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Quest for Scientific Temper

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PREFACE

India's Many Trysts with Skeptical Humanism

SEVERAL thousand years ago, when human thought rose to organize itself to understand the laws that govern the natural and moral universes, two divergent streams began to form. This was particularly true of our part of the world than any other, even at this early date, four thousand years before the present. One, more resilient than the other, argued in favour of supernatural forces, and wisdom received from these sources through divine intervention through teachers specially appointed and texts specially written, reinforced this teleological understanding of what was the beginning and the end of all phenomena. They even made the case for an all pervading spirit, ineffable and immeasurable, yet to be accepted as fact and truth.

Even in those days, the alternate route to truth was also emphasized, by many movements that we identify with the materialist tradition, the Samkhyas, the Carvakas, the Jains and the Buddhists. They arrived at the most parsimonious of explanations, that the moral and natural universe are one, that the same laws govern their operation, that understanding of causality is what allows truth to be sifted from fact. In effect they said, the removal of doubt using the instruments of reason and evidence, and the alleviation of suffering by compassion and humanism, were the most noble of all principles of right action. Thus, 2550 years ago, what the enlightenment philosophers re-discovered as skeptical humanism, was born in our part of the world.

Thus, when India re-gained independence on the midnight hour on 17 August 1947, Pandit Jawaharlal Nehru promised that India would keep its tryst with destiny by enshrining the following article of faith:

> *'To develop the scientific temper, humanism and the spirit of inquiry and reform' (Fundamental Duties Articles, 51-A (h)).”*

It is a given in the euro-centric world-view that reason originated with the Greeks. One factor that promoted this was that there has been an unbroken (or nearly unbroken) thread of continuity from the ancient Greeks till now, a world dominated for nearly five hundred years by European or North American powers.

To illustrate my point, let me quote from an essay by Andrew Baker, which appeared on 13 April 2008:

> *"The Ancient Greeks sowed the seeds of science. They invented science's golden rule – reason – to ask questions of the world. The Greeks asked, how do we know what we know?"*

From Thales, through Anaximander and Anaximenes, and then through Socrates, Plato and Aristotle, it is this legacy that is always emphasized. It is in echoing this spirit, that Whitehead once said that, "The entire history of western philosophy is a series of footnotes to Plato." Indeed, Plato attributed to Socrates, the famous saying, "The unexamined life is not worth living."

However, on closer examination, we find that the first person that reliable written historical accounts give credit to for emphasizing the primacy of using reason to conduct one's life was from our own part of the world. Gautama Budhha had said, "Do not take the authority

of the teacher or the text. Always, question yourself." He meant that one should not accept received wisdom but should always seek empirical evidence.

How do we know what we know? Seemingly, there are four irreducible steps. They are:

1. There is a phenomenon (something) that needs to be explained.
2. That this must have a cause.
3. That this cause can be found by the exercise of **reason**.
4. Having found the cause, one is then in a position to promote that phenomenon (if that is something we want) or eliminate that phenomenon (if that is something we do not want) by addressing the root cause itself.

Note the emphasis on **reason**. The other steps are commonplace and no one will be surprised by its appearance in this four-fold formula of logic. However, reason is emphasized, and not an appeal to the authority of teacher or text.

This four-fold logic is exactly the procedure that all trained doctors use in diagnosing an illness.

1. There is an affliction and the associated symptoms.
2. That this must have a cause.
3. That this cause (virus, bacterial, etc.) can be found by the exercise of **reason**.
4. Having found the cause, one is then in a position to eliminate that affliction by removing the root cause itself.

Again, one would find that the first person to use this four-fold logic was from our part of the world. And not one book that is commonly found and read seems to recognize that such logic was the foundation for one of the greatest religions ever invented.

This religion (if one can call it a religion) was unique in that it believed that a moral order could be found based only on reason and without recourse to the intervention of an Almighty. Unfortunately (or fortunately, who can tell in such things), the most recent evidence from evolutionary biology seems to indicate that groups that do not believe in reason but prefer to accept blind faith have greater chances of survival in the Darwinian sense. But again, a society that is based one hundred percent on blind faith is likely to destroy itself.

So it would seem that an optimal society would have a large number of the faithful and a smaller but crucial number of critical thinkers who are the insurers of its long-term survival.

About 250 years ago, in the tradition of western philosophy, emerged the great empirical philosophers, of whom, David Hume is well remembered for the positions he took on the issue of God, the eternal soul and the unalterable ego.

Empiricists believed that "there is nothing in the mind except what was first in the senses," that man has no "innate ideas...about the world we are brought into before we have *seen* it." Experience is the ultimate test.

These ideas were first expounded by our eastern sage, in almost exactly the same fashion, nearly 2500 years ago. Life “[was] an unbroken succession of mental and physical processes which keep people in a continual state of change”. “The infant is not the same as the adult; I am not the same today as I was yesterday. There is nothing of which I can say 'this is mine' and nothing of which I can say 'this is me.' There is thus no 'I' or unalterable ego.” To continue this idea further, there is no eternal soul, and no way to prove or disprove the existence of God. It was for this reason that it was imperative that any moral order should be founded on reason and not by appealing to an authority that went beyond reason.

We must keep in mind that the absolute truth may never be known but one can come closer and closer to it. Our ancient sage knew this 2,500 years ago. A learned man once said to him, “The things you teach, sir, are not to be found in the Holy Scriptures.”

“Then put them in the Scriptures,” said the sage.

After reflecting for a while, the learned man took courage and added, “Sir, some of the things you teach actually contradict the Holy Scriptures.’

“Then amend the Scriptures,” said the sage.

The authority of teacher and text can never be final. It is always provisional. So always add to or amend what is found in the fund of human knowledge.

So we have had long ago established a tradition of reason and wisdom that somewhere down the course of history, we neglected. Doubt, removed by reason and evidence, and compassion and humanism, is the twin-edged Occam’s razor for a fair and sustainable brotherhood of man.

Dr Gangan Prathap
Director, CSIR-NISCAIR

INTRODUCTION

The builders of modern India realized very soon after independence that, if the country had to develop and progress, a strong indigenous S&T base had to be laid down. This was echoed in the outlook of the first Prime Minister of the country, Pandit Jawaharlal Nehru, who laid great stress on science and technology as vehicles of progress.

Pandit Nehru also emphasized the need to inculcate 'scientific temper' — a phrase taken to mean an enquiring attitude and analytical approach that leads to rational thinking and the pursuit of truth without prejudice – among the country's citizens. Subsequently, a clause was added in Part IVA in Article 51A of the Constitution of India that lays out the Fundamental Duties, which reads, "it shall be the duty of every citizen of India to develop scientific temper, humanism and spirit of inquiry and reform".

The Science Policy Resolution of 1958 recognised the importance of "encouraging individual initiative for the acquisition and demonstration of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom". The S&T Policy Document 2001 also recognised "the growing need to enhance public awareness of the importance of science and technology in everyday life", and the special support of the Government "for programmes that seek to popularize and promote science and technology in all parts of the country".

Thirty years ago, in 1981, independent India released the first document articulating the need to inculcate the values of scientific temper in the Indian society to rid the country of its socio-economic ills at that time. It was named the 'Statement on Scientific Temper' (full text at Appendix 1). This document articulated the need to inculcate the values of Scientific Temper in the Indian Society to rid the country of its socio-economic ills at that time. The Statement was expected to usher in a movement—a second Indian Renaissance—in India to 'provide the necessary fillip for restructuring our country embodying the aspirations of our people'.

The debates and discussions on Scientific Temper that the Statement should have triggered, unfortunately did not take place in India, at least to the extent that the signatories wished. Scientific Temper remained largely confined to rhetorical statements. Sadly even social scientists did not make an effort to refine this concept or operationalise the concept for measuring/gauging Scientific Temper.

The scientific community cannot afford to close it eyes towards the fact that during the past 20 years there has been a marked increase in public display of religious identities, religiosity and wielding of religious symbols. Privatisation of the electronic media has also led to unabashed promotion of superstitions and non-scientific dogmas and notions through TV serials and the highly competitive news channels. It is being increasingly realized that in a democratic setup, where people's power not only makes and breaks governments, but also decides the fate of critical national projects, the progress of the country depends in a much large measure on the scientific temperament of its citizens.

It behooves us, therefore, to retrieve this concept before it is lost in the cacophony triggered by the changing scientific, technological and economic order. There was thus a need to revisit the 1981 Statement, look at the concept of Scientific Temper afresh and impart to the concept a renewed vigour.

It is for this reason that in its Diamond Jubilee Year (2011-2102), CSIR-NISCAIR got together with the National Council for Science & Technology Communication (NCSTC) and Vigyan Prasar of the Department of Science and Technology, Government of India to give a second push, so to say, to the concept of Scientific Temper in the country.

Having been in the business of science communication for the past six decades, NISCAIR took the initiative in this regard. First established as the Publications & Information Directorate

(PID) in 1951, NISCAIR has over the years carved out a niche for itself in the field of science communication in India. It is engaged in disseminating information to the scientific community through its 17 peer-reviewed research journals covering all the major disciplines of science & technology and two abstracting journals. It is also a repository of information on plant, animal and mineral wealth of the country through its encyclopaedic volumes The Wealth of India.

NISCAIR has also played a prominent role in popularizing science in the country through its three popular science magazines – *Science Reporter* (English), *Vigyan Pragati* (Hindi) & *Science ki Duniya* (Urdu) – all of which are well circulated throughout the country. The Institute has also brought out a large number of well-illustrated and moderately-priced popular science books on topics ranging from cells and genes to computers and artificial intelligence, from atom and materials to space technology and stars.

It was therefore in the fitness of things that NISCAIR took up the responsibility of propagating the concept of Scientific Temper throughout the country together with like-minded institutions such as NCSTC and Vigyan Prasar.

The efforts bore fruit with a *National Workshop on Scientific Temper* organized during 15-17 June 2011. Scientists from all over India congregated for the national workshop in Palampur in the hilly state of Himachal Pradesh to work out strategies to spread the spirit of Scientific Temper in the country. The Workshop was organized in collaboration with Vigyan Prasar and the Institute of Himalayan Bioresource Technology (IHBT), Palampur, CSIR.

This was followed by the *International Conference on Science Communication for Scientific Temper,* held in New Delhi during 10-12 February 2012. The three-day international conference was a joint effort of the CSIR-NISCAIR, Vigyan Prasar and NCSTC.

NISCAIR's quest for promoting Scientific Temper during its Diamond Jubilee celebrations continued with yet another international conference on *Vaigyanik Drishtikon Tatha Chetna Jagane Mein Sanchar Madhyamon ki Bhumika par Antarrashtriya Sammelan* (International Conference on Role of Communication Media in Promoting Scientific Temper) being organized during 29-30 May 2012 in New Delhi. The international conference was organized in collaboration with NCSTC and Vigyan Prasar, Department of Science & Technology, and the National Council of Science Museums (NCSM).

The common thread that ran through the deliberations in all these conferences was the need to refocus attention on inculcation of Scientific Temper with a renewed vigour. It was felt that there was an overarching need to spread this concept at all levels of the society. The strategies may have to be worked out, and fine-tuned, but this was an issue that could brook no further delay. We, therefore, realized that the deliberations in the conferences specifically focusing on the concept of Scientific Temper could be compiled in the form of a book.

And so, we present here brief reports of the significant deliberations held during the course of the three conferences organized by CSIR-NISCAIR to promote the concept of Scientific Temper in the country. The publication also contains a few selected speeches and papers presented in the conferences, which give a broad view of the discussions happening around the concept of Scientific Temper.

The publication also serves as an account of the efforts made by CSIR-NISCAIR together with like-minded institutions in giving a renewed thrust to the concept of Scientific Temper during its Diamond Jubilee year (2011-2012).

Gauhar Raza
Hasan Jawaid Khan
Surjit Singh

Conference Reports

National Workshop on Scientific Temper

15-17 June 2011
IHBT, Palampur, Himachal Pradesh

THIRTY years ago, in 1981, independent India released the first document articulating the need to inculcate the values of scientific temper in the Indian society to rid the country of its socio-economic ills at that time. It was named the 'Statement on Scientific Temper'.

Between 15 and 17 June 2011, scientists from all over India congregated for a national workshop in Palampur in the hilly state of Himachal Pradesh to review the statement released in 1981 and work out strategies to spread the spirit of scientific temper in the country. The "National Workshop on Scientific Temper" was organized by the National Institute of Science Communication And Information Resources (NISCAIR), CSIR, in collaboration with Vigyan Prasar and the Institute of Himalayan Bioresource Technology (IHBT), Palampur, CSIR.

People's Science

In this age of boom of the news industry when one witnesses the use of a plethora of novel techniques to influence public opinion, the draft of the reviewed statement emphasized on the proactive use of various forms of mass media to spread scientific understanding among the public.

Given the inadequate coverage of science in popular media, a government-funded television channel dedicated for the purpose was recommended at this workshop. The channel should be geared towards removing the unscientific ideologies that govern the lives of cultural subgroups and discriminations they face due to barriers that exist between them and the policymaker—one of the main objectives specified in the draft.

The government-funded channel found a backing in the words of science journalist Dr R. Ramachandran from *Frontline.* He also underlined the necessity of more science magazines supported by public institutions to make for the lack of science news in commercial media, which believes that such news does not sell and leaves them in the cold in the rat race for grabbing public attention.

But, generating the interest of the public also depends on how attractive a subject like science can be made to the public and communications consultant K.P. Madhu described varied methods for bringing this about. Just as science can be popularized through the use of mass media, misuse of the media spreading wrong information can be equally damaging. Former editor of *Science Reporter,* Mr Biman Basu, cautioned against promotion of unscientific temper by a section of the media.

Without the right strategies to spread the spirit of scientific temper, the draft cautions against a situation in which scientific progress outstrips scientific understanding, putting citizens increasingly reliant on science and technology, but ignorant of its workings, at a disadvantage.

In order to avoid such a situation, science and society should evolve together, said Prof E. Haribabu from the University of Hyderabad who explained how participatory innovations and participatory plant breeding contributed towards progress in this direction. The importance of developing technologies that empower people and science policies towards that end was also stressed by Dr Dinesh Abrol of the National Institute of Science Technology and Development Studies (NISTADS) and Dr Subodh Mahanti of Vigyan Prasar.

Such efforts require increased involvement of the common people in discussions on science and scientific temper and Dr J.S. Pillai, scientist at NISCAIR underscored ways of doing so.

However, awareness generation should not only be confined to the media and to dialogues with the public. Even in this age of cynicism, common people still look up to scientists, teachers and government officials as icons. So it is important that these sections of society set the right examples for people to follow.

Training the Icons

The workshop highlighted that in order to ensure this, the spirit of scientific temper needs to be inculcated within the government and scientific community so that they do not set bad examples by supporting those who go against it and promote beliefs that are not supported by evidence. The workshop discussed the need to chalk out obligations that leaders in the society need to fulfill to carry out their duty of developing a spirit of scientific temper as enlisted in the Indian constitution.

"Science academies and teachers can play an important role in propagating the obligations of citizens to cultivate the spirit of scientific temper enlisted in the Indian constitution so that the message can reach the remotest corners of India," said Dr P.M. Bhargava, the former founder director of the Centre for Cellular and Molecular Biology (CCMB).

Drawing from the example of Gautama Buddha's insistence on cultivating beliefs based only on evidence, Dr Gangan Pratap, Director-NISCAIR, showed how religious preachers can play an important role in disseminating the scientific spirit among the common people. Along with Gautama Buddha, he also showed how scientists like Laplace and Charles Darwin have contributed in replacing the blind faith that common people bank on to lead their lives, with the modern concept of reason as a religion.

Dr Obaid Siddiqui, FRS and National Research Professor at the National Centre for Biological Research, Tata Institute of Fundamental Research, Bangalore, recalled India's first Prime Minister Jawaharlal Nehru's socialist principles in shaping science policies of the country and stressed on revoking them to achieve inclusive growth.

Dr P.S. Ahuja, Director, Institute of Himalayan Bioresource Technology (IHBT), Palampur, said that discussions among scientists and at different fora were necessary to chalk out the path in which the visionary statement that had been drafted 30 years ago could be revisited and value added to the historic endeavor. Citing the controversy over genetically modified seeds, he pointed out that absence of transparency among scientists and their refusal to answer questions posed by public, can lead to lack of trust among the common people which in turn can undermine scientific temper in the country.

In order to address this, the statement stressed that leaders of the society should encourage people in general and students in particular to ask questions and not take anything for granted—not even certain dogmas that may exist within the scientific community.

The marginalized communities need to be specifically targeted in the efforts to spread scientific temper and it is pertinent that the universities focus on this. Prof P. Thirumal of the University of Hyderabad talked about the role people with social values in universities can play in infusing scientific temper among the marginalized.

To map out strategies to spread scientific temper among different sections of society—one of the major objectives of the statement—one needs to know the current state of scientific temper among them.

Survey Necessary

This calls for a national survey for measuring scientific temper in the country. Empasizing this need, Gauhar Raza, scientist at NISCAIR said, “We need to measure the scientific temper existing in different parts of the country and among different groups in order to make strategies for propagating it to the different parts of the country “.

Elaborating on the methods to be adopted to carry out the survey, Dr Surjit Singh from NISCAIR talked about how culture, education and sociological aspects influence scientific temper among common people while Dr P.V.S. Kumar, scientist at NISCAIR, deliberated on the efforts that have already been made to study it.

Though the quantity and quality of how India performs on this score is yet to be measured, throughout the deliberations, scientists underlined instances that showed a lack of scientific temper in the country.

Prof M. Annadurai, director of the Chandrayaan Mission, in his inspiring lecture on the last day of the workshop underscored how the Chandrayaan Mission along with other breakthrough technological missions like the launch of several INSAT satellites had played a major role in boosting scientific temper in the country. “Not only has the mission brought about significant technological spinoffs, it has jettisoned the country to become one of the few with successful moon missions and placed India in a position where its achievements in space research are regarded all over the world with respect,” he elaborated.

He stressed that not only did the mission achieve the difficult task of finding water on the moon, but also brought about technological outputs that will benefit the people at the grassroots in several ways and create scientific temper among them. “It was also an iconic mission that can reverse the trend among young people being drawn away from the world of science,” he added.

Prof. Annadurai pointed out that the scientific temper created by the mission led to Chandrayaan-II being approved in two months, a process that had taken four years for Chandrayaan-I.

Ms Neerja Bhatnagar of Action Aid talked about lack of scientific temper leading to decline of child sex ratio in the country and appealed to the scientific community to find ways to inculcate the spirit of scientific temper among people in the grassroots.

Dr Ram Puniyani, former professor at IIT Mumbai, emphasized that marginalization of women through religious hierarchies in society is largely responsible for several irrational acts justified by means that are totally unscientific in nature. He advocated steps to discourage such irrational hierarchies in society to propagate scientific temper in society.

Revisiting the ‘Scientific Temper Statement-1981’

One of the major purposes of organizing the Palampur National Workshop was to revisit the ‘Scientific Temper Statement 1981’ (Appendix 1) and come out with new recommendations. Consequently, several consultative sessions were held during the National Workshop where the ‘Scientific Temper Statement 1981’ was discussed at great length and efforts were made to recast it in light of current concerns and issues. The effort finally culminated in the ‘Palampur Declaration’.

The Palampur Declaration

Recapitulation of the 1980s Spirit

The concept of Scientific Temper was articulated first by Pandit Jawaharlal Nehru in 1946 in his book *Discovery of India,* referring to it as "a way of life, a process of thinking, a method of

acting and associating with our fellowmen". The tradition of skepticism and humanism is not new to Indian intellectual tradition. Such notions go back to antiquity – Jain, Sankya, and Buddhist traditions have repeatedly emphasized the spirit of enquiry. During the Indian renaissance many leaders popularised the notion of scientific enquiry and gradually it became part of the Indian ethos.

Nehru was instrumental in laying the foundations for building the infrastructure for science and technology in India – the Universities, the IITs, the CSIR labs, etc. These became the 'hardware' of science and technology in India, while Scientific Temper among the people of India was to be the 'software'. In 1976, India became the first country to include in its Constitution 'Scientific Temper with humanism' as a fundamental duty of all citizens of the country (Article 51-A(h)).

Four years later, in October 1980, a group of academicians and intellectuals deliberated for four days at Coonoor, near Ooty, on the state of Scientific Temper in the country. Out of those deliberations was born 'A Statement on Scientific Temper', which was released on 19 July 1981. This document articulated the need to inculcate the values of Scientific Temper in the Indian society to rid the country of its socio-economic ills at that time. The Statement was expected to usher in a movement—a second Indian Renaissance—to 'provide the necessary fillip for restructuring our country embodying the aspirations of our people'. Broadly, the statement extolled the virtues of the scientific method as an antidote to the traditional religious and/or superstitious dogmas that prevail in our country. In recent times, the hold of such antiquarian beliefs has become greatly widespread in the country through television channels, and lately, through the Internet.

The preamble to the Statement noted the continuous accumulation of knowledge that allowed mankind to exercise control over the environment. However, the spread and adoption of mankind's knowledge has been uneven due to prevalent schisms across the world and control over such knowledge by the elites. In such a bleak situation, fatalism prevails, reinforcing obscurantism, irrationalism and a retreat from reason. To advance in the scientific age, we must understand the meanings and imperatives of scientific temper – which in essence is 'humanity's assertion of being in charge of its destiny and not a passive victim of malevolence of stars'. Scientific Temper thus becomes an imperative for a brighter future for our country.

The Statement goes on to include in its definition of Scientific Temper the method of science that encompasses all human knowledge cutting across the natural sciences and the social sciences. 'The spirit of inquiry and the acceptance of the right to question and be questioned are fundamental in scientific temper.' It considers knowledge as open ended and ever evolving. Scientific Temper is incompatible with theological and metaphysical beliefs. While science is universal, religions and their dogmas are divisive. Scientific Temper cannot flourish in a grossly inegalitarian society where 50 per cent of the population lives below the poverty line and almost 70 per cent of our people, especially women, are functionally illiterate. Social justice, widespread education and unrestricted communication are pre-requisites for the spread of Scientific Temper and, therefore, optimizing the results of science and technology becomes imperative.

The Statement called for a major role of Scientific Temper in reviving confidence and hope and dispelling a fatalistic outlook. The campaign to promote Scientific Temper must inculcate values like equality and dignity of labour and social accountability of one's actions. The Statement also cautioned against using scientific and technological solutions as 'magic bullets' for every problem in the country. 'The nature of social stratification and the power structure in a society prevents the acceptance of such solutions. Technologically, one may be able to grow enough food for everyone, but the pattern of income distribution prevents the benefits of increased food production reaching large segments of the population. When the social structure and stratification prevent the application of rational and scientifically proven solutions, the role of Scientific Temper is to lay bare the anatomy of such social barriers.'

The debates and discussions on Scientific Temper that the Statement envisaged initially, have not continued in India towards ushering a second renaissance, at least to the extent that the signatories wished. Scientific Temper remained largely confined to rhetorical statements. Sadly, even social scientists did not make an effort to refine this concept or operationalise the concept for measuring/gauging Scientific Temper. It behoves us to retrieve this concept before it is lost in the cacophony triggered by the changing scientific, technological and economic order. Thus, there is a need to revisit the 1981 Statement.

The intellectual space left untapped by academicians and the state structures has been to an extent occupied by various voluntary organisations (also called NGOs and Civil Society organisations). Since the 1980s, there has been a substantial growth in the number of these organisations. What impact these various efforts have had on the inculcation of Scientific Temper in the population is yet to be studied, but what is clear is that these efforts, though commendable, have not been able to change the direction of the tide of irrationality.

Ever since the 1981 Statement was released, two opposite, and yet synchronous, changes have been observed in the country. It should be noted with some satisfaction that the combined effect of efforts made to propagate scientific ideas in the country, to which people's science movements and scientific institutions have contributed in a large measure, have definitely made a difference, however small it may be. Such efforts had modest impact as in the case of bringing out large numbers of people to watch the 'total solar eclipse' during 1995 or critically appraising public policies as in the case of the Silent Valley Project.

But, at the same time, during the past 30 years there has been a marked increase in public display of religious and sectarian identities, ascendance of irrational cults, glorification of obscurantist practices, religiosity and wielding of religious symbols. This has provided the ideological basis for, at times, brutal unscientific actions in both public and personal domains. Discrimination based on caste, gender and ethnic identities, perpetuated on the basis of irrational beliefs and superstitions are still widely prevalent, and are a blot on our society. Privatisation of electronic media has also had the undesirable effect of providing increased space for forces responsible for the spread of irrationality and undermining Scientific Temper.

Changing World Order

During the last two decades many parts of the world also witnessed new and large-scale social movements against the new world order—often described as neo-liberal regimes advocating market fundamentalism and withdrawal of the state from economic and social sectors. These movements were ostensibly mobilised on the basis of rational objective knowledge on issues facing different sections of the populations.

The most significant development in the world during the past two decades has been the accelerated globalisation of trade and services aided by the extensive penetration of Information and Communication Technologies (ICTs). The ushering in of the Internet and the World Wide Web paved the way for consolidation of economic hegemony of transnational companies (and TNCs) all over the world and its natural resources.

On the other hand, neo-liberal regimes also laid the ground for organised international resistance against such hegemonies. Creation of large cyber spaces has revolutionised the storing, searching and retrieval of electronic documents, including scientific publications. The barriers that confined scientific knowledge among a few have been broken, empowering researchers in developing countries by making scientific corpora available to them with considerably reduced lag period. Today, a possibility exists for non-experts to access scientific knowledge on varied subjects with a click of a button. This process is causing erosion of the 'almost religious authority' that science experts exercised hitherto. The democratic, open, transparent and egalitarian nature of science is reasserting itself on a much bigger scale today.
It is needless to overemphasise that this cyber space is also available to those who spread occult and unscientific ideas. In fact, using this space they are meticulously trying to enlarge

their constituency. In India, efforts to counter these forces by making use of the same cyber space has, unfortunately, been found wanting.

Developments in biotechnology have also had a profound impact on all spheres of human existence. It has started bringing new research insights into almost all conventional disciplines of natural and social sciences. It has also generated heated public debates all over the globe and has given birth to resistance movements.

The above developments are likely to have a profound impact not only on social relations but may also intensely influence man-nature relationships.

Current State of Science and Technology

In the last two decades there has been an unprecedented increase in the World's stocks and flows of human resources and research output, in terms of academic publications and patents. The world has witnessed a shift from an industrial economy to a 'knowledge economy'. In this changed world order, India is struggling to increase its scientific and economic share. However, with its still high rate of illiteracy and lack of universal education the relevant questions such as 'what constitutes education?', 'what does knowledge society mean in the Indian context?' and 'whose knowledge counts in this knowledge society?' assume importance.

The character and nature of scientific praxis has also changed during the last 20 years or so. For a long time production of scientific knowledge and its application and relevance were not separated and science was expected to serve the state in respect to the security and welfare of its citizens. Thus, S&T served well in the growth of industrial economies of both the capitalist and the socialist countries. Unfortunately, the neo-liberal regimes of many countries (including India) have changed this social contract of science in favour of markets and corporate entities.

The privatization of research and academic institutions through IPRs has resulted in blurring the boundaries of basic and applied research and their relation to technology, such as in biology. In the academic and policy circles science is being replaced by 'innovation'—which is a mix of science, technology, management, marketing, organisations, and a host of other things. It is innovation studies or innovation policies and competition among firms and nations that now dominate the intellectual and policy space. It is innovation that is used as a benchmark of economic growth and development. For ordinary citizens technology and gadgets are today the most tangible manifestations of 'science'.

The fast pace of technological intrusion, without essential back-up support of scientific knowledge base, introduces cultural and social distortions within traditional cognitive structures. Lack of effort at providing the necessary complementary scientific knowledge base for the population at large is consolidating these distortions resulting in the corrosion of democratic structures. Moreover, technology-driven modernisation creates a cognitive gap due to loss of traditional knowledge, which is being filled in by religiosity in new forms.

Relevance of Scientific Temper in Today's World

In view of the concerns expressed above, we feel that Scientific Temper should be strengthened and diffused widely in our society. In some sense, Scientific Temper can be equated to application of the scientific method based on logic and evidence. Scientific Temper in this sense is also privileged and seen as antithetical to 'revealed knowledge', evidence for which does not go beyond religious scriptures or superstitious beliefs. Science, on the other hand, holds that life, mind and universe can be understood without invoking the supernatural and revealed knowledge. Scientific knowledge is thus universal and is reliable in contradistinction to the so-called revealed knowledge and the diverse metaphysical interpretations of life and the universe, which form the basis of the various religions and associated superstitious beliefs.

Scientific Temper is essentially a world-view, an outlook, enabling ordinary citizens to choose efficient and reliable knowledge while making decisions in their individual and social

domains. It is not the content or extent of knowledge base of one or other domain of scientific corpus that a citizen acquires, but rather the pursuit of rational enquiry, which is the hallmark of Scientific Temper.

Social phenomena do not easily lend to experimentation or verification. Thus, if Scientific Temper were to be diffused to 'solve mundane problems' of ordinary citizens, the methods of science would have to be enlarged and re-defined in inter-disciplinary perspectives. "The understanding of the social phenomena and human behavior, knowledge about the social process and its determinants are essential for designing policies to promote social change and to produce a dynamic society capable of absorbing and utilizing the scientific and technological developments for the welfare of human beings" (VKRV Rao).

Science and technology have contributed at a macro level to the socioeconomic development of India and the world at large. India could ward off famines and import of food grains in the 1960s largely through the Green Revolution, which also had the unfortunate effect of causing income disparities and environmental degradation. The solution to these problems will come from new scientific and technological initiatives and people-oriented policies.

The average life span of Indians increased due to availability of antibiotics against some common diseases. Similarly, communication facilities have expanded with the advent of the TV, mobile phones and the penetration of computers and Internet. Yet disparities in the availability and access to education continue to grow, and fruits of science and technology do not reach across the regions, religious sects, gender, and castes. It may be worth gauging how far these economic and scientific achievements – and Scientific Temper – in India have percolated down to the common man. As scientific progress outstrips scientific understanding, citizens that are increasingly reliant on science and technology and yet largely ignorant of their workings, would be at a great disadvantage. Correspondingly, their participation in the democratic process would be increasingly marginalised. The growth of Scientific Temper is a measure of the extent to which the society applies the methods of science to solve its problems.

Advocates of Scientific Temper have often identified superstitions and religious beliefs as the main target of opposition. In this sense, Scientific Temper is an 'ideology' pitted against these religio-centric ideologies. Unfortunately, in India this process – termed as 'transmitter model' in literature – could not succeed in effecting changes in the people's attitudes or values. In fact, over the years, there has been an increase in the public display of religious activities by public figures in all walks of life.

This situation is made worse when even scientists actively participate in such religio-centric rituals in the public domain. Many scientists publicly profess their faith in 'gurus' and 'babas' in India. With the spread of the electronic media – the TV and the Internet – these public (and private) activities are in constant public gaze and much of this content can also be stored and recalled. Such displays by scientists weaken their position as role models for the practice of Scientific Temper.

Public display of religious symbols, figures, images and artifacts in government offices, religious ceremonies in institutes and educational institutions and religious invocations during inaugurations of scientific conferences, mar the secular character of these institutions in particular and the Indian State in general. A number of these acts are legitimised in the garb of 'culture'. In order to secure its constitutional obligation, the State must forbid such displays within government owned spaces.

The recent spurt in providing legitimacy to the 'occult' by dubbing it as scientific is a disturbing phenomenon. Some may argue that it is in a way acceptance of supremacy of science over other forms of knowledge generation, but such acts not only discredit 'science' they also use science as a saleable commodity. It is necessary to create regulatory mechanisms against the dissemination of such unscientific and irrational messages and devise ways that enable corrective measures to be taken.

Modern education is the strongest determinant of scientific information, knowledge and attitude. It is true that over the years scientific information base in the country has enlarged, but it will be far from reality to assume that this information is getting transformed into knowledge thereby bringing a change in attitude. Unfortunately, our education system is still not sufficiently evolved to inculcate Scientific Temper in young minds.

The growth of mass media as a means of transmitting science related information started with the print media – academic journals to communicate the results of scientific research, newspapers and magazines to communicate science to citizens. Later radio broadcasts have added to these channels of communications. The biggest impact of mass media, however, came with television. It should be noted with utmost concern that TV has emerged as the most potent agency spreading anti-scientific temper in India. Freedom of expression is being used as freedom of propagating irrational, outmoded and antiquated ideas. Thus, ironically the latest technology is being used to propagate anti-science beliefs. Today, there are a large number of religious channels but there is not a single Indian science channel.

Fundamentalist forces selectively embrace technology and make use of these technologies to propagate outmoded ideas. It is propagation of modern scientific knowledge that hits at the core of irrationality and is therefore not acceptable to them.

A Strategy for Spread of Scientific Temper in India

- Scientific Temper breeds within the confines of scientific information base. Therefore, it is imperative to make relevant scientifically generated latest information available to the common citizen. However, it will be erroneous to equate Scientific Temper with scientific information.
- It has been repeatedly observed through survey studies that the thought structure of a common citizen is constituted by scientific as well as extra-scientific spaces. These two mutually exclusive spaces co-exist peacefully. Act of invocation of one or the other is a function of social, political or cultural calling. Those who consider spreading Scientific Temper as their fundamental duty must aim at enlarging the scientific spaces.
- We call upon the people of India to be the vanguard of Scientific Temper.
- Use of religious symbols and ceremonies with religious overtones performed in the garb of cultural activities must be stopped in government offices and institutions run with public funds.
- A national monitoring system with powers to issue guidelines must be set up to continually monitor for unscientific content in the media channels and the education system, particularly up to school level.
- Scientists and scientific institutions should not only function in a more transparent manner but also reach out to the public at large with an objective to instill confidence in science, scientists and scientific institutions.
- A television channel dedicated to the spread of Scientific Temper should be operated with funding from the government.
- Science communication activities mandated in the government agencies should focus more on rationality, inquiry and method apart from content.
- India is a stratified country and cultural and religious minorities have special needs. Fundamentalist, unscientific and antiquated ideas are not prevalent only among the religious majority, these are also as rampant among the minority and marginalised sections of people. On the one hand, similar unscientific beliefs govern the lives of the minority; on the other hand, they are further marginalised because of lack of Scientific Temper among the majority community. It is necessary to identify their special needs and devise intervention policies.
- Everyone is born with a Scientific Temper. The child wants to touch, feel, experiment and explore everything on its own – the basic ingredients of Scientific Temper. However, somewhere down the line, owing to societal or traditional influences or due to the type of

education being imparted in our schools, the child loses the tendency to ask questions and explore natural phenomena, leading to acceptance of notions forced upon it without putting them through the scientific rigour. Therefore, Scientific Temper needs to be incorporated into the school curriculum at all stages so that the spirit of scientific inquiry can be inculcated from a young age.

International Conference on Science Communication for Scientific Temper

10-12 January 2012
NASC, Pusa, New Delhi

IS it acceptable for a country to have pockets of brilliance while a major part of its populace continues to wallow in ignorance and superstitious beliefs? Why have our efforts at inculcating scientific temper not given the desired results even after 64 years of independence? What, after all, is scientific temper? Can it be taught and inculcated later in life?

These and many other issues were thrashed out at the *International Conference on Science Communication for Scientific Temper* held in New Delhi during 10-12 January 2012. The three-day international conference was a joint effort of the CSIR-National Institute of Science Communication And Information Resources (NISCAIR), Vigyan Prasar and the National Council of Science & Technology Communication (NCSTC), Department of Science & Technology.

The International Conference had five Plenary Sessions and 15 Parallel Sessions with about 102 lectures spread over three days. All the sessions were chaired by eminent scholars and science communicators. Altogether, there were thirteen invited lectures by resource persons from different walks of life.

The three-day International Conference was attended by around 200 people from varying backgrounds – judiciary, film industry, journalism, sociology, astrophysics, medicine, history and science communication. In all, experts from eight countries representing five continents participated in the conference. These included South Africa, UK, Canada, Columbia, Argentina, South Korea, Switzerland, and Bulgaria. The composition of experts included intellectuals from Judiciary, Film Industry, Journalism, History, Sociology, Political Science, Medicine, Education, Public Understanding of Science, Philosophy, Agriculture, Museum, Science Communication, Science Policy, Statistics, Economics and Management.

While Justice Markandey Katju, Chairman, Press Council of India, was the Chief Guest at the inaugural function, the other key speakers were Dr P.M. Bhargava, former Vice Chairman, National Knowledge Commission; Prof. Bernard Schiele from the University of Quebec, Montreal and noted film producer Mr Mahesh Bhatt.

Inauguration

In his Welcome Remarks, Dr Subodh Mahanti stressed on the need to form a network of like-minded agencies and organizations that are working in the area of science communication and science popularization to carry forward Pt Nehru's legacy of Scientific Temper. He said that following Pt Nehru's legacy of a strong S&T infrastructure and his dream of inculcation of the spirit of rational enquiry in every Indian citizen, several efforts had been made over the years. Although substantial headway had been made in this direction, some leading to perceptible changes, a lot still needed to be done.

In his inaugural address, Justice Markandey Katju set the stage for the conference by remarking that as long as the country was on the scientific path it prospered, but when we took to the unscientific path of superstitions and empty rituals we fell far behind the Western countries in science. This was the real cause of our poverty and other social evils. Inculcating scientific temperament on a massive scale is the need of the hour, he said. The way out for our

nation is to go back again to the scientific path shown by our great ancestors such as Aryabhatta and Brahmagupta, Sushrut and Charak, Ramanujan and Raman.

Justice Katju stressed on the need to spread a scientific outlook and rational and logical thinking among our masses to enable them to give up backwardness and superstitions. He said, we need more democracy, not less, which would mean educating the masses, raising their cultural level and involving them actively in the task of national reconstruction. Justice Katju maintained that democracy and science go hand in hand—scientific growth requires values such as freedom to think, to criticize, to dissent and free flow of information, which were precisely the values of a democratic society.

Dr P.M. Bhargava, former Vice Chairman, National Knowledge Commission, in his presidential remarks talked about a study he conducted on 1000 people asking them what they would do if a black cat crossed their path – 70% of the people, mostly the educated and financially secure, said they would change their path. This is the state of scientific temper in India, he said.

Dr Bhargava said that Pandit Nehru's commitment to scientific temper and his belief that the country could progress only on the basis of science and technology was well known. He even became the president of the Association of Scientific Workers of India, an association that Dr. Bhargava helped set up.

He said that we keep talking about scientific temper, but what do we mean by it? Understanding the basic methods of science is scientific temper. Scientific knowledge is verifiable, repeatable and falsifiable. It keeps on changing and there is no ultimate truth. There has to be a realization, he said, that using the methods of science is the only reliable way of dealing with problems, not by invoking supernatural powers. But promoting scientific temper among the masses is not going to be easy. He said that there was a need for a dedicated Indian science television channel to dispel such irrational beliefs and promote scientific temper.

Dr Bhargava said that it was Prof. Nurul Hasan who in 1977 persuaded the then Prime Minister Ms Indira Gandhi to include Scientific temper in the Constitution of India. However, he lamented that governments over the years have themselves not functioned as the Constitution demands. The biggest culprits in not promoting Scientific Temper and in some instances actually promoting irrationality, he said, had been successive governments.

The second biggest culprit, he said, were scientists. He said that when he along with a few other like-minded individuals brought out the Statement of Scientific Temper in 1981, many scientists were not willing to sign it.

Dr Bhargava said that we all are born with a Scientific Temper. However, it is due to the weakness of our parents and the indulgence of the clergy in propagating miracles that irrational thoughts get embedded into the children's consciousness. He said that it was extremely important for the country to develop Scientific Temper among its citizens.

In his keynote address, "Science Communication: New World, New Challenges", Prof. Bernard Schiele from the University of Quebec, Montreal touched upon the science-society dynamic, how science was communicated in the past and what are today's challenges. He stressed the need for participation and dialogue processes in spreading scientific temper. He said that today we live in a world that is more difficult to decipher. We have a public that is much better informed but certainly not convinced. The public has become cautious, skeptical and distrusting, he said.

Prof. Schiele remarked that today the diversification of means of communication had brought new actors to the scene—from scientists to amateurs. So there are now more actors than ever engaged in producing science news, with scientists and mediators representing but a

small number of them. Therefore, constant negotiation and dialogue would be required if science communication is ever to make an impact, he said.

Mr Mahesh Bhatt, renowned film producer, was happy to be associated with a forum that hoped to re-ignite the fires of scientific temper in the hearts of every Indian. But inculcating scientific temper meant bringing in doubt. He said that "doubt", which has been looked upon by cultures as a sign of weakness, requires more courage than conviction. The scientific temper that Jawaharlal Nehru crusaded for is born from a heartbeat, and that heartbeat is doubt. A society that is not decorous enough to concede that we are billions of times more ignorant than knowledgeable is doomed, he said.

However, Mr Bhatt stressed that even the scientific community needed to wake up and face the blunt truth that their uncritical faith in scientific knowledge had created many of the problems now threatening the planet; and our wholesale reliance on scientific progress is both untenable and myopic. He said that knowledge and insights accumulate fastest in the minds of those who hold an 'ignorance based' world view. Saying no two leaves or snowflakes are the same, we need to recognize this uniqueness of every moment in every individual, to realize the true wonder of life.

Earlier, in his presentation Dr Gangan Prathap, Director-NISCAIR, tried to link the core concept of scientific temper with the various thought processes that prevailed in ancient India – the Samkhyas, the Carvakas, the Jains and the Buddhists. In his presentation, "India's Many Trysts with Skeptical Humanism", Dr Prathap said that prevailing wisdom of those times believed that the removal of doubt using the instruments of reason and evidence, and the alleviation of suffering by compassion and humanism, were the most noble of all principles of right action. Thus, 2550 years ago, what the enlightenment philosophers re-discovered as skeptical humanism, was born in our part of the world, he said.

Dr Prathap said that even though it is widely claimed that it was the Greeks that invented science's golden rule – reason – on closer examination, we find that the first person that reliable written historical accounts give credit to for emphasizing the primacy of using reason to conduct ones life was from our own part of the world. Gautama Budhha had said, "Do not take the authority of the teacher or the text. Always, question yourself." He meant that one should not accept received wisdom but should always seek empirical evidence.

Thus, when India re-gained independence on the midnight hour on 15 August 1947, Pandit Jawaharlal Nehru promised that India would keep its tryst with destiny by enshrining the article of faith that called upon all "to develop the scientific temper, humanism and the spirit of inquiry and reform" (Fundamental Duties Articles, 51-A (h)).

Notion of Scientific Temper

In a session "History and Notion of Scientific Temper"**,** Dr Dinesh Mohan, who played a part in the drafting of the 1981 'Scientific Temper Statement', said that the scientific temper statement preached the spirit of enquiry. However, he said that our society had today become more obscurantist. What we do or not do is all governed by our political ideology. A free and fair discussion is not allowed, hence how can this society learn scientific behavior? There is no sense of security which otherwise should be high when we express our thoughts. Today, we can't even watch a movie, see a painting, an exhibition etc. that a section of people doesn't like.

Even highly developed and scientifically advanced societies are killing thousands of people without listening to their point of view and do not discuss with others which is clear from the bloodshed in Afghanistan, Iraq, Libya and Somalia.

He said we cannot develop scientific temper unless and until all children get equal opportunities to education and health care. Despite all the technology and innovations, better

health care, education and housing conditions are still not available and a distant dream. He said that no Indian should be charged for health care and education. But unfortunately no scientific lobby advocates the thought of equality in opportunity. He condemned all political parties and ministers for not discouraging privatization of water, electricity, health services and above all the education sector.

Prof. Mridula Mukherjee from the Jawaharlal Nehru University said that India has a strong legacy of engagement with the public, especially during the freedom struggle. She pointed to Amarty Sen's work that seriously questions the fact that the tradition of science and questioning came from the West.

Prof. Mridula said that during the freedom struggle, moderates were the top intellectuals who built a solid and reasonable foundation for the freedom struggle. They did research, presented data and argued about poverty and that nationalism had to be built up because tangible outputs after freedom. This is also the method of science, she said.

She said that when Gandhiji asked not to hate the West and the Whites, but to agitate for freedom, this was rationality. He also wrote in *The Harijan* that he could not let any scripture supercede his reason. He wrote that he had the right to interpret the scriptures his own way. Religious texts had a historical location and had to interpreted in light of present circumstances.

Dr Dinesh Abrol from CSIR-NISTADS said that after independence the feudal class pushed people towards faith because they wanted to maintain the colonial setup. He said when the ruling class establishes itself it does not appreciate the spirit of reasoning. A major role player in the Peoples Science Movement, Dr Dinesh Abrol said that PSM uncovered miracles and superstitions without actually attacking religion. PSM wanted science to be open to people and problems. He said that the basic philosophy of PSM was that science should be used as a tool *for* people not *against*.

Dr T.V. Venkateswaran from Vigyan Prasar stressed that if people have to participate in a healthy democracy then they need to understand the need for science and technology. They should have convincing arguments to say that nuclear power is necessary or not. He said that we need to draw upon science to question outmoded thoughts such as female foeticide, honour killings etc.

Mr Irfan Habib from NUEPA talked about Prof Ramachandran who advocated reason and rationality for developing scientific temper. Apart from being a teacher and mathematician, Prof Ramachandran engaged in science popularization. He gave the concept of 'Haqeeqat Nigari', which means 'realism'. Without a realistic approach, the outcome could be irrational and unscientific. Prof Ramachandran introduced realism and rationalism in Urdu literature. In the words of Mohd Saadiq, it was Prof Ramachandran who introduced literary and social reforms in Urdu literature and advocated modern literature. He said that e should accept what is real and rational from the western culture.

He wrote text that attacked superstition and answered doubts in a rational and scientific manner. Ramachandran was at that time located in Delhi College, now the Zakir Hussain Delhi College. He was also a student leader at the Delhi College.

Irfan Habib stressed on the institutionalization of science in the recent past, emergence of religion, clergy and importance of rational thought. He stressed that reasoning power should not be lost.

According to Prof. Soo Kim, scientific temper is a product, outcome of a learning paradigm like knowledge, attitude etc. According to Dr Kim, Nehru emphasized scientific temper to solve human problems. Prof. Kim said scientific temper is a theoretical notion unless and until we practically get involved. He said that it was necessary to understand what behavior brings to

science and what science brings to behavior.He said if we do not focus on what science brings to behavior we can't develop scientific behavior.

Dr Kim also questioned superstitions, astrology, rituals and other religious dogmas. He gave a clear-cut message that only questioning can save us and inculcate in us a sense of scientific temper and behavior and thus help us in solving our day-to-day problems.

Electronic Media and Scientific Temper

While the electronic media can claim to reach the nooks and corners of the country, sadly, these media, especially television have also turned out to be the purveyors of irrational beliefs and superstitions. Driven as most television channels are purely by the lust for making huge profits, shows dealing with occult phenomena and superstitions are often jazzed up with special effects, screaming headlines and exciting story lines to lure people in.

The electronic media seems to have gone too far in their quest for TRPs. Unbalanced, sensational and unscientific TV programmes have a lasting impression on ignorant and gullible minds. But unmindful of all this, the electronic media persists with its staple of sensational ghost stories, alien landings and totally unfounded mystery claims. In fact, with their regressive themes such programmes run contrary to the spirit of the Indian constitution where inculcation of scientific temper is well enshrined.

This view was also reiterated in a session "Television and Scientific Temper" by the chairperson Dr B.S. Bhatia, former director, DECU, Ahmedabad when he said that television was propagating anti-scientific ideas widely. He stressed on the necessity for setting up a dedicated science channel that could disseminate authentic science information to the masses.

Speaking in the session, K.P. Madhu, a freelance science journalist said that the purpose of television was to inform, educate and persuade the masses but its focus was shifting these days on what to wear, what to use etc. E.R. Subrahmanyam said that several myths and superstitions still exist in our society and electronic media offer unexplored ways of eradicating these irrational beliefs from the society

Dr. R. Ramachandran, noted science journalist and Associate Editor, *Frontline* while chairing the session on "New Media and Scientific Temper" said that often the information provided by electronic media was not completely correct and raised unfounded fears among the public as happened in the case of eclipses or the Large Hadron Collider. Channels often are not concerned with the origin of the cause and how it can be dealt with. Once an issue arises they just screen it and that's the end of it. They don't go for deeper research. This was scary because visual media was overtaking print media very fast, he said.

Aparna Vaish from the All India Radio said that AIR reaches 99% of the Indian population and thus was an effective way of disseminating science. Speaking in the session "Radio and Scientific Temper", she said that AIR's reach had now become global through the Internet. P. Rajamanickam said that radio programmes could be instrumental in increasing the public understanding of science and inculcating scientific temper as they provided a forum to ask questions.

However, Manas Pratim Das from AIR, Kolkata pointed out that while FM channels focused mainly on music, there was little or no space for science programmes and no tradition of live science programmes. Citing the example of *Bigyan Rasiker Darbare,* the first live science programme that he initiated on AIR-Kolkata, Manas said that lucid explanations laced with humour was a good way to impress the listeners and attract them during live science programmes.

Valedictory Session

The three-day International Conference on Science Communication for Science Temper concluded on 12 January 2012. The valedictory function was presided over by Dr R. Chidambaram, Principal Scientific Advisor, Government of India, while Prof Samir K. Brahmachari, DG-CSIR and Secretary, DSIR, delivered the Valedictory Remarks.

Dr Chidambaram in his presidential remarks observed that science communication for scientific temper would work only if the information is true and comprehensible. He said that the right information was very important. Even illiterates could be thought to think rationally if given proper information, and even educated persons could be taught to think irrationally as was evident in the case of suicide bombers. Citing the example of the Kudangulam Nuclear Power Plant, he said, even though the nuclear power plant would fulfill the power demands of Tamil Nadu, it was facing resistance. The role of science communicators, therefore, was the most important, he said.

However, he cautioned against partial scientific literacy and said that science communicators should be careful while communicating science. Science communicators should also note that the publics are not merely empty vessels where they could simply dump their information. He said that communication increases knowledge, which in turn spreads economic well-being.

Prof. Samir K. Brahmachari in his valedictory remarks observed that scientists should themselves demonstrate scientific temper in their day-to-day life (full text on page). He also stressed scientific temper could be spread only by making our scientists the heroes. Unfortunately, today the heroes are players or film stars whose images are beamed into the living rooms through satellites made possible by scientists. He stressed the point that scientists should be given due value in society.

Dr. Brahmachari also said that rationality ends where knowledge ends, and it was from here that ignorance begins. Hence, there is a need to push the frontiers of knowledge and this is the primary duty of science communicators. Science communicators have the responsibility to motivate the young to question interpretations. He also called upon science communicators to harness the potential of social media like Facebook. The future lies in new cyberspace, he said.

In his brief remarks, Dr. Mylswamy Annadurai Director of the Chandrayaan Project, said there was a need to spread scientific temper among the youth of today. And this could be done only if we had role models. Everybody, including the parent can be a role model, he said. He also said that the objective of scientific temper should be to create an ambience so that people could take informed decisions rather than forcing information on them.

Recommendations of the Conference

Consultative sessions were organized during the course of the Conference to finalise the recommendations. The Resolutions framed during the Conference were adopted unanimously by the House.

RESOLUTIONS ADOPTED

Passing through the twists and turns of intellectual debates and empirical studies, during the past 30 years, the research on public understanding of science and science communication has matured. The house strongly feels that Indian experts and agencies should put together intellectual and material resources and take the lead to initiate focussed research on 'Scientific Temper'.

With the advent of new media and proliferation of science movements, the mass base for communicating science has enlarged many folds. Even the marginalised sections of stratified societies,

who did not constitute the audience for science communication during the previous century, today, are being drawn into various debates on scientific issues. The house recognises that all the efforts made to communicate science, eventually, are directed towards spreading 'Scientific Temper' among the publics. However, the house also noted that a disjuncture, between the research outcomes and actual practice of science communication, exists and there is an urgent need to bridge the gap.

The house endorses the broad understanding of the term 'Scientific Temper' proposed in the 'Statement of Scientific Temper Statement, 1981' and further reviewed and enriched in the 'Palampur Resolution, 2011'. We call upon the international community of experts working in the area of 'Science Communication', 'Public Understanding of Science', 'Scientific Literacy' and 'Science Policy' to develop conceptual models that, on the one hand, may help in developing culture specific application of the notion 'scientific temper', and on the other may help communicators of science to spread it across the globe. The house strongly feels that Indian experts and agencies should put together intellectual and material resources and take the lead to initiate focussed research on 'Scientific Temper'.

The house also takes note of the issues raised in the resolution passed during the 'International Meet on Mapping the Scientific Consciousness: National and Global Efforts, held in Delhi, in March 2008':

> *It was observed that, during the intervening period, new ways of probing the scientific consciousness among the people have being proposed; new relatively robust models of analysis are being constructed to help refine conclusions. The number of scholars working in this area has further increased exponentially and cross-fertilization of different disciplinary perspectives has intensified. However, the number of institutions dedicated to research has not yet matched the growth in the number of scholars.*

The house reiterated the concern that barring a few, in most culturally rich countries (generally known as developing countries) the research efforts have not even started.

RECOMMENDATIONS

International Level

- Scientific temper as a notion cuts across traditional boundaries of natural sciences and includes disciplines such as arts, philosophy, and literature. Therefore, a transdisciplinary approach to scientific temper is required.
- There is an urgent need to establish synergy between research and actual communication of science. For this the level of discourse has to shift from 'scientific literacy'/'public understanding of science'/'public engagement of science' to creation of scientific temper among the publics at large.
- International community of experts should make concerted efforts to initiate and encourage scholars in developing countries to work on 'scientific temper'.
- Scholars and institutions in fast developing economies, such as India, China, South Africa, Brazil and Argentina, should deepen their cooperation and may institutionalise it through memorandum of understanding.
- In order to facilitate further research, a three-pronged strategy suggested earlier must be followed: inventory and compile existing databases; make these available on Open Access on Web; and create an inclusive network of scholars and communicators working in the areas of science communication, public understanding of science and science education.
- The efforts to communicate science through traditional and new media must be intensified and communicating science should be considered as 'public good'. Governments, especially in developing countries, must take the responsibility of running and financially supporting science communication activities.
- The transmitter model of communication should be shunned and public should not be considered as ignorant-scientifically illiterate-clean slate, on which any scientific information can be written. Instead, all channels of communication, including science museums, extension

centres, TV and radio channels must take the cultural-worldview of the target audience into cognisance.

- Science Movements led by the Civil Society organisation, at times, have divergent views on science and technology policies formulated by the governments. It is recommended that efficient channels for continuing dialogue between the two must be opened.
- Of late, there is a spurt in the anti-science and extra-science propaganda the world over, at times, specifically directed to spread unfounded fear among the masses. Scholars have a social responsibility to lobby and pressurise the Governments to formulate strict rules to deal with such propaganda.

National Level

- The house suggests that every country should strive for adoption of implementable government policies to spread scientific temper among its citizens specifically in the local languages.
- The house reaffirmed the earlier recommendation to establish research/teaching institutes dedicated to the furtherance of scientific temper having strong linkages with other cognate institutes/disciplines.
- Since scientific temper is a continually changing notion – in space and time –regular national and international consultations to review the developments are required. Efforts should be made to institutionalise these deliberations and the conclusions should be widely publicised.
- Regulatory bodies monitoring and auditing mass media such as print, radio and television should issue guidelines to create an atmosphere where individual citizens could perform their fundamental duties of spreading scientific temper, humanism, secular values and spirit of inquiry.
- The house noted that no national level study of 'scientific temper' has been conducted. It is strongly recommended that apex institutions in these countries must come together to carry out studies to measure national 'scientific temper' levels.
- In addition to common minimum indicators, region/country and culture/theme specific indicators of 'scientific temper' should also be developed and shared with other scholars for their benefit.
- We believe that spreading 'scientific temper' would strengthen the democratic spirit among the people to enable them to articulate their entitlements based on rational scientific temper.
- Specific efforts should be made to develop tools and materials to spread scientific temper.
- To promote scientific temper at the grass-root level, a web-based database should be created to document science communication activities – both successful as well as failures. Incentives and recognition to successful science communicators should be institutionalised.
- Each country should have a dedicated TV channel, exclusively to communicate science and a mechanism should be created to share resources without IPR restrictions.

Vaigyanik Drishtikon Tatha Chetna Jagane Mein Sanchar Madhyamon ki Bhumika par Antarrashtriya Sammelan

29-30 May 2012
NASC, Pusa, New Delhi

CAN we dream of an India where all its citizens are imbued with scientific temper, where there is no place for irrational beliefs and superstitions, no exploitation of the blind faith of the gullible, and where dubious babas and faith healers have closed shop and turned to other vocations? Almost 65 years after the country gained independence the dream still seems far-fetched. A dream that Pandit Nehru crusaded for when he laid the foundations for a scientific and industrial infrastructure in the country.

It was this dream of inculcating scientific temper in the country's citizens that the conference held in New Delhi sought to articulate. The Conference titled *Vaigyanik Drishtikon Tatha Chetna Jagane Mein Sanchar Madhyamon ki Bhumika par Antarrashtriya Sammelan* (International Conference on Role of Communication Media in Promoting Scientific Temper) was organised by the National Institute of Science Communication And Information Resources (NISCAIR), Council of Scientific & Industrial Research along with National Council of Science & Technology Communication (NCSTC) and Vigyan Prasar, Department of Science & Technology, and the National Council of Science Museums (NCSM). The Conference held during 29-30 May 2012 was hosted at the National Agricultural Science Complex, Pusa, New Delhi.

While Dr Lalji Singh, Vice-Chancellor of the Banaras Hindu University (BHU) was the Chief Guest at the inaugural function, the other key speakers were Dr G.S. Rautela, Director-general, National Council of Science Museums (NCSM) and Prof. S.K. Joshi, former Director-General of CSIR. The Valedictory Function was graced by Prof. Yashpal, noted educationist and Ms Mallika Sarabhai, renowned dancer and choreographer.

Inaugural Function

Welcoming the delegates to the Conference, Dr Subodh Mahanti, Director-Vigyan Prasar, said that an effort was being made to bring Scientific Temper to the centrestage of public discussions. He said that Vigyan Prasar, NCSTC and NISCAIR had got together during the past one year to make this possible starting with the Palampur National Conference last year, which was followed by the International Conference in New Delhi, the Ramgarh Conference in Uttarakhand and now the present International Conference. Dr Mahanti remarked that Pandit Nehru's vision of Scientific Temper could be achieved only when science dissemination was taken up in all major Indian languages and only when all sections of the society came forward to work together.

Dr Lalji Singh, VC-BHU, was more specific. In his inaugural address he remarked that while Nehru declared that India could prosper only by following the path of science and technology, much of the development had bypassed the villages of the country where 70% of its population resides. He exhorted science administrators to set up institutes and organizations in villages rather than implementing programmes sitting in cities. The city infrastructure had to be replicated in villages too.

Dr Lalji Singh called upon science communicators also to increase their catchment area. We should be talking about Scientific Temper in villages, he said. That is where the real change would come about. But this change could not be brought about by piecemeal programmes run for short durations. Institutions to disseminate Scientific Temper needed to be set up right in the

villages so that practical knowledge about the benefits of science could be demonstrated instead of theoretical presentations, he said.

Appreciating the efforts of NISCAIR in promoting Scientific Temper, Prof. S.K. Joshi, former DG-CSIR, wondered how much of our Fundamental Duty of spreading Scientific Temper had we fulfilled. Although the media could have played a major role in this, he said, it was more interested in sensational news. He said that if the media were to spend even a thousandth of the time it spent on scams, glamour and sports on spreading Scientific Temper, it would bring about a big change. Prof. Joshi also lamented that there were very few science communicators in the country and that NISCAIR should get together with other agencies to train science communicators.

Is there a way of measuring Scientific Temper? In his keynote address, Dr G.S. Rautela, DG-NCSM, remarked that Scientific Temper was a complex concept and measuring it was difficult although an effort was made by analyzing the responses of visitors to science museums. It was revealed that there was no increase in the Scientific Temper of those visiting the museums. But whether the analysis tool was faulty or the programmes were ineffective was difficult to say. Dr Rautela said that NCSM was exploring the option of initiating a research project to measure Scientific Temper and was looking for collaborators.

Earlier, in his special remarks, Dr Gangan Prathap, Director-NISCAIR, said that in his study of history, he had noted that India was the first civilization that brought reasoning and evidence into public discourse. This was indicated in the texts of the Samkhyas, the Carvakas, the Jains and the Buddhists. Dr Prathap said that prevailing wisdom of those times believed that the removal of doubt using the instruments of reason and evidence, and the alleviation of suffering by compassion and humanism, were the most noble of all principles of right action. Applying reason and logic was the true sense of Scientific Temper, he said. He said that despite the proliferation of the electronic media throughout the world and also into cyberspace the battle for Scientific Temper was far being won and was rather in a precarious state.

Deliberations

The deliberations during the two-day conference, which progressed through 12 sessions and 20 invited lectures, gave some incisive insights into the state of science communication through various media in the country.

The session focused on international scenario of Scientific Temper revealed interesting information. Dr Gyaneshwar Dutt Gaur said that the infrastructure in the US was excellent both with regard to schools and electronic media and connectivity. And since labour is expensive, most people learn to operate sophisticated gadgets themselves bringing them closer to science & technology. For India, he said, electronic media should be made cheap and operating systems should be made in local languages. Indira Gazieva from Moscow talked about her efforts at increasing accessibility to Hindi language. She said there were problems of lack of Hindi software and fonts due to which accessibility to scientific information was limited for many people knowing Hindi.

Ms Charu Verma and Mr Sanjay Burde from NISCAIR also focused on the necessity of developing IT resources in local languages. They suggested setting up of a nodal agency that could develop a portal where all IT resources in regional languages could be hosted.

Dr Om Vikas said that the volume and quality of science articles in Hindi needed to be improved. Propagation of Hindi on the Internet should be nurtured, he said. Strengthening translation software in Hind language would also lead to enhanced access to scientific information for the Hindi-knowing public, said Dr H.C. Pandey.

Science coverage in newspapers came in for some sharp criticism. An analysis by Mr K.K. Mishra of coverage in newspapers of the solar eclipse of 2009 revealed very little coverage most of which was not scientific. A survey of the front page of newspapers in and around Bhopal by Mr Chakresh Jain of the Madhya Pradesh Council for Science & Technology revealed that science news rarely made it to the front page. The ones that did, did so because an eminent dignity was involved, for instance, the Prime Minister at the Indian Science Congress or where significant patriotism was involved such launch of missiles or satellites.

The role of communication in eradicating superstitions and irrational beliefs was highlighted in several sessions. Dr Amitabh Pandey from SPACE categorically condemned programmes on astrology and channels that sought to promote babas. He said that only when the public stopped watching such programmes would channels be forced to take them off air. Manoj Mishra talked of the various irrational beliefs that people harboured such as *shagun-apshagun, mahurat-bela, bhagyaphal, kundli*, reincarnation, Vaastu Shatra and so on, which should be discarded and a scientific temperament acquired. Zeeshan Haider Zaidi cited several instances to prove that well-presented crisp programmes with scientific content could be popular rather than simply banking on stories of ghosts and spirits and superstitions.

Science fiction is often touted as an excellent means of communicating science. Chairing the session on this topic, Dr. Devendra Mewari lamented that most people considered science fiction to be completely fictitious; the test tube baby was born in science fiction before the laboratories. Dr. Ramesh Upadhaya said it is not necessary to write science fiction only about subjects one is deeply familiar with (e.g. no one has actually engaged in Space Travel) and said that science fiction also provides information. Ms Rufiya Khan presented experimental examples of how the use of science fiction aided science learning in a classroom in Shahjahanpur.

Science communicators should also be able to convince the masses of the importance of the spirit of scientific reasoning in daily life. For this science communicators need to be aware of the knowledge level of the target group. This was revealed through various studies carried out by Dr Surjit Singh of NISCAIR in his studies at the Kumbh Mela. Through various questionnaires Dr Singh was able to gauge the scientific temperament of the respondents, which becomes important in designing targeted programmes for inculcating Scientific Temper.

Some deliberations also focused on new initiatives in the field of science communication. Ms Ujjwala Tirkey told the audience about the Community Radio Programme of NCSTC targeted at women and which was giving spectacular results. There was widespread change in the outlook of the women, she said. Women who had never stepped out of their homes were now heading community radio stations and spreading information about health & hygiene, expiry date of medicines, healthy nutrition and so on.

Mr Kapil Tripathi from Vigyan Prasar talked about activity kits being prepared by Vigyan Prasar for communicating science in a practical and fun manner. He said unlike other modes of communication an activity kit apart from providing information on a scientific topic also provided materials for practical demonstration. But for such kits to become popular they should be low cost and self-explanatory.

The under-current throughout the deliberations was that Scientific Temper required to be propagated and strengthened in the country. Ms Madhu Pant, former Director-National Bal Bhawan, said that today's children are creative, confident and scientific from birth – it was necessary to reach their minds. However, Dr Priyanka expressed the view that the current science education did not nurture scientific thinking; and one needed to ask if the goals were science education or science for education. Science education should be easy, interactive, investigative, observation-based and should encourage asking questions. Mr. Darshan Lal said that most students were not interested in science, but only passing examinations. As a science

teacher, he dealt with this problem by introducing humour into scientific teaching to decrease boredom and encourage discussion.

Mr Anuj Sinha, former Director, Vigyan Prasar, was emphatic that unless various organizations came together the battle against blind faith and irrationality could not be won.

Valedictory Session

The message was once again reiterated by Ms Ujjwala Tirkey from NCSTC in her welcome address at the Valedictory Function on 30 June. She said that it had been noted that as long as civilizations internalized science and technology, they flourished. In an emotional appeal to those present at the function, she said that this journey to unfurl the flag of Scientific Temper must go on until all the people in the country realize what a miracle science has wrought in their lives. Let not irrationality and superstition spoil this journey, she said.

In her Keynote Address, Ms Mallika Sarabhai pointed to the fact that if we went back to the Puranas and Vedas, we would find that everything began with questioning. But today questioning by children has come to be frowned upon. The reasons could be many – in the hurly burly of life teachers and parents do not have the time, or perhaps do not have the answers. She said teachers today need to upgrade their knowledge levels, for knowledge was becoming obsolete at a rapid rate.

The philosophy of "don't ask, just follow" had become prevalent in all spheres of public life. If we simply become acceptors we would be crushing Scientific Temper, she said. Scientific Temper was a mental attitude, a necessity to live life. Unless we evaluate all parameters and take decisions accordingly we would simply be following the leader. Mallika called upon science communicators to accept the challenge of demystifying science as it was necessary for nation building.

Prof. Yashpal sought to caution the audience saying that while science grows fast, non-science grows faster still. It was a challenge for all of us that dubious babas still managed to call the shots in this day and age, he said. But we need to have patience. It is an ethical responsibility for us all to see that our capabilities are not used for nefarious ends. Prof. Yashpal said that the task of reform must start with children. Children are born curious. We must work hard to answer their questions so that their innate questioning ability was not curbed. Only then would people grow and science grow, he said.

Earlier, in his brief remarks, Mr Gauhar Raza, Chief Scientist, NISCAIR said that we should be proud that our country was the first to talk about Scientific Temper. However, over the years, he said, there has been a feeling that Scientific Temper had been consigned to the backroom and literally forgotten. It was therefore that NISCAIR along with a few like-minded organizations had taken up the responsibility to bring back Scientific Temper to the forefront of the national agenda.

Mr Gauhar Raza said science could not be like stagnant water. We have to irrigate young minds with new thoughts. He said that at the first conference held at Palampur certain resolutions had been finalized, also known as the Palampur Declaration. These were further refined and strengthened based on inputs received during the International Conference held in January. He said efforts would be made to keep working on the resolutions and take them to the masses for their endorsement.

In her Vote of Thanks, Ms Deeksha Bist, Chief Scientist, NISCAIR said that deliberations during the course of the conference had been fruitful. She especially emphasized on the fact that if science were to be made popular in Hindi, the use of difficult words needed to be avoided and some popular technical terms could be used in English only rather than making an effort to translate such words.

Scientific Temper – A World View

The Four People's Principles

JUSTICE MARKANDEY KATJU
Chairman, Press Council of India
(former Judge, Supreme Court of India)

WHEN we discuss science, we must ask: What is the purpose of science? The answer, to my mind, is that its purpose is to make our lives better and happier. Science is that knowledge by which we understand nature and harness it for our benefit.

Some people may oppose this view by saying that the atom bomb destroys lives, and that science has created terrible weapons of destruction. It is true that scientific knowledge can be misused, but it can also be used to benefit mankind, whereas without science we will be living precarious, wretched lives.

It can also be objected that it is only applied sciences (technology) that benefits people, but not fundamental sciences. It is true that a scientist doing fundamental research does not care whether his discoveries are of any utility or not. Newton and Einstein never bothered to know whether their discoveries would benefit mankind. However, the fundamental sciences benefit mankind *in the long run,* even though not immediately.

Today, India is facing huge problems, and I believe that only science can solve those problems. Eighty per cent of our people are living in horrible poverty, with massive unemployment, skyrocketing prices, massive problems of healthcare, education, housing, etc. Forty-eight farmers have been committing suicide on an average every day, and 47% of our children are malnourished, a figure which is over 10% higher than in countries of sub-Saharan Africa, for example, Ethiopia and Somalia.

Our national aim must be to abolish these evils and make our country highly prosperous for all our citizens.

To address the nation's problems I am propounding the Four People's Principles (following Sun Yat Sen's 'Three People's Principles'), which should be our guiding principles for solving India's problems. These are:

1. Science
2. Democracy
3. Livelihood, and
4. Unity of the People

Science

When our country was on the scientific path it prospered. With the aid of science we had built mighty civilizations thousands of years ago when most people in Europe (except in Greece and Rome) were living in forests. We had made outstanding scientific discoveries, e.g. the decimal system in mathematics, plastic surgery in medicine, etc. We had solved the problem of town planning 5000 years earlier in the Indus Valley Civilization, with covered drains, sewage system, etc. (something which is lacking even today in most cities in India).

When our country was on the scientific path it prospered. However, we subsequently took to the unscientific path of superstitions and empty rituals, which has led us to disaster. The way out for our nation is to go back again to the scientific path shown by our great ancestors.

However, we subsequently took to the unscientific path of superstitions and empty rituals, which has led us to disaster. The way out for our nation is to go back again to the scientific path shown by our great ancestors – the path of Aryabhatta and Brahmagupta, Sushrut and Charak, Ramanujan and Raman.

I will give just three examples of our scientific achievements in ancient times.

1. Decimal System: The decimal system was perhaps the most revolutionary and greatest scientific achievement in the ancient world. The numbers in the decimal system were called Arabic numerals by the Europeans, but surprisingly the Arabs called them Hindu numerals. Were they really Arabic or Hindu? In this connection it may be mentioned that the languages Urdu, Persian and Arabic are written from right to left but if you ask any speaker of these languages to write any number, for example, 257, he will write the number from left to right. This shows that these numbers were taken from a language that was written from left to right and not from right to left. It is accepted now that these numbers came from India and they were copied by the Arabs from us.

I would like to illustrate the revolutionary significance of the decimal system. As we all know, ancient Rome was a great civilization, the civilization of Caesar and Augustus, but the ancient Romans felt very uncomfortable with numbers above 1000. This was because they wrote their numbers in alphabets: I standing for 1, V for 5, X for 10, L for 50, C for 100, D for 500 and M for 1000. There was no alphabet expressing a number higher than 1000. If one would have asked an ancient Roman to write the number one million he would have almost gone crazy because to write one million he would have to write the letter M which stands for millennium (or one thousand) one thousand times. In the Roman numerals to write 2000 we have to write MM, to write 3000 we have to write MMM, and to write one million one has to write M one thousand times.

On the other hand, under our system to express one million we have just to write the number one followed by six zeros. We could thus express astronomically high numbers by simply adding zeros. Thus, if we keep adding 2 zeros to 1000 we get lac, crore, arab, kharab, padma, neel, shankh, mahashankh, etc. On the other hand, in the Roman numerals there is no zero. Zero was an invention of ancient India and progress was not possible without this invention.

2. Town Planning: 5000 years ago in the Indus Valley Civilization we had created the system of town planning, with covered drains, sewage system, etc., something which is absent even today in most cities of India.

3. Plastic Surgery: Plastic surgery was invented in India as early as the 6th Century B.C., while the Westerners discovered it only about 200 years ago.

I am not going into our other great scientific achievements (for details see 'Sanskrit as a Language of Science' on the website kgfindia.com). I have only referred to it to prove that there is nothing inherently inferior in us. However, today there is no doubt that we are far behind the Western countries in science, and that is the real cause of our poverty and other social evils.

Today there is no doubt that we are far behind the Western countries in science, and that is the real cause of our poverty and other social evils. We must therefore spread science on a massive scale to every nook and corner of our country.

We must therefore spread science on a massive scale to every nook and corner of our country. And by science I do not mean physics, chemistry and biology alone. I mean the entire scientific outlook. We must spread rational and logical thinking among our masses and make them give up backwardness and superstitions. The entire mindset of our masses, who are presently steeped in casteism, communalism and superstitions must be changed, and made scientific.

I must clarify that by science I do not mean the natural sciences alone, I also include the social sciences. Today a worldwide recession is going on – in fact the Second Great Depression after the first one from 1929 t0 1939 – and this can only be solved by knowledge of economic theory, not by knowledge of natural sciences or engineering.

Democracy

The second Great People's Principle is Democracy.

In this connection it is interesting to note that when King Ajatshatru of Magadha was planning to attack the Vajjian democracy he sent a messenger to the Buddha for his advice. Instead of speaking to this messenger, the Buddha said to one of his disciples, "Have you heard Anand, that the Vajjians foregather often and frequent the public meetings of their clan? So long, Anand, as the Vajjians so foregather and so frequent the public meetings of their clan, so long they may be expected not to decline but to prosper."

Similarly, in the *Avadan Shatak*, a Buddhist Sanskrit text of the second century AD, it is mentioned that a group of merchants went from North India to the Deccan and were asked by the Deccan King as to who was the king who ruled over North India. The merchants replied, "*Deva, kechit deshah ganadheena, kechit rajaadheena, iti"* which means "Your Majesty, some regions are under democratic rule, while others are under kings".

This shows that democracy is nothing new to India.

The method of *shastrarthas* was developed in ancient India, which permitted free discussion in the presence of a large assembly of people. This resulted not only in tremendous growth in philosophy, law, grammar, etc. but also tremendous growth in science including medicine, mathematics, astronomy, etc.

Some people say that democracy is not good for India. I totally disagree. The problem in India is not that there is too much democracy but too little. We need more democracy, not less, and that means educating the masses, raising their cultural level, and involving them actively in the task of national reconstruction.

It may be mentioned that democracy and science go hand in hand. Scientific growth requires certain supportive values viz. freedom to think, to criticize, and to dissent, tolerance, plurality, and free flow of information. These precisely are the values of a democratic society.

Livelihood

The third great people's principle is livelihood for the masses.

Today 80% people in India are poor, and there is massive unemployment, lack of healthcare, housing, good education, etc.

The problem in India is not that there is too much democracy but too little. We need more democracy, not less, and that means educating the masses, raising their cultural level, and involving them actively in the task of national reconstruction.

What we have noticed in the last 25 years or so is that the rich have become richer, and the divide between rich and poor has greatly increased. The economic growth in India has benefited only a handful of people. Unless this trend is stopped it will be disastrous for the country.

As the great French thinker Rousseau wrote:

*"It is obviously contrary to the law of nature for a handful of people to gorge themselves on superfluities while the starving multitudes lack the necessities of life." (*Rousseau: *Discourse on the Origins of Inequality)*

We must, using our creativity, find out ways of raising the standard of living of the masses. Ultimately, that is what matters. Whether the system we adopt, capitalism or socialism or communism or any other *ism*, the real test is whether the standard of living of the masses is going up under that system or not. Surely a system in which a quarter million farmers commit suicide in the last 15 years and vast masses live in abject poverty is totally unacceptable.

Before the Industrial Revolution, which began in Western Europe in the 18th Century, there was feudalism everywhere, and in the feudal system the methods of production (the bullock in India and the horse in Europe) were so primitive that very little wealth was generated, and so only a handful of people could be rich while the rest had to be poor. When the cake is small obviously few people can eat it.

In contrast, modern industry is so powerful and so big that enough wealth can be generated to meet the basic needs of everyone. This being so, now no one need be poor. And it is the duty of the state to ensure that no one today remains poor, unemployed, sick, illiterate or homeless.

Unity of the People

India is a country of great diversity having a large number of castes, languages, religions, ethnic groups, etc., because it is broadly a country of immigrants (see the article 'Kalidas Ghalib Academy for Mutual Understanding', and the video 'What is India' on the website kgfindia.com). So, the only policy that will work here is secularism and giving equal respect to all communities. This was the policy of the great Mughal Emperor Akbar, who was really the architect of modern India. It is this policy that was continued by Pt. Jawaharlal Nehru, the first Prime Minister of India, and his colleagues who created our secular Constitution.

Powerful vested interests are trying to destroy our unity and make us fight each other on the basis of religion, caste, region, language, etc. It is the duty of all patriotic people to expose these nefarious designs and maintain the unity of the people, for without that we can never progress.

In 1947, religious passions were inflamed, and Pakistan had declared itself an Islamic State. There must have been tremendous pressure on Pt. Nehru and his colleagues to declare India a Hindu State. It is not easy to keep a cool head when passions are inflamed, but it is the greatness of our leaders that they kept a cool head and said that India will not be a Hindu but a secular State. It is for this reason that we have relatively more stability in India than in our neighbouring country.

Powerful vested interests are trying to destroy our unity and make us fight each other on the basis of religion, caste, region, language, etc. It is the duty of all patriotic people to

expose these nefarious designs and maintain the unity of the people, for without that we can never progress.

(Inaugural Address delivered at the *International Conference on Science Communication for Scientific Temper* held in New Delhi during 10-12 January 2012)

Scientific Temper: A National Dream

MAHESH BHATT
Film Director & Producer

AT the core of every human being there is a revolt against that which is fixed.

The wandering, searching life is just too deep a part of our genetic memory for us to forget it completely.

It is hard for me to say where my own nomadic tendencies come from. All my life I had the sense of a wandering god within me.

But there is no romance in this kind of life. It is just a hard slog, of putting one foot in front of the other and hoping you will land on solid ground. There is no salvation on this path, only questions, indications, possibilities. But there is no other way I have been able to live. And that is why I am happy beyond your imagination, to be a part of this forum which hopes to re-ignite the fires of the scientific temper in the hearts of every Indian. But in order to do that, we have to bring doubt into the arena.

Doubt, which has been looked upon by culture as a sign of weakness, requires more courage than conviction does, and needs more energy. Conviction is a resting place and doubt is infinite.

No wonder then that even the mystics value darkness. Darkness is doubt, and doubt was their sniffing hound on the trail for truth. Two Christian mystics of great repute, Teresa of Avilla, and John of the Cross, spoke at length of the dark night of the soul. They spoke about arriving at light through darkness, not by negating darkness.

Doubt, which has been looked upon by culture as a sign of weakness, requires more courage than conviction does, and needs more energy. Conviction is a resting place and doubt is infinite.

There is a wonderful quote of John of the Cross, which says 'Oh night that guided me, oh night more lovely than the dawn, oh night that joined beloved with lover, lover transformed in the beloved.'

The scientific temper that Jawaharlal Nehru, one of India's greatest sons crusaded for, is born from a heartbeat; and that heartbeat is doubt. A society that is not decorous enough to concede to itself that we are billions of times more ignorant than knowledgeable, is doomed. In the dawn of the second decade of this new century, India must recognize that it is through the door of ignorance that one may journey towards reliable knowledge. Even the scientific community needs to wake up and face the blunt truth that their uncritical faith in scientific knowledge has created many of the problems now threatening the planet; and our wholesale reliance on scientific progress is both untenable and myopic.

The scientific temper that Jawaharlal Nehru, one of India's greatest sons crusaded for, is born from a heartbeat; and that heartbeat is doubt. A society that is not decorous enough to concede to itself that we are billions of times more ignorant than knowledgeable, is doomed.

The seekers all through the dawn of time have uncovered an interesting paradox. That knowledge and insights accumulate fastest in the minds of those who hold an 'ignorance based'

world view. Knowledge imposes a pattern and falsifies, for the pattern is new in every moment and every moment is a new and shocking valuation of all that we have been before. No two leaves are the same, no two snowflakes are the same.

It is only when we recognize this uniqueness of every moment in every individual, that we realize the true wonder of life.

But unfortunately, the problem with biases is that we often don't know that we have them, and aren't aware of how strongly they influence how we act.

Even the scientific community needs to wake up and face the blunt truth that their uncritical faith in scientific knowledge has created many of the problems now threatening the planet; and our wholesale reliance on scientific progress is both untenable and myopic.

Take a look at a flowering plant, for example. As it grows, it unfolds, leaf after leaf. When the plant grows up towards flowering, the lower leaves die away, so a plant lives by unfolding something very important at that moment, then moves on to make new structures, while past forms fall away. What a wonderful guiding image of how we can work with our ideas, concepts, and beliefs in every sphere of our lives.

The plant shows us what it means to be undogmatic. To put it simply, it shows us how to stay dynamic and adaptable.

That is what scientific temper is all about.

(Special Address delivered at the *International Conference on Science Communication for Scientific Temper* held in New Delhi during 10-12 January 2012)

Pushing The Frontiers of Knowledge

PROF. SAMIR KUMAR BRAHMACHARI
Director-General, Council of Scientific & Industrial Research
Secretary, Department of Scientific & Industrial Research, Govt. of India

HISTORICALLY, CSIR or Indian science was very conscious about science communication. I don't know how many institutions in our country were dedicated for science communication and for public science. All of us grew up as young scientists with our interest and excitement in science. And because journals like *Reader's Digest* or *Scientific American* were expensive, *Science Reporter* was the most exciting thing; we waited for it every month. I congratulate the leadership of CSIR-NISCAIR for publishing such documents for the last so many years. Even today *Science Reporter* is so beautiful and exciting and is contributing to scientific temper dissemination.

But there is always pursuable knowledge and there is unpursuable knowledge. The ignorance part always remains large. If we go back to the human civilization, when there was thunder, when there was eclipse, the knowledge was not available about the solar system or about electricity. So people thought, it is the task of god. Vivekananda said we are born educated; the problem is we have layers of ignorance like dust. All you have to do is to remove the dust. The extent to which this dust can be removed will decide the level of emancipation that we reach.

Vivekananda said we are born educated; the problem is we have layers of ignorance like dust. All you have to do is to remove the dust. The extent to which this dust can be removed will decide the level of emancipation that we reach.

In the 1980s we did not know that the human genes are broken into pieces, they are sliced. In the 1960s we did not know how the DNA is organized. In the 1940s we did not know the genetic material is actually DNA and in 1920 we did not know what causes bacterial or viral infection. So our ignorance in those days was superstition; today our ignorance is still superstition. When a conscious human mind is unable to find answers, his intellect is unable to answer the queries of his mind, it seeks for irrational submission and that irrational submission often gets manifested in belief in another individual who perhaps occupies the status of a religious leader – we look for someone who distributes happiness and teaches us to handle life as it manifests.

Therefore, I don't say there is any contradiction as a scientist between the individual's religious beliefs, an individual's interpretation of ignorance just because we don't know and just because we cannot give rational explanations. Over the centuries, over the millennium, human development has occurred continuously through questioning. Science communication and science communicators have a big responsibility of convincing the young generation of India to question, don't take statements as facts. If you find no other interpretation, then only take the interpretation as a fact understood with present knowledge.

Over the centuries, over the millennium, human development has occurred continuously through questioning. Science communication and

science communicators have a big responsibility of convincing the young generation of India to question, don't take statements as facts.

This is the single problem. You have to differentiate between a few unusually gifted scientists in India and a very large number of me-too scientists. The reason is we would like to do a thing that is doable; we like to believe in a thing that is pursuable. You would like to do science that you feel will happen; you don't like to do science where you have no clue how to work out. So, when you say scientific temper, first focus on scientific temper among the scientists. My request to science communicators is create an information-based decision making system that lasts for years. I have tried to implement this in CSIR – look at the facts and figures and then talk, don't carry opinions.

When we say India is not doing good, it is surprising. We published 38000 odd papers in 2009 in science journals, which everybody is quoting but in 2010 we published 46000 papers, we have grown 20% in one year against the global average of 4%. Yes, our base is low but we have grown 20%, earlier we were going at 11%.

We are the only country where the life expectancy from 32 in the 1960s has gone up to 64, now it is 67, without massive increase in economic status i.e. per capita income. How? Because we give the world powerful generic drugs and because of our science and scientific capability. ISRO spent in the last 50 years what NASA spends in one year. But we achieved the task of connecting 800 million Indians. We have been able to cover the outstanding play of Virender Sehwag and Tendulkar and also the miserable match they played in the last few matches in Australia through the satellites. We have made them heroes, but we haven't made the scientists, who have allowed you to see the match, heroes.

Hero is the player or the film star who could be seen by a billion people, but the people who made it possible are not heroes. I am sure hardly anybody would be able to tell who is responsible for fiber optics, or CCTV cameras or the communication channels – those are the heroes. So, the scientific temper and the scientific mood will only come when we make scientists heroes – science communicators' single-point agenda should be to identify and make scientists heroes. Give a value to the scientists in the society higher than everybody else; then only you'll see scientific temper.

I tell this with a sense of satisfaction because I was born in the city of Kolkata in the state of Bengal. Unfortunately I was born 50 years later. I wish I was born 50 years earlier, then I would have had Satyen Bose, J.C. Bose, Rabindranath Tagore, Meghnad Saha all these people as my colleagues.

Scientific temper and the scientific mood will only come when we make scientists heroes – science communicators' single-point agenda should be to identify and make scientists heroes. Give a value to the scientists in the society higher than everybody else; then only you'll see scientific temper.

What was there? Why in a single small location you created so many people with so much of scientific capability. How come all Ramanujans and Chandrasekhars and Ramachandrans came out from the south part of India. What creates extraordinary scientific creativity, what is the environment that is needed, how do you transmit that scientific temper to create fantastic science? Science drives the economy. When science-driven economy takes place, people benefit, when people benefit, eventually all appreciate science and scientific temper and you draw the best minds to science and not to sell Pepsi or potato chips.

In Gottingen in Germany, you go to a pub and introduce yourself as a professor, you will be offered a complimentary drink, that is the respect in that city. No wonder the streets of the city talk about Oppenheimer and Max Born. Great scientific temper is created by worshipping scientists, making them heroes.

Actually, we should not focus too much on the negative part of the problem. Yes, when I go to the Doctor, the Doctor gives me a medicine to take care of my cancer and then says, "Sorry the drug is not working". What is the option left for me? I just go to the next-door temple; I sit in the temple and pray to God. Please understand, mind and body are linked. We know nothing about mind; we know something about the brain. We have no clue about the chemistry of our mind but we have some clue about the chemistry of our brain. Until we have been able to understand our mind, the chemistry of our mind, the molecular biology of our mind, the electronics of our mind, the way we understand the ether space, the way we understand the electromagnetic waves, then only we will start doubting and questioning.

How do I know what is the relation between body and mind? I have seen extraordinary doctors, at the end of their scientific careers as doctors, they become spiritual, especially very brilliant cancer doctors, very brilliant neurosurgeons, because they realized that all their knowledge still could not save lives and they don't know why some lives get saved. So, when rationality ends, you could say irrationality begins. I would say no – rationality ends when knowledge ends and ignorance begins. So, push the frontiers of knowledge so that the darkness of ignorance decreases. And secondly, celebrate what you have; the people who create that knowledge. That is the job of the science communicator. If you are able to do that then you will see that the best mind will come to science, best people will come to science, they will have the highest social respect and then their voice will be heard.

Rationality ends when knowledge ends and ignorance begins. So, push the frontiers of knowledge so that the darkness of ignorance decreases.

Unfortunately, even in our Science Congress we put cards like VIP: very important person. We do not write very important scientist. Scientists are forgotten. The rows are filled up with VIPs. Science can only be communicated and Scientific Temper in society can only be brought to the highest level when scientists are made heroes.

One of my happiest days was when hon'ble parliamentarian Mr. Dhoot, who happened to be Videocon chairman, invited me and Radhakrishnan when NASSCOM organized a special function after the Chandrayan and where a large cake was brought to celebrate the success of ISRO's Chandrayan and Radhakrishnan's birthday. I said, when politicians and industrialists can salute the scientists, then only we can be sure that we have got scientific temper.

In the new cyberspace, in the era of Facebook and YouTube, our approach to science communication has to be different. I have a YouTube on which I issue office memorandums on whatever topic I want to communicate and it is accessible to all the 5000 CSIR scientists. All my communications for the Twelfth Plan were through video memo. These are short You Tube clips; it's very easy to communicate through social networking. I think this has been missed and I believe that's the future.

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The future lies in this new cyberspace and we are thankful to Dr. Chidambaram and the Sam Pitroda team to have given India the most powerful national knowledge network backbone and I am sure the Indian science communicators should be able to use this very effectively to create Indian science news, Indian science heroes, and remove superstitions like Ganesha drinking milk.

Who'll make the content? My feeling is you don't need a professional to make content. The content can get created by ordinary people. I want NISCAIR to create an open studio like an open source document, with open access to a large number of Indian kids who are very creative. But our education system is so stifling that their creativity doesn't come out. I think we haven't exploited our natural curiosity based education system. This can be done, experimental learning by creating a large studio. CSIR can afford it, put some 50 crores and we can create this studio where children can come in and explore and create products and contents, which then can be checked and improved upon by professionals. This is my dream.

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Science Communication: New World, New Challenges

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THE history of the complex science-society relationship may be simplified by stating that this history is primarily a growing integration through time, to the point where today's society develops only in parallel with science and technology. The notion of economic and social progress is now so intimately associated with developments in science and technology that the two factors tend to merge.

The Science-Society Dynamic

Add to this history a progressive awareness of the increasing impact of science and technology on society. Originally peripheral, with a limited effect on the social dynamic, over time they have induced a profound transformation, one that we grasp through their advancements and applications, a transformation that has upturned the familiar structure of existence and stunningly revolutionized the associated representations. Science and technology are so pervasive in our daily lives that their descriptive words and ideas pervade our thought. They "invent and present a major portion of the objects, concepts, analogies and logical formulations we use to address our economic, political and intellectual tasks.

I wish to explore the evolution of growing interactions between science and society from the perspective of the strategies and means of communication adopted to bring science to the general public and to foster the appropriation of knowledge.

For over 30 years, individual and collective appropriation of scientific knowledge has been perceived as a social necessity. Why is this? Because adapting populations to a perpetually-renewing social and technical environment means a constant acquisition of new skills; and keeping these up to date in turn demands an ongoing collective capacity of innovation, seen as the engine of economic and social development. While the notion of progress has long been linked to scientific and technical progress, the two are inextricably bound to that of economic development. And the necessity to regularly upgrade skills, to maintain collective performance, is but the counterpart "of the process of change", as so aptly stated by Schumpeter, "that constantly revolutionizes the economic structures from within by endlessly destroying its aging elements and continually creating new ones.

While the notion of progress has long been linked to scientific and technical progress, the two are inextricably bound to that of economic development. And the necessity to regularly upgrade skills, to maintain collective performance, is but the counterpart "of the process of change".

This means constant social mobilization. And governments, anticipating the expected positive spin-offs, have redoubled their efforts to develop and promote science literacy. This political will has served to underpin and shape the successive strategies in public communication of science and technology (PCST) for more than 30 years. This is worth keeping in mind as we try to determine their evolution over this period of time.

A Nod to the Past

But a nod to history is useful in understanding this recent dynamic. From the time that the scientific effort as we now know it began to emerge, it adopted means of dissemination for its own expansion and perpetuation, a reminder that producing and publicizing knowledge have always been pursued. Science from the start sought to be open. The 18th century scholars opted for an exchange of knowledge and the inherent increase of knowledge it made possible. They renounced secrecy, first amongst themselves and then towards the general public. In short, the development of science owes much to this choice of transparency adopted from the beginning. In this respect, the book played and still plays with other means of communication an instrumental role.

Communication among researchers, that is, communication to produce new knowledge, distinguished itself from communication to disseminate knowledge from the time that mathematization and formalization entailed a self-enclosure. The notion of mediation to maintain contact with the general public originates from this dissociation. If the idea of mediation itself *ipso facto* involves a self-enclosure of the scientific field, it equally demonstrates a necessary willingness to socialize science, that is, to place it within social discourse. Without which, being no longer part of public consciousness, it would deny its underlying principle of universality.

The public communication of science, as we understand it today – long referred to as "vulgarization" or "popularization" – appeared in the 19th century. In the first half of the 19th century, the pace of scientific progress accelerated and progressed thanks to better work organization. The 18th century amateurs gave way to professionals trained by standard science instruction dispensed by a network of specialized institutions endowed with libraries, collections and laboratories. Research then became better organized, with specialization, a genuine model of division of labour, better equipped, and it progressed rapidly. Practical spinoffs also gained in importance. From the early 19th century forward, the application of scientific knowledge to agriculture, industry and transportation progressively transformed economic life, fostering the emergence of big industry and, as I propose, generating a massive flow of information geared to scientifically educating the general public. It was in this context specific to the 19th century that "popularization" truly blossomed.

Research was notably fundamental during this period. The desire to know in order to know. Pushing the limits of the unknown was paramount. This of course meant discovering the world revealed by science. But most of all it persuaded the population to espouse the idea that a quest for knowledge in itself gains its whole worth and merit through this quest itself.

The communication model of the era was a template of the master-student relationship: the scientists often simultaneously played the roles of master and mediator with the public. They spoke to a public deemed ignorant that must be taught the rudiments of scientific concepts, to bolster their minds and extricate them from their condition. Those with knowledge spoke to those without. It was an encyclopedic approach: the accession of scientific knowledge was perceived as the accumulating of parcels of purportedly essential knowledge whose assimilation was mandatory for anyone claiming to be science literate.

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However, the spinoffs from scientific research, albeit disinterested, ended up accumulating with ever-gathering force, clearly demonstrating the radical transformative power

of science and technology, increasingly present daily in an environment being constantly recast. As a result, once science's power to transform became evident, science itself was quickly put to the service of economic and social development. It has been this way ever since, reversing the previous logic, and from then on, to know in order to innovate, and no longer knowledge for knowledge sake while leaving to others the task of finding applications inherent in this knowledge. Furthermore, today it is imperative to innovate, and to search only when the knowledge leads to innovation. This new thrust characterizes post-industrial society. The turning point, inverting the polarity, happened around the 1970s.

Today's Challenges

As mentioned earlier, beginning in the 1970s and gaining momentum in the 1980s there were considerable efforts to raise the general public's level of science literacy to one closer to that of scientists, to convince it of the positive spinoffs of research, and to involve it dynamically in the considerable changes. Indeed, and here's the upshot I think, the result of all these efforts, is a public much better informed but not necessarily more convinced, certainly less at any rate than at the beginning of the 20th century when advances in knowledge were still associated with enhanced well-being. This observation led the Select Committee of the Chamber of Lords to summarize the conclusions of its work in a stunning statement: "Society's relationship with science is in a critical phase.

No longer is it possible to ignore the intricate complexity of problems that stride alongside the upheavals of daily life jolted by the changes on the affairs of the world impacted by science and technology. Everything occurs as if the combined effect of promotional campaigns, of developing and raising the level of the public's science literacy to adapt to these changes were accompanied by a shower of uncertainty and doubt. The Select Committee of the Chamber of Lords, based on various enquiries, observed, at the turn of the 21st century, that "public interest in science" in the United Kingdom "is currently high", but that "there is however, an apparent crisis of trust. While people appear to have an appetite for popular science, the paradox is that this is accompanied by increasing skepticism about the pronouncements of scientists on science-related policy issues of all types".

No longer is it possible to ignore the intricate complexity of problems that stride alongside the upheavals of daily life jolted by the changes on the affairs of the world impacted by science and technology.

This observation was not new. Already in 1970, Jean-Jacques Salomon, a French scientist, stated: "Science and technology are our destiny, in the same way that politics is the destiny of science and technology: we can learn to have it serve us better, we cannot choose to escape [from] it". In other words, today, 30 years later, it's a certain idea of progress that is questioned in our coming world: a future that is no longer designed without the structuring input of technology and science, no more than it can escape a questioning about these.

But let us go back a few years to better grasp the sequence of circumstances that spurred this questioning. In the early 1960s, two ruptures would occur. The first was characterized by an accelerated movement of autonomization of PCST. This affirmed its legitimacy. The popularizers, until then auxiliary to the scientific community, demanded to be its exclusive mediators with the general public. They justified this demand by denouncing scientists, henceforth deemed unsuited to communicate with the public, to decipher its expectations, or to share with it the "immense power that knowledge bestows".

While these scientists had certainly contributed in a major way to purveying scientific thought in the 19th and early 20th centuries, they had to be replaced by a "third man", neither scientist nor lay person, who would serve as intermediary between the scientific community and the general public. The two were brought closer together thus narrowing the gap between scientific and ordinary knowledge. This approach is exemplary because it constructs and condenses a representation that is diffuse yet portends the role of media. In hindsight, we now know that denouncing an ever-widening gulf also helped incite the autonomization of media. The arrival of an intermediary sealed this autonomization. It kept the scientific community and the general public reasonably distant from one another, while defining the conditions of their presence via a media portrayal.

In short, it was during these years that the notion of *deficit model* came in, bolstered by the movement of media autonomization. The *deficit model* presupposes a *knowledge gap* between scientists and non-scientists. The most famous proponent of this vision, still popular, is of course C. P. Snow.

The second rupture is the observation – mentioned earlier – that with progress comes hazards and risks. Bhopal in 1984, Chernobyl in 1986, Fukushima last year, etc. remain in the forefront of people's minds. Add to this the risks associated with persistent pollutants decried since 1962. Too many and repeated accidents spurred a questioning of the notion of progress and this systematic doubt in people's minds has become a fact of society. As the report of the British Lords states: "[t]oday, fear of such risks is a major feature of public attitudes toward technology across the industrialised world". The public has become cautious, mistrusting and critical. Gone is the force of conviction for a Utopic society transformed by the reason of the Enlightenment, represented in scientific and technological progress, and tangibly manifesting in economic development.

In sum, today's public recognizes the benefits of science and technology development (improved lifestyle, better working conditions, medicine, etc.) but with a pragmatic proviso. It also acknowledges the inherent risks. This has made it more difficult to teach the public the "truths" of science or to define the public as incompetent with no voice in the matter. Especially since the advocated choices or decisions could adversely affect it sooner or later. Another way to describe this examination of the role of PCST is to say that if society is transformed by its constant interaction with science, this transformation itself redefines its relationship with science. Suddenly, the current conception of knowledge and ignorance must be revised. And the PCST strategies must adapt, because the previous accompanying justifications no longer apply.

In sum, today's public recognizes the benefits of science and technology development (improved lifestyle, better working conditions, medicine, etc.) but with a pragmatic proviso. It also acknowledges the inherent risks.

But there's more. We now know that science is more like an "archipelago" than the ideal island once dreamt of. Will the disciplines continue to fragment into increasingly autonomous specialties as knowledge proceeds? An evolution that leads to a paradoxical observation: the effort to reduce the diversity of the world to a few fundamental laws, to simplify the world, so to speak, became one with its complexification. Today we live in a world that is more difficult to decipher, since attuned to a multitude of different outlooks.

The effort to disclose and reveal culminated in a parceling of knowledge. And thus "the level of ignorance in a particular field is just about as high in the scientific community, where

most of them work in other areas, as among lay persons. So we aren't dealing with just one major gap separating scientists from non-scientists, but a multitude of particular hiatuses separating specialists". As a result, the science and technology ignorance is doubtless the most common thing in the world. And this will only continue to increase in future.

Regardless of the extent and scope of knowledge mastered by anyone in a given area – insofar as specialists can agree amongst themselves on what's considered essential – this knowledge is always out of sync with other areas and even to new knowledge in its own area. The accumulation of knowledge thenceforth prevents anyone from boasting of purported mastery in their own area, which even more quickly encloses specialties within themselves, with imaginable consequences. The gap is structural. In the "archipelago of science", the hiatus can only widen between scientists themselves and non-scientists. This situation is such that when a researcher is invited to pronounce on a question outside his discipline, his opinion becomes but one among others. And that of a lay person is worth just as much.

Thus the Utopia of a would-be encyclopedic PCST designed to fill the gap between researchers and laypersons leads nowhere. Confronted with an accumulation of knowledge in increasingly "airtight" areas in respect to each other, faced with increasing specialization, as well as the ever-accelerating "obsolescence" of knowledge, the actualization of anyone's knowledge can only be contemplated in terms of the professional preoccupations of the moment. And thus it is the individual trajectory that prevails. Which implies that the relationships to knowledge will be very different from one individual to another. Moreover, these relationships will vary in keeping with the wavering concerns of the moment whether broaching a general question of scientific knowledge or a specific topic.

The development of the Internet and transformation of the accompanying modes of mediation also converge to reinforce this trend. Cyberculture is primarily characterized by a communicational immanence engendered by the Internet, based on the three great properties of the Web: surfing that shatters the constraints of space and time of traditional modes of writing; a hypertext that enables "a generalized looping of knowledge within itself"; and more interactions, now "permanent and retroactive" between the producers and users of information "with any point of the communication network".

This cyberculture leads simultaneously to the emergence of new actors and marginalizes the traditional forms of mediation of scientific knowledge. The diversification of means of communication brings new actors to the scene, from various horizons – from scientists totally invested in their work, to the passionate amateur – engaged in producing and dispensing more science information. Which results in more sources and a challenge to the habitual modes of scientific mediation. So there are now more actors than ever engaged in producing science news, with scientists and mediators representing but a small number of them.

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So the sharply defined borders between scientists and lay persons today tend to become rather blurred. And whether or not it was intentional for the traditional public oriented science mediation to fragment into target audiences, the new communication format tends to

essentially put specific interest groups in contact, to elicit such groups, and to very obviously try to be part of it. Which radically changes the deal.

This aspect is of prime importance in that information search draws on vast-ranging search engines while the media is diversifying: portals, e-zines, forums, personal home pages, chat groups, address lists, blogs… in pace with an equally diversifying Net attuned to the interests of these groups. It follows that specialized information aimed at professionals in a particular field is also accessible to the general public, or at least to an interested public. Thus a hodge-podge of information co-exists pell-mell – promotional material, publicity, advertising, marketing, services, reports, public information, guides, directories.

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First, and notable, what is disseminated to certain audiences is very quickly accessible to everyone. Second, amid all the material produced for and circulating on the Net, it is increasingly difficult to discern the information strategies among those touting and promoting organizations. Third, in this system of generalized communication and exchanges, based on exacerbated competition between organizations, it is impossible to be certain that the information has been validated, by internal review mechanisms and by peers reviews alike and to control the sources.

Participation and Dialogue

In conclusion: the science-scape has been completely transformed in just over 30 years. Science exerts such impact on today's society as to have completely remodeled it. And the ways of appropriating knowledge, individual and collective, in terms of parceling disciplines, the burgeoning knowledge produced by each of them, the de-multiplication of information sources, can no longer be thought of in terms of models that prevailed up to now. To imagine other models, one must try to understand what has changed. I've tried to do this by highlighting some aspects of the present situation that I see as significant.

The science-scape has been completely transformed in just over 30 years. Science exerts such impact on today's society as to have completely remodeled it.

As I've tried to show, the individual trajectory seems to me a path to be explored more fully. Because it will no longer be possible in future to conceive of the dissemination of science in encyclopedic mode – if perchance anyone ever seriously believed that acquiring science literacy was but the sum of elements of knowledge deemed essential and indispensible. Today, no one can master the corpus of knowledge produced in his or her own field. Everyone navigates alone in the labyrinth of knowledge, according to professional preoccupations, personal interests, specific constraints, or concerns of the moment. Mediation now plays out at the interface of individual expectations and access to timely information. The results will of course differ from one individual to another, as from one context to another.

But mediation cannot limit itself to being a mere contact point or contact facilitator to the desired knowledge. Unlike the outmoded conception of PCST as an exercise dispensing

would-be neutral truths to a so-called lay audience, only an approach that fosters a confrontation of ideas between actors engaged in a reflection yields a critical appropriation of knowledge in a world governed by complexity. The mediation must therefore be conceived like creation of a discussion space, where arguments propped up by a commonality of knowledge are advanced and debated.

And indeed, this is what happens with the *Consensus Conferences* that engage the actors in a process of negotiation, with the *Science Cafés* that put scientists in contact with the public without interposing a mediator, and it's the discussion itself which, in the *Sciences Cafés*, then defines the mediation, communication and information spaces, with the science museums that become *forums of discussion* on matters where science raises genuine problems for society. In this kind of a dynamic, the knowledge relationship alters. It becomes deliberative, that is, a critical outlook emerges. And ultimately, it is through the confrontation of such outlooks that knowledge is acquired, put to work, and a collective consent forged.

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Nehru's Scientific Temper as Battling against Pseudo Sciences

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NEHRU'S popular notion of "scientific temper" (Ramesh, 2011) seems to cover many things, including the spread of scientific knowledge for the economic and spiritual development of India. Its essence is "a questioning mind … not prisoner of any dogma, modern or archaic".

Therefore, scientific temper needs to be considered as a cultural product (e.g., scientific knowledge, disposition or predisposition), that which behavior brings to science. It functions as the temper of a free man, as the approach of an open mind. It is what science is as behavior, not just what science brings to other behaviors – like problem solving. Especially, Nehru seems to have emphasized in the notion of scientific temper the battle against pseudo sciences such as religious bigotry, superstition and astrology.

Current popular notions of scientific literacy and public understanding of science are also the outcomes of what behavior has brought to science – such as interest in, knowledge of and/or attitudes toward science (Bauer, Durant and Evans, 1994; Durant, Evans and Thomas, 1989; Miller, 1983). Whether we speak of scientific temper, scientific literacy or public understanding of science, any or all of these necessitate our *prior* engagement with science as a behavioral process. Otherwise, we will not get the product of scientific temper. Thus, it is clear that the concept of scientific temper presupposes a process of behavioral engagement with science.

Engagement with science as a behavioral process has been conceptualized as two engagement processes in sequence: engagement with a problem and engagement with science as a problem solver (Kim, 2012). The former is common and omnipresent; there is no shortage of problems to be engaged. The latter is less common, as solutions are sought from other, non-scientific sources. These non-scientific sources may also be anti-scientific sources, at war with scientific temper.

Scientific temper needs to be considered as a cultural product (e.g., scientific knowledge, disposition or predisposition), that which behavior brings to science. It functions as the temper of a free man, as the approach of an open mind. It is what science is as behavior, not just what science brings to other behaviors – like problem solving.

Engagement as a Behavioral Process

Behavior, the steps we make and take, is conceptually independent of body (Carter, 2010a, 2010b). It has its own structure and principles distinct from those of the body. Basically it consists of *act* components, modes of relating, for example: exposing, focusing attention, cognizing, questioning, remembering, and imagining (Kim, in press). Thus, the process of behavior can be explicated as any of a vast number of sequences of such acts – in one step or a molecular compound of several steps.

Engagement is an exposition of the process of behavior in a problem-solving context. Our world is full of problems. So, we must inevitably engage with these problems in order to survive. Even if we are exposed to many problems, we focus attention on the most important problem and cognize its consequentiality and its solutions. Communication can help those acts of exposing, focusing attention, cognizing, and so on. Here, we see engagement with problem as the first step of behavioral preparedness to engage with science.

Often problems pass by, not getting a person's focal attention. A society may have too many problems so that its people may be fatalistic, that is, ignore all those problems. They may think they can't control them individually or collectively. Thus, control capability may be more important than control need. In such a society, any engagement with problem is difficult to achieve. They may need no 'scientific' temper to solve the problem.

Very recently we surveyed South Korean students from 4th grade of the elementary school to 2nd grade of the junior high school about what problems they have, personally or socially (Kim et al., 2011). As expected, their most salient personal problem was found to be test grades. However, their most salient social problems were environmental problems such as littering or river pollution. They were little concerned about food poisoning, which we wanted them to engage with. Therefore, to bring forth youths' engagement with food poisoning, we had to provide information of how many children die of or suffer from food poisoning every year. Without achieving engagement with food poisoning, we can't lead youths to engage with scientific solutions such as cleaning hands, boiling properly, irradiating meats, and so on. The bottom line: scientific temper can't even start without engagement with a problem.

Sometimes, we may focus attention on a problem beyond exposure to it. But, we are not easily able to project its consequentiality without critical information being provided. For example, many environmental problems impact us on a long-term basis. We tend to overlook their potential risks, because they usually appeal to short-term benefits rather than long-term harms. In this case, we may also lack a perceived need to engage with those problems.

When our engagement is extended to cognizing a problem's consequentiality, we must have obtained considerable engagement with the problem. Then, we may be ready to search or construct some possible solutions to that problem. Now, science may have a chance to be summoned to deal with it.

Engagement with science is likely to follow *cognitive* engagement with a problem, because science tends to contribute to defining and solving the problem. However, science does not readily relate to problem definition and problem solution. We rarely remember scientific information, even though we learned a lot of science during school days. We have to make special efforts in order to engage with science again. Engagement with science can easily be lost or avoided, even if engagement with the problem was successful. That's why scientific temper as behavioral preparedness and process is often missing even among highly educated people.

Now, we find that the full process of behavioral engagement with science – that is, engagement with *science* plus with *science as a problem solver* – is not easily completed. What leads us to fall short of completing the process?

We rarely remember scientific information, even though we learned a lot of science during school days. We have to make special efforts in order to engage with science again. Engagement with science can easily be lost or avoided, even if engagement with the problem was successful. That's why scientific temper as behavioral preparedness and process is often missing even among highly educated people.

Failure of Engagement with Science

Everyone wants to solve a problem as fast as possible, as the problem is crucial and imminent. Behavioral efficiency is also a major concern, because we don't want to waste energy. For example, crisis is enough to bring forth high engagement with a problem, but not necessarily high engagement with science with regard to solving it. Rather, very impromptu but non-scientific solutions (e.g., prayer) might be mobilized with a hope to control or avoid the crisis.

Nehru's notion of scientific temper, especially as battling against religious bigotry, superstition and astrology, becomes critical to engagement with science, followed by *science's* engagement with the problem. He seems to stress the scientific temper with regard to scientific problem solving, that is, relating science to problem solving.

Imagine a cancer patient. S/he is really in a critical, problematic situation. To wit, engagement with problem is sufficient. In this case, the patient must make many efforts to solve the cancer problem. S/he may go to temple or church to pray for miraculous recovery, visit a fortuneteller or astrologist to invite some positive prediction, purchase a talisman hoping to expel evils, search all kinds of relevant information through the Internet, join a group of the same kind of patients in order to get useful information, meet a medical scientist or doctor, and so on.

A miracle may be most needed to the critical cancer patient. It is the most efficient solution. Typically it is expected not to need much time and pain. Most pseudo sciences emphasize such a miracle as *the* problem solution. The miracle is considered the only option of solving the problem all at once. Many miracles are longed for to solve numerous problems in an uncivilized society lacking scientific temper. Also, persons and things that summon a miracle demand unconditional respect and absolute authority from the patient. This accelerates her or his full dependence on them. Indeed, engagement with the miraculous problem solver appears immediate, efficient, and panacean.

The more distant a problem and its solution are from a miracle, the more scientific the behavioral process may be. For example, going to hospital demands many steps from making an appointment with a doctor to making diverse examinations of bodily symptoms. Many sciences are also involved in those steps. Engagement with science becomes complex, tedious, and perhaps more uncertain.

Not only scientific but also financial engagement is highly needed by and/or for the cancer patient. S/he should be able to endure financial burdens. Then too there are the physical sufferings from hospitalization, operation, and treatment. Engagement with science may be just a companion to other engagements. In this situation, pseudo sciences such as religious bigotry, superstition and astrology penetrate too easily into the patient's problem-solving situation. Nehru's scientific temper as battling against pseudo sciences seems to stress the second step of problem solving, that is, engagement with science, followed by the first step, engagement with problem. Now, the question is: How do we advance the applicability of the scientific temper when the sequence is reversed to the more natural order of problem first?

Nehru's scientific temper as battling against pseudo sciences seems to stress the second step of problem solving, that is, engagement with science, followed by the first step, engagement with problem.

Engagement with Science

Again, our engagement with a problematic situation does not always lead to our engagement with science in solving it. People can readily bring some type of a magical cure into the picture. That's why pseudo sciences still prosper even in highly industrialized societies.

A problematic situation implies a situation of incomplete instruction for behavior. Incomplete instruction can indicate non-instruction or multiple instructions, both of which lack the singularity needed for a move (Carter, 2010b). So then we have to construct a solution so that we can make the indicated move to solve the problem. Thus, problem engagement via science is to construct a solution scientifically.

A problematic situation can invite many questions in order to clarify unclear ideas or elicit new ideas and to establish dubious facts or discover new facts, which is mainly what science serves. Thus, the act of questioning must be a key to enabling engagement with the scientific temper. Questioning may summon existing scientific information or new scientific inquiry. Problem solving is beyond fact finding. It is likely to entail constructing a new idea. So, scientific questioning includes not only "what/how is and was it?" but also "what if?"

On the other hand, a miracle or panacea excludes the act of questioning. It may comfort us but not solve the problematic situation. Rather, it promotes the ban on questioning. Its advocacies, whether religion, superstition or astrology, enforce unconditional acceptance and obedience. As long as the act of questioning is stifled, science is doomed to be futile, whether it is established scientific knowledge or new scientific inquiry.

The act of questioning especially enriches the act of cognizing (Kim, in press). Cognizing relates one element to another via a relation, which produces a relationship (e.g., an idea). Using just one element with a relation, questioning can evoke a possible element (e.g., an imagined thing). This cognitive capability, in cooperation with communication's capability to objectify anything, actual or imagined, is critical to constructing a new solution. Problem solving is not limited to orienting to, and choosing among, available solutions but extends to the possibility of constructing a new solution. The latter gets helped a lot by cognizing's constructing mode.

Thus, engagement *with* science and engagement *of* science in problem solving – the *full measure* of the *scientific temper* – may be realized mainly through *questioning.* Questioning elicits not only available scientific solutions but also scientific inquiry to produce a new solution. In that sense, questioning must be the key act in and for Nehru's scientific temper in battling against pseudo sciences.

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Conclusion

This paper tried to *redefine* India's popular notion of "scientific temper," advocated by Nehru, the first prime minister of India. In a broad sense, it is found to refer to scientific literacy, public understanding of science, the scientific culture and/or mind. In addition, we found that Nehru's scientific temper notion emphasized battling against pseudo sciences such as religious bigotry, superstition and astrology. Focusing on the rather narrow notion of battling, this short essay tried to conceptualize the concept of scientific temper in the problem-solving context.

Scientific temper may be seen as engagement with science to be followed by engagement with a problem. But the latter's achievement is indispensable to bringing forth the former's achievement in the problem-solving situation. When we are seriously engaged with a problem, we are likely to try to solve it, using many options including science. However, human desire to

expedite problem solving tends to invite many non-scientific solutions that are referred to as pseudo sciences. In this situation, the process of problem solving, as a matter of fact, is disconnected and unproductive.

We argue that the act of questioning promotes engagement with science, that is, Nehru's scientific temper as battling against pseudo sciences. Questioning evokes not only established science but also new scientific inquiry. It enriches cognizing, whose three modes are orienting, constructing, and reorienting (see Kim, 2003). Especially, cognizing's constructing mode may serve questioning well so that a new solution can be constructed in problem solving.

India's battling against pseudo sciences such as religious bigotry, superstition and astrology seems to be very important to our planet's development not just India's.

India's battling against pseudo sciences such as religious bigotry, superstition and astrology seems to be very important to our planet's development not just India's. When India's huge population is constructive via questioning in problem solving, we may advance the 21st century's human civilization in a much better way. Otherwise, we may face a more difficult world in which to survive and thrive.

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Communicating Science: Shifting Boundaries of Perception

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WE are complex beings that fill the world with complicated systems in order to understand, control and exploit each other and the planet we live on. We continuously interact with our environment in a manner that is characteristically difficult to analyse due to continuous shifts and changes in our environment.

According to Paul Cilliers (1998), human beings, representing complex systems, demonstrate a robustness and capability to perform strategically under different circumstances and conditions in order to ensure their survival. In our efforts to self-organise the world, we designed a number of systems, devices and tools to enable us to also function in a synchronised and organised manner. The separation of knowledge into complicated and organised streams of knowledge, according to what constitutes a discipline, serves as example.

Organised knowledge (originating from René Descartes, 1596–1650) followed efforts to lay a philosophical foundation of western thought during the modern scientific age of the European Enlightenment. To this end, Descartes introduced a form of epistemological foundationalism, based on the assumption of prior (*a priori)* knowledge within a universal (thinking) subject (*cognito)* tradition of thought. In the quest for 'true' knowledge, western philosophers believed that scientific thinking represents the best possibility of achieving this goal.

On the strength of the assumption of *a priori* knowledge of the human universal forms of thinking, Descartes argued that philosophy-as-epistemology can best account for the success of scientific thinking and its related ideal of revealing the objective reality (nature) of truth. To reach 'true' knowledge Descartes (1644) introduced a method of systematic doubt, as a pre-requisite for the possibility of achieving absolute certainty (the normative condition with the possibility of truth). The assumption of *a priori* form of knowledge represents the foundationalism of the modern philosophical-epistemological tradition.

Descarte's (1644) philosophy of foundationalism has given respectability to the idea that only reason can provide true knowledge. He defended this idea by stating that empirical knowledge is of lesser importance. Rationalism is taken to be a superior form of knowledge to that of empirical knowledge (the view that all our knowledge is derived from sensory experience). According to Descartes it is because the latter cannot provide the certainty that originates within the structures of *a priori* knowledge.

Descartes's importance lies in his placement of man as the foundation of rational thought. With man as the centre of knowledge and the seat of rationality, modernity became equated with humanism, and science was given

the prestigious position of representing the highest form of human rationality within the modern philosophical tradition.

Implicit in Descartes's form of foundationalism is the claim that we can overcome the problem of circular reasoning by demonstrating the possibility of absolute certainty as the source and justification of all knowledge. Descartes, therefore, felt justified to dismiss everything that could not be accounted for in terms of absolute clarity and distinction, which meant that he would dismiss everything that he perceived to fall outside the logical scope of the thinking subject as the privileged seat of rationality. It is from this perspective that we are meant to understand the rhetorical significance of Descartes's (1644) statement; *I think therefore I am.*

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Immanuel Kant (1781), on the other hand, attempted to demarcate the legitimate limits and limitations of human knowledge and rationality. Kant (1781) emphasised the 'possibility of experience' as the parameter for defining the limits of human knowledge, and he seeks to reveal the underlying universal and necessary *a priori* condition of the 'possibility of knowledge'. According to Kant, although we relate to the world of empirical objects through our senses, we can only know and understand the world on the conditions of certain pre-suppositions, all of which originate in the mind of the thinking subject (man). Without man there can be no knowledge. Empirical knowledge is therefore preceded by an *a priori* conceptual framework, which determines the subject's experience of objects (nature) and knowledge.

For Kant (1784), the possibility of science is accounted for in terms of the philosopher-as-epistemologist's ability to show that science originates from within the cognitive structures of a universal subject of knowledge (western man). The Kantian epistemological approach is therefore as foundationalist as that of Descartes in so far as (western) man is privileged as the centre and seat of rationality. Scientific knowledge originates from human rationality (thinking) and as such, it represents the highest form of knowledge and human rationality.

Epistemology explains how this is possible by grounding scientific knowledge in the philosophical thinking of man as a rational being. Kant (1784) viewed all forms of dependence on traditional knowledge systems as an expression of intellectual laziness and inferiority. He therefore challenges man as a rational being to have the courage to use his own reason and intelligence in the search for knowledge. As he puts it: "*Sapere Aude!* Have the courage to use your own intelligence!" This became the motto of the enlightenment.

Today we face the Cartesian and Kantian legacy that dictated an approach and a way of reasoning that elevated the status of science above that of the social sciences. However, philosophers like Jürgen Habermas and his theory of knowledge-constitutive interests in *The Theory of Communicative Action* (1984), and *The Philosophical Discourse of Modernity* (1987) initiated a change in direction for scientific thinking. According to Habermas (1984), we could begin by distinguishing between empirical-analytic (positivist), hermeneutical (interpretive) and critical approaches in science research. Each of these follows a certain approach that guide the production of knowledge.

Empirical-analytical research focus on a technical or instrumental (means-end) interest, hermeneutical (interpretative) research has a practical interest and critical research follows an emancipatory interest. One could now begin to argue that critical social science is under threat from postmodern and poststructuralist challenges – especially under the notion of an

emancipatory approach in action research. Habermas's (1987) thesis of 'uncoupling' systems and life-worlds and his thesis of the colonization of the life-world will allow us to look at the differences between steering problems (disciplinary methods) and problems of mutual understanding (interdisciplinary and multi-disciplinary methods).

The Notion of a Scientific Temper

What I tried to establish in the above introduction is to argue that the historically embedded notion that man is central to the growth of knowledge has been a persistent driver in our quest for knowledge. Within this argument comes the embedded assumption that man is a rational being. However, we also witness, as illustrated above, consolidated efforts throughout history to establish 'western man' as exclusively 'rational' and the notion of 'reason' being claimed as the domain of western science.

The introduction of the notion of a 'scientific temper' in India is therefore a dramatic, revolutionary and greatly significant gesture. It requires our attention both in regard to its national application as well as the international significance embedded in the notion of *being able (qualified) to have the ability towards a scientific temper*. Not only does the notion of a scientific temper challenge the artificial barrier between the natural and social sciences. It also challenges the society of researchers to consider a universalist concern for the 'values of life' rather than focussing on narrow and specialized questions of scientific research and application.

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Investigating issues related to scientific temper provides 'the space to engage in indigenous discourse' and is 'rich with potential for cross-cultural, gender and environmental sensitivity'. This debate around scientific temper is often burdened by the continuous struggle against the ill effects of technology and belief systems on society. In essence, we experience a conflict of interest between human complexity and complicated systems – as demonstrated by Cilliers (1998).

What does the term 'scientific temper' refer to? Shortly before India's independence in 1947, Jawaharlal Nehru took India through the necessary steps of liberation from British colonialism and made vital recommendations for the restructuring of the country. One of the incentives that Nehru introduced was the promotion of a 'scientific temper' amongst the Indian population. Recorded by Pachauri (1983:3), Nehru proposed as follows:

> "People should develop along lines of their own genius and we should avoid imposing anything on them. Tribal rights in land and forest should be protected. We should try to train and build up a team of their own people to do the work of administration and development. We should not over-administer these areas or overwhelm them with a multiplicity of schemes. We should judge results not by statistics or the amount of money spent but by the quality of human life that is involved."

One can argue that a 'scientific temper' is indispensable for acquiring scientific literacy. This is clear when the description of B.M. Udgaonkar (1980) is consulted:

> "… the essence of scientific temper is an active, sensitive, questioning understanding and a creative relationship between man and his environment. It is a rational approach to the discovery of truth through free and creative thinking, experimentation and objective analysis, and a steadfast commitment (with humility not arrogance) to established truth. At the same time it recognizes the tentative and continuous enfolding character of our scientific understanding of phenomena disentangling the different forces and motivations at work" (Udgaonkar, 1980:3).

Of special interest is the post-independence conceptualization of the Indian national identity. Ivan Karp (2000:3) points out that cultural identity in India – strategically linked with science knowledge – was considered to be fairly free from racial issues. In fact, racially motivated assertions were challenged whenever and wherever it cropped up. According to Karp (2000:4) Indian society was, probably due to these collective efforts, seldom accused of a lack of analytical skills.

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Africans, on the other hand, had to persistently justify the existence of a 'vaguely collective unconscious' as well as being blamed for not having 'anything remotely akin to philosophy'. This accusation of having a 'collective unconsciousness', disregards individuality and prompted a racially informed idea that African conceptual systems are the product of collective work rather than the elaborations of individuals (Karp, 2000:4). At the same time, the colonial system placed undue value on the thoughts of political leaders, supplementing colonialism with authoritarianism. Therefore, the scientific (common sense) knowledge of the public, as well as individual contributions to science by the colonised, were easily marginalised.

Scientific Temper and Culture

i) Influence of Orientalism: In a way, early scholarly perceptions about India and Africa shared the common fate of being considered as 'the other' in the world of science and research. The most popular and influential perceptions came from the research field of 'Orientalism'. Orientalism served, firstly, as an academic term. According to Edward Said (1978:2) "… anyone that teaches, writes about or researches as sociologist, historian or philologist – either in its specific or its general aspects [of the East] – is an Orientalist". Secondly, Orientalism has a more general meaning and is "… a style of thought based upon an ontological and epistemological distinction between 'the Orient' and 'the Occident'" (Said, 1978:2). Thirdly, Oriental Studies are historically and materially defined, making it possible that the Orient "… can be discussed and analyzed as the corporate institution dealing with the Orient" (Said, 1978:3).

The Orient was experienced through the lenses of "… the journey, the history, the fable, the stereotype, and the polemical confrontation' of western travellers and artists" (Said, 1978:58–59). When confronted with a foreign world, the trend is to see the foreign as just a version of a previously known entity and thereby becoming not so much new information but 'a method of controlling what seems to be a thread to some established view of things' (Said, 1978:58–59).

The Orientalists provided a sublime platform for an intellectual debate that culminated in Edward Said's (1995) creation of the concept of 'the other'. It facilitated a continuous exploration of the conceptually linked objective and subjective worlds and complex relationships between divergent east and west cultures and identities. Syed Hussein Alatas, author of *The Myth of the Lazy Native* (1977), tried to analyse the lasting effects of Orientalism by contesting its enduring stereotypes.

Homi Bhaba in his *The Location of Culture* (1994) saw Orientalism as an apparatus of power, created to provide space to control the knowledge production of the subjects by the colonizer and to construe 'the colonized as a population of degenerate types on the basis of racial origin, in order to justify conquest and to establish systems of administration and instruction' (Bhabha, 1994:70). Anouar Abdel-Malek (1981) distinguished between '*traditional Orientalism'* and '*neo-Orientalism'* and considered both groups to be guilty of treating the Orient as an 'object of study inscribed by Otherness'. A. L. Tibawi (1964), in his classic study on the English colonial approach to Islam and Arab nationalism criticized Orientalist scholarship of lacked clear thinking, objective standards and basic courtesy, tolerance and moderation towards Muslim points of view.

Ziauddin Sardar (1999:vii) considered the term Orientalism to represent an incomplete partisan subject as well as an artificial construction by the west and argued that the Orient provided Europe with suitable contrasting images, ideas, personalities and experiences. In similar vein, Edward Said (1995) studied routine comparisons made throughout the ages of the differences between East and West whereby in the hands of the philosophers, and all who shared their intellectual temper, the Orient was a treasury of ideas for rethinking and remodelling European attitudes and understanding. To summarise the influence of Orientalism it is apt to comment that the Orient is perceived to be a constant source of ideas to feed western political needs and aims which are conceptually influenced by the current politics of the time.

ii) Cultural differences: Conceptual difficulties arise when trying to understand different cultural objectives that originates and exists within diverse cultural contexts (Gouthier 2005). These conceptual difficulties are aggravated by the perceived division that exist in the western world between the roles of the scientist on the one hand and his/her obligation towards the public at large. It is undoubtedly true that different ideologies will influence science perceptions and create different social realities in a variety of cultures. In the debate regarding cultural differences, for example, the role of constructivist criticism surfaced among researchers who specifically consider the contribution to science by the *'lay-knowledge'* of non-experts as valuable.

In the debate regarding cultural differences, for example, the role of constructivist criticism surfaced among researchers who specifically consider the contribution to science by the *'lay-knowledge'* of non-experts as valuable.

In this regard, Wynne (1995) highlighted the importance of social context and the legitimacy of local knowledge as an important basis for the application of science by members of the public. Deemed important is the fact that there are communities and societies that constantly exchange scientific information without being explicitly aware of it – and without directly interacting with the formal scientific world. Wynne (1995) argued that communities

consist of individuals who not only *receive* scientific information but also *provide* information to scientists.

However, Steve Fuller (2007) indicates that science, in its function as 'common sense', is rendered 'self-conscious' by modernity. This current self-concern happened despite the fact that human beings flourished, over millennia, in their 'right to life' in an ever-expanding variety of environments. As a result, science, according to Fuller (2007), in a sense overestimates the human 'being in the world' in its efforts to control the natural environment. However, modern science developed a set of principles to organise the 'imperfect reasoning of society' and engage in efforts to enable scientists to bend the world to their collective will. This makes science a highly disciplined 'social movement' – a movement that we can refer to as a vocation (Fuller, 2007:158).

Science Communication in a Culturally Complex World

Gauhar Raza (2002) stated that the intrusions of modern technologies in people's lives and education have a bearing on the structure of people's thinking. This observation is an important contribution to the current Public Understanding of Science (PUS) *'science-in-and-of-society'* paradigm (mid-1990s to present). The 'science-in-and-of-society' paradigm gives recognition to the fact that "… science and technology operate in society and therefore stand relative to other sectors of society" (Bauer, 2008:122). The advantages of PUS research is recognised in its contribution to policy as well as its being a facilitator for bringing together multi-disciplinary researchers in the areas of the sciences and the social sciences.

Though Europe still dominates the field of PUS, it is becoming clear that countries such as India and China have been working 'quietly and on the side' in the field of PUS for up to 30 years. We are now experiencing an awareness of the wealth of information embedded in the so-called developing world's research efforts in the field of PUS. Raza (2002:57–58) stated that developmental models for the third world countries often originate in the west with a '… lack of understanding of culture, which is a decisive force and which inhibits or accelerates the pace of accepting science and technology in a society, introducing distortions in the social fabric". What is required, according to Raza (2002), is a deeper insight into the cultural complexities of thought prevalent in a society to ensure workable solutions for socio-technical problems.

Of utmost importance is the deliberate inclusion and acknowledgement of Indigenous Knowledge Systems (IKS) in PUS research. This, in turn, requires the acknowledgement of prevalent cultural practices, social and technical concerns existing within specific geographical locations and the socio-political impact of market forces (global as well as local) on indigenous populations.

However, science communication research is still guided by the 'scientific literacy' paradigm (1960s to mid-1980s) which was built on two ideas: science education [that] is essentially part of the secular drive for basic literacy in reading, writing and numeracy; and science literacy [that] is a necessary part of civic competence (Bauer, 2008: 115). Jon Miller (1998) who designed surveys to establish society's science literacy in the early 1980s, considered four elements to essentially guide the process:

i. knowledge of basic textbook facts of science;
ii. an understanding of scientific methods such as probability reasoning and experimental design;
iii. an appreciation of the positive outcomes of science and technology for science;
iv. the rejection of superstitious beliefs such as astrology or numerology.

Though establishing a population's level of science literacy is a handy measure for governments to guide policy as well as indicate educational progress in the fields of science, too many serviceable factors are left out. When we consider the original intent to establish a population's science literacy, as proposed by Shen (1975), it is becoming clear that we currently face a highly selective and exclusive perception of the science literacy domain. The three types originally proposed consisted of:

- 'practical scientific literacy' which indicates the possession of a kind of scientific knowledge that is used to solve practical problems;
- 'civic scientific literacy' that enables citizens to become aware of science and the scientific process in order to participate in the politically democratic processes;
- 'cultural scientific literacy' which is the knowledge and appreciation of science as a major human achievement and a cultural heritage (Shen 1975:50).

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Role of 'Questions' in the Evolution of Humans

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AN important marker that distinguishes humans from other animals is their ability to raise questions relentlessly, and seek answers by observing keenly, gathering data, hypothesising and validating the hypothesis and finally revalidating as the instruments of probe improve. In order to make this statement one does not have to be a serious researcher in the area of science communication or public understanding of science or scientific temper.

However, this simple statement led me to another question. When did human beings acquire the ability to ask questions and seek answers systematically? And, what affect did it have on the evolution of the cognitive process? A cursory scanning of literature, first on Internet and then in books and journals, led me to palaeontology, anthropology, archaeology, linguistics and cognitive science. It was interesting to note some of the conclusions that experts have drawn while studying the evolution of humans.

It was important to note that a dietary shift brought about a change in the brain to body ratio, and high protein diet could sustain a high-energy requirement of a bigger brain size. The increase in the size of the brain, technically known as encephalization, during the transformation from *Homo habilis* to *Homo erectus* to *Homo sapiens*, made it possible to store larger data for a longer period.

Recent advances in cognitive science[1] tell us that cognitive structure of the humans developed and changed radically during this period.[2] Liane Gabora argues, "recent collaborations at the frontier of philosophy, archaeology, anthropology, linguistics, and cognitive science are culminating in speculative but nevertheless increasingly sophisticated efforts to unravel how modern human cognition came about"[3]. Gabora further informs us that enlargement of the brain made it possible for humans to retrieve and recall events and skills, which were now broadly distributed and stored in various parts of the brain. The experts differ on the direct causal relationship between brain size and departure that resulted in the formation of a complex cognitive structure[4].

However, experts agree that in order to find an answer to this elusive question we need to study the cultural dimensions of evolutionary processes. The three contending hypothesis propounded by the experts during the late eighties and nineties suggest that the departure came about when a) humans started 'interpreting the intentions' of another human being, b)

[1] George A. Miller, The cognitive revolution: a historical perspective, *Trends in Cognitive Sciences*, Vol.7 No.3 March 2003, p 141

[2] The hexagon, comprising Philosophy, Psychology, Artificial intelligence, Neuroscience, Anthropology and Linguistics, was christened and later popularized as Cognitive Science (some scholars prefer to use Sciences instead of Science); today it includes many more traditional and new disciplines.

[3] http://www.vub.ac.be/CLEA/liane/papers/htma-mind.htm, 06.07.2012

[4] Robert G. Bednarik, On the cognitive development of hominids, http://home.vicnet.net.au/~auranet/cognit/shared_files/hominidcognition.pdf 09.07.2012

when the 'capacity for imitation' increased and c) when 'episodic mode' of cognitive functioning transformed into 'mimetic mode'. Tomasello in his book forcefully argues that 'only human beings engage in cultural learning' and this cultural learning is characterized by imitative learning, instructed learning and collaborative learning'[5].

Curiously, though I cannot claim to have done exhaustive literature survey, none of the experts has posed a question 'when did the humans acquire the ability to formulate questions and seek answers?' explicitly. However, Tomasello comes quite close to raising the issue, elaborating on the cultural learning he concludes that 'cultural ratchet', through practice (imitation), teaches humans what a 'tool' or a symbol is meant 'for' and what do we 'do with it'. He does not in this context comment on how this 'cultural ratchet' was constructed in the initial stages. Other scholars while examining the early engravings, paintings, artefacts and tools also implicitly point out that humans must have observed and gathered data, posed a question, sought answers and used the conclusions to experiment and then construct or transform the surrounding natural, social or cultural reality. This ability, to establish the dialectical relationship between cognitive processes and human labour, constituted a major turning point in the evolutionary process. Bednarik, in the concluding paragraph of his article on 'cognitive evolution of hominids' cautions that 'we are only at the beginning of a long and arduous road – where it leads no one really knows.' It is suggested that one of the paths that needs to be explored is the evolution of the ability to raise questions.

The purpose of the above discussion was to merely emphasize that the ability to ask questions and seek answers has not only been important during later periods of 'cultural evolution' of humankind but, probably, was the root cause of its construction. However, as humankind developed we learnt to ask more complex questions. The questions that we ask and seek answers for could be divided into two broad categories. Questions that we ask during the course of the day, questions that are important for performing day-to-day work, for example, 'how do you do?' or 'how do I solve a mathematical problem?' or 'which job I should apply for?', etc. There is anther set of questions such as 'what is this cosmos made of?', 'how did human kind come into being?', 'what is the difference between life and death?', 'is there life after death?', 'why are some people born rich and others poor?', 'what holds the stars in the sky?', etc. These questions have persisted over the centuries, but the answers have changed profoundly.

Let me borrow a term from Aristotle and call these questions as 'Sophic'. Answers to these questions often do not have immediate practical use in our lives, but they have overpowering impact on our understanding of the cosmos. If we look at the history of ideas they have also radically changed our social, cultural and religious relationships. These questions could be divided into two categories – questions that begin with 'how' and those that begin with 'why'.

The questions that begin with 'why' are not being dealt with in this article at length. It would suffice to mention here that a 'Sophic question' beginning with 'why' essentially leads us to the existence of supernatural powers, and that too to a conscious supernatural power that controls the entire cosmos. For example why was cosmos created? The question cannot be answered without invoking existence of God. Let us take a simpler example 'why does sun rise in the east every day?'. The answer would be 'because earth rotates on its axis'. The next logical question would be 'why does earth rotate on its axis?, and so on. The final answer as we reach the periphery of knowledge would be 'it is god's will'. The studies carried out in India have

[5] Tomasello, M. The Cultural Origins of Human Cognition, 2002, Harvard University Press, p 5-6

repeatedly shown that a substantial population believes it to be true.

The Sophic questions that begin with 'how' lead us on to a different path, a path that is open ended, without a cardinal truth at the far end. For example, how did cosmos come into being? This has been asked repeatedly by humans over centuries and the conclusions were very different from the earlier ones. In our quest beginning with 'how', when we reach the frontier of knowledge, either we expand the boundary understanding or we say 'as of now we don't know?' and that leads us to sharpen our tools of investigation and carry on further probe.

In order to illustrate the point let us take evolution of our knowledge about the cosmos.

Cosmos – Evolving Realities

Experts tell us when human beings were still living in caves and had not acquired the ability to cultivate grains, their needs must have been very limited. Probably the only needs were sufficient food around to gather and/or hunt, a secured shelter and procreation. The questions that they must have asked would have been also simple. Like any other animal, every new day was primarily spent in search of food and after dusk they retreated to a place, cave or tree, relatively safe from the reach of other animals. The biological clock of the body must have guided most of what humans did.

It will be fairly close to reality if we assume that when humans were just wanderers and gatherers they had no need to fix the four directions. They did not travel beyond the identified territory and depended on animal instinct to find ways, especially back to the caves where they lived. They also did not have to communicate the directions to each other. When the tribes moved out of an area, and covered a long distance, they did not come back. For example, they moved out of Africa in waves, separated by long periods of time, and did not go back to Sub-Sahara Africa. Those tribes that would have travelled on a definite route based on seasonal changes, as even now some gipsy tribes practice, would have depended on the memory of leaders who passed on the information to the new generations through practice and not through verbal or textual communication.

Experts also tell us that humans were omnivorous. They ate fruits, seeds and other parts of the tree. Some one must have observed that when a seed falls on the ground it germinates, the plant grows, flowers bloom and then many seeds grow. And this sequence of events must have got recorded in their memory. The shared social knowledge of the life cycle of a plant, especially rice, brought about the agrarian revolution. This knowledge that one seed can produce many seeds, which could be stored for future use, changed humans forever and set them on an evolutionary path that was unidirectional. A direction that demanded closer coordination of body and mind, a social organization, a faster cultural revolution, innovations to overcome new problems, asking relatively more complex questions and seeking explanations that could help solve new challenges.

With the invention of the plough and domestication of animals, when food production increased, humans must have asked the question 'how do I preserve grain for a longer time period?' This must have given them reason to develop pottery for storage purposes. A secured shelter near agricultural land would have been another big problem. This must have given impetus to build relatively robust huts and houses, invent bricks and use wooden logs for building houses, which eventually formed clusters of human habitation near water sources.

With the increase in interdependence, proto cities transformed into cities that became cradles of civilization. Over the centuries, humans encountered many problems and for solving each of these a set of specific questions must have been asked, and answered. Construction, barter system for exchange of goods, division of labour, digging canals to irrigate fields, and town planning could not have been possible without invention of measurement and numerals.

Need to keep records and communicate wherever verbal communication was not possible gave birth to scripts, inscriptions and writing.

However, after the agricultural revolution, the four basic directions had to be fixed and east became the reference point. Soon humans must have realized that the repeatability of sunrise could serve as an important reference point. This collective realization that the sun always rises in the east must have led to the question: why does the sun always rise in the east? The search for an answer led to the first conceptual model of the universe with a flat earth and heavenly bodies traveling in the sky from east to west and either going into the sea or hiding behind the mountains to once again come out in the east the next day. This conceptual model is embedded in folklore of various civilizations and cultures with culture and geography specific variations.

The dependence on repeatability of seasons and floods, which at times leave a settlement devastated and often surrounding land fertile, would have forced humans to ask questions related to seasons as well. Repeatability of natural occurrences was explained by designating natural forces and heavenly bodies as conscious beings beyond human control. The control could only be exercised by worshiping them. Methods to keep the gods happy and favourable were invented. These explanations much later became the basis for organized religion. The operand Sophic question was 'why things are the way they are?'

In order to track the seasonal changes, lunar and solar calendars were invented. Sexagesimal system of time measurement was invented in Sumer. The day was divided into two 12 hours by Egyptians and now it was possible to observe the movement of the sun, moon and other heavenly bodies both on hourly basis as well as on yearly basis[6]. Humans kept on asking questions that began with 'how' as well. The religious structure though based on meta questions that began with 'why' did give space to questions that began with 'how' and thus knowledge and data gathered contributed to scientific development. For example, in order to keep the god happy by performing *havanas*, at a given time and in a strict order, in India, complex mathematics and geometry developed.

However, irrespective of existing religious structures and religious predispositions individuals and collectives kept on posing questions that began with 'how', sought explanations and constructed conceptual models to fit in the gathered data.

For centuries the flat-earth-conceptual-model served the human needs but gradually as complexity of social and cultural life increased data gathered on the movement of heavenly bodies also increased. Trade between various civilizations developed. Groups of humans along with domesticated animal laden with goods travelled long distances. This was qualitatively different from the migration of the wanderers and gatherers. For example, if they travelled from Egypt to the Indus Valley, they had to come back to Egypt. The group had to keep records of routes that they followed, with directions. Traveling was time consuming. Deserts, mountains, thick jungles posed almost insurmountable problems, but also gave a lot of time to think and observe the surroundings keenly. Shifting landscapes and disappearance of landmarks must have hindered following a definite route. This gave impetus to ask a simple question: 'how could the knowledge of the position of heavenly bodies be used for determining geographical locations on earth?'

Observations were made, data was gathered and recorded, constellations were named, seasonal shifts in the positions of sun, moon and other heavenly bodies were logged. Folklores

[6] It took centuries to arrive at a consensus and adopt the present day Julian calendar. Until recently i.e. till the 20th century different countries followed different calendars.

were composed to pass on the knowledge from one generation to another. Temples became the repository of this knowledge gathered over centuries. Division of labour gave rise to a community of scholars who studied theoretical and conceptual issues. They noticed that the position of heavenly bodies observed from two points separated by long distances did not match. It was an irreconcilable problem. It could not be explained by the flat-earth-conceptual-model. It is argued by historians of cosmology that the round earth model was first suggested by seafarers. Historians also tell us that though in Greece the spherical earth model was suggested before the 6th century BC, most Pre-Socratic philosophers continued to believe in the flat-disc-floating-on-water or air model. It was Aristotle who gave a final blow to flat-earth. Though there is evidence that many Greek philosophers after Pythagoras to the time of Plato believed in spherical shape of the earth, none of them offered irrefutable arguments in favour of rotundity.

It should be noted that, even after Aristotle, who offered convincing basis in favour of spherical earth, for centuries together the two models competed with each other. His logic for eclipse being always circular in shape is quite well known; he also reasoned that constellations appear at different position in the sky from two different positions on earth and this could be explained only if the globe is spherical. However, there were still people who believed that the earth was flat. Most of the ancient religious and cultural texts available in Egypt, China, India and the Middle East suggested that almost all the early religions had accepted the flat-disc model of earth. This includes early Christian writings.

This new conceptual model was exceedingly versatile. Ptolemy worked out a detailed cosmology with celestial spheres revolving around the earth, which was located in the centre of universe. The beauty of the model lay in providing explanations of all the data that had been collected through observations and experimentations. For example, for each heavenly body moving with a different speed one celestial sphere was added. The model suggested that the celestial spheres were made of crystalline material because only then one could explain as to how light coming from a body embedded in the hard crystalline outer celestial sphere which revolved at a constant speed, could reach earth if it was transparent. Aristotle suggested that nothing moves without a cause. Therefore a god, the prime cause, had to be invented so that movement of celestial spheres could be explained. This model of cosmos not only explains the observations but also was capable of explaining the future findings. For example, any discovery of a new celestial object moving at a different speed compared to other bodies, required addition of just one more celestial sphere.

In other words, pursuing the Sophic question, ‘how does cosmos work?’ led humans to gather data and construct a mental model that considered earth as flat. Later, the unexplained data gathered over the years forced us to shun this model and go in for spherical earth model. The first model survived for centuries because it satisfied the human curiosity to probe and explain and it also served the socio-cultural needs of that era. The Geocentric theory also survived for centuries, it explained most of the data that humans had gathered. However, it also had a few inbuilt weaknesses.

Firstly, it presumed that all heavenly bodies have a unidirectional circular motion, from east to west. The second assumption was that since everything revolved around the earth, nothing revolved around any other celestial body. Since as per this model the crystalline spheres (skies) were made of solid transparent material, there was no way that it could permit revolution of one body around the other. Most religious philosophies, including Islam, adopted Aristotelian model of universe and added ‘God’s will’ to it. Once within the ambit of religious philosophies, the model froze in time. The door was closed for any further investigations that challenged the basic structure. The Sophic question that these philosophers were posing was ‘why was cosmos built the way it is?’ and ‘who built and kept the cosmos going?’ The axiom is,

any deviation from the accepted religious text, the frozen or so-called revealed knowledge, is tantamount to blasphemy.

By the time Copernicus started his investigations, the instrument of investigations had improved radically, scholars knew that there were planets that did not follow the dictates of the church (Ptolemy's conceptual model). For short durations they regularly disobey the Aristotelian law of planetary motion that every heavenly body should move from east to west. Newer facts had started asserting and along with mathematics a strong message was beginning to emerge, loud and clear, that the earth revolves around the sun.

This new knowledge had become a threat to the old model of the cosmos. Galileo Galilee hammered the final blow to the geocentric model of the cosmos. A simple fact that Jupiter has its own moons and Saturn has a ring around it, completely demolished the geocentric model of the universe. The centre of the universe had shifted from the earth to the sun, nonetheless, the heliocentric-conceptual-model of universe survived for a relatively much shorter period of time.

Those who favoured extra-science or frozen knowledge, tried hard to contain the damage caused by the heliocentric model, but the evidence was irrefutable. The Copernican revolution brought a major change in the relationship between science and extra-science. Until the time of Galileo, the religious philosophy had supremacy over all forms of knowledge, in post Galileo period, the roles reversed. Scientific epistemology was now ruling the roost. Socially, politically and economically science established its hegemony over other forms of knowledge. At a mundane level this reveals itself in claims made by the religious clergy, of all shades, after every new scientific discovery, that our scripture had already indicated such a possibility.

After the demise of the geocentric model a new puzzle needed to be cracked. If there are no celestial spheres, how is the cosmos held together? Newton solved the riddle by proposing the law of gravitation. Ptolemy's cosmos was finite with a definite boundary, Newton made it infinite. Newton's model of cosmos was static, where time, space and mass were absolute.

As we approached the 20th century, it was observed that Newton's model of cosmos could not answer certain questions and this gave birth to the theory of relativity. Finally, the observation that universe is expanding led us to the theory of the big bang.

Questions of Science

Probably even before the days of Alhasan, scientists had started their effort to define science. In order to arrive at a definition that must distinguish science from extra-science, sift valid knowledge from the invalid, scientists first had to reckon with the question 'what is scientific method?' Historians of science tell us that Abu Ali Alhasan (965 to 1040 AD) was the first scientist who listed the parameters of what constitutes scientific method. In the twentieth century, J.D. Bernal is credited with clearly defining scientific method as a sequence followed to either revalidate the old knowledge or generate new knowledge. He proposed that scientific method involves *Observation*, *Hypothesis* (theory), *Prediction* based on the hypothesis and *Testing* which could be peer reviewed.

However, when we communicate science for increasing the scientific temper in a given society we need to keep a few important factors in mind. History of astronomy as of any other discipline of science tells us that the Sophic questions of science are different from what extra science poses. For example, whether god exists or not is not a question of science. The Sophic quest of science begins with 'How'.

The culture of science also demands a specific behaviour from the community of scientists and science communicators. Scepticism is one of the hallmarks of science. There is no final word in science. Since there is no gospel truth in science a scientist while announcing the results of investigation is expected to reveal under what conditions the theory does not work or the

unexplained territory that may cause future revision of the theory itself.

When the scientific community encounters the boundaries of knowledge it is not expected to resort to intervention of divine power but accept the unexplained and to seek answers invent methods to surmount the barriers of technology and improve upon the instruments of observation. The CERN experiment is a good example to cite. When the Standard Model could not be validated and the search for irrefutable evidence of the existence of Higgs Boson was rendered futile scientists decided to create conditions that existed during the initial period of the Big Bang. It is interesting to note that while reporting the conclusions of analysis the scientists were sceptical. The conclusion as reported was 'there is evidence that we have found a new particle.' They did not report that Higgs Boson had been created during the high-energy collision of the two beams. The footprint observed did not completely match with the predictions of the Standard Model.

Since there is no final word in science, it keeps on revisiting its accepted old conclusion. There are specific filters in every discipline of science that sift scientific from non-scientific and these filters keep changing with time, as mathematical rigour and technological improvements take place. The history of astronomy also tells us that more often than not it is the unexplained that has brought about a paradigm shift in our understanding of the cosmos. Extra-science explains the unexplained in terms of divine intervention. In science there are no god men. A scientific fact is not accepted because a great man has proposed it. Conversely, science progresses by challenging the thesis propounded by great scientists – and it is not considered as blasphemy.

When a theory in science proves the old understanding wrong, there is always excitement and jubilation as was observed recently. Scientists or groups of scientists who propose some thing that was not a part of the valid scientific knowledge, are not declared outcastes, instead they are showered with awards. Where as deviations from tenets of extra-science invite violent reactions.

In science the latest books, research papers and lectures by experts working in a specialised field of knowledge are referred. However, extra science demands going back to the oldest scripture and the words of ancient sages for proving the validity of an argument. The final proof of validity of a religious question lies in the Old Testament, New Testament, Quran, Vedas or Puranas. In astronomical science, in order to prove the validity of the big bang theory, no one would ever turn the pages of books authored by Aristotle, Ptolemy, Copernicus, Galileo or Newton.

In science what is already known is trivial and the unknown is profound, where as in extra-science it is the other way round.

A common citizen's thought structure is shaped by both, the scientific and extra-scientific. It is the responsibility of science communicators to enlarge the areas of scientific thinking. Communicating scientific information surely helps in enlarging these spaces. However, in order to inculcate scientific temper among the citizens it is imperative to communicate the difference between science and extra-science.

(Based on the Paper presented at the *National Workshop on Scientific Temper* held in Palampur during 15-17 June 2011)

Myths, Superstitions and Propaganda in Scientific Age

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OUR grand universe was born with a 'big-bang' about 13.7 billion years ago. In this marvelous expanse, earth, the only known planet to harbour life, was formed some 4.5 billion years back in the solar system. Over the last 3.7 billion years or so, life on earth has evolved from a unicellular organism to highly complex and assorted forms. In the intervening period, several million species flourished and have gone extinct. To our knowledge, in this tree of life no other species was endowed with an inquisitive brain that was sufficiently advanced to ponder over things and indulge in abstract reasoning.

Hitherto, the inhabitants of earth were impervious (not by choice though) to the secrets and wonders of the Universe around. Compared to the enormous time scale, the arrival of humans on Earth is very recent. It is only about 5-8 million years back that we had split from our closest relatives, the chimpanzees, and evolved as a separate species. It wasn't until the emergence of *Homo sapiens* about 200,000 years ago that the vast Universe wrapped in grand mysteries was ready to be explored. Man's evolving brain had just begun to marvel at the impressive regularity and remarkable spectrum of events occurring in the physical world.

Watching a clear night sky, dotted with seemingly innumerable stars, journeying almost like a divinely ordained fashion, must have been the most amazing and inexplicable experience for early human beings. Right from prehistoric times, people were driven by genuine curiosity and reverence arising from the observations of periodic motion of the heavenly objects. For thousands of years, humans have understood the cycle of changes occurring in the night sky, discovered familiar patterns of stars and also struggled to make sense of rare events like lunar and solar eclipses or an unexpected arrival of a comet. As a species, humans are predisposed to look for visual and auditory patterns and assign meanings to them. From the survival viewpoint, this instinctive ability had clear evolutionary advantages as it helped primeval beings guard against real or imagined threats that often lurked in hostile and dangerous environment.

The relentless struggle to understand the heaven and earth also laid the basis for supernatural beliefs, cultural taboos and numerous superstitions and ritual practices to please and appease the powerful and ill-tempered gods who allegedly controlled the destiny of earthly beings.

The relentless struggle to understand the heaven and earth also laid the basis for supernatural beliefs, cultural taboos and numerous superstitions and ritual practices to please and appease the powerful and ill-tempered gods who allegedly controlled the destiny of earthly beings. It is not at all surprising that most civilizations around the world have developed their own fascinating stories resembling myths about the Universe. These primitive belief systems were eventually transformed into organized and powerful religions forcing people to dogmatic conformity and servitude.

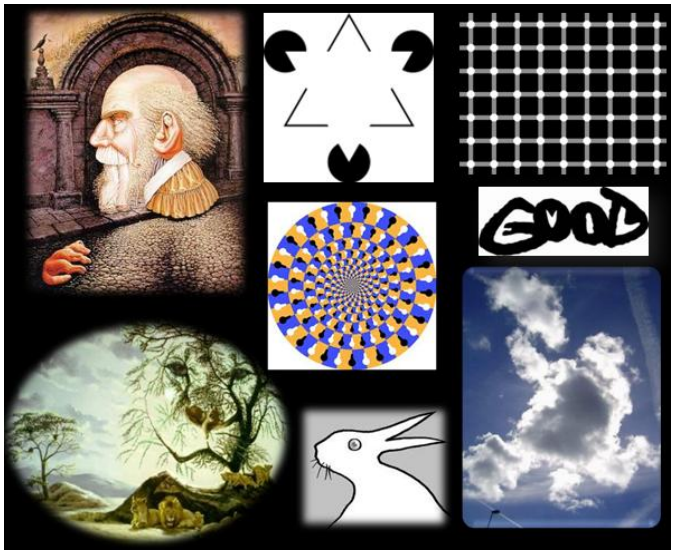

Fig. 1. Perception shift by optical illusions

Lessons from Optical Illusions

As pointed out, we prefer an orderly, meaningful and simplistic world as opposed to the random, purposeless and chaotic arrangement of things. Keen observation with predisposition to detect pattern and make connections has also lead to several scientific discoveries.

However, there is a downside to this "pattern finding" and "order seeking" mechanism. By looking at certain patterns, we can get thoroughly deceived and may conjure up things that really don't exist. How easily the mind and brain can be mislead is understood from the simple optical illusions illustrated in Figure 1. Reexamination or some kind of mental exercise will not make these illusions disappear. The cognitive deception, however, is not confined to optical illusions alone. In general, it forms the basis for holding erroneous beliefs, making false assumptions, arriving at wrong conclusions and most importantly pushing aside good judgment and rational thoughts while interpreting facts.

The cognitive deception is not confined to optical illusions alone. In general, it forms the basis for holding erroneous beliefs, making false assumptions, arriving at wrong conclusions and most importantly pushing aside good judgment and rational thoughts while interpreting facts.

Now take a closer look at Figure 2. It gives us an idea of the complexity of the world we live in. Good or bad, what these images show is a direct outcome of our convictions, our conflicts, our aspirations and our beliefs. Scientific approach and rational thinking have largely triumphed in understanding several aspects of our physical universe. The meteoric rise of science in the last 400 years has in fact altered the very landscape of human existence. Basic research and gradual advancement in technology have thus far exceeded expectations of ordinary minds.

Science has not disappointed those who knew how to harness its latent power. Despite many noteworthy achievements, modern societies are also

Fig. 1 – *Triumphs and tribulations of the technological age*

deeply mired in all sorts of contradictions, absurdities, propagandas and irrational practices. We have created many divisive walls and dangerous ideologies based on religion, ethnicity and racial differences. The unfolding climate change, global warming and dwindling natural resources are all emerging crises for humanity. On top of that, irrational impulses of dominance and greed make the future look pretty bleak.

Technological Onslaught

The information age is not free from its perils. This may sound like an oxymoron. But there is a growing body of evidence that clearly raises serious concerns of increasing influence of technology in our daily lives. We are constantly bombarded by an enormous amount of information flowing from the Internet, television and other forms of mass media. Our brains are not tuned to process a message – dense and often conflicting stream of information. Whatever we see, read or hear could be skewed in one way or another.

Sometimes it is hard to discern relevant from frivolous, good from bad and desirable from deceitful. For lack of better skills, we fail to make an independent and critical evaluation of what we see, what we read and what we hear. The problem worsens when the information is deliberately distorted to mislead the recipient in some predetermined way. The dividing line between useful and useless, genuine and fraudulent, just and wrongful, factual and fictitious, true and false, thus becomes blurred. This is where someone else can take control over our critical faculties. The lack of critical and independent thinking, for example, makes people extremely vulnerable. It compels them to seek guidance and personal cure from sources that are hardly benign and authentic.

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At another level, irrational faith can become a breeding ground for collective indoctrination, forcing absolute compliance to supremacist authority of one kind or another. Uncritical acceptance of claims results in convoluted thinking and wrong reasoning. Despotic leaders, popular cult figures, religious heads and soothsayers, for example, often take advantage of basic human psychology and the veil of ignorance. They appeal to people's deepest fears and irrational hopes before taking control of their lives.

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In recent years, the celebration of religious festivals, superstitions and rituals have become regular practices in many research and educational institutes in India. The case of the Indian Space and Research Organization (ISRO) is particularly appalling. The achievements of India's space programme are commendable, but when it comes to the responsibility of developing scientific outlook and rational thinking to fight the social ills, the organization perhaps did not quite live up to the desired standard. Instead of spearheading a campaign (by virtue of its privileged position and wider resources) to eradicate superstitions and illiteracy, ISRO officials often hit the headlines for wrong reasons. You may wonder why the name PSLV-

C13 was missing from the Polar Satellite Launch Vehicle (PSLV) series. This omission was purely based on widely held belief in numerology about the number 13, which is considered unlucky. Following the advice of some numerologist, ISRO had chosen to skip the problematic number and name the next space mission as PSLV-C14 after PSLV-12. Last year, the success of India's first mission to moon, *Chandrayaan-1,* was an astounding feat. As usual, before the launch, ISRO officials visited the Tirupati temple to offer special prayers for the success of the mission.

Trajectories of modern space flights are not controlled by prayers, but meticulously computed from the orbital mechanics derived from Newton's law of motion and gravitation. Deity puja and godly faith cannot fix a technical fault. In fact, attributing success to higher powers and seeking divine interventions grossly undermine the capabilities and achievements of human ingenuity. The proven success of the moon mission was solely due to the diligent efforts of individuals and nearly flawless engineering design.

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The alarming manifestation of religious zeal in public sphere is a mighty blow to the Nehruvian legacy of scientific temper in India. Someone must explain why such ceremonial gesturing is necessary or even desirable when we fully understand how reactionary and communal forces exploit these myths to unleash social violence. Public display of personal beliefs and religious fervour is not just irrational and regressive, it also violates the foundational principles of our constitution. A distinction that we should not fail to make as science communicators.

Consumer Market and Entertainment Industry

The consumer market and entertainment industry too have forged an unholy alliance with technology to exploit the gullible public. The mass media and digital technology has emerged as a most powerful instrument of propaganda and persuasion. In his book, *Propaganda and Psychological Warfare*, T.H. Qualter defines propaganda as "*the deliberate attempt by some individual or group to form, control, or alter the attitudes of other groups by the use of instruments of communication, with the intention that in any given situation the reaction of those influenced will be that desired by the propagandist*".

Emotive words and false analogies are drawn to promote free market ideology by depicting the consumer as a king and the market as an empire. Subtle ideas and values are ingrained through clever visual imagery, tantalizing graphics and sound effects. Products are embedded in popular entertainment, movies and other media forms. Children are highly susceptible to propaganda and become soft targets for mind control. Findings indicate that more than 90% of pre-children group want to buy things that are advertised in television commercials. They are made brand conscious right from a tender age and grow up as trained and loyal customers. '*Catch them young'* is an unconcealed motto for many brand managers. It is not terribly surprising that companies hire the best psychologists and designers to invent ways that entice kids to buy their products and foster a life time allegiance for the brand.

Advergaming is another new concept where brands are introduced to the audience through online games. In United States alone, advergaming is expected to grow to a $68 billion industry by 2012 (*Business Standard,* 7 January, 2010*)*. Closer home, we can take the example of

the recently made science-fiction movie Ra.One. The marketing budget of the movie was well over 52 crore of which 15 crore alone was spent for online publicity (*The Tribune*, 5 November 2011). Special video games and electronic gadgets were launched to lure the techno-savvy audience before the movie was released worldwide. The official online store of *Ra-One* sold over 40,000 merchandise items (e.g. coffee mugs, mobile pouches, video cameras, tee shirts, caps, school stationary and toys) in just about 15 days. The order for additional 100, 000 items was awaited. That is how technology is used to create a maniacal obsession for celebrity culture and almost insatiable desire for consumption and non-stop entertainment.

The increasing numbers of 24x7 TV channels are willing to cater to anything that will amuse people to death. The lucrative entertainment business thrives on sensational soaps, family dramas, tele-shopping, paid news, advertising, doomsday theories, reality shows, mythological serials, fear mongering, superstitious themes, faith preaching and dedicated time slots for highly paid astrology, feng-shui, vastu and yoga experts. In particular, the live telecast of religious festivals (e.g. Kumbh Mela, Ganesh Chaturthi and Navratri etc), and big sporting events has been shown to boost the TRPs.

Serious issues, no doubt, fail to touch the conscience of the nation. Otherwise, a country that is constantly struggling to meet its fuel and energy demand would not have chosen to disgrace itself by burning a whopping 2-lakh liter of petrol to host a rather infamous *Formula-1* racing event (*Indian Express,* 24 October 2011). The dazzling show was endorsed by most famous sports personalities, business tycoons and cinema stars. Our national media, especially the English TV channels, who otherwise never shy away from pontificating to bureaucrats and politicians, colluded in this show-biz propaganda in an almost hysterical manner. Most *'prime time shows'* were virtually transformed to high-pitch *'sale time shows'* with a singular agenda to impress upon viewers that pride, prestige and prosperity of India was solely hinging on this one mega event.

There are many other examples how technology is used to (mis)educate and enslave people. These techno-hyper challenges pose a greater threat to the advancement of scientific temper and critical thinking among people. Someone seriously engaged in spreading science education, rational inquiry and developing scientific temper should also be prepared to deal with such pressing issues. We cannot stop propaganda, but we can certainly take some discrete steps to stay immune to it.

The goal is not to spot other people's weakness and follies and laugh at it. The efforts should be directed, as Baruch Spinoza has famously said, " ... not to ridicule, not to bewail, not to scorn human actions, but to understand them." The first thing we can do is to learn how to identify various forms and means of propaganda and understand how human thinking can go wrong. Many ways in which errors and biases in human judgment can occur are explained with some well known examples.

Misinterpretation of existing theories: Theories can influence observations. This happens when new findings are wrongly interpreted to seek conformity with known theories. For instance, Christopher Columbus had set out on a westward journey with the hope to reach Asia that was well known for silk, spices and opium. He landed in the Caribbean islands and found people using red chilies, which he mistook for pepper and wrongly thought that he had arrived in India.

Another well known example of misrepresentation of scientific theory is social Darwinism. It is based on the misplaced notion that the biological principle of evolution and natural selection also regulate the social order and hierarchy among humans. Those who are rich and powerful are innately considered better than those who are weak and poor, thus legitimizing the existing structures of power and dominance in society.

Usage of scientific jargons: Products are sold with scientific sounding words and labels to fool people who are not quite familiar with their precise meaning. That explains why books written on quantum healing, thought waves, subtle energy fields, scientific astrology, trans-dimensional energy etc are so popular among the highly educated class of people!

Anecdotal and after-the-fact reasoning: Untested and ambiguous claims of miracles and magical cure are forcefully advanced based on personal experiences and experiences of others. Abnormal behavior of animals and birds is reported in the aftermath of major natural disasters such as earthquakes and tsunamis! Rumors of miracles spread like wildfire. Claims such as Ganesha drinking milk, blood flowing from Jesus statue and Sai Baba's moon miracle are assumed true by followers without casting any doubt! The Internet is full of studies claiming a positive effect of prayers on healing. But upon close scrutiny, it reveals more about the expectations and biases of the people conducting these studies than the efficacy of the prayer itself.

Fig. 2. Independent evidences for the spherical shape of the earth.

The burden of proof: "*Extraordinary claims require extraordinary evidences*". The burden of proof lies with those who make the claim in the first place. For example, there is hardly a shred of scientific evidence to support intelligent design. On the contrary, many lines of evidences (genetics, DNA sequencing, evidence from fossil records etc) exist which independently prove that life has evolved on earth. Similarly, the spherical shape of the earth can be independently established from different observations as illustrated in Figure 3.

A belief should come from the positive evidence supporting the claim and not from the lack of evidence for or against it. For example, one cannot disprove the existence of aliens, fairies or ghosts. It does not mean that they exist; neither does it imply that they don't exist. Carl Sagan had conveyed it succinctly, "*the absence of evidence is not the evidence of absence*."

Confusing coincidence with causation: Just because two events follow one another, it is assumed that one is responsible for the other. Coincidence and correlations do not imply causation. We have a strong tendency to remember false positives and ignore misses. Changing the bat at a particular stage of the game, wearing the left pad first or keeping a red handkerchief in the pocket while fielding**,** are some of the common forms of superstitions among cricketers!

Limitations of the experiment: Experiments are performed to deny or prove the validity of a particular claim and also deepen our knowledge of the phenomenon. However, the outcome of an experiment is limited by the range and sensitivity of the instrument. For example, the size of the fishnet cannot be used to infer the size of the largest or smallest fish in the ocean. Likewise, the knowledge of the observable universe is constrained by the size of the largest telescope available.

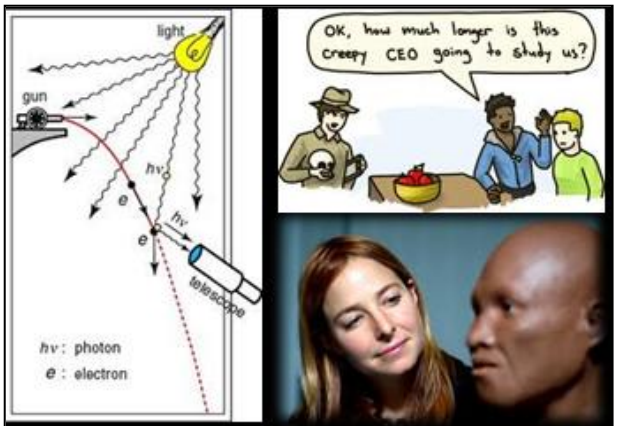

Fig. 3. Observation & experiment influencing the observed

Unexplained is not inexplicable: It is said that our knowledge is limited but our ignorance is infinite. Given the limitations of human intellect, it is likely that many things will remain beyond the realm of our knowledge. Scientific frontiers are always stacked against terrains that are unknown and unexplored. What is the nature of dark matter and dark energy? Can we ever cure cancer and AIDS? How does human brain function? Why does the placebo effect work? We do not yet know answers to these questions. But unexplained does not imply inexplicable. Instead of drawing premature conclusions and attributing mysteries to the supernatural power, it is better to be agnostic and hopeful before they are understood.

Experimenter effects: Observations and experiments can change the observed phenomenon. For example, to detect an electron it must interact with light photons. But the very interaction of photon with electron changes its state, i.e., speed and direction. The expectations and biases of anthropologists studying a tribe can alter the behaviour of its members. This may explain why only certain groups or individuals are able to perform a particular experiment. Psychologists use blind and double blind tests to minimize the effect of observations.

Interestingly, a scientific study carried out to examine the impact of prayers on cardiac patients found no significant effect on health recovery. However, a slightly higher rate of complications was reported for patients who knew that they were receiving the prayers. In this case, as the researchers later explained, “patients' knowledge that they were the subject of intercessory prayer might have induced a form of performance anxiety or made them feel doubtful about their outcome."

Wishful thinking: The skeptic dictionary defines wishful thinking as, "interpreting facts, reports, events, perceptions, etc., according to what one would like to be the case rather than according to the actual evidence." One of the classic examples of wishful thinking is those who believe that ancient scriptures (e.g. Vedas, Quran or Bible) contain solutions to every problem in the world – be it global warming, terrorism, or chronic illness. Some people have well meaning, but intense wishful desire to see India becoming a superpower by 2020! The assumption that science and technology alone will solve all our problems is another example of wishful thinking. Genetically modified (GM) crops are expected to yield an "ever green revolution!" The energy crisis has to be met by import of nuclear reactors. It is safe and really green!

Glittering generalities: This is a technique of associating a product or an idea with some universally held virtue and emotions. Words like *patriotism, democracy, honesty, liberty, justice, morality, freedom, spirituality, national pride, truth, scientific, logical, love, human values, etc*, have positive connotations that are not only effective in concealing the ulterior motive of the perpetrator but also grant a certain degree of legitimacy and appeal to the idea.

A significant surge in cigarette sale was recorded when the tobacco companies in the West explicitly tried to portray smoking as a symbol of women's *liberation.* A literate person is more likely to believe in *scientific* astrology and *scientific* Vastu as opposed to using astrology and Vastu alone. A perceived threat of *national security* is generally used to quash citizen’s rights and genuine aspirations. A higher sale is expected when a consumer product is advertising with slogans like be *Indian* buy *Indian!* The support and justification for Iraq war was built on empty rhetoric of bringing '*democracy and freedom*’ to the Iraqi people!

Name-calling and ad hominem attack: Name-calling and ad hominem attack is used as a tactic to arouse hatred and xenophobic feelings with intent to demonize and discredit the opponent. These fallacies deflect the focus from the main argument to personal attacks and baseless allegations. If you criticize someone's closely held beliefs then you will be called arrogant or atheist. People advocating Indo-Pak peace are labeled as traitors. In a vicious propaganda the Nazi blamed Jews for every malady that the Germans were allegedly suffering from. Senator Joseph McCarthy lead a witch-hunt in the 1950s in which he accused thousands of Americans, including Einstein and Charlie Chaplin, as Communists spies.

In the 2008 U.S. presidential election, the right wing tabloid ran an insidious campaign against Barack Obama linking him to some secret Muslim brotherhood. Dr. Binayak Sen, a well-known human rights activist, was wrongly implicated of charges of sedition and waging a war against the state on flimsy grounds. A strategic alliance is sought by peddling myths such as: "India is surrounded by powerful enemies from all sides. Hence, we must become a superpower by aligning economically and militarily with other superpowers!" All kinds of conspiracy theories are propagated to target and question the patriotism and loyalty of certain religious groups.

Figure 5 – Myths, ideological propaganda and social violence.

Overreliance on authority: People have a tendency to place too much confidence in authorities. What we don't realize is that authorities too can be fallible. Trusting authorities when the matter lies outside their field of expertise is even more problematic. For example, there is a widely held belief that during the full moon there is high rate of crime, violence, suicides, and mental illness. Apparently, the popularity of the myth can be attributed to many mental health care experts and medical professionals who strongly believe in the phenomenon. Studies conducted so far, however, have failed to establish a credible link between the full moon and human behavior.

Uncertainly and fear of the unknown: The human desire for certainty and simple explanation of events interferes with our ability for sound reasoning and critical analysis. The anxiety of unforeseeable events such as unfortunate accidents, death of near and dear ones, fear of financial loss in business, relationship breakup and visitation of a dreadful disease etc drives people to seek help from fortune tellers, astrologers, faith healers, psychics and new age gurus. Fake investors and insurance industry is known to exploit deep-seated fears and uncertainties to expand their business. Mystics, swamis and mullahs make use of irrational fears to spank more religiosity and obedience towards the leader.

The preceding description of myths, superstitions and ideological propaganda is neither rigorous nor complete. For a comprehensive and detailed study, the interested reader should consult a vast amount of published literature and excellent books written on the subject.

Conclusions

The underlying cause of erroneous beliefs and propaganda machinery, which reinforce and exploit human fallibility for communal, political and financial purposes, cannot be completely eradicated. It has to be compensated by cultivating certain habits of the mind that promote

critical thinking and sound reasoning. An acquaintance and understanding of various kinds of myths, superstitions and propaganda tactics can reduce the likelihood of deception and entrapment. The habit of raising doubts and asking questions can prevent the formation of dubious beliefs. The authenticity of claims should be checked from credible and independent resources. One cannot expect to get a fair coverage of an event or a breaking story, if for example, the reporters are given patronage by interested lobbying groups (WEF: Red Spider, Black Spider Redux, *The Hindu,* November 24, 2011).

Another important thing to realize is that worldly events are not completely deterministic. Everyday life experience presents us only with limited and biased samples of information. In the real world, we have to deal with incomplete and unrepresentative datum. Developing an awareness and appreciation of the provisional nature of things can reduce the discomfort of uncertainties. Collecting and analyzing data from different case studies can be a valuable exercise in developing a rational approach and methodology to understand the role of chances and probabilities in real life experiences.

Most importantly, greater familiarity and involvement with scientific concepts, methodologies and measurement processes can help in weeding out dubious and questionable propositions. Errors and uncertainties in data can teach us the importance of statistical reasoning to handle claims and counter claims based on numbers and prophecies. A valuable exposure to conduct control experiments is necessary to clearly recognize the significance of variables that can alter the outcome of an experiment in many possible ways.

Modern science and democracy have common origins. Making realistic and informed choices is the essence of democratic principles. Just as it is imperative to combat the menace of various forms of superstitions, pseudoscience and irrational practices in the society, it is equally important to recognize and resist the sophistic ploys and sly practice used by the entertainment industry, marketers and mass media that reduce people to helpless and passive consumers.

The struggle for scientific temper and rationality has to overcome many such obstacles. In doing so, let me recall the inspiring words of George Orwell, "*In a time of universal deceit, telling the truth is a revolutionary act.*"

(Based on the Paper presented at the *International Conference on Science Communication for Scientific Temper* held in New Delhi during 10-12 January 2012)

Developing Scientific Temper through School Education

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SCIENCE not only inculcates the spirit of curiosity among the students but also helps in developing scientific temper. This scientific temper, or scientific attitude, is basically characterized by traits like healthy scepticism, universalism, freedom from prejudice or bias, objectivity, open mindedness and humility, willingness to suspend judgment without sufficient evidence, rationality, perseverance and positive approach to failure. Normally, a person having a scientific attitude uses the method of science in his/her daily life decision-making process, knowingly or unknowingly.

Our first Prime Minister, Jawaharlal Nehru, was very fond of using the term "Scientific Temper". He was keen that we should not learn science superficially; i.e. just the facts of biology or chemistry and physics. He wanted people to possess scientific temper so that they could be better scientists, better citizens and capable of governing their personal thoughts and actions in a scientific manner.

The importance of developing scientific temper is very clearly established by the fact that Article 51 A of our constitution makes it one of our fundamental duties to develop scientific temper and spirit of inquiry and reform amongst fellow citizens**.** Our science policy also reiterates the same thoughts. For developing scientific temper among the students, a number of efforts are being made by the Government as well as several Non-Government Organizations.

The National Curriculum Framework (NCF) 2005, which is now considered as the Bible of school education, has also pointed out that sciences, like the systems of mathematics, have their own concepts, often interconnected through theories, and are attempts to describe and explain the natural world. Scientific inquiry involves observation and experimentation to validate predictions made by theory (hypotheses), which may be aided by instruments and controls. The National Focus Group on 'Teaching of Science' suggested prevention of marginalization of experiment-based learning in school science curriculum.

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Role of School Curriculum in Developing Scientific Temper

The basic purpose of education includes all round development of an individual in the society and consequently overall development of the society reconciling technological and scientific advancement with general well being. The basic 'method of science' and 'scientific temper' help in tackling problems we face in everyday life.

The attributes of scientific temper like honesty, truthfulness, humility, perseverance, positive approach to failure, are essentially universal human values that are very important for the happiness of an individual as also for the society. Inculcation of these and other universal human values should become an integral part of the education process.

Although the education sector does not deal directly with scientific temper, it plays a very important role in this context as it comprises of almost all those components that develop scientific temper among students. However, recognizing the need for inculcating scientific attitude among the students and the immense potential with the school education system, special measures have been taken over the last few decades. For example, the school syllabus has now some interactive experiments and learning-by-doing sections for the students. According to the *India Science Report 2004*, one third of the students do not study science or they do not feel motivated enough. The school curriculum has to play a great role in this context.

Scientific temper is not confined to science subjects alone or to laws, theories and formulas. Instead, it is what we call a state of mind that always questions every thing seeking knowledge and is satisfied only when proved with substantial facts and evidences. Thus, school curriculum needs to encourage students to seek logic and question all that they observe and find out answers.

The spirit of enquiry is the principal element of scientific temper. A person who follows the method of science (observation-hypothesis-experimentation-analysis-conclusion) directly or indirectly possesses scientific temper. Scientific temper is encouraged by various ways and means. Some traditional media are print, folk lore, folk dance, street plays, puppet shows etc.

Electronic and digital media are the advanced media that are being utilized today for disseminating science effectively. With the advancement of Information and Communication Technology (ICT) a number of ways are being followed for science communication aiming at developing scientific temper. Blogs, Facebook, e-news paper, wall newspapers and mobile phones are some of the ultra modern and innovative means of science communication through which scientific temper may be developed.

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Review of the Recommendations of Educational Committees and Commissions

NCF, 2005 is not the only document that has given directions for developing scientific temper among the students, but several commissions and committees on education have also urged inculcation of scientific temper, development of the spirit of inquiry and focusing on learning-by-doing through activity-based science teaching in school curriculum.

When India became a free country in 1947, the first Prime Minister Pt. Nehru envisaged India as a secular democracy with a state-led command economy. Education for all and scientific and industrial development(s) were seen as crucial tools to unite a country, divided on the basis

of wealth, caste and religion. Nehru used the word "scientific temper" first in his book *Discovery of India* in 1946. He used this word in the Indian perspective for human growth and national development.

Drawing on Nehru's vision, and articulating most of his key themes, the Kothari Commission (1964-66) was set up to formulate a coherent education policy for India. According to the Commission, education was intended to increase productivity, develop social and national unity, consolidate democracy, modernize the country and develop social, moral and spiritual values. Other features included were the development and prioritization of science education and scientific temper. The Kothari Commission felt that India's development needs were better met by engineers and scientists than historians.

Emphasizing on the need for developing scientific temper among children, the Kothari Commission envisioned that science education should be an integral part of school education and ultimately become a part of all courses at the University stage. The Kothari Commission recommended a child-centered and activity-oriented syllabi in schools in order to develop science concepts and understanding and above all a scientific temper.

The National Education Policy, 1968 also emphasized that with a view to accelerate the growth of the national economy, science education and research should receive high priority. Science and mathematics should be an integral part of general education till the end of school education.

In 1986, Rajiv Gandhi announced a new education policy, the National Policy on Education (NPE), which was intended to prepare India for the 21st century. The key legacies of the 1986 policy were the promotion of privatization and the continued emphasis on secularism and science. According to the National Policy on Education, 1986, science education should be strengthened so as to develop in the child well defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to question, and an aesthetic sensibility.

NPE, 1986, recommended that the science education programmes should be designed to enable the learner to acquire problem-solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. It was emphasized that every effort would be made to extend science education to the vast numbers who have remained outside the pale of formal education. Such recommendations are basically aimed at promoting scientific temper and attitude among the children.

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In March 1992, a National Advisory Committee (NAC) was set up by the Government under the chairmanship of Prof. Yash Pal, former Chairman of the UGC, to suggest ways and means to reduce academic burden on school students.

Even the 11th Five Year Plan had emphasized sensitisation of teachers and others involved in nutrition, hygiene, cleanliness, and safety norms to rectify observed deficiencies, which is possible only when scientific temperament is developed among the people. The 11th Five Year Plan had observed that the proportion of students opting for science courses was far too low. Consequently, a large segment of our graduates were inadequately equipped to meet the changing needs of the emerging labour market. The Plan emphasized on enlarging the pool

of scientific manpower and making focused efforts to identify and nurture bright young students who could take up scientific research as a career.

As part of the National Science Survey-2004, undertaken by the National Council of Applied Economic Research (NCAER), the first *India Science Report-2004* was brought out. The basic objectives of the study were to quantity and analyse the impact of S&T on various sectors like basic science research, space and atomic energy programmes, services (education, health, climate change etc.), industrial research and life style of the common man. Overall, the report indicates that science education needs to be strengthened in terms of method of teaching, teacher quality and infrastructure.

National Curriculum Framework and Scientific Temper: Existing Scenario

The existing school education system in the country is basically based on the guidelines set up by the National Curriculum Framework (NCF), 2005. According to the NCF 2005, the scientific method involves several interconnected steps: observation, looking for regularities and patterns, making hypotheses, devising qualitative or mathematical models, deducing their consequences, verification or falsification of theories through observations and controlled experiments, and thus arriving at the principles, theories and laws governing the natural world.

As per the NCF, teaching should aim at enhancing children's natural desire and strategies to learn. Knowledge needs to be distinguished from information, and teaching needs to be seen as a professional activity, not as coaching for memorization or as transmission of facts. Activity is the heart of the child's attempt to make sense of the world around him/her. Therefore, every resource must be deployed to enable children to express themselves, handle objects, explore their natural and social milieu, and to grow up healthy. NCF recommends the softening of subject boundaries so that children can get a taste of integrated knowledge and the joy of understanding. The teaching of science should be recast so that it enables children to examine and analyse everyday experiences.

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Further, NCF 2005 states that science is a dynamic, expanding body of knowledge, covering ever-new domains of experience. In a progressive forward-looking society, science can play a truly liberating role, helping people escape from the vicious cycle of poverty, ignorance and superstition. The advances in science and technology have transformed traditional fields of work such as agriculture and industry, and led to the emergence of wholly new fields of work. People today are faced with an increasingly fast-changing world where the most important skills are flexibility, innovation and creativity.

According to NCF 2005, the simple observation leads to the following basic criteria of validity of a science curriculum:

1. Cognitive validity requires that the content, process, language and pedagogical practices of the curriculum are age appropriate, and within the cognitive reach of the child.
2. Content validity requires that the curriculum must convey significant and correct scientific information. Simplification of content, which is necessary for adapting the

curriculum to the cognitive level of the learner, must not be so trivialised as to convey something basically flawed and/or meaningless.

3. Process validity requires that the curriculum should engage the learner in acquiring the methods and processes that lead to the generation and validation of scientific knowledge and nurture the natural curiosity and creativity of the child in science. Process validity is an important criterion since it helps the student in 'learning to learn' science.
4. Historical validity requires that the science curriculum be informed by a historical perspective, enabling the learner to appreciate how the concepts of science evolve over time. It also helps the learner to view science as a social enterprise and to understand how social factors influence the development of science.
5. Environmental validity requires that science be placed in the wider context of the learner's environment, local and global, enabling him/her to appreciate the issues at the interface of science, technology and society, and equipping him/her with the requisite knowledge and skills to enter the world of work.
6. Ethical validity requires that the curriculum promote the values of honesty, objectivity, cooperation, and freedom from fear and prejudice, and inculcate in the learner a concern for life and preservation of the environment.

If we look at the basic objectives of the science popularization programmes, we find that the purpose of all such programmes and activities are also almost the same as that highlighted in the NCF, 2005. This clearly indicates that science teaching at the school level is also primarily aiming at promoting scientific thinking and creating scientific attitude among the students in particular and the people in general. The recently implemented Right to Compulsory Education Act, 2009, also recommends learning through activities, discovery and exploration in a child-friendly and child-centric manner.

Challenges and Limitations of the Existing Education System in Developing Scientific Temper

Though a number of efforts are being made for developing scientific temper among the students through the school education system, there are several problems and challenges in achieving the objectives of providing minimum science for all. Some such challenges are:

- The traditional chalk and talk method of teaching science, which hardly creates any interest among the students towards science.
- Minimum use of learning science by doing. Hardly any special effort is taken to raise the curiosity of the students. Even if any student dares to ask questions beyond the scope of the class, he/she is not encouraged.
- Lack of trained teachers and science communicators in schools. Normally, science teachers aim at completing the syllabus instead of inculcating the basic scientific skills including scientific attitude among the students.
- Lack of interaction between science communicators and teachers/students also reflects a challenging scenario before the existing education system. Trained science communicators contribute to the development of scientific temper in the society and their absence augments the hindrance in developing an informed society.
- Science laboratories are not equally equipped and are not used for experimentation and discovery.

- The biggest challenge in developing scientific temper is the existing examination and evaluation system because the examination system does not allow thinking out of the box, which is the basic requirement for developing a scientific attitude. In fact, students are taught to answer the questions, rather than questioning the answers. Unless we develop the ability to raise questions, it may not be possible to achieve the objective of developing scientific attitude among the people.

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Conclusion

It can be said that though our education system has all provisions for developing scientific temper, these are not being implemented the way they should be. Activity-based teaching learning methods are talked about but are seldom practiced in our schools. The teaching-learning is mostly school-centred whereas for developing scientific attitude and scientific skills the education system should be made child-centred. The principal component of education should be the development of scientific temper.

The objective of school education is to develop an active and informed learner not a passive and unaware one. The curriculum must talk to the learners and enable children to examine and analyse everyday experiences. As the NCF recommends, the spirit of 'Children's Science Congress' should be revolutionized in order to promote discovery learning across the nation. Efforts should be made to encourage maximum use of innovative teaching learning aids/instruction materials like audio-visual aids in science learning which in turn help in developing scientific temper among the students.

As per the *India Science Report-2004*, seventy-seven per cent Indians feel S&T makes their lives healthier and easier. It is therefore, imperative to make people scientifically literate by way of integrating the concept of scientific temper in the school curriculum.

(Based on the Paper presented at the *International Conference on Science Communication for Scientific Temper* held in New Delhi during 10-12 January 2012)

APPENDIX 1

A Statement on Scientific Temper-1981

Introduction

The nation owes a deep debt of gratitude to Jawaharlal Nehru, more than to any other, for the sustained growth and many-sided development of modern science and technology in India, as viable instruments of social transformation. The need of the time is the diffusion of fruits of science and technology into the societal fabric at all levels. This can only be achieved by promotion of what Jawaharlal Nehru chose to call the Scientific Temper – a rational attitude, the importance of which he emphasized time and again. Indeed, the Scientific Temper has to be fostered with care at the individual, institutional, social and political levels. -

July 10, 1981 **Dr. Raja Ramanna**

Foreword

The Nehru Centre arranged for some of us to assemble together in a quiet corner of our country to share our common concern at the accelerating pace of retreat from reason. The venue of our meeting was Coonoor, so lush and green and full of promise as our entire land is.

For four days and nights, from October 22-25, 1980, we discussed and debated what needed to be done to halt the process of decay of reason and rationality. I had the honour of presiding over the deliberations. The end result of it all was a Statement on Scientific Temper.

That Statement was subsequently shown to others. It was further refined. We now present this Statement as revised. We are not unaware of its inadequacies. However, it is our earnest hope that the Statement will generate a wider debate and discussion in our country.

There are more than two million scientists and technologists in our country. In addition, we have a large number of economists, historians, sociologists, lawyers, doctors, administrators, management specialists and teachers who, in one way or another, apply the scientific temper and scientific methodology in pursuit of their respective professions and disciplines.

If the Statement succeeds in generating a nation-wide discussion, it will also, hopefully, generate a movement for the much needed second renaissance in our country. The first renaissance inspired the struggle for freedom. The second must of necessity provide the necessary fillip for the re-structuring of our country embodying the aspirations of our people.

Only in the measure we succeed in installing Scientific Temper as a dominant ethos of our collective being, can we hope to face the accumulating problems of our national existence. We must understand that it is not going to be easy. We shall have to do a great deal of heart-searching ourselves.

It is often argued, with seeming profundity, that while scientific temper is alright, it does not satisfy humanity's spiritual needs; that the entire realm of art and music, poetry and drama fall outside its ambit. In answer to such critics, I can do not more than remind ourselves of how Jawaharlal Nehru resolved the seeming contradictions between out material and spiritual needs. In the *Discovery of India*, he defines in the following terms his own attitude:

> *The real problems for me remain problems of individual and social life, of harmonious living, of a proper balancing of an individual's inner and out life, of an adjustment of the relations between individuals and between groups of a continuous becoming something better and higher, of social development, of the ceaseless adventure of man.*

In the solution of these problems the way of observation and precise knowledge and deliberate reasoning, according to the method of science, must be followed. This method may not always be applicable in our quest of truth, for art and poetry and certain psychic experiences seem to belong to a different order of things and to elude the objective methods of science.

Let us, therefore, not rule out intuition and other methods of sensing truth and reality. They are necessary even for the purposes of science. But always we must hold to our anchor of precise knowledge tested by reasons... we must beware of losing ourselves in a sea of speculation unconnected with the day-to-day problems of life and the needs of men and women. A living philosophy must answer the problems of today.

February 17, 1981 **P.N. Haksar**

Preamble

The history of humanity bears witness to periods of enlightenment as well as to periods of darkness. It bears witness to the rise and fall of civilizations. Through all the vicissitudes of time the knowledge gained by humanity has retained a quality of indestructibility. Viewing the entire panorama of the universal history of mankind, one becomes conscious of a continuous but forward movement towards greater knowledge, and to an increasing capacity of human beings to exercise control over their environment.

While humanity as a whole accumulates knowledge, there is no guarantee that the availability of such knowledge will, by itself, enable every country to use it successfully for its own advancement and the well being of its people. There are examples in history where predominant social, political, cultural and value systems inhibited the absorption of knowledge resulting in periods of stagnation, decay and retreat from reason, rationality and science. Though the Renaissance began in Italy, and Galileo, the harbinger of modern science, was an Italian, adherence to obscurantism enforced by the Church led Italy to losing the benefit of the Renaissance, which fertilized Northern parts of Europe. The Renaissance and the Reformation then combined together to revolutionise thought as well as society.

In our own country too we have known of periods of creativity when the spirit of enquiry led to the accumulation of scientific knowledge; there was creativity in literature, music, arts and crafts. However, we have also known of periods when the spirit of enquiry got extinguished. During those long stretches of time everything was reduced to unquestioning dogmas and to the performance of dead rituals. There was deadening of curiosity and questioning. There was only passivity and acceptance. And finally, we were overtaken by the greatest of disasters – our complete colonisation and subjugation to British imperialism.

Contemplating our decline, decay and subjugation, some of our best minds began asking themselves why and how it all happened. This spirit of enquiry and questioning gave birth to a wide social cultural movement, which we call the Indian renaissance. The best Indian minds in the pre-independence times insistently propagated the need for the people to think independently and fearlessly, and to question traditional beliefs. This effort, in time, produced a critique of the colonial system. Out of this critique was born a powerful national movement for our liberation. The British imperial system, aligning itself with the vested interests, endeavoured to counter the broad stream of nationalism by encouraging revivalism and obscurantism. And though Indian renaissance never elaborated a critique of our entire ancient society and

unfortunately made compromises, the urge to acquire knowledge and the scientific outlook remained strong. The spirit of questioning ultimately overwhelmed an imperial system, which seemed so powerful and even immutable.

There is a wide awareness in our times that we are living in a scientific age of great discoveries in science, affecting and moulding both our material and social existence. It is indeed remarkable how a comparatively small number of physical laws seem sufficient to explain a great part of behaviour of matter, right from the huge and massive heavenly objects located in the very edges of our universe to the minute regions of atoms and atomic nucleus. In life sciences, we are in the midst of far reaching, even revolutionary, changes. The entire history of humanity shows that it is the scientific temper which not only created and promoted science, but also gave humanity the means to affect the natural and social environment. It is, therefore, the scientific temper which is the most precious heritage of humanity. It is the result of incessant human labour, search and struggle.

Jawaharlal Nehru gave an impetus to Scientific Temper by setting before the people the target of catching up with the rest of the world with the help of science and technology. He unfolded the perspective of leap-frogging the centuries. Implicit in such a vision was a vast change in the intellectual climate of our people. Our Constitution and the subsequent Resolution on Science Policy were predicated upon the assumption that our ancient society needed basic changes. However, there was not enough appreciation of the relationship between the objectives to be achieved and the methods as well as the instrumentalities appropriate for bringing about the desired changes. No systematic and sustained effort was made to work out, specifically and concretely, what needed to be done to build a society which is animated by a spirit of enquiry rather than passivity and acceptance. The result of this lack of directed efforts was accommodation, even compromise, with the forces of obscurantism and with the existing inegalitarian social and economic structures. Failure to give mass dimensions and appropriate institutional forms to Scientific Temper, more specially to our educational system, led to the erosion of confidence in our capacity to mould our destiny.

In such an environment, Scientific Temper is beleaguered and besieged by deep-rooted structures of an ancient society with superimposed colonial structures. Consequently, there has been frustration of our hopes of optimising the results of the application of science and technology for our national reconstruction. Inevitably, such frustration has encouraged a search for and reliance upon authority. Inevitably too, there has been a growth of tendencies to escape into magical beliefs and instant solutions. Even science and technology are being offered not as methods of enquiry or value systems but as magical cures for our ills, reminding one of the time when Roman intellectuals sought refuge in Levantine magic. There is inadequate appreciation of the close interaction between science and technology and society and of the fact that the benefits of science and technology can reach the people only if the socio-economic conditions are conducive. If the cultural environment, socio-economic conditions and institutional structures inhibit the spirit of enquiry, the desired results can never be achieved.

The gravity of our predicament is increasing day by day. While we rank high among the industrialised countries in the world and are the third largest country in the world in regard to the stock of manpower trained in science and technology, we are close at the bottom of the list in terms of per capita food consumption, longevity, health care and general quality of life. We have all the technology available right now within the country to give water, food, shelter, and basic health care to our millions. And yet we do not. Something has gone wrong. The logic of planning and the logic of our socio-economic structure are at variance. Hence, our failures and disappointments.

In such an environment, there is an erosion of belief in the capacity of human faculties to solve national problems through a systematic critique of the existing social situation. There is a cancerous growth of superstition at all levels. Rituals of the most bizarre kind are frequently performed often with official patronage. Obscurantist social customs are followed even by those whose profession is the pursuit of scientific enquiry. Our entire educational system works in an atmosphere of conformity, non-questioning and obedience to authority. Quoting authority of one kind or another substitutes enquiry, questioning and thought.

Obscurantism and irrationalism practised by a hierarchy of authorities has the predictable effect of reinforcing retreat from reason. Voices raised against such a state of affairs get silenced. The decision-making processes are increasingly being divorced from any rational purpose or design. There is no long-term perspective based on ascertained facts and scientific analysis. Ad hocism, whims and the narrowest of considerations take the place of well-planned programmes. Priorities, if any, are fixed without sufficient database and without any attempt at scientific evaluation of national needs, potentialities and feasibility of implementation. Mere slogans tend to be used as substitute for action and for creating an illusion of achievement. Dramatic crash programmes are launched. These, inevitably, crash. There are no perspective plans. Even Five Year Plans have been reduced to annual exercises of allocating funds.

As our country enters the last two decades of the 20th century, the need to move forward is becoming ever more insistent. We either overcome the obstacles or we shall be overcome by unreason and dark reaction. We must understand the meaning as well as the imperatives of Scientific Temper, representing as it does, humanity's assertion of being in charge of its destiny and not a passive victim of malevolence or benevolence of stars. To do so, we need to actively combat beliefs which erode Scientific Temper and undermine its growth. Only then shall we illumine our darkening national horizon and a method for translating that vision into reality. Such a vision must have a Scientific Temper as its integrating bond.

Attributes of Scientific Temper

Spread of Scientific Temper in society is much more than the spread of science or technology. Scientific Temper is neither a collection of knowledge or facts, although it promotes such knowledge; nor is it rationalism although it promotes rational thinking. It is something more. It is an attitude of mind which calls for a particular outlook and pattern of behaviour. It is of universal applicability and has to permeate through our society as the dominant value system powerfully influencing the way we think and approach our problems – political, social, economic, cultural and educational.

Scientific Temper involves the acceptance, amongst others, of the following premises:

(a) that the method of science provides a viable method of acquiring knowledge;
(b) that human problems can be understood and solved in terms of knowledge gained through the application of the method of science;
(c) that the fullest use of the method of science in everyday life and in every aspect of human endeavour from ethics to politics and economics – is essential for ensuring human survival and progress; and
(d) that one should accept knowledge gained through the application of the method of science as the closest approximation to truth at that time, and question what is incompatible with such knowledge; and that one should from time to time re-examine the basic foundation of contemporary knowledge.

The method of science, therefore, constitutes a regenerative process for collecting information and processing the collected information to create meaningful patterns leading to

an ordered understanding of nature of man himself, his natural and social environment. In this sense, the method of science encompasses all aspects of communicable human knowledge and cuts across all artificial compartmentalisation like natural science, social science, applied science, etc.

The spirit of inquiry and the acceptance of the right to question and be questioned are fundamental to Scientific Temper. It calls upon one to ask the 'how', the 'what', and the 'why' of an object, event or phenomenon. It further calls upon one to exercise the right to question, provided of course, the questioning of an existing theory, hypothesis or statement or social situation is done in accordance with the scientific method and is not merely a bare assertion of one's belief. Scientific Temper is, therefore, incompatible with the acceptance of authorities of all kinds or of 'high priests' who may not be questioned & leads to the realisation that events occur as a result of interplay of understandable and describable natural and social forces and not because someone, however great, so ordained them. These forces are often complex and intertwined and have to be analytically disentangled.

Scientific Temper is compatible with observation and insight, reasoning and intuition, systematic work and creative impulse. It gives rise to an attitude of mind which while being conscious of vast areas of ignorance, is nevertheless, optimistic about human ability to gradually unravel the mysteries that surrounds us. In this process, Scientific Temper becomes a part of the culture, a philosophy, and a way of life which leads to pursuit of truth without prejudgment.

Scientific Temper implies the recognition that knowledge often progresses by disproving earlier ideas, beliefs, theories and laws. It considers knowledge as open-ended and ever evolving. It lays emphasis on verifiability and repeatability, wherever possible, and on the fact that scientific theories, law and fact allow one to make predictions which can be tested. It recognises that answer to many questions that may be asked at any given time, may not be available at that time. It, then, demands the courage and humility to say, 'I do not know'.

Scientific Temper calls for recognition of the several major differences between the scientific attitude and the theological and metaphysical attitude specially in respect of dogmas proclaimed in the name of religion. There is in fact, essential incompatibility of all dogmas with science. While science is universal, established religions and religious dogmas are divisive. Consider the divisions which exists between Christian, Islamic, Buddhist and Hindu denominations. Science, in contrast, transcends divisions and is universal.

Scientific Temper has deep emotional content and has, within it, a sense of beauty. That is why considerations based on beauty and simplicity have been often invoked to choose between alternatives theories that are otherwise equally tenable.

Inherent in Scientific Temper is a system of value judgments. The inculcation of Scientific Temper in our society would result in our people becoming rational and objective, thereby generating a climate favouring an egalitarian, democratic, secular and universalist outlook. Consequently, Scientific Temper cannot flourish in a grossly inegalitarian society where 50 per cent of the population lives below the poverty line and almost 70 per cent of our people, especially females, are illiterate. Social justice, widespread education and unrestricted communication are therefore, per-requisites for spread of Scientific Temper and for optimizing the results of science and technology.

Role of Scientific Temper

Having outlined the essential elements of Scientific Temper, let us survey our national scene. Despite Jawaharlal Nehru's advocacy of Scientific Temper, we are witnessing a phenomenal growth of superstitious beliefs and obscurantist practices. The influence of a variety of godmen and miracle makers is increasing alarmingly. The modern tools of propaganda and

communication are being used to give an impression that there exist instant and magical solutions for the problems that confront our people.

In an age when man has travelled to the moon and returned safely, astrological predictions based on the movements of planets or the lines of one's palm or the number of alphabets in one's name, are widely believed. Food fads, irrational health practices are on the increase. In a poor country where millions live below the poverty line, vast amount of wealth is consigned in *havans* and *yagnas*.

Myths are created about our past. The origin and role of the caste system is explained in a way that would justify it and imply that some castes are inherently superior. The ancient period of our history is interpreted to inculcate chauvinism which is false pride; the medieval period is misinterpreted in a way that would fan communalism; and the struggle of our people for freedom is over-simplified as if it was the handwork of a few great leaders and the masses of our people did not matter.

While it is important to understand the origin of these unscientific beliefs, the more immediate and pressing problem is to understand the remarkable phenomenon of their persistence and the resulting social consequences.

The sustenance of such beliefs and superstitions must be recognised primarily as a historical and social process. Such beliefs continue, because they have ready relevance to the personal situations of the majority of our people. Vast uncertainties of our daily lives, frustration of hopes and aspirations of millions, denial of any vision which would sustain the spirit drives millions to seek mental equilibrium in faith healing. Thus, when one believes that one's miserable personal situation cannot be improved, acceptance of fatalism becomes natural. Beliefs then rationalise the status quo and breed fatalistic doctrines. In such a situation of social and cultural malaise, a major role of Scientific Temper is to revive confidence and hope and to dispel fatalistic outlook. The campaign to promote Scientific Temper must inculcate values like equality and dignity of labour and social accountability of one's actions. All these are essential for bringing about social, economic and cultural transformation of our country.

The emphasis on the method of science does not imply that science and technology have solutions to all human problems at any given time. Indeed, Scientific Temper warns one against the simplistic view that through the introduction and pursuit of science and technology, most social problems and contradictions will automatically get resolved. The role of reason is to apply scientific knowledge to problems, to grapple with them through the method of scientific inquiry and to work for social transformation inspired by Scientific Temper.

We must equally combat the tendency to treat science and technology as a sort of magic. It should be explained that it is unscientific to believe that if scientific and technological solutions exist to a range of problems, these will be automatically adopted. The nature of social stratification and the power structure in a society prevents the acceptance of such solutions. Technologically, one may be able to grow enough food for everyone, but the pattern of income distribution prevents the benefits of increased food production reaching large segments of the population. When the social structure and stratification prevent the application of rational and scientifically proven solutions, the role of Scientific Temper is to lay bare the anatomy of such social barriers.

If we have to regain our place in the world and are not to be relegated once again to the dustbin of history; if we wish to offer a life of fulfillment to our destitute millions, indeed, if the light of our civilization is not to be extinguished, we have to undertake, on a priority basis, the task of nurturing Scientific Temper. All of us scientists, technologists, social scientists, educationists, teachers, media men have to join hands and undertake this task. We draw inspiration from the way our people in all walks of life joined hands and struggled against

colonial domination of our land and of our minds. We believe, it must be done without any loss of time. Our nation's survival and its future depends on upholding Scientific Temper. Superstition shall not pass and darken our portals.

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At the function where the document was released, Dr. P.M. Bhargava, one of the convenors, announced that the following had signified their complete agreement with the Statement: Dr. M.G.K. Menon; Dr. Yash Pal; Dr. Romila Thapar and Dr. Rais Ahmed.

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APPENDIX 2

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