Face to Face

This section features conversations with personalities related to science, highlighting the factors and circumstances that guided them in making the career choice to be a scientist.

Face to Face with Professor C N R Rao*

Prof. N Sathyamurthy talks to Prof. C N R Rao

Professor C N R Rao is one of the world’s leading solid state and materials chemists known for his contributions to solid-state and structural chemistry. A recipient of many awards and honors including the Bharat Ratna, the highest civilian award in India, Prof. Rao is presently the National Research Professor, Linus Pauling Research Professor and Honorary President of Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru which he founded in 1989. Prof. Rao served as Chairman, Science Advisory Council to the Prime Minister of India. He is also the Director of the International Centre for Materials Science (ICMS) and serves on the board of the Science Initiative Group.

Prof. Rao’s work on transition metal oxides has led to the basic understanding of novel phenomena and the relationship between materials properties and the structural chemistry of these materials. He was one of the pioneers to synthesise two-dimensional oxide materials such as $\text{La}_2\text{CuO}_4$. His work has led to a systematic study of compositionally controlled metal-insulator transitions. Such studies have had a profound impact in application fields such as colossal magnetoresistance and high-temperature superconductivity. He has also made major contributions to nanomaterials, besides his work on hybrid materials.

Prof. Rao has authored/co-authored about 1600 research papers and 52 books.

Prof. N. Sathyamurthy (NS): Professor Rao, first of all, I want to thank you on behalf of the Resonance team and on my own, for agreeing to do this face-to-face interaction. Secondly, on behalf of all of us, I wish to felicitate you on your 85th birthday.

Prof. C N R Rao (CNR): Thank you.

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NS: You have had an illustrious career. Next to Raman, you are the only scientist who has received the Bharat Ratna award from the Government of India. You have published more than fifteen hundred research papers and more than 50 books, you have received 70 plus honorary doctorates and you are Fellow of various academies in the world. To sum it up, other than the Nobel Prize, you have received most of the coveted awards that one could think of. Our readers, the young readers of Resonance, would like to know how you did it all.

CNR: Well, “It is not a question of how”. It is a question of what made me do it. Somehow, at a very young age, I got excited about doing science. The first time I got all excited was by looking at C V Raman, right in my school.

NS: How old were you then?

CNR: In nineteen forty-five, I was eleven years old, and somehow, he made such an impression. Later, he asked a few of us to come and see him in the Indian Institute of Science (IISc), and he talked to us for about half an hour. Of course, I did not understand anything he said at that time, but I was terribly impressed.

NS: He was still the Director of the Indian Institute of Science?

CNR: He was in the Director’s laboratory, and he was talking to us as if we all understood what he did. It was a fantastic meeting. Somehow, I felt, you know, it would be wonderful to be someone like Raman. Raman was the most excited and excitable person when it came to science. You talk to him good science, he would really get excited; bad science, he would be equally upset. He was an amazing person. And much later, when I was in my M.Sc., I was very much taken up by Linus Pauling’s work and his book *The Nature of the Chemical Bond*, which I read for the first time in 1951–52. At that time, he had discovered the alpha-helix. I thought that it was the kind of work I should be doing. That excitement continues till date. As I went on doing research, I found that publishing papers is a wonderful way to live. I was influenced by some professors in the US in my University where they would say, “It is not worth doing unless it is worth publishing”. I believed in that. In pure science, publishing is very important. I continue publishing. Even though I am 85, I am excited. Even today, I am more excited about some new research than some of my students. But, that is how I am.
NS: Sir, somewhere you mentioned that Linus Pauling, G N Lewis, and Michael Faraday as your heroes. Who is your role model?

CNR: My role model: Linus Pauling! I was tremendously influenced by Linus Pauling in the early days, I wanted to do molecular structure, bonding and things like that. That was why my PhD thesis was on the structure of molecules by gaseous electron diffraction. I got to know about G N Lewis later when I went to Berkeley. I knew that he was a great chemist; probably the greatest chemist of the 20th century. You know, the way he came up with new ideas, for example, the chemical bond in 1916. When they did not give him a Nobel Prize for that, he said, “Ok”. Lewis acids and Lewis bases, they would not give a Nobel Prize for those either. But, every time he would come up with a new idea – the idea of ionic strength, triplet state, emission spectroscopy and photochemistry. The number of things Lewis did, one after the other, were amazing. He was the one who made heavy water and studied its properties. I remember thinking, “Here was a man who kept himself so busy all his life”. He had fantastic students like Glenn Seaborg. He was the one who wanted “Lewis acids and Lewis bases” for his PhD thesis. When I went to Berkeley, the ghost of Lewis was very much there in the department. When I was doing my postdoc work, everyone was influenced by Lewis, including my research supervisor. It was a wonderful period. The way Lewis worked day and night; He would sit at 8:00 in the night and dictate papers to his students till mid night. Doing research and doing science was the only thing he knew. He never travelled much; he stayed in Berkeley always. That Department of Chemistry he built, even today, is the best chemistry department.
in the world. They have never lost that ranking since the 1940s.

NS: Very difficult to stay at the top all the time. I think, you had somewhere mentioned, you had seen Hildebrand.

CNR: Hildebrand was already there. I knew him well. He was already seventy-five or so. He even took me once to Sierra, where he used to go skiing. He was a very good man, a very important figure in the Chemistry Department. More than research, he was one of the binding forces in the Berkeley Chemistry Department. My professor was then the Dean of Chemistry, and he always depended on Hildebrand for advice. So did others in the department. He was a wonderful man. When he turned hundred, there was a symposium in Oxford. I was one of the invited speakers. I think it was the Faraday Discussion Symposium. Hildebrand had sent a letter: “I am sending you the manuscript; unfortunately, I am unable to come; I hope that I have earned the right not to come at the age of hundred (or hundred and one)” . He wrote four more papers before he died at the age of hundred and two.

NS: So, that means, you are going to work for another 15 years.

CNR: Well, I do not know whether I can live that long; but these are the people that excite me. Look at Faraday with three years of schooling; four hundred and fifty papers without any grant, without any students and postdocs. How did he do that? How did he come up with so many ideas!

NS: Sir, somewhere, somebody presented the data that after you formally retired you have published more papers than before that!

CNR: Well, not only papers! My citations, for example, after my sixty, made a leap; after seventy, it took another jump. In fact, right now, I think I have been cited about one hundred and eleven thousand times or something like that. The same thing happened to the h-index. It was somewhere around sixty and seventy when I was sixty, and now, it has passed one hundred and fifty (as of today). All this has happened within the last eight to ten years.

NS: You have the largest number of citations, among the scientists?

CNR: Not among all the scientists. In India, maybe. But there must be people with more citations elsewhere.

NS: I know, some people have more than one hundred thousand.

CNR: H-index, I have not checked. There are people I know who have h-indices well above one hundred.

NS: Well, one thing that is curious for students is your academic journey. You did B.Sc.,
from Bangalore and M.Sc., from Banaras. You first went to IIT Kharagpur for a PhD, but then decided to go to Purdue to do a PhD. After that, you went to Berkeley for a postdoctoral fellowship, and then you came back to India promptly. The question that young students would like to be answered by you is, “What made you go and what made you come back?”

CNR: Well, going was simple. I was working with Sir J C Ghosh, who left IISc and went to IIT Kharagpur as the Director. I was in his laboratory, and I was to be his PhD student. But, somehow, the influence of Linus Pauling was always strong in my mind. Research at IIT did not excite me much; measuring something, which had no theory or no real explanations.

NS: But, he did make an important contribution to the Debye–Hückel theory.

CNR: Yes, he did. He was the one who had the idea of interionic attraction before ionic strength came. Later, he became a prominent administrator. He was a very good man.

NS: He was in Dhaka before coming to Bangalore?

CNR: Yes, he did. He was the one who had the idea of interionic attraction before ionic strength came. Later, he became a prominent administrator. He was a very good man.

NS: He was in Dhaka before coming to Bangalore?

CNR: Yes, he came to IISc after Raman quit the directorship. He was a wonderful man. I told him, “I feel like going to the USA”. He said, “OK, that is fine”. I wanted to do research similar to that of Pauling. That is why I wrote to Pauling. But I did not know the difference between proteins and molecular structure at that time. I wrote to him, “I want to work on molecular structure”. He wrote back, “I no longer do molecular structure, but I am working more on biological things.” I did not understand that. Otherwise, I would have gone to Pauling probably. I worked with his student as my PhD supervisor. I did electron diffraction of gases. I was also a research assistant to an organic chemist. I did a lot of spectroscopy with him. That is where I became a spectroscopist, partly. I published some papers on my own.

NS: Brown?

CNR: I did not publish with Brown. I have published two or three papers on Brown’s work. As a student, I could publish at least a dozen papers of my own, and then I went to Berkeley. After my stay at Berkely, I was about to decide what I was going to do. Everyone asked me to stay in America. “You have done so well here, you are very productive; you know the American way; you know how to do things here”, is what they said. I had two or three very good offers for a faculty position in the US. One of them offered me an assistant professorship and promised a promotion to associate professorship within two years, since I had already published over 20 papers. I was about to decide, but I also thought of coming back. I am the only child of my parents, and they asked if I would come back sometime. That is the only time they ever wrote about it. As my luck would have it, at that time, Vice-Chancellor of Panjab University, Professor Joshi visited the US, and I met him. Immediately, he offered me a readership at Panjab University. Later I found out that it was in a technology department. I then got an offer
from IISc, Bangalore as a lecturer. Since I was considering returning to India, IISc was as close to the best offer that India could make at that time. I came to IISc.

**NS:** But at that time going to IIT Kanpur was probably the best thing to do?

**CNR:** IIT Kanpur was not there in 1959. Except for some glassware here and there, there were not many facilities in IISc. Imagine IISc did not have a Raman spectrometer even though Raman was there. There was no infrared spectrometer. That is when I decided in IISc that I would make a career in solid state chemistry. I did spectroscopy whenever I could, wherever I could do, but not locally in Bangalore. I slowly shifted to solid state chemistry because I could do something with the facility I had. It has now become an expansive field, and many people think that I am a grandfather in the subject. When IIT Kanpur started, with American aid, it was going to have better facilities. At that time, I was considering whether I should leave India. When the offer from IIT Kanpur came, it was decided. I was destined to be in India. They offered me a position, and a few months later, they made me the first Head of the Department of Chemistry.

**NS:** I think by the age of 29, you had become a Professor.

**CNR:** I was a Professor around 29–30, and I was also the first Head of the Department at IIT Kanpur. The institute put tremendous trust in me. We had a fantastic Director Dr Kelkar who would accept whatever I recommended, be it the recruitment of the faculty or anything else. He gave us the freedom to build the curriculum, the chemistry program, integrated M.Sc., etc. Nobody thought of all that at that time. We were the first to offer integrated M.Sc., in the country and course work for PhD.

**NS:** Course work for PhD was unknown in the country at that time.

**CNR:** Yes, even integrated M.Sc. was unknown. Let me tell you honestly, those 14 to 15 years in IIT Kanpur were some of the best years of my life. C V Raman was kind enough to make me a Fellow of the Indian Academy of Sciences after seeing my books on spectroscopy. I got the Bhatnagar Prize when I was 34 years old. Then I got this invitation from Oxford unexpectedly. One day, I got a letter inviting me to be a Commonwealth Visiting Professor, offering to pay for me and my family and a Professor’s salary in Oxford. I got the same salary as the Head of the Department! That was amazing. I went with my family to Oxford. Oxford had state-of-the-art facilities for solid state chemistry or materials chemistry, in electron microscopes and all kinds of spectroscopies including XPS. I was very excited about working there. You may not believe it, but I worked like a student and not as a professor and collaborated with many people. Then I got to meet Nevill Mott at Cambridge. I started working with him. I published many papers while at Oxford, about 15–16 in one year. Then I decided that Kanpur was not my place. I had
to find a place in India or somewhere else, where I would have the facilities of this kind to do advanced work.

NS: So, you created your own?

CNR: That is why I left Kanpur and came back to Bangalore. I got the Centenary Award from the American Chemical Society in 1976. When I went to receive the award in New York, I almost came to an agreement with one Dean and half an agreement with another Dean to go to the US. Salary and everything else was discussed. Then, Satish Dhawan met me at the meeting of the Indian Academy of Sciences in Nagpur. I will never forget that. He was a very close friend of mine.

He asked me, “Ram, why are you leaving? What is it that I can do to get you back?” How many people will ask such a question? He was a wonderful man!

I said, “All I want is the freedom to build a fantastic department”. He said, “I can give you a professorship, but nothing else.” “Well, I will get the money somehow”, I said.

He asked me to come to Bangalore and build a new department. That is how the solid state and structural chemistry unit (SSCU) and the materials research center (MRC) at IISc came into being. I got at that time the highest possible grant of Rs 70 lakhs from the Department of Science and Technology, New Delhi. Dr Arcot Ramachandran gave me that. Without that, I could not have built SSCU. Those days, things were not that expensive. We got a lot of equipment with that money. The institute got some grant from UGC (Rs 50–60 lakhs), for building the MRC.

NS: I remember that. I came to visit you in 1977.

CNR: I remember that. I wanted you to come there, but you had to go to Kanpur.

NS: You have had six decades of research.

CNR: Yes, exactly. Anyway, I came back to Bangalore and that changed my life. I could do many things in Bangalore. Then, of course, I became the Director of the Institute. In the meantime, I had gone to Cambridge as a Nehru Professor. That was very nice. All these experiences were very good.

NS: I think Cambridge also offered you a Chair, is not it?

CNR: Well, Oxford had offered me a permanent position. I did not tell anybody. I have not talked about it much. Well, my wife was interested in Oxford. She had a diploma from Oxford and she liked the place. But somehow in this life, I am destined to live in India. Even when I was about to leave India, I did not leave it. I could not.
**NS:** Something pulls you back. But, you have a position at the University of California, Santa Barbara (UCSB).

**CNR:** Some universities have offered me Distinguished Professorship for any number of months that I am prepared to spend. I used to spend two to three months in UCSB. I have published 30–40 papers from there with Anthony Cheetham and others. I stopped going there because as I get older, travelling to California is becoming more tiring.

**NS:** But when you formally retired in Indian terms you were seriously considering making a move.

**CNR:** Yes. I did not do that because the idea of Nehru Centre came, and building the Nehru Centre was a great pleasure and an opportunity. I found it more important than going abroad.

**NS:** Before I ask you a question about the Jawaharlal Nehru Centre. In the six decades of independent research, what gave you the most satisfaction? You have made a name in materials, high $T_c$ superconductors, fullerenes, nanomaterials, etc. Now you are working with non-noble metals as catalysts.

**CNR:** Chemistry of materials is a very broad subject; highly cross-disciplinary. You need physics as well as theory. I collaborate a lot with theoreticians. Half of my papers have contributions of theoreticians. Otherwise, it won’t be complete. Working in the discipline has given me tremendous satisfaction. It is not restricted to one material, one phenomenon or one property. I have broadened my horizons like that. In this process, I have tried to discover a few things in the last few years. I have worked on completely new, unprecedented materials. They were completely my own creation. I will give you an example. Suppose you have an oxide like $\text{TiO}_2$. I replace one oxygen by nitrogen and the other by fluorine, which in the periodic table are, next to oxygen. I make $\text{TiNF}$, which has the same number of electrons as $\text{TiO}_2$, but the resulting electronic spectrum is different. We have made such materials in the last several years and have studied their properties. That is one thing. Secondly, I still work on things which are very standard. Like, making new materials to study known phenomena like superconductivity or magnetoelectricity. I have a childlike way of doing things, you may say. I get excited about doing different kinds of things in science.

**NS:** Last time I listened to you, in one of the talks, you were emphasizing on non-noble metals.

**CNR:** That is the future of chemistry. You know the most expensive metal in the world is rhodium, the next is ruthenium followed by platinum and gold. I find experiments using rhodium or ruthenium unacceptable. They are so expensive and unsustainable. Same is with platinum. Even electrolysis of water using platinum electrodes is not to be encouraged. I have done a lot of work on this aspect. One of the things that I have done is using non-metallic
systems as catalysts. I was invited to write an article, summarizing my work in *Advanced Materials* recently. It came out a month ago. Another thing is solar energy. I work on the solar photochemical decomposition of water and reduction of CO. But more interestingly, I use solar thermal energy. Sun gives a lot of heat, let us not forget. We can use the heat. Well, after all, Israelis use solar energy to heat up to 3000°C. I have done a lot of work on that. The US National Academy of Sciences asked me to write a perspective on the solar thermal way of doing chemistry. I believe, there is one company that is trying to establish a plant based on this idea of producing hydrogen and carbon monoxide. I have enjoyed this kind of work.

**NS:** A lot of people are concerned about many elements in the periodic table essentially becoming extinct.

**CNR:** Many are, already! Well, to be honest, the world is facing a crisis. In fact, there was a beautiful write-up in a newspaper last week. Chinese, for example, control the rare earths. Why did not we use the rare earths we have? I don’t know. We should have done something with it, better marketing and so on.

**NS:** Separate department for rare earths?

**CNR:** Yes, we must! Actually, it is big business. Let us forget that. Let us take lithium-ion batteries for example. Everyone uses lithium-ion batteries, but where is the lithium in the world? It is in short supply. One of these days, there will be no lithium-ion batteries. More than that, cobalt; it is only available in Congo, Africa. Can you imagine depending on Congo for all the cobalt for our future batteries? That is why I am against lithium batteries for energy. I think we should find other batteries – sodium and magnesium among many other things. Why not fuel cells? Why not hydrogen? There are many things we can do with hydrogen. I am a big champion of hydrogen. Like you, I am a chemist, and as a chemist, you know, we should make our own contributions. I just saw it in the newspaper, for example, that the first airplane running on hydrogen energy is flying in the US.

**NS:** I suppose we can say, *Jab tak sooraj aur chand rahega, tab tak hydrogen rahega!*

**CNR:** Yes. There are many things that we can do with hydrogen. The world is full of water. Earth is only accidental; we are just little islands in the ocean around us. So, water is available. I have been invited to write for a special issue of *Chemistry: European Journal* in which I have discussed how to get hydrogen out of seawater. However, potable water is becoming scarce. In fact, if you go to Chennai you see the problem. This time, apparently, there is water scarcity even in Bangalore.

**NS:** Chennai is becoming like Johannesburg.

**CNR:** We must use sea water. We must learn to purify sea water for other purposes. Why
not produce energy out of that? I have just written my first paper on the use of seawater for splitting water. The problem is, there is a lot of chloride ion in seawater. You cannot just do electrolysis, because a lot of chlorine will come out. So, you have to come up with new tricks.

NS: Will making enough energy from the Sun for desalination solve our water problem?

CNR: We will have solved a major problem. Once we have hydrogen, we can have hydrogen fuel cells. I have travelled in hydrogen cars, both in Germany and Japan. Unfortunately, the problem is the storage of hydrogen in the car. You know, they all keep a high-pressure cylinder under your seat. I do not like the idea of a high-pressure cylinder under my seat. It can take off anytime.

NS: So, they talk about using water and sunlight to generate hydrogen which can fuel the car.

CNR: I know. In fact, we have used semiconductor heterostructures for one or two weeks on this roof (Prof. Rao points to the roof of his office in Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru). My students have put it up on the roof of this building. It goes on giving hydrogen. There is no problem. We have done many such things. But, still, that is not the best way. The best way is to store it and use it. One should be able to stop it when required. For that, we have to have the right solid. In one of my papers in *PNAS*, I have proposed graphene to store hydrogen. Many people are now saying that graphene is not so bad. It is amazing: Six-membered rings in graphene become cyclohexane rings. Just at 100°C or so, it decomposes. The C–C–H bond decomposes under UV light. Many other possibilities are there. Today there are already many hydrogen cars, and the first hydrogen plane is in the sky. I am very pleased with that. I want all the planes to fly on hydrogen.

NS: Yeah, well, there was this Zeppelin airship with hydrogen.

CNR: That balloon you mean. That is an old German type. They used hydrogen, and it caught fire. Helium is preferred. You know, hydrogen has the highest energy density of all the chemical compounds. Burning hydrogen and getting water is environmentally safe. I can breathe in Bangalore afterwards. Water is what you get by burning hydrogen.

NS: Professor Rao, somewhere you mentioned that you were happy publishing and you have not bothered to patent. Do you have any regrets?

CNR: CSIR published a report. Dr Mashelkar was responsible for that report on how much of my research has been used in the industry. They came out with a flattering report; I was impressed. For example, according to the report, many people use our method to make carbon nanotubes. I never applied for patents because I belong to the old world. Our culture is like that. All our rishis in India were like that. They created and distributed knowledge. Shankaracharya did not create knowledge to sell it. We should share our knowledge with everyone. J C Bose
was also like that. He could have easily patented his work, and of course, he missed the Nobel Prize. I think that science is for sharing; science is for enjoyment. Even today, I believe in this. There are people who patent for money. Let them make it their way. Mine is freely available.

**NS:** I understand, with this philosophy, you have spent a lot of energy on education. You have written books for school children, for NCERT syllabus. You have revolutionized chemical education in the country by introducing the American model in IIT Kanpur. You mentioned that you introduced the course work for PhD, and you have written a large number of books and even recently published a book on the periodic table, essentially for school children. You and Mrs Rao go out addressing school children. Normally people who do research do not get into this. People who do this normally don’t get into research, but you have been able to successfully do both.

**CNR:** I feel that all good scientists and in general people must serve the society in some way. As a teacher or as a scientist, I cannot create big factories. Maybe my work can be used by somebody else to do that. But what I can do is talk to children. In my own life, if I had not met C V Raman or if I had not read Linus Pauling’s book when I was young, I would not have become a scientist. One always needs some source, some catalyst in life. It could be a good teacher. I had fantastic teachers in the school. After school, I never had good teachers until I went to the US. In the US, I had excellent teachers. In India, teaching at undergraduate and postgraduate levels is hopeless. I feel that the secret of success of India depends on exciting the minds of young people. There are 60 million of them in our villages. That is why I go to the villages in Karnataka and in the Himalayas.

**NS:** Every year you go to Nainital?

**CNR:** Far away from Nainital. From Nainital, Gangolihat is about 7-hours drive. There, we were able to build a lecture hall. Just recently, we have created a Hall of Science in Lakshmeshwar, near Hubli in Karnataka. In Kerala, every year, for the last 14 years, I have been giving lectures along with many of my colleagues to selected children on chemistry. About 6–7 professors from IISc and JNCASR come with me. This has been very successful. Kerala is contributing more students to IISERs and people are saying that it is because of that program. I do not know if that is true. It is nice to see the bright eyes of children in our villages. They are not perturbed by anything. They have no issues like our children here in Bangalore. Most of them have nothing, yet they are excited about science. Many of them are smart and speak in English. In fact, you will not believe it. Every year, we arrange a program in Lakshmeshwar. A lot of professors come with me. You must come there. It is really an experience. Students there speak in English. They go to Chandana School. (We have built a Hall of Science there). The prayer is in Sanskrit. Independent of religion, caste and economic background, those children
are fantastic. We had yesterday or the day before yesterday, the periodic table program, which saw the participation of a lot of children from these villages. I will never forego programmes to talk to them. Unfortunately, I am getting old.

**NS:** I remember, in IISER Mohali, a large number of students came from Kerala. And this is true for all IISERs.

**CNR:** It was all from Bengal earlier, now it has been replaced by Kerala. I think they are still not bitten by this engineer or doctor thing.

Students from Kerala seem to be open-minded. The worst hit city is Bangalore. You may not believe it. In the last 25 years, I have not had a single PhD student from Bangalore city. From Karnataka, yes. I get students from all other cities as well, but not from Bangalore.

**NS:** I remember, to the INSPIRE program, Tamil Nadu, Karnataka and Andhra Pradesh contribute something like only 4%. Kerala contributes a large chunk and other parts of the country too.

**CNR:** A lot of people are now coming from Assam and Bihar. Bihar does not offer many opportunities. I have a lot of students from Bihar and Bengal.

**NS:** In the last ten years, a lot of students coming to the IISERS are from Rajasthan. Somebody called you the Chief Architect of IISERs. What made you plan this, and how do you look back and how do you look at the future of IISERs?

**CNR:** I will tell you about the IISERs. Long ago, when I was still in IIT Kanpur (in 1971), Mrs Gandhi created a National Committee for Science and Technology (NCST). I was one of the members. There were nine members, Swaminathan, Raja Ramanna, Ramalingaswami and a few other good people. We prepared the first Science and Technology Plan at that time. DST came out of NCST. One of my recommendations was to form national science universities. This could not happen. Though I was from an IIT, I was a bit tired of IITs being only for engineering. Why not an equivalent institution for science? A lot of parents were asking me where they should send their children to study science. Other than good colleges and universities, we did not have special institutions. Hence IISERs had to be created. Fortunately, Dr Manmohan Singh agreed to this proposal.

**NS:** Are you happy with them?

**CNR:** Some of the IISERs have done very well, I think. Some of them have had teething problems.

**NS:** Are they on the right track?
CNR: Yes, I think so. There are no fixed and rigid criteria. They have to be flexible enough to keep changing. Are they good enough to do that? I can’t say. IISc is doing something in undergraduate education. It is rated number one, but is it really number one in the world? I do not know.

NS: You have been an administrator: you have been the Head of the Department, you were a Dean, then you were the Director of IISc, Bangalore. You built JNCASR. You were the President of JNCASR and then, of course, contributing to nation-building, you participated in building new institutions, and yet you managed to keep publishing. This is something remarkable. What is the secret?

CNR: A very simple thing. I have never taken any job or any commitment in my life which interfered with my research. My priorities are my research and teaching. I could add something else only without affecting this. I was the Director of the Indian Institute of Science for two terms. They offered me a third term. Rami Reddy was then the UGC Chairman. Rami Reddy, Raja Ramanna and all others came to my house asking me to take on one more term. I said under no condition would I continue. This would completely destroy me in science because, during the second term, the quality of my science was coming down. I am honestly telling you.

NS: I think you also did not agree to become a Minister of Science and Technology.

CNR: Not only that. Twice, Manmohan Singh, Sonia Gandhi and others called me to become a Rajya Sabha member. I did not want to. I have nothing against the MPs. I wanted the company of scientists.

NS: Is there anything you would like to look at, if you have another 20 years, problems in chemistry?

CNR: In chemistry itself, there are many interesting things I would do. One problem is energy. There are many problems to be worked out, broadly related to energy. Other than that, in catalysis, there is a new regime of catalysis.

Energy itself is very big because that is going to hit us badly in India. I am too old. I would not be alive in about 10–15 years when the young people of today will become middle-aged. Today’s young people will face problems related to energy. Our plan is to have around 300,000 megawatts of electricity. I do not know how it would be created. From nuclear energy, we are producing around 20,000 megawatts, maybe double this 40,000 megawatts. So, what we require is far more than what we have. As somebody joked with me the other day: if everybody decides to take a bath in the morning, there will be no water in India.

India is managing because the benefits of modernity are only for a small percentage of people. Energy is the same way. If all people use electricity, if all people have a nice kitchen with all
the gadgets and so on, there will be no energy for anybody. India should concentrate much
closest to this. Secondly, in science, there is completely a new area of physics coming
about, like the two-dimensional materials in nanoscience and quantum materials, for example.
There, you have a tremendous opportunity to work. I am working mainly on 2D materials.
My God, if I were younger I would have done many more things. Unfortunately, I cannot take
problems which would take five or 10 years to solve because I may not be around that long.

**NS:** So much of investment has gone in nanoscience.

**CNR:** Not much. Actually, compared to the world we have not spent much. We have spent
around a thousand crores the first time. Now, maybe another 500 or 1000 crores. Compared
to international standards, it is very little. Our total scientific investment is still less than 1 per
cent of GDP and most of it goes to space, atomic energy, etc. People like you and me working
in small laboratories, get very little. In higher education institutions and universities, we are
spending very little on research. In nano, we are doing this badly in Karnataka. I have been
able to get the government to spend about 25 crores for scientific efforts. This itself is big
money in a state. We have to spend much more money on science and education. There is no
Cambridge, Harvard or MIT in India. The facilities there are of a completely different class.

**NS:** Yes, unfortunately, even for the IISERs the kind of funding they received in the first ten
years is no longer there. You have been the President of the Indian Academy of Sciences,
Bangalore. You have been the President of the Indian National Science Academy, New Delhi.
Two terms, you were the President of The World Academy of Sciences, Trieste, Italy. You have
a global view. How do you look at India and the rest of the developing world and the developed
world?

**CNR:** I know that India is no longer in the developing world. It used to be, when people used
to feel sorry for India. We used to be so grateful for little aid at that time. Do you remember,
the entire PL 480 money came because somebody gave us bags of wheat, rice or something.
India is now grown up. India has to be a mature country. What we have failed to do is to
capitalize on its education. People like you and me and other teachers must influence the rest
of the developing world. That is what China has done. Investment of China in Africa is more
than any other country including US and Europe. That is why all the cobalt goes to China.

**NS:** Yes, I went to Nepal, Sri Lanka and a few other neighboring countries. China is ahead of
us.

**CNR:** I got an award from Nepal. They made me a member of their Academy. I was talking to
the President of Nepal. He said, “I would love to have India with us, but India has always a big
brother attitude”. They think that we consider them to be inferior. I do not know if it is true.
We have to be more friendly to Africa, much more to Nepal, and Sri Lanka and the Maldives. I am not saying that they have to be our colonies. No, not politically. But we should have a bigger influence.

NS: Many of these countries have expressed interest in sending their students for doing PhD in India.

CNR: I have been a member of the Chinese Academy of Sciences for some time. They have invited me recently for a big meeting where the president of China, Xi addressed all the scientists. I was supposed to give one of the talks. Unfortunately, my health was not good at that time. I could not go. Let me repeat the last sentence of the speech of President Xi. He says, “Till now China was following something, copying what others did. Those days are over. We are going to take a quantum leap and be in leaders of the world”. I want to see such a speech from India. They (Chinese) want to take over the world. They are competing with America. As of this year, the amount of science from China is the same as from the US in terms of the number of publications. Quality is most comparable to America, but the number being equal itself is a big thing.

NS: For one thing, they have been able to stand up to the United States.

CNR: One of my friends, who is the president of the Chinese Academy, Bai Chun-Li was asked to start a new university for Sciences. It is called the University of Science and Technology. He started with 5,000 or 10,000 students. Now, there are 40,000 students. They are offering 1000 or more postdoctoral fellowships for the rest of the world. Many Indians are going as post-doctoral fellows to China now. Here we are not even paying our students properly. Our post-doctoral fellowship is not very good. I think we should spend more on science and on education and until we invest 6% of our GDP for education and 2% for Science, India’s future is doubtful.

NS: We have never crossed 1 percent for Science and Technology.

CNR: Almost 1% when Rajiv Gandhi was the Prime Minister. But again, it went down to 0.8 or 0.9.

NS: There was the Indian Chemical Society for almost a hundred years and you decided to establish the Chemical Research Society of India about 20 years ago. That has made a sea change. What made you do it and what would you like to do now?

CNR: The answer to that is simple. I could be a chemist in India without ever knowing that there was an Indian Chemical Society. It had no influence on me except that it gave me a medal some time ago. A professional society must influence your professional activity including your research. A community of chemists has to grow in the country. For that, there was
no organization. The same is true of materials science. The Materials Research Society was formed. I hope, that will continue to serve India. As I am getting old, I am unable to do much myself, but I think CRSI serves chemists.

NS: This face-to-face interaction we have done for Resonance is for our readers, who are largely undergraduates. What would you like to tell them as a kind of a take-home message?

CNR: What I would like to see is that our education system produces leaders in various professions, our own young people becoming some of the world’s best: best economists, best journalists etc. Anything you like. But that type of challenge, that type of opportunity is not being given by our system. The example given to people is to go for engineering or medicine. There are 67 engineering colleges in Bangalore. People are going for medicine, paying crores of rupees of money and then most of them would be jobless in the end. What has happened is that our education system is not channeling our intelligent boys and girls to all streams of professions that a country should be interested in. I would like to see that happens in India in the future. It is not just Science. Science is one of them, but, there are many other areas. Why is there not much innovation in India? Innovation will come only when there is an environment for innovation. That is an atmosphere in which people innovate and discover. That atmosphere, we have to create. I think India’s challenge lies in this.

NS: Do you think that is because we don’t let our children get their hands dirty?

CNR: People say, it starts with the parents. They will always put down the children: “Do not do this, do not do that” and they will tell you what is good for you. I owe a lot in my life to my parents. I am the only child of my parents. My father was very good. Even when I was 10, he would ask, “What is your opinion about this?” Second, whatever I wanted to do, he would let me do it. I got a rank in B.Sc. whatever it meant in those days. Everybody said that I should go for IAS. India had just got freedom. I said, “Nothing doing; I will never do IAS”. My father said fine. I wanted to do chemistry. He said, “Ok, very good”. Then I said, “I want to go to Banaras. I do not want to go to Indian Institute of Science”. “Why do you want to go to Banaras? You be in Bangalore”, he said. “No. There they have research and course work for M.Sc.; I like that”, I said. “Ok, well, go there”, he said.

My parents were very very good, giving me the freedom to do what I wanted. I think our children; our bright young people should decide what they want to do and be determined. Doggedness, dedication, and tenacity are the three qualities required for success anywhere, particularly in India. If you are not dogged you cannot succeed. But to be a real success, you have to be dogged like Mahatma Gandhi. His success was because he would not give up. He had tremendous courage. Our children should get those qualities.
NS: I remember, in one place, you addressed the students and you said, “Each one of you should become famous”.

CNR: India should produce a lot of famous people, a lot of great people. In pre-independence days, there were more famous people than today. We had Tagore, we had J C Bose and C V Raman. May be the atmosphere and our objectives in life have changed and somehow we have produced wrong models. Look at Bangalore. We have so many children here and there are three hundred thousand children or young people working in IT industry, for example. What is the total intellectual content? What is new that they are doing? They have good jobs and good salaries.

We need an India with people like Shankaracharya. Even 1300 years ago, he gave the biggest importance to intellect. You remember, “The brain, the mind and the consciousness”, the order he talked about. I think we should bring up our children to worry about our future based on intellectual effort.

NS: Sir, it has been wonderful talking to you about your work, your contribution to science, research, education and institution building. You have been standing there like a tall figure, as a lighthouse for generations to come. From the time you started doing research, if we count every 15–16 years as a generation, you have guided almost four generations. We really want to thank you for spending time with us and conveying the message to our young readers. On behalf of all of them. I want to thank you.

CNR: Can I thank you and the Academy for this interview? Of all the academies, I am very fond of the Indian Academy of Sciences. As you know, after Raman’s death, I was very closely involved in running the Academy. I was the first Secretary of the Academy. I think the Academy should do many more things and I hope it will be a shining star in India. I am very happy to give this interview today with you (whom I have known for so long). Thank you.

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