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Message from Nobel Laureates to Young People (2)

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(Interviewed in August 7. 2000 in Budapest by Professor Yoshito Takeuchi)

Professor Takeuchi (T)
Professor Kroto, thank you very much for kindly accepting our request to be interviewed on behalf of IUPAC/CTC which is going to publish a new journal not only for teachers, but for young students and citizens. First of all, I would like to ask you how you became interested in Chemistry and when you made up your mind to be a chemist. Did you receive encouragement from someone—some of your teachers for instance?

Professor Kroto (K)
I was encouraged to do as well as possible at science by my father who was a refugee and felt that it was better to work hard at science than anything else in order to get a job. He was very pragmatic. My main interests were not only science but also art and graphics. I was good at drawing and did reasonably well at science—chemistry, physics, and mathematics. When it was time to go to university, it was natural for me to go and do a degree in the subject which I was best at which was chemistry, physics, and the sciences. I didn't make any "decision." The decision was made for me because there didn't seem to be any other opportunities. I think there are so many more opportunities for young students today that I would have, perhaps, done architecture or design graphics. Then, there just didn't seem to be a career prospect to do art or to become an artist, so few people could. So I didn't make a "decision," I just went to university to do chemistry and then I got a very good degree and I decided to do a Ph.D. After I got my Ph.D., I wanted to stay at university for a while. I was art

editor of the university magazine and I wanted to continue to do that. My chemistry Ph.D. enabled me to continue to work at university and pursue my other interests as well. Later, I wanted to live abroad, so I did a post doc in chemistry on spectroscopy in Canada. However, the most important thing was to me at that time was to live abroad and to expand my experiences. Even so, I still didn't make any "decision." I mean, the "decision" was simply "you're walking along the road and you follow the road the way it is." As far as the influence of teachers is concerned, I certainly had two very good chemistry teachers whose teaching I enjoyed, but I also enjoyed the subjects of physics, English geography and the art—particularly the art because the teacher there recognized that I had some talent in this area. I didn't even make a "decision" when I came back [from Canada]. When opportunities open up, you accept them. I was offered a position in chemistry at University of Sussex in England and I came back to England. Even then, I just hadn't "fully decided." So, I tried the position at university to see if I would be successful and, as it turned out, I was moderately successful.

T. Initially, you said you were a spectroscopist. How did you get involved in the research of fullerene?

K. Oh, that's much more complicated. Originally I did a Ph.D. in spectroscopy and pursued spectroscopy in my postdoctoral work. When I came back to Sussex I continued to do research in spectroscopy. My first work was really using spectroscopy to detect new molecules on carbon double bonds to phosphorus, so I was involved in phosphorus/carbon chemistry. Then, I started to study carbon chain molecules because I was interested in molecular dynamics—the way in which chains vibrate or rub molecules and rotate—and that led, naturally, to discovery of carbon molecules in space by radio astronomy. After trying to understand how these molecules came to be in space I began to think that they were produced in carbon stars. It was in trying to reproduce the conditions in a carbon star that led to the experiments that uncovered the existence of C_{60}. So, the discovery of the existence of C_{60} was an accident.

T. Well, but even if it was an accident such an accident could be achieved only by the very vigilant, well prepared person with a well prepared mind.

K. That's true. I mean, it's fair to say that the experiment had been carried out by two other groups and they missed the discovery. Two other groups did the same experiment and overlooked C_{60}, so, I think, although it was an accident as far as I was concerned, it wasn't an accident as far as the "discovery." The discovery was going to be made. It was clearly an interesting carbon vaporization. It was a very important area and was becoming more and more important so, if we hadn't discovered it, someone else would have. The accident was that *we* did. Yes, we were vigilant. We were trying to understand what was going on. We weren't looking for this molecule—this was a big surprise—but it's fair to say we noticed it and that's important.

T. Well, people say that C_{60} is probably the most important compound found in the 20^{th} century. What do you expect to be the future of your compound in the 21^{st} century?

K. Certainly, I wouldn't say it's the most important compound of the 20^{th} century. I think it's an interesting compound and it's certainly important because it tells us something about carbon chemistry and materials that we didn't understand before. In fact, it's important from a fundamental point of view in that it explains the behavior—the dynamics and static structural behavior—of sheet materials. That's very general. If one is to say what's the most important molecule to be discovered in the 20^{th} century, the most important molecule has to be DNA. There haven't been any major applications of C_{60} fullerenes so far and, perhaps, I'm not the best person to predict what those applications might be because I'm a fundamental scientist. If one thinks of the very unusual electrical and electronic properties of the molecule and the nanotubes (which Iijima discovered) which also have very interesting electronic properties and are related to the electrical and electronic properties of C_{60}, it's in this area, probably, in the electrical and electronic applications of C_{60} and the nanotubes where the first uses and valuable applications might lie.

T. It opens some entirely new fields.

K. Well, I think so. I mean, one could imagine that C_{60}—species related to C_{60}—may be components in the next generation of computers—microscopic or nanoscale computing devices. But there are still some massive technical problems to be overcome before that can be realized at this stage.

T. Returning to the subject of the promotion of chemistry or science in general, you mentioned in your lecture the literacy in science among citizens. Although we have tried quite a number of things in Japan and although the government has invested a bit of money in your project, we feel, generally speaking, that the general public looses its interest in science. What sort of things would you suggest to remedy that?

K. Well, I think first of all, they may have lost it before they even had it. I think that, just as fluency in a language is acquired very early on, so I think that fluency in the understanding of mathematics and an understanding of analyses and experimental techniques and curiosity and discovery occur very early on. I have a feeling that it's probably by the age of 4, 5, or 6 that some important developments occur which may not be achievable later on. Just as language fluency becomes more and more difficult as one gets older so it may well be true of some aspects of scientific understand and scientific culture. How you do something about it, I don't know because we've been trying to educate our children for a long time and we still don't know how to do this. I actually think it would be very good for children to be taken back to the 19^{th} century to let them relearn and find out just how hard it was. I think the big change that has come since the war is that young children now who are growing up today have not seen the quantum leap forward that science and engineering have achieved for us. They seem to think that they've always had television sets, they've always had refrigerators. My generation didn't have refrigerators, didn't have a car, didn't have a television set, maybe didn't have a radio, didn't have toilets inside, didn't have decent sanitation, and didn't have fast food. All these things are the result of the exploitation of science and technology by society. It's got to such a stage that I think that the average child today just thinks these things have always been there and, therefore, has no respect for the technology and less respect for those who created it. That's got serious implications because we have some massive problems that must be overcome to survive in the 21st century.

T. I understand that you expended lot of energy on the Vega project. When did you start and how much energy did you expend?

K. More now than in the past because it started very slowly. I just made one or two programs and gradually got money together, employed professional teams to do the programs except for ______ __________________, which I basically engineered myself in the studios in Sussex. By and large, I always tried to employ professional film people to do the program which is, of course, expensive now. In the future, it should be possible to do programs of this kind more inexpensively because it can be broadcast on the web through the internet and high band width. I think this is a major step forward because this capability allows individuals to make programs. With all this technology, recordings like we are doing here can be done with several people and you could actually publish the interview on the web.

T. Do we have to ask the copyright owner for translations of the Vega project?

K. No, all our programs are copyright free.

T. Oh, is that right?

K. Yes. We sell them intending that you might to broadcast them yourself on the Internet. We will be broadcasting them and we would like to exchange our programs for those of other people. I'm looking toward networking these programs and I want them all to be freely available and free of copyright problems.

T. Of course, it's impossible for Japanese teachers and their students to appreciate (to understand) anything written in English, so we have to translate it into Japanese.

K. Well, yes, but that problem should die away because in Japan you are going to start teaching English.

T. Well, that project seems to be quite hopeless. Not very effective, actually.

K. I suppose because you have to start language education much earlier. So, Japanese-speaking children should watch television programs in English and English-speaking children should watch them in Japanese.

T. Well, yes, if they are more used to English, that would make it slightly different.

K. Sure.

T. Finally, could you offer words of encouragement to young students who are interested in chemistry, but who have not decided yet to be chemists?

K. There are some aspects of chemistry that today's students should certainly find interesting.   For example, genetics is biological chemistry.   It's very exciting and the possibility of using biochemical techniques for solving some of the major ecological problems we encounter today looks extremely exciting.   There are fantastic possibilities in the future for using new materials.   Nanotechnology, which is chemistry in that you are making structures at the atomic molecular level, is getting to be recognized as a major field.   I think I would be particularly keen on going into the area of genetics where one has the possibility of developing new approaches to structure formation--building enzymes that create particular molecular structures.   For example, the possibility of producing wheat that will fix it's own nitrogen.   If you could genetically modify wheat to fix it's own nitrogen, you would save 20% of the world's fuel resources and you would reduce the carbon dioxide concentration increase by about 20%.   In that respect, chemistry is as exciting now as it ever was.   The possibilities for exciting research in chemistry are endless and I would encourage students to learn as much as they can about the various subdisciplines of chemistry in order to discover the area that presents a challenge to them.

T. Thank you very much, Professor.

K. My pleasure.

This transcription was done by Ms. Rita Wilkinson, Administrative Associate for Profesor J. J. Lagowski.