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E-CONVERSATION

An E-Conversation with Dr. Raghunath Mashelkar

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Dr. R. A. Mashelkar is currently National Research Professor, Chairman of India's National Innovation Foundation and President of Global Research Alliance. He was the Director General of Council of Scientific and Industrial Research (CSIR), a chain of 38 national laboratories for over a decade. He was also the President of Indian National Science Academy.

Subhas Sikdar: Ramesh, I am very gratified that you have agreed to do this E-conversation with me for the benefits of the readers of this journal. Your scientific and engineering stature is so immense that it can only be approximately sensed by the enormity of recognitions and awards you have received from all over the world. To cover it all would require a book. I can only focus on a sliver of your life's work as it relates to the specific interests of this journal. And I will begin at the end. Now that you can easily take it easy, as they say, you are still leading several research foundations, some multinational and multientity. What thoughts and aspirations are motivating you for this leadership? What do you want to achieve at this juncture?

Raghunath Mashelkar: Let me begin with an anecdote. Bharat Ratna Prof C. N. R. Rao is the most decorated scientist of India. He has been my mentor, my Guru. I remember going to him, when I became a Fellow of Royal Society. I was only the third engineering scientist from India to receive this honor in the twentieth century. So I thought he will be pleased. All that he said when I broke the news to him was 'not bad'! Then I was elected to US National Academy of Science, again only two engineering scientists from India have received this honor so far. So I thought he will be happy. Again he said 'not bad.' And this happened each time I got a high honor or an award. Each time it was the same 'not bad.'

Finally, in frustration, I asked him, what will it take to impress him? His answer was profound. He said 'You are climbing a limitless ladder of excellence. Always keep on thinking that your best is yet to come.'

That has been my motivation. Continue to climb on the limitless ladder of excellence! Besides this call from the head about striving to reach one's potential, and then striving to even exceed it, there is this call from the heart of giving back to society, which has given me so much. Anything that I do will not be enough, so much is the debt!

So Subhas, I am still doing 24 into 7, day after day, week after week, month after month, year after year and will continue to do so till I breathe my last!

SKS: You ran the prestigious National Chemical Laboratory, Pune, and I know how deep technically you can be. When you give talks, however, unlike other technical

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thinkers, you take a broader view, transcending into an inspirational and emotive statesman. An American lady who attended your talk at Karlsruhe, Germany, was brought to tears by your plenary presentation which touched on the plight of village women of India. What is the origin of this bent of your character?

RAM: I am a great believer that 'excellence' and 'relevance' must go together. Excellence of the highest order in the science that we do but at the same time, relevance to the society of that science is paramount. Science must make not only an economic sense but a sense from a societal perspective.

Coming from a poor country like India (which is now emerging as a leading economy, of course), I feel we as scientists in India have a special responsibility. I always say that science must solve, technology must transform and innovation must impact. For the poor of the world, science must solve their problems, technology must transform their lives and innovation must impact their present and also their future.

So, that deep faith, compassion and passion, I believe, has shaped my emotion, my aspiration, my expression and my action all my life, I suppose.

SKS: Your response triggers two follow-up questions. First, did this deep faith in the beneficial effects of science, passion, and compassion come to you naturally? Or was there a source of inspiration somewhere in your childhood, perhaps a close relative, a national hero, or a teacher imbibed it in you? Second, with this narrative you are describing the common currency of sustainable development. I would like to call it inspired sustainable development. Would you agree?

RAM: Yes, you are right. There was a trigger in my early life. I remember going to a poor school in Mumbai. But that poor school had rich teachers. I remember Principal Bhave, who taught us physics. Today's children have this 'Book vs. Look' problem, since they are so overburdened that they don't have time to look around. Principal Bhave emphasized the 'look' part of it. I remember his taking us out into the sun to demonstrate how to find the focal length of a convex lens. He took a piece of paper, moved the lens till the brightest spot emerged on the paper and told us that the distance between the paper and the lens was the focal length. But then he held it on for some time and the paper burnt. For some reason, he turned to me and said, 'Mashelkar, if you can focus your energies like this and not diffuse them, you can burn anything in the world!'

This simple experiment was a turning point in my life. First it gave me a philosophy of life—focus—and you can achieve anything. Second, it told me about the power of science. I decided to become a scientist. These two lessons came to me on the day I saw the experiment. But later in my life I were to learn other lessons.

As I moved forward, I saw a third lesson in that experiment. Today we talk about sustainability. Solar energy is going to play a big role in this. So I saw the essence of what you have beautifully titled as 'inspired sustainable development' in that simple experiment. When I can burn the paper simply at no cost by using the thermal energy created by sun rays, why should I use a fossil fuel?

I grew by not only doing science but leading science. And while leading science, I discussed what I like to call a 'convex lens leadership.' What does convex lens do? The rays of the sun are parallel so they can never meet. The convex lens makes them meet and converge together. So is the case when institutions with people with diverse disciplines, locations, etc. work together for a common goal.

I started heading a Polymer Science and Engineering group, then the Department of Chemical Engineering in National Chemical Laboratory (NCL), then I became the Director of NCL, then becoming the Director General of Council of Scientific and Industrial Research (CSIR), where there were forty national laboratories, and then I became the President of Global Research Alliance, which had nine CSIR-like institutions from Australia, Battelle, Denmark, Finland, Germany, India, Malaysia, Netherlands and South Africa.

While leading all these, I realized that it was important to have 'Team NCL,' 'Team CSIR,' 'Team GRA' and the spirit of all that was embedded in the 'convex lens leadership' lesson that I learnt on that sunny Friday afternoon!

SKS: Your precise memory of the key lesson learned in high school is telling. I like the leadership attributes which you have displayed through several nuggets of wisdom, such as the convex lens principle and encouraging teaming to implement this principle. I remember a day in your office in the late 1980s when you told me that one of the first things you asked yourself after assuming the leadership of the National Chemical Laboratory is why the Indian researchers would not be able to publish in Nature or Science. That question was put to practice to uphold excellence and relevance, and the rest has been history. Tell us broadly about what you did at NCL to transform that premier laboratory, especially from the ideas of excellence, relevance and innovation.

RAM: On June 1, 1989, I became the director of NCL, which already had a high reputation in chemical research. The challenge was to convert NCL from a very good laboratory into a front ranking world-class laboratory. It was a time in India when the Indian industry was protected by huge tariff barriers. Industry was in sellers' market. NCL scientists responded by essentially doing import substitution, because that was what the Indian industry demanded.

Context decides the content. It was clear to me that if NCL continued to operate in this context, the content of the NCL research agenda would be just copy, copy and copy.

There was no way NCL could have changed the 'national context' in those pre-1991 days, which was all centered around import substitution. So I said NCL will change its 'own context.' NCL will become the International Chemical Laboratory by shifting its role from a seller of knowledge to Indian industry to a seller of knowledge to the whole world, even to the USA and Europe.

The very statement that 'National Chemical Laboratory' will become an 'International Chemical Laboratory' created an incredible aspiration, which, to me, is always the biggest driver of change. But here was the big challenge. Until 1989, that is, in 39 years of its existence, NCL had not been able to secure even one single patent in the USA! How can a laboratory with such an abysmal record of US patenting even dream of being an exporter of its knowledge to USA? It looked impossible.

I challenged the laboratory by saying that there is no limit to human imagination, no limit to human achievement, excepting the limits we put on ourselves. In the import substitution era, we had put limits on our thinking. I said let us unshackle ourselves. Think boldly. Think ahead. Let's lead and not follow. NCL was charged with a new 'yes, we can' spirit!

NCL learnt to read patents, write patents, break patents as it went into this tough game. When NCL licensed its hydrodewaxing technology patents to the multinational company, Akzo, in Europe in 1990, it was a historical event, since this was the first time a reverse transfer of technology from an Indian national laboratory to an advanced nation had taken place. This was followed by the licensing of patents on an innovative new process for an engineering plastic to the US multinational giant, General Electric. This success created great awareness about the value and rewards of patenting among the NCL scientists. Within less than five years, NCL developed a big client list, which included the top few global leaders from around the world, from General Electric to DuPont and from Cargill to Polaroid.

And there was no looking back even after I left as the director. Two of Procter and Gamble's very recent products in the market are based on NCL patents that it had recently licensed!

Achieving all this required a big cultural change at and by NCL. We said no more 'publish or perish.' The new driver was 'patent, publish and prosper.' We said Indian ideas must generate wealth for our nation, not for other nations, as used to be the case then.

We incentivized the scientists. On NCL's foundation day, we started giving a silver medal and a cash prize for anyone who had succeeded in acquiring a US patent. Initially, there were barely a couple of medal winners. But the number kept on swelling as the awareness grew. Finally, the number became so large that NCL stopped giving this medal! After all, the purpose for which the initiative was started was fulfilled.

The feeling of becoming an International Chemical Laboratory was heady. NCL raised its global ambitions. It started exploring unchartered territories. A new aspiration that NCL should also be a global knowledge-based services provider emerged. In 1990, NCL saw an invitation for a global bid for a World Bank consultancy contract for reforms of some leading Chinese chemical research institutions. NCL had never participated in a global bid before. But we said, let our past not be a burden on our future. We participated in the bid. NCL had to compete with the formidable US players, Arthur D Little, Chem Systems and International Development Planners. NCL beat them and won the consultancy contract. Later on, NCL learnt from the Indian embassy in Beijing that it happened to be the first ever consultancy offered from China to India! Interestingly, it had to come from a national laboratory that had got into the good habit of making impossible possible!

All this journey was not easy. There were some fundamental mindset issues. We dealt with them by challenging ourselves. For instance, for all these years, NCL was used to getting government grants, no loans. NCL went out and got a World Bank loan. The good thing about the World Bank loan was that it had to be returned, not by the government, but by NCL itself! How could it be returned, if NCL did not create surpluses or profits? That meant doing research as a business. That was not easy. When I created a new Business Development Group in NCL, I came under attack from some leading scientists. They said Mashelkar is bringing the word 'business' in the organization. That is going to corrupt the minds of the scientists. But none of that happened.

NCL grew its business both qualitatively and quantitatively, and so was the case with its scientific research output. Speaking more specifically about the science done in the Polymer Science and Engineering Group that I had established, it was good enough to lead to some of the highest global recognitions. These include even the election to the Fellowship of Royal Society, Foreign Fellowship of US National Academy of Science and Foreign Fellowship of US National Academy of Engineering.

SKS: These are extraordinary gifts from you to your colleagues, and to scientific and business professions writ large. This is also a story of leadership. In your case, this leadership trait is probably partly innate and partly acquired through the process of doing. Leaders in the best cases must create other leaders; otherwise, the natural tendency of conditions to degrade will eat away the gains over time. It would be interesting to know your thoughts on sustained scientific leadership by motivating a generation of scientific leaders for a long-term cause.

RAM: My own experience is limited to doing science and leading science in India. Let me reflect a little on the Indian experience to start with. When India gained independence, we were fortunate to have a leader like Pandit Jawaharlal Nehru, who believed that science was man's greatest enterprise and that investment in science was the only way forward for India. Great leaders in science like Shanti Swarup Bhatnagar, Vikram Sarabhai, Homi Bhabha emerged in the fifties and the sixties. Bhatnagar built CSIR, which I had the privilege to lead for over a decade. Vikram Sarabhai was responsible for laying the foundation for our space research, which is an envy of the whole world today. It was Homi Bhabha, who built India's mighty atomic energy establishment.

What was the common trait among all these leaders? I believe they were all true innovators. What is a good definition of an innovator? Some say that innovator is one, who does not know that it cannot be done. For them, obstacles can be converted into opportunities. Innovator is also one, who sees what everyone else sees but thinks of what no one else thinks. These science leaders were able to see what no one else saw at that time. They had an ability to take a great peep into the future. It is remarkable that Bhabha saw the importance of nuclear energy so early. Vikram Sarabhai conceived of the Indian Institute of Management, Ahmedabad at a time, when the importance of management education was not evident to most of the people in India.

Good leaders are necessarily dreamers. They have the capacity to think of the impossible and motivate the people to do the impossible. An important characteristic of a leader in any walk of life is his ability to enthuse everyone about seizing that part of the rainbow that they have dreamt. Robert Kennedy summed up the essence of leadership best when he said, 'Others see things as they are and wonder why; I see them as they are not and say why not?' When we say 'why not,' we create an ambition among the minds of the people. Great leaders should not only create an 'ambition' but also provide the 'ambience' in which to fulfill that ambition.

Strong leadership shows up in a crisis. In the words of Seneca, the Greek philosopher, 'Fire is the test of gold; adversity, of strong men.' Our former President, A.P.J. Abdul Kalam, always recalls the great leadership of Satish Dhawan. When SLV-3 launch failed he told Kalam that he will face the press. Subsequently, when the next launch succeeded, he asked Kalam to address the press.

A science leader must also understand the subtlety of science. It is difficult to plan and control the process of scientific research with the kind of analytical certainty that the conventional manager associates with other operations. The process of scientific innovation tends to advance in a bubbling way. It is intense and tumultuous. The challenge before a scientific innovator is converting inspiration into solutions and ideas into products.

A science leader must understand that true innovators are those, who refuse to preserve the status quo. Their incentives are personal and emotional. They are not institutional and financial. They enjoy the fun of creation, the admiration received from them by their peers, and the excitement and glory of taking part in a total process of creation. They have some extent of 'irreverence' associated with them. Innovators are sometimes extremely intense. A great scientific innovator like Carothers, who developed world's first synthetic fiber nylon, committed suicide. Diesel, who invented diesel engine, also committed suicide. Leading scientific enterprises involve managing such creative and intense people. Good science leaders must understand that innovation management in science is not based on turnaround strategy. It is based on turn around thinking.

Finally, the greatest science leaders, I believe, have to be themselves builders of future leaders as well as institutions.

SKS: The focus on 'patent, publish, and prosper' framework and 'Yes we can' motivation inspired innovation in a direction away from import substitution-type copying. The beauty of innovation is that it is self-stimulating. More inspires even more. As you say, it could not have been easy to achieve. What were the barriers and how were they overcome?

RAM: The first challenge for me was building open minds that not only embrace new ideas but escape the old ones. James Dewar had said minds are like parachutes. They function only when they are open.

I found that the second barrier was the challenge of change of mindset. There is a continuous battle between Indian mind and Indian mindset.

There was never a doubt about the quality of Indian minds. Today, everybody talks about global village as a great idea but who talked about global village first? It was an Indian mind, who said *Vasudhaiva Kutumbakam (meaning the whole world is one family)* centuries ago.

That is fine wisdom by ancient India. But what is the ground reality? Someone asked me when one Japanese and another Japanese come together, how many Japanese do they become? I said two. He said it was wrong. They become eleven. They form such a great team. When he asked me 'when one Indian and one other Indian come together, do you know how many Indians they become?' I again said two. He said again I was wrong. Not two but they became zero! They neutralize each other! They do not form a team.

Removing mental barriers in building 'Team NCL' was a big challenge. So was building 'Team CSIR.' And then building a 'Team India' programme like New Millennium Indian Technology Leadership Initiative (NMITLI), which became India's biggest public private leadership ever.

The third barrier was many a time, a lack of self-belief, which always stands on the way of 'yes I can' spirit. I often had to tell my team that someone tells you that it can't be done, take it that it is more a reflection of his or her limitation, not yours.

The fourth barrier was that I found people will always be waiting for the opportunities to knock on their doors. I had to tell them that if opportunity does not knock, build a door of your own. Seizing opportunities rather than using opportunities was more important.

The fifth one was about keeping the aspirations continually high. Reverse transfer of technology to multinational companies in their own areas of strength was considered impossible. But at NCL, we had a high aspiration to accomplish this impossible-looking feat, and we did it. One had to constantly remind people that only when you dream big, you can achieve big things.

SKS: This discussion of course could go on, but I think I have been able to capture your thoughts on the essential ingredients of becoming a technological power in a short time starting from a fairly modest beginning. My last question is this: Globally, how do you foresee technological advancements in the coming decades, considering that population rise and improving living standards everywhere can be a limiting factor, as can be the inevitable sociopolitical issues of inequality and justice? In your crystal ball, which countries are likely to take dominant positions in technological innovation?

RAM: As regards technological advancements in the coming decades, I have written a chapter titled 'Technology 2050: A Potential Landscape' in the book titled 'Emerging Markets through 2050,' which has been published by 'Oxford University Press' earlier this year. So I recommend the readers to refer to it.

There I have shown as to how technologies such as mobile internet, internet of things, cloud, advanced robotics, artificial intelligence, additive manufacturing (3-D and 4-D printing), NextGen genomics, nanotechnology and new storage technologies are going to be game changing.

I feel the human mind will continue to explore new science and that will lead to new technology. How was the universe born? Is there life in the outer space? Can aging be postponed? What secrets do genes hold? Will we ever understand how the apparently useless DNA in the human genome contributed to our evolution? As our understanding of the DNA world improves, will we turn to the RNA world? May be build an organism based on RNA in the laboratory? Will we ever understand how decisions are made, imagination is set free or what consciousness consists of? Will we be able to identify the neural correlates of our thinking? Will the attempts to 'quantize' the gravitational field succeed? Will string theory really fulfill its promise of being the true description of the particles of matter or will it be another blind alley? Would we ever be able to provide those uniquely relevant experimental data to prove the so-called theory of everything? I feel the scientists around the world will continue to grapple with these problems.

As regards the second part of your question, it is certainly true that the geography of science, technology and innovation is going to change significantly in the 21st Century.

For instance, take the case of Asia, which I understood better than I do Africa or Latin America.

In terms of technological innovations, Asia has so far moved unevenly. Japan had made a head start after the Second World War with such rapid progress that it could be called a technological superpower and joined the OECD in 1962 itself. South Korea and Taiwan became technologically advanced nations, thanks to the emphasis on and investment in higher education, and science and technology. Singapore joined the club of technologically advanced nations by carving out a niche in specific areas (e.g., biotechnology) and also making innovative changes in public policy on welcoming and encouraging foreign nationals who had achieved eminence in science and technology, so that it did not suffer from the disadvantage of having a small human capital base because of its small size.

China's own prowess today in many high technology areas such as advanced space technology, aerospace technology and nuclear technology is well known. China's achievements range from high-speed bullet trains to advanced fighter jets and from navy carriers to advanced nuclear reactors. Massive investments in clean technology are already showing rich dividends. China has acquired a second position after the leader USA in nanotechnology even after a late start.

Let's take the case of a specific field. It has been argued that the twenty-first century will belong to Asia. And further that twenty-first century will be the century of biology. Then what will be the Asian position in this century of biology? Or from a technological angle, where will Asia be in modern biotechnology? Asia could be a leader in modern biotechnology by 2050. It could have a dominant position in a variety of frontier fields like stem cell technology, synthetic biology and pharmacogenomics.

Some of the Asian countries took an early lead in stem cell technology. Today South Korea and Singapore are counted among the leaders. India and China are beginning to build on the promise created through judicious investment in human capital and infrastructure.

Asia has all the competitive advantage to become a leader in stem cell technology and therapy. This unique positioning in regenerative medicine can have an interesting consequence in medical tourism, with some Americans

coming to China for stem cell therapy to the Beike Biotechnology in Taizhou. This trickle could potentially become a torrent.

Despite the rise of many emerging economies as economic powers, there will be a disparity of income as well as opportunities for a vast number of people in these countries. The challenge will be to aim not only for growth but for inclusive growth. This will require us to master and lead in what might be termed as 'inclusive innovation,' which creates products and services which are available, affordable and accessible to the whole population, who, for various reasons, will continue to remain at the Base of the Economic Pyramid (BoP).

The examples of inclusive innovation include world's cheapest car, Tata Nano (priced at just US$2500), world's cheapest mobile phone sets (priced at US$20), world's cheapest phone call rates (costing just one cent per minute as against eight cents in the USA), world's cheapest cataract surgery (costing just US$30 as against US$3000 in the USA), world's cheapest tablet (costing just US$35) and so on. And these are not dreams, they are reality. And they have been achieved by using ingenious technological innovations, business process innovations and work flow innovations.

Since affordability and sustainability are the two strategies on which inclusive innovation is firmly anchored, it is going to help the global leadership deal with the challenges of the crisis of global economic meltdown (and no one can guarantee that there will not be another one) or deal with the crisis of climate change (with the world still grappling with this challenge as the currently emerging economies continue to consume more and more).

My own vision is that new technological advances should lead to a balance of people, planet and prosperity with a rider that it should not be prosperity for some privileged few, but prosperity for all. This alone will ensure that we will see not just the privileged few of the 9 billion plus inhabitants of this globe smile but all 9 billion plus smile.

SKS: Ramesh, many thanks for taking the time to work with me on this E-conversation. As I said before, we could go on and on, but since we are limited by both time and space, this is a good place to stop. This conversation yielded a plethora of remarkable observations on science, technology and society, and again I thank you for sharing those with our readers.