# The problem of growing science in developing countries

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On the ninth centennial celebrations of the University of Bologna, on behalf of the academies and the scientists of India, I greet this ancient seat of learning, the *alma mater* of many European scholars like Copernicus, Galvani and Marconi who transformed our ways of thought and life. Being in the heart of Italy let me also pay tribute to the Italians who enriched us in India—the Romans who traded with us from time immemorial, the travellers who reintroduced the forgotten knowledge of India to Renaissance Europe, the scholars who delved into our Tamil language, and the teachers and the missionaries who exposed us to Western education. Let me also thank this city and its fathers, the Collegium Ramazzini, and the New York Academy of Sciences for this bold experiment of inviting the academies of the world to a convocation to discuss the issues of the next century. I am amongst the few here from developing countries. I have been persuaded that, instead of presenting a technical paper, it may be more profitable if I were to discuss (even if it be impromptu) some of the problems we in the developing countries face; and these may perhaps be amongst the more important scientific and human issues facing us in the next century.

## The coming in of the new sciences

I shall start with an incredible story of why the British introduced Western education into India. They needed clerks who could understand English. Lord Macaulay decided to kill two birds with one stone. Expose the Indians to the English language and English Law; the majesty of the former and the dignity of the latter cannot but produce a sense of inferiority in the Indian! Because of this notorious 'minute' in history a multitude of colleges were started in India; the missionaries too came and established many schools and colleges, culminating in the formation of the early modern universities.

Said Thomas Paine: Such is the irresistible quality of truth that all it asks and all it wants is the liberty of appearing.

What Paine said of truth applies equally well to education and the British had allowed education the liberty of appearing.

Years passed and Sir Richard Temple, a later representative of Britain in India, felt that the Macaulay method had not been entirely successful. Indians still tended to display a sense of equality with British learning. He stated that

> . . . Indians should therefore be exposed to an education of the practical sciences, which is a special preserve of Western culture. These disciplines with their exact method will overwhelm the Indian mind and induce the requisite sense of inferiority.

This is a strange idea considering the traditions India had in technology.

Herodotus talks of some 'wild trees cultivated in India which bear wool' from which Indians made clothing of such delicacy and fineness. Europe looked upon India as experts in every line of *manu*facture, wood work, ivory work and metal work; the Romans thronged the markets of Dravidian India and Pliny condemned the vast sums of money spent on Indian silks and brocades, muslins and cloth of gold, spices and perfumes (and even cheetahs, elephants and peacock feathers). The West looked on India as the most skilled nation in the 'chemical industry'—bleaching, dyeing, tanning, soapmaking, fireworks and cement; Indians were skilled in mining and metallurgy (copper, zinc, tin, gold, silver and iron). The tempering of steel was brought to perfection in India and the secret of the sword of Damascus came to the Arabs from India. Bernier says that India was humming with industry in the seventeenth century. But India could not fight history when the Industrial Revolution came. Europe carried out many of these processes more cheaply and on a larger scale and the flourishing Indian industry was overshadowed and Indian technology declined. But the introduction of education 'in the practical sciences' by the British had therefore a salutary effect on Indians and India.

Nor should we confuse the diabolical intention of the British government with the remarkable individuals who came to India from Britain—men like Sir William Jones who was administrator, scholar, indologist and humanist who discovered India for himself and made the West (and what is more, Indians themselves) become aware of the rich heritage of India: her philosophy, her literature, her arts—painting and sculpture—and even her traditions in science and technology. It was he and men like him who formed the first modern Academy in India in 1784, the 'Asiatick Society of Bengal' (now Asiatic Society of India) to embrace all sciences and arts.

It is also difficult to say whether Sir Richard Temple's 'minute' was prompted by the desire of Britain to exploit India and her resources. In any case to do this the British had to bring in Western science and technology: the railways for transport of troops over this vast land, then the 'surveys'—land, geological, forest, agricultural, botanical, fishery and so forth. Consequently Indians got trained in these new techniques and sometimes even excelled in them.

Slowly Western science took root, a process aided by the British scientists in India. Important contributions made by them include the discovery of the principle of isostasy in geophysics (Pratt), the discovery of helium in the Sun during a total solar eclipse, the design and fabrication of precision survey instruments (Everest), the researches

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into the urban civilizations of India three millennia before Christ (Wheeler, Marshall and others), the nature and physics of sunspots (Evershed), the close relationship of Indian (and world) climate to sea surface temperatures (Walker), the cause of malaria (Ross), and the vaccine for bubonic plague (Haffkine). These are just a few of the discoveries made by men who were devoted to India and Indians.

Then the inexplicable fever which comes to all human beings in bondage—to be free—gripped Indians, and many men of destiny appeared, including the incomparable Mohandas Karamchand Gandhi. This phenomenon of throwing up great ones also happened in the arts, literature, poetry and in science too. I shall just mention a few in science: J. C. Bose (a contemporary of Marconi), who in 1895 discovered millimetre electromagnetic waves; the genius S. Ramanujan, who streaked across the firmament of mathematics like a shooting star; M. N. Saha, with his pioneering work on the spectra of stars; S. N. Bose, with his quantum statistics and after whom a class of fundamental particles are named *bosons*; and C. V. Raman, with his remarkable researches in acoustics and optics and his discovery of the Raman effect for which he was awarded the Nobel Prize in 1930. When the reknowned German physicist Sommerfeld came to India in 1929 he opined that India was an equal partner with the West in science. It was also in this pre-Independence era (1934) that the Indian Academy of Sciences was formed by Indians because

> the conviction that research is civilization and determines the economic, social and political development of a nation has not yet been unreservedly accepted as a part of the administrative policy of India.

## Science and technology in India after Independence

Independence came in 1947. For a brief period the Indian subcontinent went berserk and brother killed brother. But Independence also brought in the vision of Nehru:

> Science is the very texture of life. It is science alone that can solve the problem of hunger and poverty, of insanitation and illiteracy, of superstition and deadening customs.

Nehru made science a part of the administrative policy of India'. His was a magnificent obsession and the country and its scientists responded to it.

The first problem tackled was that of food. When the monsoons failed, famine stalked the land, and millions died. Our worst was the Bengal famine of 1943—during World War II—a famine said to be man-made, when three to six million Indians died, equalling the number of deaths in the Second World War. Such was the dread of starvation that Gandhi said: The test of our country, when we are free, is not the millionaires we produce but the absence of starvation amongst the masses.

The green revolution was ushered in by first importing thousands of tonnes of hybrid seeds and by systematic application of the scientific method. Since then we have had droughts, yet few have died of starvation due to them.

It is not my intention to recount all the steps taken during the Nehru era. How we chose the path of science and technology, how we searched and found oil on land and offshore and exploited it; how we chose satellite and space technology as the least expensive method of education and communication, how we constructed mighty multipurpose dams, how we started hundreds of laboratories in various fields of pure and applied research, how we chose the way of nuclear energy, how we established factories, how universal school education was introduced with partial success and how in states like Kerala which took advantage of it, literacy amongst men and, more important, amongst women shot up (with the consequent decrease in these states in infant and maternal mortality and even the rate of population growth).

We did face a million problems. The universities were greatly weakened by its scientists migrating to better-paid positions in the newly started research laboratories, creating a serious man power problem for the growth of science and technology. To counteract this, the 'aid' given by the Western countries was used to start institutes of technology. These produced some of our brightest engineers, who promptly emigrated to Western countries, which conveniently changed their immigration laws to attract them. Doctors went over and became the mainstay of the Medical Service in Britain. Critics said that Western countries seemed to find it cheaper to give aid to India (to get highly trained scientific and technical personnel) than to mount their own expensive educational programmes at home. Humanist scientists (like Dame Kathleeen Lonsdale) protested, but to no avail.

The choice of high technology appeared quite promising because of the immediate gains. The multipurpose dams irrigated large tracts of land and also produced power. At that time their environmental effects were not assessed, and there was no dearth of food. The whole of India was dotted with scientific and industrial laboratories and a variety of factories manufacturing fertilizers, pesticides, petrochemicals, pharmaceuticals, iron, steel, aluminium, electronic goods, television sets, telephones, machine tools, cars and aeroplanes. Some of our products sold well in foreign markets, although there was much scope for improvement in quality. Our blue-collared technicians who went in numbers to work in the Middle-East filled our coffers with their repatriated earnings while our white-collared scientists and engineers who emigrated adorned the universities, laboratories and industries of the West and were honoured by us as our ambassadors (and not thought of as prodigals).

## Newer pathways

Gandhi once said: The contrast between the palaces of New Delhi and the miserable hovels of the poor must not last after we are free.

Four decades after Independence, poverty is still rampant, and the contrast between the rich and the poor is more marked. As our science grew, our population grew even more, negating all progress we made. Our per-capita income appeared to increase, but after discounting for inflation and 'debt servicing', one was not too sure.

During this period the belief began to grow that copying the Western model may not be the best solution for India and that new patterns have to be evolved by looking into our problems in depth using science. I shall relate some instances of these 'smaller' ways of viewing these problems.

Let me start with the touching story of the children who seemed to absent themselves from the free-school of their village. A probe revealed that these

infants were literally 'hewers of wood and drawers of water' since they spent their day collecting firewood for the kitchen and bringing drinking water from a well two miles away and so had no time for school. When a biogas plant was set-up using the dung of the village cattle and cooking gas was supplied to each house and it also ran an engine to pump water from the distant well, the school room got filled with bright-eyed children!

Almost 60 to 70% of the population of India (400–500 million people) uses firewood for domestic cooking. Even in large cities like Bangalore with its 3–4 million population (whose parochial inhabitants, like me, call it the scientific capital of India) with its 'all-electric homes' and plentifully available liquid petroleum gas (LPG) for cooking, uses 1200 tonnes of fire wood per day hauled from distances of 100 to 500 km, destroying 10 to 20 hectares of forest every day. To reduce this deforestation, as well as the time and effort of gathering wood, two methods were attempted. The first was to improve the cooking stoves using the most modern engineering design practices, rather cleverly keeping the external form almost identical to the conventional ones, but increasing the efficiency two- to three-fold. So effective were these that it is gaining rapid acceptance and almost a million of these are in operation all over India, decreasing the wood consumption by almost a factor of two. The next method was to convert nonusable biomass into usable forms of fuel. By generating power by (i) briquetting combustible garbage, and (ii) using gas to drive outdated airplane engines (primarily produced for defence purposes) it is estimated about 20% of the domestic electric consumption of a city can be satisfied—a truly modern version of Isaiah's vision of beating swords into plowshares and spears into pruning hooks. A more ambitious scheme (the feasibility of which has been established) is power generation from gasified agricultural wastes, sugarcane bagasse and even the millions of tonnes of leaves that our deciduous trees shed with wasteful abandon. (Some question the advisability of the last method, which deprives soil of its natural nutrients.) The relentless solar heat with which we are blessed is being used to heat water or air for industry where low-quality heat is required. Here again, by the use of high science, one of the best low-cost solar absorbers with an optimum absorption-to-emission index has been produced by electrochemical means.

Another aspect connected with urban and rural housing is manufacturing consolidated clay bricks with hand-operated machines on site and improving their quality and strength by proper additives to compensate for deficiencies in the local clay compositions (again saving fair amounts of fuel and energy) and also developing the necessary civil engineering protocols. Modern design concepts were used to improve the traditional handlooms, increasing productivity by 80–100% and bettering the quality of the product so that even simple jacquards and traditional patterns and many of their variations can be easily woven. New methods of distributing such products and technologies by Western franchising methods are also being tried.

I shall now briefly touch upon some of our 'adventures' into biodevices since these are of some scientific and human interest. All our bone replacements are at present imported and the prices so prohibitively high that only the richest can afford them. Because of this, a group has evolved elegant concepts for bone replacements using inexpensive biocompatible composites whose elastic moduli and strengths can be matched with those of natural bone. If successful, this will be a boon to the hundreds of thousands of children who require bone replacements every year. Another area involved the development of blood transfusion bags. In rural areas a large number of women (estimated at a few hundred thousand) die every year in childbirth, many of them because of bleeding. To prevent this, an indigenous project of manufacturing blood transfusion bags was successfully undertaken and a factory established that produces millions of such bags of a quality comparable to that of imported ones but costing much less. One does not want to detail the sad story of the world manufacturers' attempting to kill this infant Indian industry by *dumping*, aided and abetted by Indian agents who get greater commissions!

## Some problems of growing science in India

Forty years have passed since Independence. It is time for us to look back and see whether we have committed any serious errors in our attempts to build up science in the country.

A strange psychological problem has cropped up. Because of the special importance attached to science in India, there is always the danger that scientists themselves will become arrogant in their judgement. For example, they have been known to show almost an irrational contempt for traditional technology without critically examing it. The Andhra cyclone in which thousands died and hundred of thousands were rendered homeless provides one striking example. A study showed that a majority of the more modern habitations with galvanized iron or asbestos cement roofing were destroyed, while strangely enough most thatched hutments remained intact. An indepth analysis revealed that the destruction of the more modern buildings was due to the well-known fluid dynamic principle, the Bernoulli effect, which causes large pressure differences between the inside and the outside of the building blowing *out* the roof. In thatched houses, however, air enters inside and equalizes the pressure on either side of the roof. The rougher elements of the thatch also cause eddies which again reduce the lift forces. Traditional technology is not necessarily a product of blind belief but often the crystallization of millennia of man's experience. It is said that to do good science, one must have humility, and it is good to remember that such an attitude of modesty can help convert the common man to be on the side of science.

Science has been 'sold' to the people by presenting it as a universal solver of problems—the 'cure all' of all our ills. The people of India have therefore been waiting for a miracle to happen through the magic of its scientists, the modern medicine men. This myth of science as the Great External Solver of all problems must be exploded People must realize that the science is not external to man but a part of him. When faced with a problem, man must take the initiative to set the processes of science into motion so that many can participate. I see no difficulty for the Indian mind to embrace this philosophy. The Indian is familiar with another similar concept in that to him God is not external to him but within him.

Further, the great Buddha 2500 years ago taught us the very essence of science

Believe not because books and manuscripts say so, believe not because it is your traditional belief, believe not because you have been made to believe it from childhood Reason it out carefully and after you have analysed it, if then you find that it will do good to one and all, believe it, live up to it and help others to live up to it.

## The basic sciences

Let me digress now, and expatiate upon the question of fundamental research. In the basic sciences India has not done too badly and her achievements are notable and on par with any in the world, at least in the fields of liquid crystals, solid-state chemistry, crystallography, astronomy, pure mathematics and theoretical chemistry. The inevitable debate as to the need to pursue basic science when there is so much poverty is ever present. The view that the community and the government has taken is that money spent on the basic sciences is so small compared to the total budget for science and technology (only 5%) and the returns so large that this investment is worthwhile; research is an essential component in the teaching and training of scientists and engineers so essential for the country and basic research is the only measure of the quality of science and scientists produced in a country and therefore one must not abandon this yardstick.

There are of course many problems to be faced. Most researchers consider that the playing fields of science are in the West. To compete adequately all research instruments are being imported and many scientific papers from India are published abroad. Science is international but these practices militate against the growth of peer groups that are so necessary for building up science and fostering a scientific community. As a strong critic says: Indian research will then tend to follow the fashions set elsewhere and Indian scientists may become just camp followers of the West.

## Hunger and poverty in developing countries

Before our Independence Nehru wrote: For a hungry man truth has little meaning He wants food and India is a hungry-starving nation'. India even now continues to be a hungry, starving nation· Why? In spite of increased food production, to which we referred, the number of hungry people in India and the world is growing because of increasing income inequalities *between* countries and *within* countries. Millions of poor round the world do not have access to food because they lack the purchasing power! It is just a question of poverty. So we have the paradox of global food surpluses reaching record levels while at the same time there are vast pockets of growing hunger around the world. The argument that the so-called hungry of the world have 'culturally adapted' themselves to low intakes of food is puerile and easily refuted by the record of infant and child mortality. Hunger is the major problem of the world today.

It is estimated that a third of the world's population (that is, 730 millions) are afflicted with chronic hunger, of which 64% live in South Asia and 23% in Africa. Then there are also the problems of urban slums and malnutrition. Almost 40% of the population of cities like Bombay and Calcutta in India are living in urban slums. By 2000 AD, of the billion people in India, the urban population will exceed 300 million and more than a hundred million of these will live in slums. Since these slums can become a source of political unrest, governments would spend disproportionately higher proportion on the urban sectors than on the larger rural sectors. Further, developing countries will also have to tackle the problem of an ageing population. Countries will face the painful choice of apportioning their meagre resources between the young and the old and between the rural and urban poor.

Poverty—the ultimate degradation of a human being—will therefore stalk the earth. Bernard Shaw called poverty a crime. But to eliminate it seems to be almost impossible. And unfortunately many in developing countries are becoming too proud to ask for help, not realizing that this poverty is not all their fault. We must also remember that 'no man is an island unto himself' and world poverty is also a problem of the affluent. It is a problem for humanity to solve.

At the Stockholm environmental conference Indira Gandhi declared that poverty was the greatest pollution on this world. Just as we think of the ozone hole, the heating up of our planet, the destruction of the rain forests, the poverty of 60% of humanity is humanity's problem

## Bhopal and the suspicions it has aroused

Then came Bhopal—the greatest man-made environmental disaster caused by the flagrant violation of all norms of environmental control. Three thousand people died and two-hundred thousand are still lingering in pain and about twenty thousand mentally and physically handicapped babies were born in the last five years. Truly, humanity was outraged. No wonder our young lost confidence in the methods of the industrial West. They saw in it the deliberate destruction of the environment mostly by greed, by general ignorance and by overconfidence in the powers of science. The pattern the developing countries, including 'official India', has been following is the dominant model of growth, provided by the industrial nations. Some in India have become suspicious of it and ask the question.

Is not economic growth a cancer destroying this fragile planet; for every unit of growth, there is an increasing amount spent solving the problems of pollution and environmental degradation *generated by growth itself*?

The industrial nations have to sell to the Third World so that they themselves can grow! And what do they sell to us—arms in plenty and petrochemicals and pesticides that they themselves are not permitted to use in their own countries and drugs and pharmaceuticals that are banned in their countries!

The pernicious doctrine of market-driven forces is destroying the world—the doctrine that has made half the food-producing lands of the developing world grow tobacco. The developing countries are also learning and benefitting from this awful doctrine. They satisfy the 'market demands' for drugs by affluent youth in the United States by growing and producing these dangerous drugs in their own countries and smuggling them into the developed countries. We wish that the West would realize the harm done by the same 'market-driven forces' which they often glorify.

The other day I read in a scientific

journal that parts of a foetal brain, if implanted in the brain of a patient with Parkinsonism, would cure this degenerative brain disorder. My immediate question was: What is to prevent a poor woman from aborting, to provide, for a price, human embryos for the benefit of patients of this disease?

The United Nations Annual report on children reads like a catalogue of a chamber of horrors:

Children are condemned to inhuman existence, trained to pursue criminal activities and even utilized for the purposes of organ transplants.

The problem of human foetuses' being sold for pharmaceutical and cosmetic industries must be investigated and stopped.

Forty thousand children are dying every day—nearly one every two seconds. The cost of immunization would be less than 2.5 billion US dollars—much less than what United States companies are spending on cigarette advertisements.

The Third World governments are allocating half their spending to armaments and 'debt servicing'. A 5% diversion of military spending of all the nations of the world will provide 50 billion US dollars a year, the amount needed to end absolute poverty on the planet within the next ten years.

The promises of biotechnology for solving the problems of the future through increasing agricultural productivity, enhancing the efficiency of photosynthesis, new tissue culture techniques, reclamation of poor soils and the control of communicable diseases may never reach the common man. The West has gone in for commercialization and privatization of biotechnology research, which is shrouded in secrecy. Scientists must take a lesson from Marie Curie or C. V. Raman, who spurned offers to patent their discoveries. The powerful multi- and transnational corporations in industrial countries, supported by often pernicious university–industrial complexes, provide ample ground for the growing fear that biotechnology may not be for the good of humanity, but for very small science-based groups in the West.

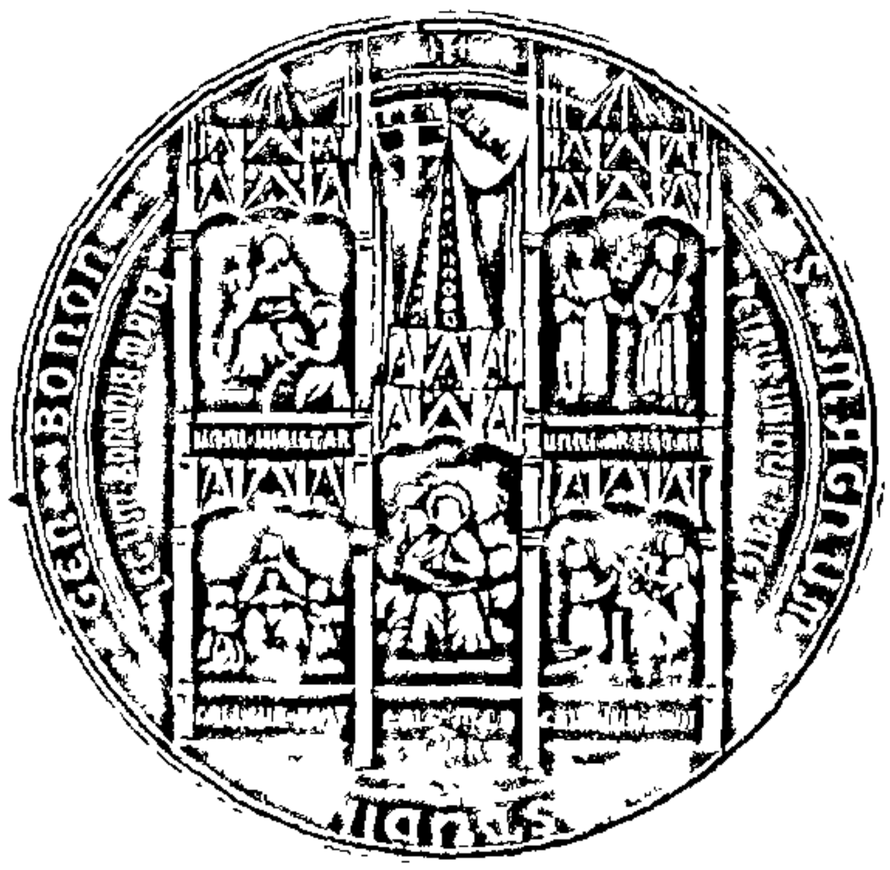
There is yet another great injustice. The developing countries provide rich plant genetic resources for the whole world. These results were freely collected without any compensation through gene-hunting expeditions from the industrial countries. It is therefore frightening that the powerful seed industries located in industrial countries are seeking patent protection for the plant genetic varieties that they are developing from resources they appropriated free of cost and compensation under the euphimistic umbrella of 'common heritage'.

## The role of the academies

I have posed some of the problems of the growth of science in India and in other developing countries—the difficulties that have to be faced and the suspicions that have to be overcome. Many forms of confrontation are created because of greed and because of poverty and hunger. This may happen within individual countries and between countries. Instead of building up a happier and more equitable world, science may become a powerful tool for the domination of the many by a few. We must prevent a neocolonialism from raising its ugly head with the backing of science—organized either by irresponsible nations or by transnational commercial interests. This is therefore *not* the time for scientists and academies to sit back and say fatalistically: 'Science is neutral and it is the manner in which science is used and applied by others that makes it ultimately beneficial or harmful to mankind'. The academies cannot wash their hands as did Pontius Pilate and send humanity to be crucified. The time for action has come. The scientists and the academies of the world must stand up and speak. When humanity cries out 'Who is on my side? Who?' if the scientists and the academies do not respond, what use is the value of truth which they profess to pursue? Therefore, I plead at this Convocation of World Academies held in this Ancient University: 'Academies of the world unite. You have nothing to lose but your ivory towers. You have a world to gain—the well being and the gratitude of suffering humanity.'

Let us remember the words of C. V. Raman:

> Academies of Science are not ornaments but indispensable institutions for directing the destinies of Humanity.



# Scientific Issues of the Next Century

*Convocation of World Academies*