Interview with C. N. R. Rao

C. N. R. Rao is a Linus Pauling Research Professor and Honorary President at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore. He had served as President of JNCASR between 1989 and 1999 and as Director, Indian Institute of Science between 1984 and 1994. His research interests are in the fields of solid state and materials chemistry, surface science, spectroscopy and molecular structure. The Chemistry and Physics of Materials Unit, JNCASR is involved in research of materials such as oxides, novel forms of carbon, organic polymers, supramolecular assemblies, micro- and mesoporous materials, nanomaterials, thin films and metal clusters, colossal magnetoresistance, etc. He holds several honorary degrees, fellowships and memberships of academies both in India and overseas. He has received medals, prizes and other honours from India and from all over the world. He has held important positions in national and international bodies. Rao is an author of over 1000 research papers and 35 books. He is on the editorial board of 15 professional journals.

Here are some excerpts from an interview with him held on 15 February 2002 at the JNCASR, Bangalore.

On policy
You have held important positions in policy-making for a considerable length of time. In your view, how has science and technology (S&T) developed in the past fifty years?

Fifty years is a very long period. The first 30–35 years – we could call this period as one when India equipped itself to face important problems. For example, we built institutions such as the IITs and the National Laboratories. I thought that by the end of the 1970s we were reasonably well-equipped. In the meantime, one major occurrence was the change in the total world scenario, globalization started and the geopolitical situation changed. Many of these had both direct and indirect effects on S&T and the industry scenario all over the world. The challenges have changed. We no longer can talk about self-sufficiency and self-reliance as we used to do before. Now there is more competition. We have to compete on a different scale. I believe that in these altered circumstances, our preparedness has to be much more, our abilities have to be much more. We are competing with the best of countries. We need much better infrastructure facilities and we must work on more difficult problems. Unfortunately, we have been used to working on problems that are somewhat repetitive. If we want to be at the cutting edge, we have to be innovators and originators.

In this changed economic climate, should there be any dramatic shift in policy?

According to me there need not be a shift, but a different emphasis. There is no question in my mind that we have to deal with three different types of efforts in science. The first type is definitely related to the immediate pressing problems of the society. We belong to a poor country and we have to worry about food, shelter and clean water. This has to be continued. These would certainly require good S&T. The second type has to do with innovation in the industry. Here, the level of input and efforts have to undergo drastic change. We have to tackle challenging problems. In fact, it bothers me that many of us even in pure sciences are not tackling difficult problems and working hard enough. I am one of those old-fashioned people who believes that we have to work very hard. We have to give our life to science. Our poor country is supporting us in some way with great difficulty and we have to make greater effort. The third type is concerned with two to four areas in which we have to be world leaders. There are various possibilities as to which of the areas are to be picked in pure sciences, engineering and technology. I do not see this happening based on a pragmatic decision-making process. We as scientists, Academies, and Government departments have to look into this very seriously.

Have we failed in this directionality for science in India? China seems to have made headway.

I would not say we have failed. In some areas we have succeeded. I saw the last PSLV launch. It was a complete Indian effort. It made me proud. Wherever we have decided on definitive missions, we have done well. This we have to recognize. However, in the competitive sector related to heavy or knowledge-based industry, or even in pure sciences, we have not done as well. How much effort do we have to make in areas such as astronomy, advanced materials, biology and biotechnology? What are those efforts? I have not been involved in policy-making and in committees in the last few years. All I can say is that the time has come to decide on priorities in S&T. China has made a very major effort in redoing its entire educational system. China is investing heavily in S&T, both in people and in institutions.

We have to do much more. There is need for understanding and compassion, and there is need for a common ground between real workers, policy-makers and administrators. We are all in the same country and we are not fighting each other. There are facts available to us in the literature and in the industrial scenario (the rate of growth, etc). We have to make an objective evaluation of the existing situation. If we are prepared to do this, we can come up with priorities. Personalities should not be involved.

The draft S&T policy statement in preparation has not undergone any fundamental change. Why so? One of the draft statements (October 2001) was available on the website.

There are some changes. I should not talk about the policy statement as the
Government is yet to announce it. Policy statements are not that important. A good policy can be stated in a few sentences. As for example. ‘Do everything possible that would benefit most of the people in the country and for the progress of the nation’. The question is of relative emphasis. This is where direction is to be given to science. For example, policies of America did not really change. All that President Kennedy said was ‘Let us reach the moon’. That one decision clearly made a big change. China has decided that it must become a world leader in S&T and industry.

What is our role and what are our targets? If India wants to be the greatest provider of the best minds in the world, then we should provide better facilities for our universities and laboratories. Look at our universities. Investment in our universities is very poor. There is a statement being made that educational institutions must earn their own upkeep. There is no way that such institutions can earn money. This has to be the responsibility of the Government for a long time to come. Until our industries come up in science (say in 10–15 years) and can take a bit of the burden, the Government has to bear the responsibility. The money involved is not so high. I am not even going to mention it as a major problem. The Government can find that kind of money.

On funding

India does scientific research. Its scientific manpower has shown immense capability to do original work – we are like the United States of America and Europe, for example. Why are these scientific achievements not able to transform the situation on the ground, i.e. aid to modernize our society?

There are 2–3 issues mixed up here. I do not know what you mean by modernizing?

...benefit to society.

This is not the role of scientists alone. This has something to do with education. I think here investment in education, particularly of women, should be the first priority. Everyone cites Kerala as an example. Our women should take over the management of society and families; this is the only hope we have. Science has another role. Some technology missions have not been continued. For some reason they are not getting enough importance. Take for example, safe drinking water. I am mentioning this because it is close to my heart. Seventy-five per cent of the illnesses in India is because of bad drinking water. There are various technologies available. This is where NGOs, the private sector, the Government and scientists have to come together to carry out the mission.

As an extension of this point, do you think funding is sufficient – or is it that we lack firm focus – a sort of target to work for? Is it funding or is it direction?

It is a combination. Direction, I think, we can all sit down and decide. There is no question that we should at least spend 6% of GDP on education. We are only spending 3%. The national policy on education states that it should be 6%. Higher education, and education in general, have to get more support. In S&T, unless the infrastructure of educational institutions is good enough, they cannot participate in useful scientific efforts. Infrastructure improvement takes a bit of money, but the money involved is not so high. I think a couple of hundred crores a year is not big money for a country like ours.

...Our overall S&T spending...

It is not enough. I do not want to make a general criticism. Again, we can have priorities of where to fund. We can do it gradually. Nobody is saying, do everything today. Improving education from the school to the university level is, however, a priority item.

You were in a position – very close to the seat of power for a fairly long time. Was it possible to raise issues such as scientific funding, etc.?

No problem at all. There was a period in our country when investment in science did increase. Of course, this should have increased further. The Governments at various times have been very responsive.

The Superconductivity Project in the 1980s received considerable funds. Several in the S&T community feel that this money has not seen any concrete results and there is general criticism of this project. Your view?

We wanted as many people as possible to participate and funded several institutions so that they could also come up with R&D as well as technology. The total money spent was not very large. I do not know whether you have seen the final report that the Department of Science and Technology has put out.

...about 30 crores...

...about 30–40 crores. That is the total project. One thing it did do. Many universities and colleges started setting up experiments in the Physics and Chemistry departments. Some good came out of that. Where we may have failed is in actually coming out with one or two technologies. In fact, one or two did come to the stage of developing prototypes. I do not know what happened to them later. Our committees stopped functioning some years ago. But somebody should have followed it up. I think people have misunderstood the amount of money involved.

On University and Education system

There is a general rot (decay) of the university and educational system. What specific steps do we need to take and what can we do to stem the rot?

In universities funding is sub-critical. Training and retraining of teachers has to be done in a big way. We have to create reasonable facilities and more motivated people at all levels. How to produce motivated teachers is one of our real problems. I also feel that commercialization and politicization of education has become a serious problem. For example, there is too much involvement of the Government in the running of educational institutions. For example, the number of colleges coming up, including in engineering, is not based on proper evaluation. Dilution of standards is not taking place only because of teachers. It is also due to commercialization and politicization. The Government is still providing much of the money. I think that it can easily control the quality and do something if it wants to. The Government is still the major provider and our politicians have to also do something about this matter.
IN CONVERSATION

The National Laboratories appear at the crossroads with some in the Council of Scientific and Industrial Research (CSIR) system proposed to be converted to deemed universities.

Is that right?

...It is a possibility...Is this a solution?

I do not want to talk about all the National Laboratories. There are so many. Some are good and some are not so good. There are some very good scientists in some of the laboratories. However, merely making them deemed universities is not enough. The National Laboratories already have a particular charter. They are supposed to be doing something. I think it is better that they do the primary task first. Be good in what they are already doing. In addition, if they also want to give degrees and train students that is OK, but that should not be their primary responsibility. What I feel is that having young people in these laboratories is good, as it helps them. Your mind is sharp when you are dealing with young people. The primary aim of these labs is, however, not to train young people. There should be a balance. There was a time when there were such a large number of Ph D students in some of the National Laboratories that there was no difference between them and educational institutions. Making them deemed universities alone would not bring in a great improvement in the situation.

What do you feel about research in National Laboratories and Universities and R&D performance?

Wherever there have been clearly defined goals such as in space, atomic energy, agriculture, etc., we have been doing well. Many of our National Laboratories have not used the personnel in the educational institutions. For example, I have worked in India for 43 years. No National Laboratory has ever said 'Look here, let us work on a problem together'. This is where I like the French system where the CNRS, industry and universities work closely. Most CNRS laboratories are in university campuses. There is tremendous synergy. This is very crucial for the success of both the educational institutions and the national laboratories. In terms of performance we are improving, but we have to improve much more. For example, South Korea, a country smaller than ours, produces many more international patents.

A lot of water has flown under the bridge since your days as a young researcher. How have things changed (for researchers of today) in comparison to your own?

...conditions of research or what?

When I started my career in the Indian Institute of Science, Bangalore, 43 years ago, we had meagre facilities. Everything we wanted in the institute had to be built. Things have changed from those days. Many people of my generation and senior to us were dedicated to science and wanted to do something in India. What I have seen as the biggest change recently is not good for India. In the last few years most people do not seem to worry about the country as much, or of their own institutions. They are money oriented, very commercial and want to become multimillionaires before they are 25 years old. This change in value system, in the last 3–4 years, has shocked me. I think that this is bad for India. Young people are not interested in becoming experts and masters of a subject. Nothing is easy, but definitely, there are more opportunities today than in the past.

There is an apparent contradiction between productivity in R&D and prolific researchers in India. This is in terms of research papers published vis-à-vis applied research. Your opinion?

I do not look at the problem this way but I understand what you are saying. It depends on the kind of person. The kind of person you require to do good R&D or the so-called applied work requires intellectual qualities similar to those in basic research. This is because the science remains similar. It is not true that we require second-rate people for one and first-rate people for the other. If you have good people you can produce both basic and applied work in an institution. There are two types of science: applied science and science yet to be applied.

Are we not tilting in one direction?

I do not think that we are tilting. R&D work can be made challenging. If challenging R&D tasks are taken up, there are many people who will do well. For example, there are small industries right in Bangalore. Excellent new technology development is being done in these laboratories. If you give good facilities, adequate salaries and environment, there is attraction to do good work. Unfortunately, our productivity (people will say I am too critical), and performance even in basic research is not great. I think that we should be publishing much more good work from India. I would like to see (say) a thousand outstanding papers in physics or chemistry per year. I do not see this happening. Similarly, in R&D we should be producing more patents, more technologies. In both, there is a lot of scope for improvement.

What is your view on experimental facilities and infrastructure and the lack of experimentalists in our country?

To do good experiments in some areas, it has become difficult. This is especially true in my area (of research). There are a few people doing good experiments, here and there. We need to create better facilities and environment, so that we can attract young talent. Young people should be attracted to the subject not only by money but because of the working conditions and the challenging nature of the work.

There is a feeling among scientists, especially from universities, that sharing of experimental facilities among groups would help them, due to their present paucity.

Certain facilities can be shared. A major facility like the synchrotron is an example. Even other types of experimental facilities, up to a point, can be shared. This can be done only after a minimum level of infrastructure is created in the universities and other institutions.

Why do breakthroughs in experiments not happen?

Well, I do not know. Computers have arrived with good benefit, but they have also made people think that it is much easier to keep typing away. To be a good experimentalist in India you have to do experiments at the cost of your health and peace of mind. You have to really work hard. I would be honest with you. Everything goes wrong starting from
electricity and water. For example, even in my lab here (INCASR, Bangalore), electricity and water supply is our own. We do not depend on anybody’s supply. Every piece of equipment, every screw, one has to worry about. Something keeps going wrong. For example, the laser tube goes off or something else goes off. You have to get spares. The money required even to have the equipment working, and the effort and attention required are enormous. It is not just getting the equipment; to maintain it is difficult. Many people do not want to do all this. Many people go in for theory and calculations, partly because they think that experimentalists are having a rough time. Secondly, we also give up easily. Some people of my generation refused to be cowed down by difficult circumstances. It is of course too much to expect the young people to be brave soldiers.

**On awards and recognitions**

You have been a recipient of several important medals, prizes and other honours, both nationally and internationally. What is your view on the existing mechanism we have currently in place for recognition of awards in scientific endeavour?

India now (compared to the early days when I was a young person) has many more awards and medals. Lots of people get them. Everybody may not get an award and some people may be unhappy about this matter. In India, recognition is there. By and large, election to academies, etc. is reasonable. But I would like to see much more importance given to young people. Young people even now have difficulty with respect to senior people. I have tried my best to get young people elected, and win awards. Though I have got many awards as you say, I do not plan my life based on that. If the awards had not come I would have stopped doing science, is the question. I do not think so.

Do we need to see a change in the constituents of fellowship to our Academies? A lot of scientists feel that applied research in the form of patents be recognized.

Not in the Academies. This is all over the world. There should be reward mechanisms. A good reward system provides a way to attract good people to work and make them do good work. There is no question in my mind that the Academies are electing good people. Yet, many people have difficulty getting elected. Many bright people get ignored. The academies have to keep evolving and carefully monitor what they do.

**On journals and editorial work**

You have been closely associated with journals and are a member of editorial boards of several international journals, as well as have been working closely with science academy publications in India. We are faced with this perennial problem of how to remove hurdles such as impact factor, greater recognition of the journal, impetus to send original contributions to Indian journals, etc. Can we tackle this in any way in the light of your experience?

I am a great believer in academies running journals. In fact, I also started two journals. One of them is doing very well (Bulletin of Materials Science). The Proceedings (Chemical Sciences) is doing so-so. I was also involved with Current Science long ago. Somehow the impact factor has become very important and people swear by it. On doing a piece of good work, they would like to see the publication in the best possible journal. The number of good papers coming out from India is not large. So a good journal in India cannot be maintained. Suppose you want to have a journal like Physical Review Letters, Journal of the American Chemical Society, etc., there are not enough papers from India to maintain such a journal. Even for the small number of papers that are published, people would like to get the maximum notice or attention. So they go for higher impact factor journals. This is a vicious circle. The situation could change.

...how?...

Suppose India produces thousand good papers in every subject, then we may be able to have good journals in India. If you improve overall performance and effort in science, a greater number of good publications will come out of India, and the Indian journals would improve.

Younger members of the S&T community feel that if more of the ‘who’s who’ of Indian science contributed to Indian journals, this would raise the level.

...the ‘who’s who’?

...make them publish...

How do you make them publish, I do not know.

... you are part of it...

I do not know. When I was Editor of Publications of the Indian Academy of Sciences, I used to write to everybody to publish at least one paper in the academy journals every year. I could not get the good scientists to submit even one paper in our journals.

There is also the opinion that selection committees in India tend to give low rating to Indian journals, while setting aside the actual content of the research paper. With this dichotomy can the situation ever improve? Would youngsters be proud and eager to publish their results in Indian journals?

Earlier, the question would be ‘How many have you published in foreign journals and how many in India?’ Our own Indian committees used to do that. Those days are gone. In fact, the impact factor is internationalized. People go by the impact factor, citation index, etc.

**On nanotechnology**

As Chairman of the nanotechnology initiative in the country what are your plans and views for the future of nanoscience in the country and how are you likely to implement this?

I can only say that we should have small groups of good people working in the area, particularly young people. Young people can make a contribution. India somehow missed out in the semiconductor revolution. Nanoscience is just beginning and India can make a good contribution to this area.

**So the timing is right?**

Perfect almost. The money required is not so high. It is a reasonably small amount of money, which we can afford. By investing about 100 crores, we can get a number of groups going and some of them may even come up with nice technologies.
So you are hopeful?
Yes, I am quite hopeful.

Others
You have been the Founder Chairman of Solid State and Structural Chemistry Unit and the Materials Research Laboratory in the Indian Institute of Science, Bangalore. How has solid state chemistry in the country shaped up?

Since I set up the Unit, the area of solid state chemistry is no longer called so but is called chemistry of materials. This subject has become important. I set up this Unit in Bangalore much before the subject became important in the world. Now chemistry has two major directions: chemical biology and materials chemistry. The Unit is well-known, but there are not enough young people. A lot of young people have gone abroad. I hope these people will come and work in India.

You are a member of the scientific academies in the country and fellow, foreign member or honorary foreign member of several international Academies. Are our Academies doing enough?

The Academies are doing well, but they can be much more active. They can do much more for the scientific community, in education and in popularization of science. They are doing something, but it is not sufficient. Secondly, our Academies should champion causes of S&T and ensure the relative importance of science in society. They can do much more.

As President of the Third World Academy of Sciences, when is the postponed but much-awaited TWAS meeting in India to be held?

It has been fixed for 19–23 October 2002.

As President of the Chemical Research Society of India (CRSI), what do you feel about the state of chemistry in the country? Chemistry is an integral science, playing a central role in improving the quality of our life.

We should have many more young chemists. We should improve the quality of our publications. I hope that a society like the CRSI would provide the necessary encouragement to young chemists. We need better professional societies helping people. I feel that this is not happening.

Your views on the state of chemistry education in the country?
All of science education is going through a bad situation. I do not like the way we teach chemistry. I do not like the way we teach science. I think that it can be made much more exciting. I have tried my best wherever I could. But individual effort is not enough. We need a social revolution. We need lots of teacher-training programmes, summer schools, etc. Ours is a large country. We need a science celebration occurring for the next ten years, so that ten years from now we have lots of young people coming into science. India should not only be the storehouse of science, but also the provider of intellectual wisdom in the world.

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Random selection
‘Octylphenol and UV-B radiation alter larval development and hypothalamic gene expression in the leopard frog (Rana pipiens)’
Douglas Crump, David Lean and Vance L. Trudeau
Environmental Health Perspectives, 2002, 110, 227–284

An increasing number of endocrine-disrupting chemicals (EDCs) in the environment results in chronic exposures of humans and wildlife to low concentrations of contaminants such as dichloro-diphenyltrichloroethane, polychlorinated biphenyls and synthetic steroids. The paper in citation assesses octylphenol (OP), an estrogenic endocrine-disrupting chemical and UV-B radiation, a known stressor to amphibian development. The experiments consisted of newly hatched tadpoles exposed to 10 days to OP alone at two different levels, subambient UV-B radiation, and later both combinations. From the results, the authors conclude that the levels of OP commonly found in the environment and subambient levels of UV-B alter the expression of hypothalamic genes and disrupt growth patterns.