Mahatma Gandhi Memorial Oration

Building Borderless Minds and Borderless Thinking

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I am truly grateful to the Centre for Human Values for having invited me to deliver the Mahatma Gandhi Memorial Oration. It is indeed a special honour. I am also privileged to be in the campus of Indian Institute of Management, Calcutta, a great institution, which is the pride of India. I have given many orations but none so far that was linked to the name of Mahatma Gandhi, our great Father of Nation.I am, therefore, truly beholden to all of you.

Mahatma Gandhi was a world leader, a visionary, a Yug-Purush. As a scientist, I am tempted to attempt a definition of Yug-Purush. The American thinker Thoreau said, " A man is wise with the wisdom of his time only, and ignorant with its ignorance". This is true of people like me because we are ordinary people. A handful of people appear amidst us once in a while, who prove exception to this rule. At one level, these exceptional people are products of their time. But at another level they transcend their times. Their perceptions, their insights, their concerns are truly universal, in time and space; they are neither constrained by the circumstances of their birth nor are they limited by the ignorance of their time. Mahatma Gandhi is one such exceptional transcendental Yug-Purush, who belongs to all Yugas. In today's times of turbulence and violence, his thinking, his teachings and his philosophy are even more relevant. I, therefore, appreciate this opportunity to pay my humble tributes to him.

Modern scientists may not realize it, but they are followers of Gandhi in one fundamental respect. Gandhi campaigned for simplicity. The hallmark of great science is indeed simplicity. Equations like E=mc2 or F=ma are path-breaking, simply because they are so simple. Unfortunately, when it comes to harnessing technology for life style, things become more complex and complicated.

My oration today is influenced by a very profound statement that Gandhi had once made. He said, *"I do not want my house to be walled in on sides and my windows to be stuffed. I want the cultures of all the lands to be blown about my house as freely as possible."* Gandhiji implied that our mind should be open and uninhibited. It should be open to new ideas and new thinking. There should be no artificial boundaries and walls or borders between the people. A borderless mind and borderless thinking alone can lead to a borderless world.

I wish to develop this theme of borderless minds and borderless thinking in my oration. Being a scientist, the experience, examples and lessons that I will draw will repeatedly make a reference to scientific and technical issues. However, I do believe that at least some of the lessons will be truly generic.

Science is built on facts. Scientific knowledge is proven knowledge, it is objective and verifiable knowledge. Hence it is considered to be reliable. In essence, the scientific method consists of careful observation of nature and cautious confirmation of all conclusions. Good science excludes all unsubstantiated hypotheses. Observation and experiment are the methods of science. As new observations are

added to the total body of scientific knowledge, some of the older observations lose their relevance and become obsolete. This dynamic aspect of science is perhaps its most outstanding attribute.

We need to recognize that scientific knowledge generated in formal laboratories is not the only knowledge system. There is knowledge generated in the 'laboratories of life' by people over centuries. Many societies in the developing world, like India, have nurtured and refined systems of knowledge of their own, relating to such diverse domains as geology, ecology, botany, agriculture, physiology and health. We are now seeing the emergence of terms such as 'parallel', 'indigenous' and 'civilizational' knowledge systems. Such knowledge systems are also expressions of other approaches to the acquisition and production of knowledge. The process of globalization is threatening the appropriation of elements of this collective knowledge of societies into proprietary knowledge for the commercial profit of a few. These fragile knowledge systems need to be protected and enhanced through national policies and international legislation, while providing its development & proper use for the benefit of its holders.

As a student of S&T, I must confess that there has been an arrogance associated with S&T and their practitioners. We have not shown enough respect for the long drawn empirical and thoughtful process by which men and women through generations have gained knowledge about nature around them, with a view to benefiting from it. These men and women over millennia transformed their fear of nature into love and respect. May be they had no choice, constrained as they were by the limitations of their own muscle power and that of their livestock.

Today, we practice science within a prescribed framework of rigorous norms and rules. We reject traditional knowledge as extraneous. We have created walls between the traditional knowledge and modern science. Why have these walls been created? During the colonial period of the world history, which was also the period of phenomenal growth in S&T, science was perceived, projected and accepted as an essential feature of the western civilization. An unfortunate and retrograde corollary of this was that modern scientific knowledge was seen as an adversary of traditional wisdom and traditional knowledge. The two were seen as mutually exclusive, as traditional knowledge was something unscientific, as if traditional knowledge was darkness itself waiting to be dispelled by the light of modern science. This has been a regrettable syndrome, because it had the effect of belittling the intellect and wisdom of vast fraction of the world's population and the heritage of the whole humankind. We know better today. Or at least we should. Science is not a series of bore wells or puddles. It is a running stream. It represents a cumulus of systematized knowledge. All societies have all times have painstakingly acquired and accumulated useful knowledge about their environment for their physical well being. To them, it was science, even if they did not use the terms.

Indigenous knowledge systems cannot be treated in the same way as we do knowledge systems based on modern science. The subtleties associated with the culture and ethos of the society, who are the holders of this knowledge, must be understood. Such knowledge systems must be sustained through active support to the societies that are keepers of this knowledge be they villagers or tribes, their ways of

life, their languages, their social organization and the environments in which they live. We need innovative ways of preventing the erosion of such knowledge, which usually vanishes with people. Equally importantly, we need an in-depth analysis of the parallelism of insights between the indigenous knowledge systems, on the one hand, and certain areas of modern science concerned with fundamental aspects, on the other. Our university education and research needs to shift the search light on this important issue, which it has neglected so far.

It is only now that we are bringing to see the benefits of bringing down the walls between the two domains of knowledge. Let me cite an example. It pertains to a medicine that is based on the active ingredient in a plant, *Trichopus zeylanicus*, found in the tropical forests of southwestern India and collected by the Kani tribal people. Scientists at the Tropical Botanic Garden and Research Institute (TBGRI) in Kerala learned of the tonic, which is claimed to bolster the immune system and provide additional energy, while on a jungle expedition with the Kani in 1987. A few years later, they returned to collect the samples of the plant, known locally as a*rogyapacha*, and began laboratory studies of its potency. These scientists then isolated and tested the ingredient and incorporated it into a compound, which they christened "Jeevani" – giver of life. The tonic is now being manufactured by a major Ayurvedic drug company in Kerala. In November 1995, an agreement was struck for the institute and the tribal community to share a license fee and 2% of net profits. The process marks perhaps the beginning of the healthy respect that the practitioners of the modern science are developing for holders of traditional knowledge.

Thomas Henry Huxley said in 1881 "It is easy to sneer at our ancestors – but it is much more profitable to try to discover why they, who were really not one with less sensible persons than our own excellent selves, should have been led to entertain views which strike us as absurd". It is in this spirit that we should build a borderless mind, which connects the past with the present. The idea is not to 'recreate' the past but 'understand' the past by using new science.

Bharatiya Vidya Bhavan had launched in 1977 a project entitled "Ancient Insights and Modern Discoveries", which was a national cooperative endeavour to explore the possibilities of meaningful correlations of ancient ideas and concepts and modern scientific discoveries. Modern scientific discoveries are made without any regard to the clues that flow from our ancient wisdom. Here is a brilliant example.

Among scientific journals, *Science* and *Nature* are perhaps the most prestigious. Real breakthroughs find a place in these journals. T.L. Lentz and colleagues reported in 1982 in *Science* that acetylcholine receptors may serve as receptors for rabies virus. In *Sushruta Samhita,* the ancient Indian Classic on the Science of Life, there is a fascinating account of *Datura* as a prophylaxis for rabies. The active principles of *Datura strammonium* are atropine and related alkaloids that predominantly block the muscarine action of acetylcholine, precisely what was discovered by Lentz and others thousands of years later. In view of Lentz's findings, *Datura* for rabies may represent the first documented example of prophylaxis by receptor blockade. However, the use of *Datura* was found by people centuries ago, who

were not trained in modern science. On the other hand, modern scientists had no clue about the work reported in *Sushruta Samhita*. How do we build the bridges between the two? I do believe that the recent initiative by the Government of India to build the 'Traditional Knowledge Digital Library' will provide this bridge.

What is this initiative? You will all recollect the patent on wound healing by turmeric that was granted by United States Patents & Trademarks Office (USPTO). CSIR fought this patent by showing that this was ancient wisdom known in India. In a landmark case, the patent was revoked. But large number of US patents has been granted on the ancient wisdom in India. To prevent its repeated recurrence, a solution was found, which has reached an international acceptability now. The Indian Government has taken steps to create a Traditional Knowledge Digital Library (TKDL) on traditional medicinal plants and systems, which will also lead to a Traditional Knowledge Resource Classification (TKRC). Linking this to internationally accepted International Patent Classification (IPC) System will mean building the bridge between the knowledge contained in an old Sanskrit *Shloka* and the computer screen of a patent examiner in Washington! This will eliminate the problem of the grant of wrong patents, since the Indian rights to that knowledge will be known to the examiner. Hopefully, wrong patents on Turmeric, Neem, etc. will be the things of the past!

Eventually the creation of TKDL could serve a bigger purpose in providing and enhancing its innovation capacity. It could integrate widely scattered and distributed references on the traditional

knowledge systems in a retrievable form. It could act as a bridge between the traditional and modern knowledge systems. Availability of this knowledge in a retrievable form in many languages will give a major impetus to modern research in the developing world, as it itself can then get involved in innovative research on adding further value to this traditional knowledge; an example being the development of an allopathic medicine based on a traditional plant based therapeutic. Sustained efforts on the modernization of the traditional knowledge systems of the developing world will create higher awareness at national and international level and will establish a scientific approach that will ensure higher acceptability of these systems by practitioners of modern systems and public at large.

Protection of knowledge based on ancient wisdom is only a limited issue. The bigger issue is to add value to our lives by creating a synthesis between ancient wisdom and modern science. Let us pursue this point further. Consider Ayurveda, which literally means 'science of life'. It encompasses the total sweep of life sciences and pursues the quest for understanding life in all its ramifications. 20th Century has revealed some of the greatest insights into our understanding of life at increasingly higher levels of organization – molecular, sub-cellular, organelles, cells, tissues, organs, organisms, species and ecosystems –the most remarkable feature of modern medicine is its close integration with the basic sciences – physics, chemistry and biology. Unfortunately these two domains of knowledge, namely traditional medicine and modern medicine have remained isolated from each other.

The World Health Assembly in 1977 evinced considerable interest in traditional systems of medicine and their promotion and development; the need to evaluate and validate their therapeutic claims on modern scientific principles was emphasized. After visiting the Central Institute of Research in Indigenous Systems of Medicine at Jamnagar on 2nd November 1955, Pandit Jawaharlal Nehru observed – " *A fascinating inquiry is going on in this research institute and it may well lead to very fruitful results. The only right approach has to be one of Science, that is, of experiment, trial and error. In whatever type of medicine we may deal with, we cannot profit by its study unless we apply the method of science. Nothing should be taken for granted. Everything should be tested and proved and then it becomes a part of scientific medicine – old and new."* Unfortunately this message was lost. Some fresh ground is being created only now. Let me explain this with an example.

CSIR happens to be the largest chain of publicly funded industrial R&D institutions in the world. We are a formal system of innovation and we had closed our mind to informal systems of innovation. But we are changing now. I will cite an example to illustrate the point. It concerns our twenty laboratory networked program on discovery of bioactive molecules for their use as drugs and therapeutics. Our research is based on the clues that we get from our vast plant based traditional medicine systems including Ayurveda. For the first time, CSIR forged relationships with Indian traditional systems of medicine, namely Ayurvedic and Siddha systems. I still remember that when CSIR signed the MOU with Arya Vaidyashala in Kottakal, Professor Valiathan, who brought both the partners together, said, *"This is a holy place where two rivers are meeting; the river of traditional*

knowledge and ancient wisdom represented by Arya Vaidyashala and the river of modern knowledge represented by CSIR." The only question I asked myself was that why did it take almost fifty years after the prophetic words by Nehru for these two rivers to merge? I believe this is because we did not heed the advice of Gandhiji and we 'walled our houses on all sides and stuffed our windows'. These windows are now opening up. It is only by fusing the ancient wisdom and modern science India can create world class products, because new products cannot compete with products, which have only tradition and empirical observation as the knowledge base. The knowledge to be integrated into the traditional products has to emerge form modern science, especially modern biology and chemistry. Such fusion will lead to better definition existing products, improved understanding of the mechanism of their action, modified compositions at molecular level and better understanding of interactions amongst various molecules.

What would be the most fundamental change required for breaking the walls and opening the windows? I believe it is going to be that of mutual trust, respect and confidence between the practitioners of modern science and the holders of the ancient wisdom. This has to get reflected in several ways, including the choice of research problems. We had Professor Ernst, the Nobel Laureate, give the Science Congress plenary lecture in Pune in January 2000. He described the work on getting a molecular level understanding of the Chinese system of 'acupuncture' by using the latest advanced tools in high resolution solid state NMR. You can see that the western scientists are scientifically probing the ancient practices of the East! Whereas our own Indian research is invariably focussed on the left

over problems of the west. We will need an attitudinal change in reconsidering our choice of problems and also a change in our value system.

We need to break some other walls too. Technologies developed by local artisans, craftsmen, potters, farmers, weavers, etc. are considered as traditional. These technologies are never included in the fabric of modern technology. Again a change of mindset and value systems is required. I tried an experiment in Pune during the Indian Science Congress in January 2000. As President of the Science Congress, I said let this Science Congress be 'knowledge congress'. Let it be 'people's congress'. We will show that we value people's knowledge. We had several grass root innovators participate in our science exhibition. They demonstrated their technologies. None of them spoke English. We had a session, where they made a presentation on their technologies in local languages to around 2000 scientists. They stood on the same platform from which the Nobel Laureates spoke. I must say that they got a bigger applause than even the Nobel Laureates. I believe the scientists, for the first time, realised the power of innovation that takes place in the field. They also saw the innovative and creative abilities of those, who were unadulterated by the modern day educational system. Can this realization now turn to respect and then to meaningful partnership? CSIR is forging such partnerships. Let me share one of them with you.

A village called Athaoni, on the border of Maharashtra and Karnataka is the place from where Kolhapuri chappals come to us. They were till recently made by age-old traditional technique. Our scientists from Central Leather Research Institute (CLRI), Chennai studied this and

helped to reduce the processing time from 30 days to 10 days through application of some innovative science. The stamping process was standardised, certain innovative changes in design, based on fairly sophisticated computer aided techniques, were made to give more comfort to the wearer. But this 'inclusion' of modern science was done gently and subtly, so that it will not be interpreted as 'invasion' on traditional practices, which had gone on for several generations. The oldest man in the village was consulted. He was convinced that the age old traditions must change. Today several hundred artisans have been trained by CLRI. This has not only enhanced the family incomes of the villagers but also changed their perception of science, development and change – in short, a micro social transformation. For us in CSIR, we have realised that it is not techno-economics alone, but also socio-economical & socio-cultural aspects, that we need to be conscious about when we build a bridge between traditional craft and modern science.

To encourage communities, it is necessary to scout, support, spawn and scale up the green grass root innovation to generate employment and use natural resources sustainably through linking of innovation, enterprise and investment. This requires building up adequate linkages with modern science and technology and market research institutions. In short, one needs new models of development, employment generation and conservation of natural resources. In this connection, one looks with hope to organisations like Gujarat Grassroots Innovation Augmentation Network (GIAN). GIAN has attempted to set up venture capital fund for small innovation providing for its linkage with R&D and scaling it up into viable enterprise. National Innovation Foundation set up by the Government of India has

launched several programmes to support and encourage grass root innovators, and most importantly, to build the bridge between the grass root innovators and modern science.

If we look at the scientific knowledge domain, we find that borderless science has already arrived. We see that discrete boundaries no longer exist between various natural sciences such as physics, chemistry, biology, mathematics, etc. Explosive advances in adjacent sciences are shaping up the future of core disciplines. New paradigms of "seamless sciences" and even "seamless engineering" are emerging. Take as a specific example, sub-disciplines such as inorganic chemistry, biological chemistry, organic chemistry and physical chemistry. The 1987 Nobel Prize winning work of Lehn, Cram and Pedersen led to the elucidation of molecular recognition and to the whole new area of supramolecular science and engineering. This work was entirely possible, because they made the boundaries between these four sub-disciplines vanish.

Today, more than ever before, we not only need "borderless science" but also need "borderless thinking" for problem solving. Yet we find that we work and think in isolation. Let me illustrate this by taking up a problem that we encounter in our everyday life, namely mixing. Mixing is a challenge in diverse disciplines. In the case of astrophysics, one is concerned about the mixing of the interior of stars. In mechanical engineering, it is combustion. In environmental sciences, we are concerned with mixing and dispersion in the atmosphere. Oceanography deals with mixing and dispersion in oceans. Chemical engineers are concerned with mixing in chemical reactors. Physiologists look at mixing in blood vessels. Bioengineers

are interested in mixing and aeration in bioreactors. Geologists deal with mixing in the mantle of the earth. All these diverse mixing phenomena occur on diverse time and length scales, differing by several orders of magnitude. However, these disciplines rarely benefit from each other, and discovery & rediscovery of concepts and ideas is commonplace.

There are many instances, where one is trying to gain understanding of a common problem. Consider the issue of a human mind itself. As was pointed out by P.N. Johnson Laird, since the Second World War, scientists from different disciplines have turned to the study of the human mind. Computer Scientists have tried to emulate its capacity for visual perception. Linguists have struggled with the puzzle of how children acquire language. Ethologists have sought the innate roots of social behaviour. Neuro-physiologists have begun to relate the function of nerve cells to complex perceptual and motor processes. Neurologists and neuropsychologists have used the pattern of competence and incompetence of the brain-damaged patients to elucidate the normal workings of the brain. Anthropologists have examined the conceptual structure of cultural practices to advance hypotheses about the basic principles of the mind. These days one meets engineers who work on speech perception, biologists who investigate the mental representation of spatial relations, and physicists who want to understand consciousness. And, of course, psychologists continue to study perception, memory, thought and action. However, I have not seen a meeting of these computer scientists, linguists, neurophysiologists, anthropologists, engineers, and so on! Understanding of mind cannot be made possible without meeting of minds of all of them.

As I remarked earlier, we need to fuse borders between several disciplines, including those in natural sciences & social sciences. For this, we need to change our culture. We need to ensure that our mind moves through diverse disciplines in a borderless way. The ability to correlate and link the non-obvious can lead to major breakthroughs. I will like to cite an example, which will interest the students of management in this institute. Can you believe me, if I were to say that the supramolecular chemistry, which won the Nobel Prize in 1987, can be used to develop modern management structures? But this is precisely what is being done. Consider the issue of self-organisation in molecular systems by using molecular recognition. The organisation of molecules finally determines the structure, the properties and the functions. But is this not what we want in creating modern management structures to derive a specific end objective, or an organisational goal, or a function? Innovative efforts have been made recently to create flexible management structures by using the concepts of self-organisation in chemical and biological systems. It is called a van der Waals model of Management. It is indeed fascinating that the chemistry of the non-covalent band, or supermolecular chemistry, is being used to create modern management systems. This is a splendid example of borderless thinking. We need more of it.

An innovator is defined as one, who does not know that it cannot be done. Invariably, individuals who are unfamiliar with the discipline are also ones, who do not know that things cannot be done. Probably it is these individuals who will be able to give us conceptual breakthroughs through their unconventional thinking. Should we not, therefore, give

away the habits of protecting our turf? Should we not organise unconventional fora, where only club members belonging to a single discipline do not meet but those in seemingly unrelated disciplines meet?

We, in India need to seriously address several issues that hinder the creation of borderless minds and borderless thinking. They include our rigid academic curricula, our process of learning by rote, our rigid examination system based on a single correct answer, hierarchical structures in management, etc. Our systems promote inhibition and imitation rather than innovation. It is only in an environment, which fosters innovation that borderless minds can be formed and borderless thinking can flourish. Finally, we must recognize that innovation is not a uni-dimensional process. It is comparable to the intermeshing gears of a clock. The challenge before us is to make this intermeshing happen. It is only breaking up those walls and opening up those windows of mind will bring that fresh wind that will build the 'Innovative India' of our dreams.