The Scientific Temper



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Introduction

A few years ago I attended an international and inter-disciplinary conference dealing with the issues man has to face in the twenty-first century. Naturally issues such as global environment, population control, food-availability, communications, education, science and technology, etc., featured prominently. As speaker after speaker covered a variety of topics of great relevance to the theme of the conference, I increasingly began to feel like a diner at a sumptuous meal searching desperately for that tiny but vital item, viz., the salt shaker. That pinch of salt is the scientific temper that is such an essential component of man's mental framework in his struggles to face the challenges of the present and the future.

What is scientific temper? Why is its relevance being felt *now* rather than in the past? Is it an individual trait or does it also extend to societies, cultures, civilizations? To what extent is it prevalent today? What can be done to make it more widespread? These are the questions I shall try to answer. But the bottom line has been stated much more effectively by Pandit Jawaharlal Nehru:

> ...The impact of science and the modern world have brought a greater appreciation of facts, a more critical faculty, a weighing of evidence, a refusal to accept tradition merely because it is tradition...
>
> But even today it is strange how we suddenly become overwhelmed by tradition, and the critical faculties of even intelligent men cease to function... Only when we are politically and economically free will the mind function normally and critically.
>
> *...(Discovery of India)*

This was written during the British Raj. Today we live in a free India which is feeling its way towards economic prosperity. Yet we are still a long way away from achieving that scientific outlook which Nehru considered so essential for our future well-being. To appreciate what the scientific outlook is all about, let us first see how science itself works.

The method of science

There are three steps in the progressive march of science: experiment and observation/ theoretical interpretation/ prediction of new results. This sequence is endless. One performs experiments in the laboratory, or observes some natural phenomenon and then tries to interpret it in terms of a theoretical framework. If the attempt succeeds, then one tries to make new predictions that future experiments or observations will verify. If the success of the theory continues, one keeps believing in the theory. *However, one never accords the theory a blank cheque for being correct.* There is always a possibility that a future experiment may disagree with the predictions of the theory, in which case it may have to be abandoned or modified or replaced by a new and better theoretical framework. Thus Newton's law of gravitation continued successfully until some sophisticated tests in the solar system showed its inadequacies and it was replaced by Einstein's theory of relativity. It was in this connection that Sir Hermann Bondi, the well-known astronomer, remarked:

> ...The essential thing in science is for the scientist to think up a theory. There is no way of mechanizing this process; there is no way of breaking it down into a science factory. It always requires human imagination, and indeed in science we pay the highest respect to creativity, to originality. It is, of course clear that since every theory must live dangerously, the casualty rate is pretty high. So we do not honour scientists for being right; it is never given to anybody to be always right. We honour scientists for being original, for being stimulating, for having started a whole line of work. Science is the most human of endeavours because it depends on co-operation, it depends on people testing each other's work and it depends on people taking notice of each other.
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> *(Cosmology Now,* ed. L. John, 1973, B.B.C. Publications*)*

Bondi's comment needs one clarification. It does not mean that any Tom, Dick or Harry can propose 'new ideas', claiming to be better than Newton or Einstein. I get such ideas from dozens of people in the post, which are vague flights of imagination with no backing of quantitative facts. Bondi here means ideas carefully worked out with rigorous mathematics and having the benefit of confirmation by physical facts. In fact there is no simple way to the truth, whatever it may be. One needs patience in putting together whatever understanding of nature our society has acquired and build on it towards a greater understanding.

The scientific outlook has evolved from this practice of science: it relies on factual evidence and statements that can be checked against established truth. It allows for pragmatism; that is, willingness to drop a paradigm if it fails the test of facts and to adopt a better one if it meets all factual checks. However, the scientific outlook need not be the prerogative of the scientist alone. After all, it owes its origin to human curiosity about Nature and as such every one of us, whether a scientist or not, is entitled to it. Indeed, just as in the case of science, progress could be achieved only when the scientific outlook prevailed over innate conservatism. So, in the case of a society of human beings this outlook acts as an antidote to the evils of prejudice and superstitions.

Science and astrology

Superstitions are born out of ignorance of how Nature functions. Science is dedicated to the unravelling of the mysteries of Nature. As one particular mystery is solved, we should expect the superstitions based on it to disappear. Yet, this does not always happen in practice because of the lack of scientific outlook in the typical human being. I give below one example.

The early human societies ascribed occult powers to planets. This assumption arose from ignorance of what planets are and how they move. Now that astronomy has answered all of the questions raised about planets by the primitive man, we should expect this assumption to be regarded as groundless. Yet this has not happened. Even in the technologically

advanced countries this belief persists among sections of educated classes. In the mid-1970s a group of leading scientists including several Nobel Laureates in the West signed a circular denouncing the very basis of this belief. I give below an extract from their statement:

> ....It is simply a mistake to imagine that the forces exerted by stars and planets at the moment of birth can in any way shape our futures. Neither is it true that the positions of distant heavenly bodies make certain days or periods more favourable to particular kinds of action, or that the sign under which one was born determines one's compatibility or incompatibility with other people ... In these uncertain times many long for the comfort of having guidance in making decisions. They would like to believe in a destiny predetermined by astral forces beyond their control. However, we must all face the world, and we must realize that our futures lie in ourselves, and not in the stars...
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> *(The Humanist,* Sept./Oct. 1975*).*

Do planets influence human destiny? The subject of astrology is based on the answer to this question being 'yes'. How will a scientist go about testing the hypothesis that the answer is 'Yes?' He will not be satisfied by the prediction by a single person based on a single horoscope. First he will require a set of well-defined rules on which such predictions are based. The rules should be unambiguous so that different persons make the same prediction from the same horoscope. Next he will need to be convinced that these rules work in a statistically significant manner to discount the possibility of the prediction being right purely by chance. This will require a systematic study of a large number of such trials under different conditions.

It is necessary for this purpose, to cast the prediction in a well-focussed form where it can be tested. Such tests as have been conducted so far by scientists have yielded negative results. But again, it is not always necessary to call upon a professional scientist to perform such tests. The educated common man can himself sift the evidence provided he adopts an objective outlook. Let me give one illustrative example of experiments of this kind conducted recently in India to test the scientific predictivity of astrology.

For this test I was associated with the Andhashraddha-Nirmulan Samiti headed by Dr Narendra Dabholkar, Prakash Ghatpande (who had been an astrologer earlier but had now become a critic of astrology), and Sudhakar Kunte from the Statistics Department of Pune University. The test was a simple one, staying away from many grey areas common in astrology. Date, time and place of 200 subject children were collected so that horoscopes could be cast for them. Of the 200, half (i.e., 100) were bright gifted children whereas half were mentally retarded. In a double blind experiment, several sets of 40 randomly chosen horoscopes were made. Thus a typical set would have, say, N horoscopes of gifted kids and 40-N of retarded ones. We then invited astrologers to participate in the test. 51 agreed to do so while some major astrological organisations boycotted the test sensing it to be some kind of 'trap'. Each participant was sent a typical set and asked to label each horoscope as belonging to class I of bright children or class II of retarded children. Neither we nor the participants, knew the value of N for his set, although our records carried full information. Our statistician had announced before the test that for any significant claim of predictive power, the astrologer must get at least 28 out of 40 right. Of the 51 only 27 responded and the average rate of success of their predictions was around 17 out of 40. If they had used the method of calling head/tail after tossing a coin, they would have registered a greater success! In addition, a professional astrologers' institution also participated in the test. To the institution we gave all 200 horoscopes. They got 102 right, again statistically no different from pure 50-50 chance! Obviously, this test revealed that astrological predictive power in such cases is non-existent.

I could go on with other examples in the USA and Europe, to illustrate that astrology has been tested for the scientific criterion of predictability in numerous ways by numerous research workers on numerous occasions – and has always been found wanting.

Conflict with traditions

Individually or as part of a larger group man has always lived by certain traditional beliefs. These beliefs are inextricably mixed with his cultural and religious heritage. Inevitably conflicts arise whenever the critical appraisal inherent in the scientific temper is applied to these beliefs. Some conflicts arise because the beliefs or the rituals they imply had a rational basis in the olden days but which they no longer possess today. Some rituals may have had a symbolic or even a practical meaning in the social ambience of several centuries ago: today they have become irrelevant. The question arises: what should one do in case such a conflict arises?

On the 'traditional' side we have the traditional virtues of the individual's responsibility to the society, the society's commitment to ensure the well-being of its members and the individual, and social commitment to preserve the natural habitat around us. Armed with these virtues man can assess what science has to offer: he can take judicious decision on what to accept and what to reject. This is where the scientific temper comes to the help of the society as a whole.

The technologically advanced nations of the West have been experiencing the ill effects of uncontrolled impact of science and technology on society. The destructive nuclear arsenal, the excessive industrial pollution, the enforced idleness brought about by automation and the consequent psychological problems of mechanisation, etc., are there to see. Does this mean that we must put a stop to all scientific and technological development? Such a response, already advocated by a few in the developing nations, indicates a panic reaction. Given the traditional virtues mentioned above as guiding principles it should be possible to identify a rational path that skirts around the above pitfalls.

The present status

Let me review briefly how we Indians stand today vis-à-vis Nehru's expectation that

> "... Only when we are politically and economically free will the mind function normally and critically".

A dispassionate survey presents a somewhat mixed picture.

On the one hand, as I had mentioned earlier, we have several NGOs devoting their efforts to spreading rationalism and to eradicating superstitions. There are

organisations which conduct public awareness programmes through lecture demonstrations, street plays, experiments debunking the so-called miracles, articles and books on the importance of the scientific temper, and so on. The National Council for Science and Technology Communication (NCSTC) in New Delhi has been supporting such programmes in an imaginative fashion.

The NCSTC had been responsible for launching the National Science Day to be celebrated on February 28, commemorating the discovery (on that date in 1928) by C.V. Raman that fetched him the Nobel Prize in physics. On this day (and indeed in the week covering that date) there are several public awareness programmes involving scientific concepts and scientific outlook, organised throughout the country. Scientific institutions keep an open house for the general public, with audio-visuals on their work, exhibitions and lectures, etc. Some institutions organise special quiz programmes and competitions for schoolchildren.

While there are several such efforts in an organised manner both in and out of the government, what is the mindset of the 'person in the street'? Can we confidently assert that in the half century since independence, we have made a significant dent in the wall of superstitions that have steadily thickened over the centuries? We remember, for example, the great social reformer Raja Ram Mohan Roy and his crusade against the *Suttee*-ritual. But there still take place isolated incidents of this ritual and they attract crowds of believers.

Nor is superstition confined to villages only. The episode of the idols of Lord Ganesha drinking milk drew large crowds in Delhi, Mumbai and other cities in India with some ministers also expressing their wonder and joy at the sight. It did not take long to debunk the phenomenon in terms of known science, but the spontaneity of belief was a give-away that the veneer of science of technology on the society is very thin indeed.

But perhaps of greater concern is the *rising trend* towards superstitions. Several symptoms can be cited of this trend.

1. More marriages are being decided by the criterion of matching of horoscopes than a generation ago. Thus I know of parents whose marriages were not passed through the 'horoscope filter', but whose children feel it necessary to apply this criterion for their marriage.
2. With new technology, new superstitions are getting hold of the society. A recent rage is Vastushastra and its Chinese counterpart, the Feng Shui. Influential politicians and leaders of society have been swayed by this new cult. None of the claims of these subjects have passed scientific scrutiny.
3. Despite debunking of Godmen's miracles by science, a large section even of the educated urbanites continues to believe in the 'Baba's who demonstrate their superhuman powers through miracles. In fact this is an area where science journalism could bring its investigative aspects to bear. So far it has registered moderate success but much more needs to be done.
4. The legitimisation of astrology as a 'science' by the University Grants Commission is another symptom of this unfortunate trend. The UGC used the word 'Vedic Astrology' implying that the subject is of Vedic origin. All historical evidence, however, shows that planetary astrology using horoscopes came from the west, from Greece, Babylon, etc.

Miracles of science benefit all

One could easily enlarge this list. Granted, there are problems with excessive reliance on automation, there are dangers of pollution with indiscriminate uses of technology, there may be serious dangers for the society from continuing certain areas of scientific research, but this does not mean that we turn away from the scientific path and re-grasp the age-old superstitions which have been proven to be invalid.

Indeed, at first sight these problems before us appear to be formidable if not insurmountable. Yet, we have only to look at the remarkable progress of science over the last few decades to see that a properly channelled scientific approach holds out hope for the future. The achievements of space technology with such highlights as the manned trips to the Moon, the landing on Mars and the SITE programme in our country, the rapid growth of communications which has dramatically brought the far corners near, the advances in medicine, biology, agriculture – are they not scientific miracles happening before our own eyes and achieved during less than the span of a generation? Unlike the so-called miracles of the so-called godmen, *the miracles of science benefit not one single individual, but a whole class of humanity.* They benefit the poor as well as the rich. The invention of electric power not only runs the gadgets of the rich, it also provides light to the remote villages.

The developed nations have recognised these facts and they not only support science in general but also continue to encourage basic research, which at first may appear 'useless' but may lead to useful applications like those just mentioned. For us to ignore basic research at this stage would mean that we will have to keep on importing new ideas from abroad. This would be contrary to our policy of self-reliance. India has plenty of talent for basic research, most of which is untapped. Suitable support for basic research will unearth this talent and bring in its own rewards in the long term if not immediately. Right now I can think of one analogy to illustrate my point of view. Imagine a country which has vast untapped resources of oil, but which will not search for these for reasons of heavy financial outlay. Such a country will forever be dependent on oil imported from abroad. And, finally let me emphasise that basic research does not require heavy financial outlay when compared to its rich potential. We must, however, ensure with adequate safeguards that the research produced is of first class quality.

When Lord Krishna finished telling the *Gita* to Arjuna, he ended by saying: *"Reflect over what I have said, fully and then do what you wish."* In a sense this is what the scientific temper calls upon us to do: to weigh in all the evidence and then decide what is best. I am confident that if, and only if, we are not blinded by traditions and dazzled by science but keep our visors open and our minds alert, our country will make a triumphant march towards progress in this century.

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