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GUEST EDITORIAL

Innovation – which way?

What has the Indian Institute of Science (IISc) or the Indian Institutes of Technology (IITs) done in terms of innovation to benefit the Society? There may not be many examples of an Ashok Jhunjhunwala (IIT, Madras) who wants to take telephony to every village, a tablet computer to every student in a village, take technology to benefit rural India or a KPJ Reddy (IISc) whose shock wave tube (Reddy Tube) seems to have a million applications: artificial insemination gun, tissue softening in tumours, growth of stem cells, dispersal of quantum dots, dust from moon surface for spectral analysis and many more. But, space, defense, transportation, power sector and almost every technology initiative of the government has involved experts from these institutions. Besides, their contribution to human resource development in the country is incredible. This editorial is not about defending institutions of higher learning in India, but the innovation challenge required to take this country forward.

The buzz word is Digital India. Google, Microsoft, Apple, Facebook and many others would invade India and make it a global hub for technology. They are all already here, but now it would be an avalanche. Every time our Prime Minister visits the US and gets an unprecedented response from the diaspora, I feel ethereal till I hit the ground with a thud as electric power has failed for the 4th time in the day in Bengaluru, our own Silicon Valley. We can look at a range of areas from nanoscience to synthetic biology and discuss a million issues from funding to societal relevance. But, I want to discuss only three examples to highlight the nature of different challenges.

The first innovation I need is to think of doing things without electricity! Over 70% of the electricity generated in the country is from coal-based power plants. Other renewable energy resources such as wind, geothermal, solar, and hydroelectricity account for 25%, and the nuclear, a mere 4% share of the Indian fuel mix. The challenge is clear. We need to decrease dependency on fossil fuels, coal, oil and hydroelectric with the monsoon playing truant. The National Solar Mission has ambitious targets. Several private industries have started building new solar plants. Can the academia bring in basic innovations to make solar modules affordable? Should it be silicon thin film or low cost crystalline silicon? How to convert a wider spectrum of sunlight to electricity? Which other semiconducting materials are to be stacked on the present solar cell? Many centres in the country have put in research efforts on renewable sources of energy ranging from biogas generation from food wastes and organic matter, efficient biofuel from plants through energy farming, conversion of cellulose from organic matter to ethanol, biofuels from marine algae to installation of energy efficient *chulas* and so on. But, most efforts have remained at local levels or even died down. The problem is one of scale and sustainability. There was a news item 'Almost all of the world's largest solar panel makers are in danger of going bankrupt within a year and the downturn is having an impact on innovation'. Therefore, individual groups should have connectivity and long-term support, although the scientists should have short-term goals in terms of delivery. Therefore the establishment of Interdisciplinary Centre for Energy Research (ICER) at IISc in 2012, as an example, to integrate individual research in photovoltaics, high storage density battery (our prime minister was very impressed with the long-term storage battery at TESLA, USA), green buildings, sustainable technologies, combustion science and technology, is a welcome step. IISc has been selected to lead a new joint US–India research centre focusing on solar energy (Solar Energy Research Institute for India and the United States, SERIIUS). One notices that this involves 12 institutions from India, including IITs and companies such as Bharat Heavy Electricals Ltd, Hindustan Petroleum Corporation Ltd and Thermax Ltd and 16 US institutions, including MIT, Stanford, Purdue and other universities and companies such as General Electric, Solarmer Energy and Corning inc. I am highlighting this because the problem with academic research in India has been one of scale and sustainability to address global issues. There could be other examples as well.

The second example I want to deal with is the health sector. India has the dubious distinction of being a global leader in tuberculosis and diabetes! Thus, we have challenges from both infectious and lifestyle disorders. Every year we have the scare of Dengue and Chikungunya. There is no dearth of research on these areas in major R&D institutions in the country. For example, leading protein structure groups made significant contributions to the elucidation of protein structure from *M. tuberculosis*

with the hope of eventually designing new drug molecules as part of the worldwide TB structural genomics group. There was a major effort involving R&D institutions in the programme on Open Source Drug Discovery (OSDD), supported by CSIR. Astra-Zeneca had a major programme on drug discovery for TB. But, one has not seen a proven new candidate drug. The problem is tough. Bedaquiline is the first drug in a new class of anti-TB medications to be approved in more than 40 years by the US Food and Drug Administration (FDA). There are a couple of other molecules in Phase III trials. Even so, TB has to be a priority and India has to come up with a solution to treat this dreadful affliction, which is only posing greater danger through XDR (Extensively drug-resistant) and MDR (Multi drug-resistant) manifestations. We have to import GeneExpert to detect rifampicin resistance, one of the crucial drugs used in treatment at present, despite several projects in India to develop TB diagnostics. What is the missing link?

We need newer vaccines, diagnostics and drugs to treat diseases. Despite all the difficulties, India is a global leader in vaccines. But, it is more due to body shopping by industry and ability to lower manufacturing costs substantially, rather than due to innovative solutions provided by academia. We need to find alternate strategies to drug discovery. The developed world will spend a billion dollar to bring a cancer drug into the market, but not a TB or a malaria drug, despite philanthropy from Gates Foundation. Maybe we should look at our backyard and validate traditional medicine and natural molecules. We are often carried away by sophisticated modern tools such as genomics, proteomics, transcriptomics, metabolomics, etc. The tools seem to direct the research rather than finding answers to fundamental questions using the tools. Can we think of an innovation like a polymerase chain reaction (PCR) to amplify DNA, that is the basis for billions of dollar worth diagnostic industry in the world?

The third example I want to deal with is modern agricultural research. We need to increase productivity by 30–50% with a burgeoning population, which will exceed that of China in a decade or so. India ranks high in the production of cereals, pulses, oilseeds and vegetables, but very low in terms of productivity. In particular, our productivity is around 50% of that seen in China. The challenge is to produce more with less land, less water and less labour. It is also clear that traditional practices, including organic agriculture despite propaganda, cannot ensure increased production. Scalability and costs are major issues. Modern agricultural practices have to be combined with modern technologies, be it GM (transgenic) or Marker-Assisted Selection (non-GM). Here, the academic community has done reasonably well, despite a hostile environment. Many transgenic varieties to protect against pests, weeds and abiotic stresses like moisture stress (low rainfall) have been developed, but withering in glass houses due to lack of policy support and opposition by vested interests.

How does the invasion by Google & Co, which are supposed to bring a technology revolution, relate to the examples I have discussed. In my perception, we need to distinguish between core and enabling technologies. I do not for a moment underestimate the power of IT and automation technologies. It will change the lifestyle in India, which one is already witnessing. There will be a revolution in business, education, transportation, communication, networking, health care, entertainment, employment opportunities. The contribution of computation and automation technologies to R&D in terms of instrumentation and data analysis will be unprecedented. Even so, I would like to categorize all these as enabling technologies. There is a proverb 'If the pot is empty, what will come in the ladle?'.

What would India manufacture under the 'make in India' initiative? Softwares? Cell phones? Assemble computers? Telemedicine gadgets? Convert to a digital world? Masses will of course get gainful employment. We will become bigger and bigger back offices. We will be the biggest consumer market for the investor, which we should not grudge. Any down turn in political relationships can lead to denial of technologies and even sanctions, which we have experienced. Can we make a new drug? Can we usher in a new material to replace silicon? Can we get rice and wheat crops to give at least 50% yield, when it is drought all over? Ease of doing business in India should include modernization of regulatory systems, be it the DCGI to approve a clinical trial or the Environment Ministry to approve GM crop trials. It is not enough to facilitate patent filing. I got a US patent in 5 years. After 10 years the Indian Patent office is in the evaluation mode of the same patent. When will the government increase investment in scientific research to 2% of GDP?

Our universities are in shambles in terms of research. Hardly two dozen universities out of close to 700 have a semblance of good research. That is why our national laboratories, which are supposed to convert basic science into products, function like universities opting for blue sky research. Paper publication and generation of Ph Ds cannot be the only goal. Can our recognized bright stars leave the comfort zone and ask risky questions? The innovative basic science has to be converted to products through industry interaction. The start-ups provide a great opportunity, if they are protected through government and private investor schemes. It is refreshing to see young men and women opting to set up knowledge-based industries, but I only hope it will be beyond innovation in Facebook, Twitter and mobile Apps.

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