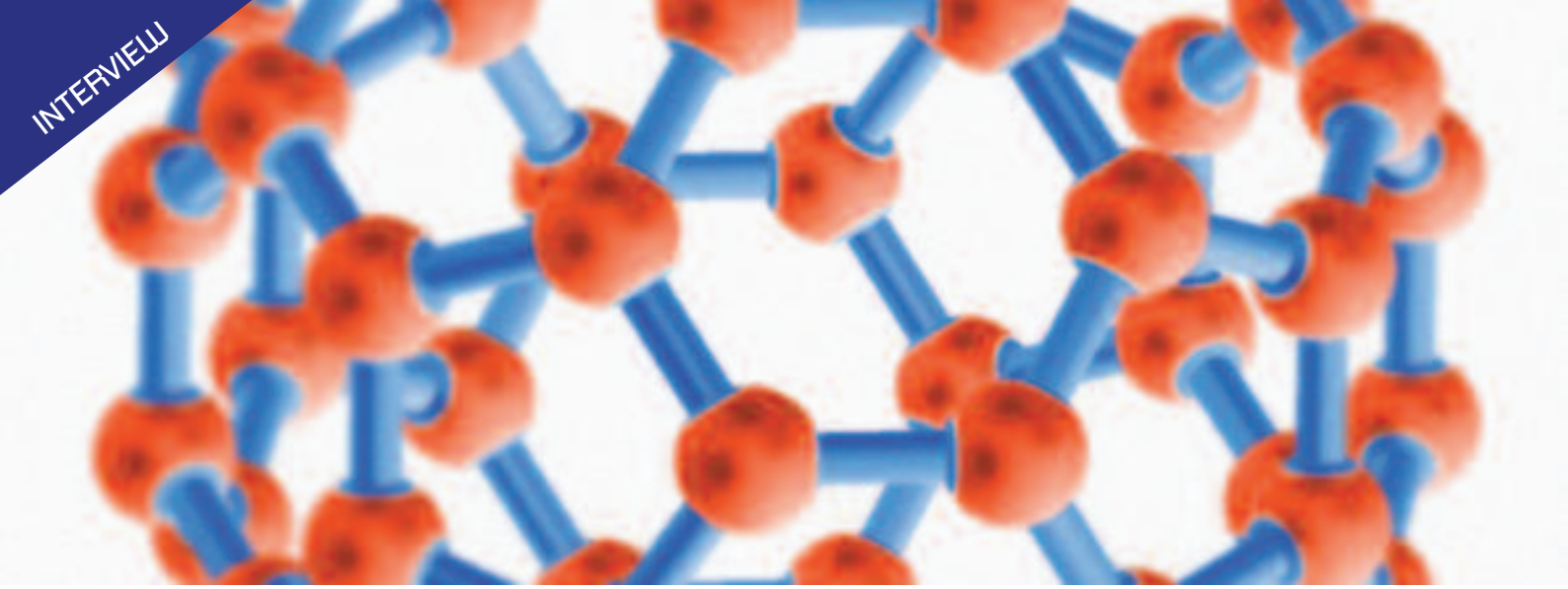
HK: One of the highlights was getting a job! I enjoyed teaching, but my big success at Sussex was pioneering studies on molecules with carbon-phosphorus multiple bonds that led to the now prolific field of phosphor alkene / alkyne chemistry. Another highlight was my work on carbon chain molecules undertaken with David Walton – polyamine spectroscopists have always had a close relationship with radio astronomers! - from which the start of my role in the discovery of C60 can be directly traced. Looking at microwave spectroscopy in the lab, and measuring absorbed / emitted radio waves had many similarities to working on interstellar space where unusual carbon molecules can be found, coming from carbon stars. This led eventually to the discovery of carbon C60 (in collaboration with Curl and Smalley).

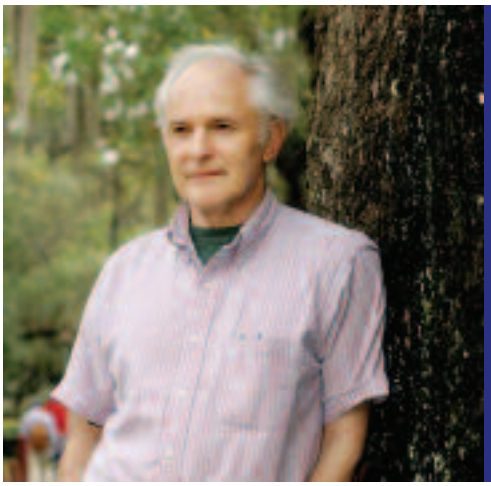
I WAS GOOD AT CHEMISTRY, BUT WHAT I REALLY WANTED TO BE WAS A WIMBLEDON CHAMPION. I WAS GOOD AT ART AND GRAPHICS AS WELL, BUT IN THE '50'S THERE WAS NO REAL FUTURE IN THESE AS A CAREER

New forms of the element carbon - called fullerenes - in which the atoms are arranged in closed shells were discovered in 1985 by **Robert F. Curl, Harold W. Kroto and Richard E. Smalley.** Fullerenes are formed when vaporised carbon condenses in an atmosphere of inert gas. Curl, Kroto and Smalley were able produce clusters with 60 carbon atoms and clusters with 70. Clusters of 60 carbon atoms, C60, were the most abundant with a high stability. It was suggested that C60 could be a "truncated icosahedron cage", a polyhedron with 20 hexagonal (6-angled) surfaces and 12 pentagonal (5-angled) surfaces. The pattern of a European football has exactly this structure, as does the geodetic dome designed by the American architect R. Buckminster Fuller for the 1967 Montreal World Exhibition. The researchers named the newly-discovered structure buckminsterfullerene after him. *Taken from the Press Release, 1996 Nobel Prize for Chemistry*

OS: Where do you think the discovery of carbon C60 is leading?

HK: The discovery of carbon C60 opened up our understanding of carbonaceous network structures that hadn't been forseen. All materials have problems based on defects, for example a diamond will crack along a defect; or a tree can be cut by sawing into a defect. The discovery of C60 led to a recognition of the strength of caged structures. If you could make these cages, the defects of many structures could be overcome. For example, a box of loose straws is weak, they will have no strength. Glue them together and the box becomes incredibly strong. Defects do not propagate in this kind of structure, and it solves a long-standing problem of how to design out defects.





Sir Harry Kroto, Dept Chemistry, Florida State University
Sir Harry obtained his BSc and PhD at Sheffield University. His early research focused on the creation of new molecules with multiple bonds; and in the late 1970's his work led him to discover that long linear chain molecules existed in interstellar space and within stars. In the late 1980's lab experiments at Rice University in Houston, were able to simulate the chemical reactions taking place in red giant stars, revealing that C60 could self-assemble. This changed the whole perspective on the nanoscale behaviour of graphite in particular, and sheet materials in general.

Sir Harry was knighted in 1996 and received the Nobel Prize in the same year for the discovery of C60, a new form of carbon, sharing it with Richard Smalley and Robert Curl.

The sticking point is that we cannot control the synthesis of carbon nanotubes. We are not going to have any revolutionary breakthrough in creating ultra strong materials unless we are able to routinely control the diameter and chirality of the » tubes. Carbon nanotubes would have incredible properties if we could make them of a consistent diameter and in large quantities, but we just don't know how to yet. Although we can produce a good yield, consistency of production is still in its infancy. What we need is a 'box' of CNT 'straws' – at least 1015 of them, 1m long and 1nm in diameter for defect-free applications. There are already niche applications of CNTs but we need to develop those that are in competition with mainstream technologies. We can't overcome the existing technologies that are in place at present, but a revolution in civil engineering will be possible once we can control the production of CNTs in a consistent manner.

OS: Sir Harry, if we can talk about the Vega Trust you formed. What is the Trust about, and what are its goals?
HK: The Vega Trust (www.vega.org.uk) was founded originally to create a platform for scientists to communicate directly with the public. I wanted to create a set of programmes where great scientists could communicate their views directly to the public on issues of importance. This has been achieved. 150 programmes have now been made, with the help of the OU; and 55 of these have been shown on the BBC. The Vega site is now a tremendous archive of the scientific thinkers of the day and I want to see it continuing to be added to.

The Vega Trust programmes include extraordinary interviews, lectures and panel debates and discussions with world-class scientists of the last 50 years. It even contains rare footage of four lectures given by Richard Feynman in New Zealand, courtesy of the University of Auckland.

We have now set up another, less costly (!) site, GeoSet, www.geoset.info which will be as meaningful for science and education as Wikipedia and YouTube are for their communities of interest. It contains video and downloadable powerpoint slides, put there by bright young scientists who are communicating their ideas in order to educate the wider world about their research, while also providing role models for other youngsters. It is a parallel initiative, and I want other universities to set up a similar opportunity for their students to contribute to GeoSet. My hope is that in 10 years, everything on modern science education will be in there.

OS: So, what about future plans?
HK: I would like to do one more good piece of scientific work in Florida, and then get back to art and graphics!

THE VEGA TRUST PROGRAMMES INCLUDE EXTRAORDINARY INTERVIEWS, LECTURES AND PANEL DEBATES AND DISCUSSIONS WITH WORLD-CLASS SCIENTISTS OF THE LAST 50 YEARS. IT EVEN CONTAINS RARE FOOTAGE OF FOUR LECTURES GIVEN BY RICHARD FEYNMAN IN NEW ZEALAND, COURTESY OF THE UNIVERSITY OF AUCKLAND.