P. K. Iyengar

Padmanabha Krishnagopala Iyengar turned eighty recently. He has lived in both colonized and free India, and has seen the birth and growth of nuclear India. He is one among the country's leading nuclear scientists, who spearheaded the facilities at the Bhabha Atomic Research Centre (BARC), Mumbai like the Purnima and Dhruva reactors, and played a leading role in the development of the peaceful nuclear explosion which was successfully tested in 1974. He started his career as a Research Assistant (in 1952) at the Tata Institute of Fundamental Research (TIFR), Mumbai went on to become the Director (in 1984) of BARC and retired as the Chairman (in 1993) of the Atomic Energy Commission (AEC), Mumbai. He served as a Member of the AEC till 1998. After retirement he was scientific advisor to the Kerala Government and headed their science and technology department, during which time he created the Rajiv Gandhi Centre for Biotechnology. He also nucleated the Agastya International Foundation (www.agastya.org), which is engaged in a novel method of taking science learning to the village level.

How do you keep yourself engaged now?

The internet gives you so much information at the cutting edge of science and technology, and in education, I wish I could start my career again. It has revolutionized information gathering and is useful to everybody. This has changed life on the planet. However, one would caution creative scientists from getting addicted to it, for much more creativity is required in all the disciplines.

How has school education changed?

I studied in Thiruvananthapuram in a beautiful campus with playgrounds, rooms, and different laboratories for physics, chemistry, biology, etc. where you could study these subjects. The teachers were all permanently assigned by the government. They were so dedicated to the subject they taught that I enjoyed going to school. The rapport between the teacher and the student was so nice, and they all liked me because I was a good student.

Today teaching in schools is so bereft of practical demonstrations that it does not emphasize the need for science in everyday life, which is what science is for. Logic, quantitative understanding and mathematical precision are all required in modern life. If our scientists have to create new knowledge, if our engineers have to invent new gadgets, or even execute large projects on their own, we have to supplement our education system. One of the important lessons I learned from working in BARC is this, the need to be indigenous in applying to tasks.

Science needs a dialogue between the guide and the student. This throws open many new ideas, which benefit the student. Now, you can get all the answers for your regular course work from the internet. Why should you even attend a lecture? But during the lecture, the teacher makes himself available for you to discuss the facts in depth. In our educational system we seem to be ignoring the role of a good professor.

The INSPIRE programme that the DST has started, should really mean that you bring in teachers and give ample demonstration of nature's activity. How does the firefly make white light? It doesn't get hot; it is not a heated element; but it still produces good white light. How does it work? Can we replicate it? Today, the efficiency of electric bulbs has increased. Solid-state devices produce white light with greater efficiency, by more than 50%, compared to incandescent bulbs. These are examples of how science can be useful in observing nature and correlating nature's activity to molecular mechanisms. The discovery of the Raman Effect was essentially based on a keen observation of nature.

Today, science students in colleges are under great pressure to perform and publish papers …

This is a hangover from the colonial style, repeating what the Western universities do. Even here, there is a big difference in the education pattern, especially before and after the Second World War. Now research has become an industrial product and therefore, people start asking the question: 'What is your research meant for?' I remember a conversation between the US Senate members and some scientists who wanted to build a big accelerator in Fermilab. They asked Robert Wilson: 'What can this do to the industry and especially defense of this country and the economy of this country?' He replied: 'This project will mean nothing in particular for the defense, but it will make this country worth defending.' Today you see missiles, satellites, high-quality electronics, and the conversation between us (through Skype) because of the internet – these would not have become possible if research was not done.

Today, we can speak to anybody, at anytime, anywhere in the world. We can be in any part of the earth in reasonable time, even by commercial aircraft. We can send a mission to the moon to find out what its resources are, so that we can exploit them if that becomes necessary. All this is possible only because basic science was given encouragement. This resulted in technological upheaval that in turn led to its application by engineers and scientists.

Today we have a strong Space programme and we can send our own satellites, our own missiles. Our defence is entirely different now. Similarly, the examinations that you do in a hospital today, in terms of blood, MRI and ultrasound, are so different from what happened before. They are so precise that you can diagnose the disease accurately and treat it. So we have the best.

Unfortunately the policy makers, parliamentarians and state bureaucrats don't realize this. While they enjoy all the benefits, they don't want to spend

too much money. In the INSPIRE programme, the government gives Rs 5,000 pm to every student because they know that ultimately it will pay; it will improve our industrial standards; it will make them innovative, creative scientists. That is what we are lacking. When I started, we picked up what our peers had done by reading journals. In my lifetime, when I started nuclear physics, there was not even a textbook. Today, we are a country of advanced nuclear science. We can build our own power stations and do innovations in reactor technology. In the last 50 years after independence, we have demonstrated that we can revive our place in the world by doing research intuitively and concentrating our efforts in technological developments.

Then, why do we need the Indo-US nuclear deal?

The nuclear deal is looked upon by the government as a short cut to progress. This is what I am opposed to. There is no short cut to progress. The service centres in Bangalore are a copy of those elsewhere, a repetition of what happened in the US. Should we continue to do that? Today even our big institutes like the Indian Institute of Science, instead of expanding themselves on developing technologies for the local industry, jump up for 'current' subjects like nanotechnology or biotechnology. In fact, students don't do physics, the basic subject in which innovations take place.

An unfortunate part of our progress is the Indo-US deal. You start by saying: 'They have big 1,600 MW power stations, let us copy that or import them on a turnkey basis'. We are not able to build 1,000 MW power stations because we don't have the industrial back-up. The Americans built steel plants and made stainless-steel alloys in a big way so that they could make big pressure vessels. We cannot do this because our industry did not grow that fast; it will take some time. To short cut and say: 'Alright let us import that here' is… It is six years now since the Indo-US deal was started in 2005. We haven't got a pound of uranium from them. We haven't got any commercial deal from the US. So what is the progress? None; except for signatures on some documents. (For more on this, see my book *Briefings on Nuclear Technology in India*, Rupa Publications, New Delhi, 2009).

I remember when we did not have uranium. Homi Bhabha decided to use the little bit of uranium in the monozite sands of Kerala, even though it would be expensive. He decided: 'I want to use uranium from this country; so let us exploit that'. So for the first reactor, CIRUS, half the charge was made from Indian uranium, that too from the monozite sand. The spirit in which it was done showed that indigenous technology is important. That is what made the Departments of Atomic Energy and Space grow fast.

People say that the reactor which is to be imported from France in Jaitapur uses untested technology …

The Jaitapur reactor is a 1,600 MW reactor, which we can't build because it is of a big size. It produces heat which is equivalent to three times that, may be 4,500 MW. When you produce that much heat in a vessel, there is no escape from real danger if any major natural calamity occurs, like what happened in Fukushima. Now, when our engineering is not mature to take care of so much heat removal through indigenous equipment, is it worth doing it? Are we not taking risk? Everybody would say: 'They have done it in France; they have done it in Finland'. But the cost of the Finnish reactor has gone up substantially since its inception and it is still not operating. Therefore, I would not immediately jump into such huge projects.

Will the deal continue?

I don't think this deal is going to take shape in the proper way. We have got diplomatic exchanges and acts of law passed. The liability law was passed by the Parliament only last year. But they say: 'You have to change it to suit our industry'. This is not cooperation. The intention was not to help India grow in nuclear power, but was more commercial. If that is not satisfied, they are not interested. Even now, after Fukushima, the Americans are not able to go ahead with the new reactors, because new safety problems are being raised. Areva itself says that we must look at the Jaitapur plant design.

When there are so many risks associated with nuclear power, should we go ahead with it? Can we use other energy sources?

Nuclear power is a very intensive source and we make safe and stable power stations. We should continue to do that. Meanwhile, we should also research on alternate methods for production of nuclear energy, we should accelerate that.

Yes, there are other sources of energy. Solar power is nuclear power produced in the sun, and nature transfers it to the earth through radiation. Now if we can re-convert that radiation efficiently into electricity like what the photovoltaic cell does, then of course you can use this solar power. But big industrial units producing 1,600 MW at one place is not possible in solar power. But then, why should we stick to this major investment in transmission towers and big power stations? You can have a distributed power system so that it satisfies one village or one district.

The Nuclear Power Corporation of India is planning to 'borrow' some money from the French to build reactors in Jaitapur …

This is purely commercial. For their industries to have their production capacities running, they need a market. For the French, 75–80% of their electricity is produced by nuclear power stations, and this requirement doesn't go up because it is saturated. Therefore, they have to find a market where big industries will support nuclear power. And what is the attraction for these companies? In their economy, 2% interest on their investment is good enough, whereas here you are willing to pay 9% in foreign exchange. Therefore, they are willing to give the money.

Is science in India helping the poor man lead a better life?

The Bell Telephone Company became rich because it produced its own technology by investing in basic research in semiconductor science and made devices that had a very large market. Today, its research output has gone down because the factors have changed. If you want to do similar things in India, you need a larger base. You need to organize a large outfit like what we did in atomic energy. In 1958, when we were rapidly expanding Trombay, Homi Bhabha said: 'Let us

recruit 200 young fellows and take them through a training school course. If I get at least 10% of them doing outstanding work, I am gratified'. Therefore, there was investment in manpower, and the result is that after 50 years, we don't have to look for experts from abroad. We don't even require training from abroad.

Take Space. They are now opening up a university system in Thiruvananthapuram, so that they can induct more people into this new technology of making and launching satellites. This is organic growth. But this did not happen, for example, in the aircraft industry. The National Aerospace Laboratory in Bangalore started in 1950s. In 1960s S. R. Valluri, the Director, told me: 'I don't have the mandate to go to industry'. To make an aircraft industry, you have to consider all aspects from materials to technology and testing. But there is no organized effort.

What you write in *Current Science* should reflect on the progress and some lessons for the reader. Reporting on science is that you go deeper, asking searching questions, asking how great scientists became so famous and whether that experience can be reflected in the new generation of people? There are many subjects in which you don't do research. Can you go and talk to the expert and say: 'This subject has been neglected'? Nobody wants to take up an M Sc in mathematics because there are only teaching jobs. But mathematics is a precise way of expressing science and natural laws. It makes our observations of nature accurate and truthful. Statistical analysis of data is used by many related fields.

Your experiences …

I was lucky enough to have joined the Department of Atomic Energy at a time when it was a baby, in 1952. Because of that and because of my association with some of the best known scientists like Homi Bhabha, Vikram Sarabhai, Raja Ramanna, and even those in other areas like M. S. Swaminathan, I was able to catch on to what is necessary to do science. The desire to make the students prosper, through which teachers themselves prosper – that philosophy is no longer there.

I worked with a man (in 1957) who eventually got the Nobel Prize – Bertram N. Brockhouse. I could see even at that time, how he emphasized on new creativity rather than multiplying the number of publications. If you are a professor and give a lecture, you must say something that is new, that triggers the curiosity of the student, of the listener.

Nowadays there is bureaucracy in funding agencies. They can't be experts on every subject, but they have produced a system by which projects could be evaluated by peers. Who are the Ph D examiners for your students? Your friends. That is not the right way of doing it. Somebody told me that if you are a student at Cambridge, the teacher will let you find your own problem. In research, there is no point in going entirely by what has been done before. Yes, it is necessary to know that. But if you stick on to that, then your curiosity is saturated and you think there is nothing more to be done. That brings down the quality of your research. Fortunately in *Current Science*, you publish things that are not necessarily proven, which is an open mind. Many other journals don't have this open mind. These are some of the innate risks involved in science, and if they are taken care of, then of course things should progress much faster.

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T. V. Jayan

T. V. Jayan (courtesy: The Institute of Mathematical Sciences, Chennai).

T. V. Jayan is a science reporter and science editor at *The Telegraph*, Kolkata. He has been reporting science for over 15 years. Jayan has worked with the Press Trust of India (PTI), Vigyan Prasar, *Deccan Herald* and *Down to Earth*. He was a panellist at a discussion held during the workshop on academic ethics, hosted by The Institute of Mathematical Sciences, Chennai, where I asked him about ethics in journalism. Jayan is a science graduate who quit the Master's programme at the University of Calicut in its first few months and joined a science communication course at Madurai Kamaraj University. Here he helped arrange guest lecturers for taking classes. Jayan likes literature and has acted in plays including one on Galileo.

How has your career been as a science journalist?

It has been pretty rewarding. Science journalism was a hard field back in 1994; we used to spend an entire day in the library and look at research journals, find some stories or research papers and bring them to our Science Editor, K. Jayaraman at PTI, where I started my career. All other forms of journalism are not that difficult. In science journalism, you need a hand on science, without which you cannot focus.

What kept you going in science journalism?

It is not only because of the science journalism course I did, I was generally interested in science. I have covered other beats as well but the reason I like science journalism is that it gives a lot of opportunity to write on different subjects. You can write on neuroscience, biotechnology, archaeology, space and so on. This variety excited me a lot.