Nobel Voices Video History Project, 2000-2001

Interviewee: Harry Kroto
Interviewer: Neil Hollander
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HOLLANDER:

Please tell us who you are.

KROTO:

Harry Kroto, and I'm a scientist, a British scientist at the University of Sussex.

HOLLANDER:

[inaudible]?

KROTO:

Well, I'm a professor of chemistry, and I do, I suppose, three things. I don't do as much teaching as I used to, which is a pity because I enjoy doing that, but I don't have the time, and it's very hard work. So that's one reason why it's difficult to do. I don't have to do teaching as much as I did.

But I do three things. I do research in nanotechnology, which is a field related to the discovery in 1985 that led to the award of the [Nobel] Prize. I do this, which I consider part of communication of science. I'm here at this conference, and I've spent the last six hours talking to students, and giving lectures around the world on science and scientists in society and science and creativity. I do research, as I said, and I'm also making television programs. We've made about forty—no, we've made more now, maybe forty-five programs, which try to uncover the culture of science and enable scientists to communicate with whomsoever they wish, whether it be young children or older children, kids at school, university students, or the public. So we're developing platforms that enable scientists to communicate.

HOLLANDER:

What led you to science?

KROTO:

It's basically because my father felt I should concentrate on science at school, because I

was more likely to get a job that way. My main interest is graphic arts and design. It always has been. My main, I suppose, passion and interest was in art and graphics. But during the war, I was brought up—I was born in the first month of the war, and in that period when I was brought up, it never crossed my mind that I could make a living as an artist or as a graphic designer. In fact, the profession didn't even seem to be a profession. I mean, I had no knowledge of it. The careerist's advice was none, was, well, zero.

I was good in science, and so I continued that way. I actually wanted to be Wimbledon champion as well, but I wasn't big enough, good enough, I lost too often, and didn't have the temperament. So I just was good at science at school and then did a Ph.D. I did a degree, obviously, in Sheffield University in chemistry, and then a Ph.D., partly because I wanted to stay at university. I was having such a good time. It was much better than in school. I was independent, and it seemed a lot better than getting a job at the time, so I did a Ph.D.

Then I went to live abroad, so I did a postdoc in Canada for two years, and then I went to Bell Telephone for a year. Then I got a job back in England. I was offered a job and came back, because I felt I owed it something to the country because it was where I'd been educated, although I quite enjoyed living in North America.

HOLLANDER:

[inaudible]?

KROTO:

Oh, yes, I mean, I still do it. I mean, it's almost as a sort of semi-professional level. I do logos and posters, and it comes in. I mean, I designed the logo for the Vega Science Trust website, which is the trust I set up to make science programs. It's sort of a foundation already as a nonprofit-making trust, not-for-profit trust, as they call it. So that's part of the thing, but, absolutely. I mean, I spend much of my spare time in bookshops and make graphics and stuff like that. I collect art books and that kind of thing.

HOLLANDER:

[inaudible]?

KROTO:

It is for me. I don't think it's necessary for all scientists. Each scientist is different. I think it's a good idea to have a wide range of interests. But there seem to be scientists who are just interested in science, so that's the way—I don't know whether it's good. It's the way I am. Whether I should say, you know, this—everybody should do graphic design or whatever. Maybe it is. I mean, I think it probably is. I think it can't do any

harm.

HOLLANDER:

[inaudible]?

KROTO:

Oh, yes, absolutely. I mean, my first competition that I ever won, my first award, was for graphic design. It was a *Sunday Times* book jacket design competition. I've won the Science Pour L'Art Prize from M_____. Also one of my designs is in a—I designed a brochure cover, which is in an international annual of graphic design, of professional graphic design. So I feel I've got a record. It's actually probably my favorite publication, actually, perhaps apart from the one or two others. Also, of course, the one that was awarded the prize.

HOLLANDER:

[inaudible]?

KROTO:

Yes, well, my usual answer is, "Don't you know?" My usual answer is, "Don't you know?" [Laughs]

Well, I was basically a chemistry sort of researcher, and my first work was in carbon in phosphorous chemistry, and I also did some radio astronomy and spectroscopy. In the mid-seventies, with the Canadian science astronomers, we discovered there was a lot of carbon in space, and this puzzled me. And I thought, thinking I'd try to understand why this was. In 1985, I just happened to visit Rick Smalley's [phonetic] lab. I was visiting Bob Curl [phonetic], who was at Rice University. Rick Smalley developed a fantastic apparatus which could vaporize carbon or could vaporize metals. I thought, "Well, if you vaporize carbon, we could simulate the conditions that occur in a carbon star."

We got together to do that experiment with research teams, particularly Jim Heath and Sean O'Brien and Yuan Liu. We vaporized carbon, and we got results which were perfectly in accord with my hypothetical ideas about how the carbon had got to be in space. That had been produced in a star and then blown out of this star. But there was a serendipity. There was something that was totally unexpected. We discovered that we could get a cluster of carbon atoms which had a beautifully symmetric structure, or we found that we could get a cluster which was special for sixty atoms. There was some way of packing sixty atoms of carbon together, which made that particular structure special and stable, sometimes called m___.

We came to the conclusion that the atoms were arranged in the same pattern as the

geodesic dome of Buckminster Fuller. I'd visited Expo '67, and so had Rick Smalley, and Buckminster Fuller's geodesic dome had been imprinted on my mind. We played around with possible structures, thinking it might be [inaudible]. We might came to the conclusion that it was the same pattern as a soccer ball in the sense that if you take sixty atoms and connect them, you can put one at the intersection of the faces of a soccer ball, and there are sixty of those. There are twelve pentagons on a soccer ball, so they have five times twelve equals sixty corners. You put the atoms of that, and you get this amazingly beautiful structure, more beautiful than a soccer ball.

I felt that Buckminster Fuller's dome was sufficiently important in arriving at the structure, that I thought we should call it after him, and I called it Buckminster Fuller Rings, and it stuck. The whole set of molecules, the cages, are called Fuller Rings. So that was the discovery.

The significance is that graphite can form cages. That was not known before. That was a paradigm shift in our understanding of graphite materials, and graphite in carbon is arguably the most important element in the periodic table. It goes further than that in the sense that we now realize it tells us even more, that all sheet materials can form cages, and that is seen to be an obvious thing, and why didn't we know this. Anyway, we didn't, and so we discovered this molecule. But we discovered that we formed implications for materials, and now nanotechnology, many of the people working in that area would call themselves nanotechnologists. This is building structures which are a bit bigger than the average molecule.

HOLLANDER:

[inaudible]?

KROTO:

Well, that's what chemists do. I mean, a chemist, basically, is someone who takes molecules, bits of tiny parts, and puts them together and arranges the conditions, maybe the thermodynamic conditions so that they come together and react. So you take, I don't know, sodium hydroxide and hydrogen chloride and you get salt. Okay? So they exchange, so the sodium exchanges for the hydrogen, and so you get sodium chloride. So that's what chemistry is. It's building edifices. It's an architecture on a nano scale, a nanometer scale, and we've learned how to do that quite well. But I think we're beginners, still, even though we've spent a long time getting to where we are now, because the living organisms build molecules, too, right, and they build these great proteinacious enzymes that put atoms together exactly where they want them.

My view is that we've got to try to do something similar. It may be not be the same way, but we have to build the molecules, the big edifices out of atoms that we want in the next century. I'm not sure we know how to do that, but biological systems do it, and maybe we can take a leaf out of their book. So chemistry is exactly what we're doing, but C_{60} is

somewhat different. You just throw the atoms up, and they come down as a soccer ball. That's perhaps our discovery, that they spontaneously form that. So we didn't have to work very hard. Only took ten microseconds or something to do this.

HOLLANDER:

Ten microseconds to win the Nobel Prize?

KROTO:

Well, it was a week. I mean, you know, no, it's a bit more than that. No, it's more than that. But the experiment, yes, the experiment took from Monday to Friday. We already had our results on Wednesday. It was clear that something special after two days, on Wednesday, September the fourth, and we started on the Monday. So on the Wednesday, we had a very interesting, extremely interesting, a damned interesting result, indeed. Then we conjectured what the explanation might be, and we were just absolutely exhilarated by this because it was so beautiful. That took till the Tuesday, so eight days, to a conjecture as to what it might be. Another two days, ten days, to write the paper and send it off. Then five years of work trying to convince first ourselves, and then others, that we had a correct explanation.

So in 1990, five years later, it was extracted and proven to be correct by the German-American group of Krätschmer and Huffman, who did a fantastic job. They extracted the material in enough quantity to be able to prove the structure. At Sussex, we extracted a few—well, it must have been a bit later, because I got their paper to referee, and we'd extracted the material on the Monday, but were still sort of thinking about it. So we came second in that one. But still, this brilliant work by Krätschmer and Huffman should be recognized as well. They are sort of equal shares in this fantastic story, as are the students as well, you know.

HOLLANDER:

[inaudible]?

KROTO:

To me, very different from what it meant to me before winning it. It's a very—actually, no one's actually asked me quite in that same way, but I've not thought about it enough. I always make the statement that I was very happy with my science before 1985, and I was thinking of doing some graphics a bit more seriously, you know, to get to do the thing that I probably always wanted to do. So I'd done some very nice work in carbon phosphorous and carbon sulfur chemistry, and I was very proud of that, in some ways, in many ways, more proud than the discovery of C_{60}, because I thought about it, and it took me a while to work out how to do this. So the phosphorous chemistry is much more important science, better science.

Then I did some very nice work, but the phosphorous, work was done with a colleague at Sussex, John Nixon, and then this really exciting work, discovering that little carbon change, carbon in space, and that was very exciting, and that made waves as well. So the phosphorous work opened up a whole area of phosphorous chemistry, which is still going on, big field now today. Although they don't realize it, it was me. I always get irritated about that. These guys, because I didn't stay in the field, and I didn't keep telling them, you know, "Those first papers are mine," so your sort of contribution sort of disappears.

Then the radio astronomy was very exciting. That was nice, very nice and every exciting. Then I did this experiment which was important to me, but not so important that I was running around telling people to do it. In that was a serendipity totally unexpected of this soccer ball structure.

Then I think I always knew there was a possibility that if it were correct, that it would be so important, whatever that means. I don't like that word in this context, but that it might be in line for *the* Prize, the Nobel Prize.

Now, I say, just to go back, that I was really quite proud of what I'd done and quite satisfied. You wouldn't have heard. I wouldn't have been here. People in the fields would have known me. I was a pretty eminent scientist, very satisfied with it. I would have liked to have done another third nice thing to add to it of commensurate stature.

I thought, well, I'll try to develop my computer graphics. I was interested in design, seeing whether I could do something innovative there, welding together my interest in graphic design and the advances in computer graphics that were coming on, and to do something that was truly original, not something that was just using the computer to do what you could. I mean something that's really not been achieved yet. They're moving that way with dynamics, but it seems to me that, you know, you should be able to do something that you couldn't even dream of, something intellectual and, in a sense, [Latin phrase], although I'm an atheist, spiritually different, you know, that sort of thing.

Then the Prize came up, and then I thought, "Well, this is such a big prize." Not prize. But this is such a big discovery, that I wanted to prove whether it was right or wrong. We conjectured. It was a conjecture, and then we needed proof. So I decided to spend five years, and in five years it was proven. It was proven, as I say, by Wolfgang Krätschmer and Don Huffman in Arizona, and Krätschmer in Germany. We came in second, and I was very proud of coming in second. It would have been nice to come in first, but I was really proud of what we did.

Then things changed again, because it was proven. But I felt that now we should sort of see whether it does something interesting, and I started to do research in that area. That was in 1990. It's now the year 2000. For ten years I'd been doing research in that area.

Now before that, I used to say, "Oh, he's won the Nobel Prize. He must be the smartest kid on the block." Now I can't say that, because I know, first of all, I'm not the smartest kid on the block, because [unclear]. I'm very lucky. I think I'm fairly smart, and I think most of the scientists who win the Prize are pretty clever, but some are fantastically clever. Some spend their whole lives in science and maybe—what's the word? Maybe wanted to get the Prize and actually managed it. But I never even thought about it. It would never in my wildest dreams would I have thought that I would be sitting here being a Nobel Prize winner. It never occurred to me. So in a sense, it's like winning the lottery.

So now I think, "Well, what's the point of this prize?" Well, it helps me in what my major new aim is, and that is to create platforms for the scientific community to communicate. So we're making television programs with the Vega Science Trust, and I created that a few years ago to explore and experiment with platforms in which scientists themselves would communicate on issues that they find are exciting and important and concerned. We've made now forty-five programs. They've been shown on BBC-2 or late night or with the opening of university, most recent ones.

So it helps to get the money, but it's a bit of a thankless task, because getting money at 10,000 quid a time for science programs, some of which are not easy, to get broadcasters is difficult, but now the Internet is coming on, and so it's helping me to try to build a network of science program providers. It's helpful because people outside science think it means that I'm someone who may have something worthwhile to say.

To me personally, it's very difficult, because, you know, I used to think, "Oh, the Nobel Prize winners are something special," and now I know they're special people because they got Nobel Prizes, but they are not necessarily special people individually. They may be very clever, may not be very clever. They may be very lucky. But they have now, I think, I feel, I have some responsibility to use it to help scientists to communicate on lots of levels, not just public, but also to other scientists, and it is helpful from that point of view.

But other scientists know where I stand. I know where I stand, so it's not much use from the scientific point of view, for me. I mean, others might find that it is because they get a job at Stanford [University] or whatever. That's not interesting to me, although I am visiting professor at [University of California at] Santa Barbara, but I was visiting professor before the Nobel Prize, and I was visiting professor at UCLA before that for many years. So it's a peculiar change.

It's like someone once said something to me, which is very interesting—well, these guys are more interesting than I am. I can't remember. They said—we have things called O-levels, which are the first things you get in [unclear]. It was really a rather interesting ambiguous and paradoxical and perceptive remark that a young woman once said to me, "O-levels, they're not worth anything unless you haven't got them." I thought of that for—I mean, I've never heard anyone else say that.

This is somehow the same when you're a Nobel Prize winner. Now, it's not quite the same. You know what I mean? It's a very, very big shift, first of all in having one, because I don't think about it. It was extremely exciting to get it. It was very tantalizing and interesting to look back when we thought we were in the running for it, because, you know, we—it's not that. Some, I think, may be surprised, but I don't think many Nobel Prize winners are actually surprised when they get it, because they know they're in the running. Now, they may have a 10 percent or a 50 percent chance, and many will be extremely disappointed because they don't get it.

In my case, I thought, well, I thought we had a 20 percent chance, a 30 percent chance. I knew we had a chance, because you know whether you're being nominated, and you've got friends who, they're not supposed to tell you, but, you know, they come for your CV and they say, "Well, this looks like—," you know, and that's very nice that they think so.

But it's a funny prize, and it has good things and not so good things, and I think some people crave it. I wouldn't say I craved it, but I thought, "You know, this is a bloody good discovery, you know. It's worth as much as one of the other ones." And if I hadn't got it, I wouldn't have been unhappy. I'd have been disappointed, but I think some people are very disappointed. So, lots of peculiar differences in feelings with that.

I'm pleased with it, very pleased, and also to come here is very important, this meeting. The genuine interest in what you've got to say that the students have is very, very good. I mean, I made a somewhat contentious comment earlier today, and I think the student got up and wanted to put me straight. I appreciated that, although I don't accept what he was trying to—

HOLLANDER:

What did he say?

KROTO:

Oh, I told him that I'm an atheist. I said, "You know, I'm a devout atheist." I said, "Actually, no, I used to be a devout atheist. I'm a militant atheist now. And if things get any worse, I'll become a fundamentalist atheist."

And he got up and felt that I ought to know things I know all about. So I know I lost a lot of friends, but that's the way it is. I feel that there are certain things I feel very strongly about and that's one. They were asking about—someone asked the question with regard to the interface between science and religion and whether they can have anything to say to each other. What it says to me as a scientist is, there ain't none, right? Other people say they don't have anything to say.

But, you know, I'm someone who believes that science is the way of understanding the

world, the universe, and everything there is that happened. If you believe that, you do experiments, and if the experiments tell you something and you do another experiment and it works, then you say this theory is right. If you have a theory and nothing seems to fit, and it seems to me nothing seems to fit at all, although it's needed, I mean, people do need this, that doesn't mean it's right. And I find that interesting, lots of aspects of this.

HOLLANDER:

[inaudible]?

KROTO:

Because that's true.

HOLLANDER:

But why?

KROTO:

Because I believe that there's a move, a fundamental religious fervor, fundamental nationalism and patriotism and all these extremely powerful movements, which are separating people. I think that religion separates one group of people from another. Nationalism does the same thing.

What I actually said was the following. I said, "I have three religions. The first is Amnesty Internationalism. The second is humanism. I'm a humanist. And the third is atheism." And then I went and took it through these sets. And that's what's happened. I object. I mean, my parents were refugees from Berlin. My father was Jewish, and my mother wasn't. I now look upon religion in the modern world as having served its purpose. It has been used, I think, to develop humanity in the human race, and now I think it's becoming—I think it has been very useful, the development and the reformation and Martin Luther and movement all towards humanity. I believe humanity is what it is. It's humanity. Humanity is our greatest discovery. It's our greatest creation, is our humanity of the human race. And I don't want to give that wonderful achievement to some mystical entity.

I don't think—it was made under the impression that a mystical entity existed by tremendously wonderful people who were religious. I now think it's divisive. I think it's causing terrible problems in Israel, as an example. It's causing terrible problems in Nigeria where Shari'ah law is coming in and they've chopped children's, kids' hands off, you know. It's enabling people to justify the call for murder on the basis of religious grounds, that Salman Rushdie should be put to death for writing a book. That reaches into my country, that people who are Muslims in Britain think that Salman Rushdie should be murdered because he wrote a book. The book's not that bad. Much worse

books. *Mein Kampf* was much worse, again.

I object to—well, I'm against the death penalty and things like this, and I think, you know, there are arguments, pragmatic arguments for it. There are no ethical arguments for it. The only argument for the death penalty is perhaps that it's you don't have to look out for this guy. But there's no argument of that kind. So these are the major issues of the future, so that's why I'm moving through that.

HOLLANDER:

[inaudible]?

KROTO:

Yes. I think it is true that I was brought up in the sixties when I—I mean, I was born in the first year of the war and—

[Taping interruption]

KROTO:

Those are some very good questions. I was really a child of the sixties. I had a good time as a student in the sixties when I think there was an immense atmosphere of optimism. It seemed to me that science and technology were changing, making people's lives better, that I felt that there's no doubt in my mind that by the year 2000 the world would be a wonderful place, much happier. I mean, it seemed to me that that's what was happening from the time of the war, 1945. Everything was definitely—I mean, I saw those changes from being a child, and I had a great time in the sixties.

Then Kent State [University] in the seventies, '74, and things, and then I was still pretty optimistic. But I became depressed at the way in which organized society started to manipulate things and started to be able to control the way that we were being governed. That's organized religion in the States, organized religions in the eastern countries, the fact there's no democracy in those countries. I've read the Koran, and, of course, I was brought up to be Jewish.

I find these may have been valuable ideologies in the seventh century and 2,000 years ago, but they're not right now. We've developed our humanity. I think human beings who don't have religious beliefs can, as I do—I don't believe in death penalty. I don't believe you should hurt anyone. I don't believe in harming other people. I believe the human rights of Amnesty International and the Humanist Association, the society of that.

Where do they come from? Oh, well, they've been developed by free-thinking people in the face of control by the state and religious groups all through the centuries, and it seems to me that they've relaxed and relaxed and relaxed. But suddenly there's been a

backlash, and there's been a use of modern communications and the power of money to try to influence the political process in a very disturbing way, particularly the people in the U.S., the "Moral Majority," or the
Moral Minority," whatever they are, in the States. I think this is anti-democratic, which is what I am. I'm a Democratic Socialist of some sort.

HOLLANDER:
[inaudible]?

KROTO:

I'm not a *Nationale Socialist*. [Laughs] I'm antagonist to nationalism, and I think that's divisive as well.

HOLLANDER:

[inaudible]?

KROTO:

Well, that's got a bad ring to it. I worry about that, too, because almost every Socialist or Communist country has ended up as a dictatorship. There's something wrong there. I don't know what it is. I mean, how can—I mean, there's nothing more Socialist than some of the parts of the Bible where everyone should—you know, some aspects of the Bible and the Koran are very good, you know. There are other aspects of why you should do this. You should do it because it's good, not because you're going to go to heaven or whatever.

My worry about Socialism is that there's an experimental—the facts. I mean, almost every Communist, certainly Socialist country ended up as a dictatorship. So I wonder what it is in that. I find that surprising, but it seems to me that that's what happens.

So I'm not so idealistic as to not take notice of what happens, and there's got to be democracy there. So I'm a Democratic Socialist, and internationalist, too, because, I mean, how could I be anything else? I mean, my parents were refugees and I was brought up in Britain. I've spent large amounts of my time in the U.S.A. I worry about the U.S.A. being so rampantly nationalistic. That's not very good.

HOLLANDER:

[inaudible]?

KROTO:

Yes, well, I'm involved in educational programs. I was on the National Advisory

Committee for Cultural and Creative Education. We were tackling a problem which was how do you legislate the prayer activity and things like this, and how do you legislate—we didn't discuss science because they were more worried about the arts, and I was a token scientist, or one of the token scientists on it.

My worry is less that there are fewer and fewer scientists coming forward, because I think there are plenty coming forward out of China and, you know, whatever. If western kids don't want to do science, okay, and they want to play computer games or whatever, that's fine. Not fine, but it's not—but the scientists we need will come forward. There's a fantastic wealth of talent in India and China in particular, and I think some of the shortfall worldwide will be filled by these people. The reason that they're coming forward is I think they can see in their own lifetimes how technology has actually affected them, whereas the western child who's grown up today who's about twenty, he's never seen this, you know.

HOLLANDER:

[inaudible]?

KROTO:

We do our programs in a studio. I'm an executive producer, producer, editor, and made programs. So you should look at our website. We'd like to link with you, actually.

I forgot to tell you. One of the prerequisites of this, of my giving you this, of my doing this program, is I'd like you to help me to build a network of science sites where good science and cultural science is to be found.

HOLLANDER:

[inaudible].

KROTO:

Yes.

HOLLANDER:

[inaudible].

KROTO:

Are they going on the boat tomorrow?

HOLLANDER:

Yes.

KROTO:

Okay. Can we get together? I've got so many kids, I may forget. You must seek me out. It's very important.

HOLLANDER:

[inaudible].

KROTO:

Okay. They know me well there. But, yes, I need to build that, because we're working out of UCSB [University of California at Santa Barbara] to do that. I mean, we're trying to do something like ScienceChannel.com.

HOLLANDER:

[inaudible].

KROTO:

Okay. I would like—that would be great, and I think we need to link together so that this network and mirror sighting and things of this nature, I would love to do that, because I can't make, you know—I physically can't keep research going, come here and talk to kids since nine o'clock this morning and arrive at quarter past twelve from Sweden last night and put together talks. I'm absolutely completely exhausted.

But to get back to it, I'm less worried about the fact that the West is producing less scientists, than I am about the fact that the West is producing less scientifically aware and educated population in general. That disturbs me very, very much, because the twenty-first century is going to be more technologically dependent than the twentieth has been and is or was. And we've now got so many people who are totally ignorant of how much they depend on this technology going right. That's in the schools as well.

I was talking to a young kid, and she said she did a very interesting experiment. I was with the British kids at lunchtime, so I didn't get any lunch. She said she gave out blank pieces of paper and asked the kids to write down anything around them in the room or whatever they thought of that was scientific, you know, something that was scientific, based on science. I mean, she basically had nothing, nothing whatsoever. One kid said, "Sugar dissolving in water." So there was no awareness of electricity. There was nothing about the paint or the polymers or the metallurgy or the glass in the window

frames. And I think that's basically the way the modern world is. Certainly in the U.K., the majority of people, (A), have very little awareness of how sensitively balanced their life actually is on technology going right most of the time. It's just too efficient. Whereas I think kids brought up in my time, they've seen it happen, and therefore they're rather more aware, not necessarily very aware.

And then there's this incredible animosity toward science which is just staggering. I was at a conference last week in Canada on science, the arts, and creativity, or creativity and the arts and sciences. A young woman got up after this, and there were people like Pinkus Zuckerman playing the violin, and there was myself as a scientist, and Arthur C. Clarke coming in by satellite, and psychologists and people on the brain discussing all aspects of this, and a fantastic presentation by Douglas [J.] Cardinal, who's an architect.

This girl got up and said, "Aren't you missing the point? Science is taking away the mystery of the way the universe is in clearing all this up." I got very angry, and when it was my turn, I said, "Look. This young woman stood up and said that basically that ignorance is bliss. Okay? That ignorance is the way the world, the way nature and the physical world works, and lack of understanding of this somehow takes away the beauty of nature. This is totally ridiculous. I want to ask the people who applauded," because it was applauded by a significant fraction. I said, "Why did you applaud? What was the reason? I want you to think very carefully about why you applauded this."

I pointed out that [Richard] Feynmann, in the fantastic interview Chris Sykes made many years ago, answered this very eloquently. He said, "I have a friend who's an artist who says something which I don't agree with. He says that you are a scientist, and you come along with your clear views and you work out how things actually are. You take away the beauty of nature in the physical world." He said, "I don't agree with this. First of all, I am a scientist, and maybe I'm not a full-time artist, and perhaps I don't have the sophistication of the artist, but the appreciation of the flower is open to me as well. Okay. Maybe I don't have this subtle perception that maybe you as an artist have, but science allows me to see more. I can think about the structure of this, and I can think about somehow how the structure is controlled by the genetic DNA and things of this nature. I can think about the bee that comes and pollinates this, and wonder what sort of effect it has in the sensory perception of the bee. I can see more because I understand how it works. I don't see how this knowledge takes away from the beauty, anything away from the beauty." I think he said it more eloquently than that, but, roughly, that's what he said.

But there's a huge percentage of society who believe that, and they believe in mystical things. It seems to me it's growing. For instance, there are a lot of people who believe in astrology. Okay? Now, I have something that I put up on the notice board. Not the notice board, but I put it up sometimes in my lecture, and it says—a newspaper cutting when we did this radio astronomy. It said, "These results were obtained by Canadian work in radio astrology." There was a big laugh from the audience.

But actually, astrology is no different from religion, okay, in my opinion. Now, of course, it's only my opinion, but mystical things, the statistics don't seem to work. A lot of people believe in it. A lot of people believe it works. They have some things. Many of these people who've laughed at astrology don't laugh when I say, "Well, what's the difference between astrology and belief that these things—?" And they have a problem with that. But there are a large number of people believe that, and there seems to be a deep need in many, a large number of the human race, to believe in these things.

So the sum genetic structure, I think, which probably comes from our ancient ancestors, or then animal ancestry, where we see genetically programmed behavior to follow a leader, and now to follow a leader who can't be seen, and therefore the failings can be sort of glossed over in some way, because we now can see that human beings have failings.

I mean, the Japanese used to think—maybe some still do—that the emperor was God, okay, and the emperor *was* God. Someone I remember, I know this story, who was religious, someone who was religious said, "Oh, do you realize that some Japanese still believe that the emperor is God?"

This guy said, "Well, how do you know he isn't?"

And they were taken quite aback by that, because they realized what the guy was actually saying. So, of course, because some people thought that Jesus was God, but you know, how do you know he isn't, is a very good question.

But there are problems, I think, coming up in the twenty-first century, which I think these very old philosophical rules and regulations will not help us to get the optimum answers. That's what worries me in the next century. They're starting to wield their strength undemocratically. An example is abortion. There is no doubt that abortion is a very, very difficult issue, and there isn't an answer to it. You know, there isn't. It's a very difficult problem for a young woman who is pregnant and in the slums of Dallas or whatever, no chance of bringing the child up in a decent—they don't even have anywhere to live, or whatever. I don't know. Are these people prepared to look after that child for the rest of its life? Are they prepared to ensure that it has a decent home? Are they prepared? If someone comes along and says that young girl should have the child, then they should adopt it and make sure that the child—if they save that child, okay.

Now, that doesn't mean that I feel that they should have the abortion. I don't know the answer. I say that I feel the best solution, to me, if I were a barrister, is to say it is for the woman to decide, with good advice, good advice from people who see, you know, is there a family going to be able to support. You know, are they going to be able to support the girl who is, after all, only thirteen and far too young to become a mother, far too young.

I think you don't look at those issues if you have simple solutions based on philosophies

which are 2,000 to 5,000 years old, or in the case of Islam, only 1,300 years old. This simplifies the problem, because you just look at this little bit. But I don't think it gives the best solution. It gives a solution which might be much worse than others.

think our problems in the future, genetic problems, are going to be orders of magnitude bigger than that one. We can't even cope with that. Then how are our offspring going to cope with a world in which we can manipulate the way in which the human race develops? It's not I don't want to be there. I'm glad I don't have that problem. [Laughs] I mean, I'm really glad, because I can't even solve the simplest problems, ethical problems, we have today. But when our children are going to be able to decide whether to program aggression because that will get them to be a good tennis player or be successful in business, I think that's a very, very disturbing time. And that, I think, looks as though it's coming.

So at the same time, I think we've got to be humanistically oriented, but also aware that there aren't simple solutions. But I'm pessimistic at the moment, because I see this tremendous need in many people for something like that. I mean, only a few days ago, I can't remember, there was something. I can't remember what, but it reminded me of Dunblane, where this guy shot sixteen children. It was just horrific, and your heart goes out to the parents. But the next day they were in church, and were they thanking God for not stopping this guy going in? I mean, what's the logic? What sort of power? What sort of power does the—I wonder what sort—there's some tremendous power that religion and mystical concepts have over individuals. And I think if anything has made me pessimistic, it is that.

This is much more powerful than I thought when I was a student. I thought that all those things which were totally illogical to me would be changed and that people would behave to each other. I honestly thought by the year 2000 after the war, that people wouldn't be racially prejudiced. I really thought that people wouldn't be nationalistic. It seems to me they're worse than they ever were before. I mean, it's not better. I think the U.S. is worse than ever, because you go around and you see these flags all over the place. When I see flags, I know these people have an inferiority complex. And why? I mean why? What do you need to show?

What is it that makes you feel it's good that you have more Nobel Prize winners or more—you know, it's—I'm affected by it, too, you know. I want England to win at football, and it's a very powerful hurt inside. It's deeper than I anticipated. But probably worse than religion is nationalism, because, you know, this ground, you know, I don't own it any more than you do, and the Germans don't own it. I mean, that water is there, you know.

I guess I wasn't aware of the magnitude of the humanistic problems when I was a student, you know. It looked like things were going to get better for everybody. Not that I played a very large part in that, but it just seemed, well, you know, some balloon is going up. I came from a poor background, and, by and large, in the western world that's

been the case. But in Africa, it's poor. I think, yes, if I learned anything, the problem, *the* problem, is bigger than I thought it was. That's my disillusion, but I'm still optimistic, a bit. [Laughs]

[End of interview]