

SCIENCE, THE SCIENTIFIC ATTITUDE AND ANTI-SCIENCE MOVEMENT

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Introduction

As the title of this article indicates, I will discuss here the interaction between science and society, refer to the growing impact of science and technology on our lives, the reactions to this effect, and why it is necessary to adopt a scientific attitude not only individually but on the part of the society as a whole if we are to survive and prosper in a world increasingly dominated by science and technology.

Time was when science was a subject to be studied in the laboratory and its impact was expected to be confined to the walls of the lab. The trend changed when James Watt discovered the power of trapped steam, how it pushed aside the lid of the pot containing boiling water. Today it may seem slow progress from this discovery to the invention of a steam locomotive. But those were early days. It was the slow but sure advent of technology following on the footsteps of science.

Today that pace has picked up and has reached dizzying heights. Let us first see how this pace has increased over the years with a few examples.

The March of Science and Technology

Let me begin with one of the major programmes in basic physics, viz., the search for the finer details of the ultimate structure of matter. In the previous century scientists had arrived at the atomic structure of matter and gradually the picture emerged at the beginning of this century of an atom built like a solar system. The picture describes a central positively charged nucleus surrounded by orbiting electrons. It was believed that the nucleus cannot be cracked open.

When Ernest Rutherford achieved the impossible by breaking up the nucleus, it was to mark the beginning of the nuclear age. His apparatus for doing this experiment was built in the workshop of the Cavendish Laboratory and could be held in hand. It cost about one hundred pounds.

That was in 1919. In 1930 Walton and

Cockcroft built an accelerator which occupied a room. The nuclear particles could be energized to high speeds and their collisions studied. Its cost was about fifteen times the Rutherford instrument.

This was the trigger for human efforts to build bigger and more powerful accelerators at higher and higher costs, in order to probe deeper and deeper into particulate structure of matter. Today the enormous accelerators at CERN in Europe and the Fermilab in the USA occupy distances measured in kilometres, have hundreds of people working as scientists, technicians and infrastructural staff, and cost billions of dollars. Of course, at this stage the efforts become multinational, with participation of scientists from several countries.

The story with computers is equally astounding, although here with increasing sophistication in technology, the size has shrunk. When I went to Cambridge, England, in 1957 for higher studies, I was using the EDSAC which was an enormous system filling a large hall with big cupboards of tubes, tapes, what not. One fed a paper tape into the computer with instructions in codified machine language punched in through holes.

Today's laptop computer is more efficient in its job than the primitive ancestor. Thanks to the contributions of basic science of materials, the design of computers has been going through one revolution after another and its usage has become more and more simplified so that common educated person can derive benefits from it. Instead of the complex machine language of the fifties, the software of today is very user-friendly.

The story in the communications area is of steadily shrinking horizons. With geostationary satellites it became possible to link places separated by continents. Optical fibre technology came along to help transmit big chunks of information in various forms. Today while we enjoy the benefits of telephone, fax, e-mail and webs of databases, it is hard to recall that information and plans of the

1857 uprising were being passed by nightrunners carrying chapatties. And, people going on a pilgrimage to Kashi bade final good-byes to their families and friends as the journey they were to undertake was considered long, tedious and full of hazards.

The advances in technology have benefited medicine and surgery too. Today's surgeons perform their operations with so many diverse tools that were unimaginable a mere generation ago. So is the case with diagnostic devices which probe different parts of the human body and bring crucial information to help doctors diagnose the problem.

Not all advances have been benign, of course. When Rutherford opened up the nucleus, he also created the path to the nuclear bomb. The devastation and human suffering produced by the two nuclear bombs in Hiroshima and Nagasaki were unimaginable. That was a little over five decades ago. Although our imaginations may have hardened in the meantime, the destructive capability of the present nuclear weaponry will still be unimaginable. Carl Sagan once put it in the following way : A nuclear war of modern times is equivalent to the destruction produced during one lazy afternoon at the rate of one world war II per second.

Strategy towards S & T

The main issue that I wanted to emphasize with these few examples is the tremendous growth of even basic science. When one comes to applied science and technology, the growth is even more pervasive and its impact on our lives is more directly felt. Evidently, human societies that cannot adapt themselves to the rapidly changing scenario are bound to suffer. Therefore we have to learn to live with science and technology. What should our strategy be?

An instinctive first reaction may be one of panic, to say that we wish to isolate ourselves from this rapid rat race, that we should turn our back to the march of science and technology, turn our clock backward and go back to the simpler more relaxed living of the last century. This anti-science approach is not only unrealistic, it is impractical. In this day and age, we cannot isolate ourselves from the rest of the world any more. Although life of the previous century may look quiet and

relaxed when viewed from the present epoch : was it really so? It too had its problems, of illiteracy, diseases, famines, short lifespans, to say nothing of minor strifes and major wars. Grass always looks greener from the other side of the fence. Likewise, wistfully selective recollections of the past are often misleading.

Let me turn next to the society-science interaction. It is very necessary that society looks upon science and technology as tools for its betterment and as such it should be fully aware of what they stand for, what they are capable of. Let me give an example.

Suppose you are invited to a banquet where a large buffet is spread before you. The variety of dishes may take your breath away : it will of course excite your appetite. So you start helping yourself, although you are aware that you will not be able to do justice to all the dishes. While you are eating, new dishes start appearing and you feel tempted to go for them. And this process goes on and on, tempting you to eat indiscriminately and beyond your capacity. In the end you return home and next day's indigestion will remind you of your previous day's indiscretions.

The response of human societies to science and technology is somewhat similar. The latter continue to pour new inventions and there is a rush to grab them. Whether highly industrialized, or developing, the societies seem to run after new gifts of science and technology in an indiscriminate way. And they suffer the consequences.

For example, having seen the benefits of industrialization, we have gone for it without thinking of it in holistic terms. So we do not care about how industrial waste is disposed of and how harmful it can be. We do not seem to worry about the damage to environment and possible threat to the balance of nature. We do not allow for adequate safeguards against accidents which can be very tragic.

A fall-out of going in for automation in the interest of convenience, efficiency, time saving, etc., is that we have forgotten to allow for the humans rendered redundant by this process. So that brings in social problems of unemployment, addiction to drugs or crime for lack of anything constructive to do, and the widening of gap between the rich and the poor.

Although we claim to be advancing on the ladder of progress, and communications are shortening the horizons, we still seem beset by parochial attitudes and to assert them, have resorted to stockpiles of weapons. These, alas, have become more and more effective in the art of destruction, thanks to the advances of science and technology. Although it is claimed that by having nuclear stockpiles, wars will be put off, because they are so much more destructive, the peace maintained on this basis is unstable. An accidental or irresponsible beginning to a nuclear war will lead to unimaginable destruction of life and environment which may put our planet beyond redemption as a habitat for life.

The Scientific Outlook

Surely if man calls himself a rational animal, human societies are expected to behave rationally and take well considered decisions on what gifts of science and technology to accept and what to reject. Like our example of the diner at the buffet, who is well advised to think and choose before he eats.

An example of irrational response to the problems facing us today, is to say that science and technology are evils and we should abandon them. This is neither practical, nor advisable. Nor is the premise it is based on, correct. Science and technology per se are not evil. They are instruments that can be used for evil or benign purposes... it all depends on the user. The human being. Or the human society. In fact they are neutral and like water which acquires the colour of what is mixed into it.

So in the last analysis the responsibility rests fair and square on the society, which wishes to harness science and technology. The society has to be knowledgeable. It is not suggested that everybody should be a scientist : but everybody should be educated to a level where these issues are appreciated. This is why higher education is important.

In our democratic set up, most funding for science and technology comes from the popularly elected government in our country. So the directions in which these subjects grow have to be decided by the government, that is by the people by proxy. Yet we do not see these issues being highlighted in any election. In fact only a handful of our politicians seem aware of these issues. One of these exceptional

ones was Jawaharlal Nehru.

Jawaharlal Nehru had said in his book *The Discovery of India* :

"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"

Nehru was a visionary, who saw decades ahead. He was talking about a rational outlook to deal with life's problems, an outlook that is commonly called the scientific outlook. He was expecting that after India became independent and all of us were left to manage our problems ourselves, we would do so armed with the scientific outlook.

Today we live in a free India which is felling its way towards economic prosperity. In 1997 we completed the fiftieth year of our independence from the British. Yet we are still a long way away from achieving that scientific outlook which is so essential to our future wellbeing.

The scientific outlook arose from the way science develops in its own self correcting way. Scientific theories do not proceed on arbitrary fiats : they have to conform to a discipline where they are tested against facts. If they pass, they continue; if they fail, they have to go. No person, howsoever great and respected can endorse a theory and expect it to be believed. It is this objectivity that is the hallmark of science that sets it apart from pseudo-science and superstitions.

The scientific outlook need not be the prerogative of the scientist alone. After all, it does owe its origin to human curiosity about Nature and as such 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 the 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.

Superstitions are born out of ignorance of how Nature functions. Science is dedicated to the unraveling 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.

Is Astrology a Science?

The early human societies ascribed divine powers to planets. This assumption possibly arose from ignorance of what planets are and how they move. The scientific method to understand why and how planets move took millennia to unravel the mystery. But, now that astronomy has satisfactorily answered most 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 (in planets controlling humandestiny) persists, even among sections of educated classes. In the mid-1970s a group of leading scientists in the West, including several Nobel Laureates, were signatories to 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 position 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 start."

I am often asked the question : Is astrology a science? Astrology is the subject that is based on the premise that planets

and other heavenly bodies and events influence human destiny and their location in the heavens at the time of the birth of a person determines that person's future. Since I am an astrophysicist by profession and my subject deals with heavenly bodies and events, the questioner, who is usually a believer in astrology, seeks my endorsement of it.

However, since the question is about the scientific basis for astrology, it cannot be decided by the pronouncement of a particular individual, howsoever expert he or she may claim to be. It has to be decided on the basis of facts, by assessing whether the subject conforms with the discipline of science. What are the facts?

Suppose a scientist is asked to examine this question : Do planets influence human destiny? How will he go about testing the above hypothesis? He will not be satisfied by the prediction of 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 large number of cases under different conditions.

A simple example will illustrate this point of view. Suppose someone claims to predict with reasonable accuracy whether a tossed coin will fall with 'head' up or 'tail' up. Will a single toss decide the truth of his claim? We all know that any one can predict the outcome with fifty percent accuracy. This chance element must somehow be reduced. Suppose we ask him to perform this prediction-test 100 times, and he predicts correctly 50 times. Again we will argue that this is not a significant indicator of his predictive power. But suppose he is accurate 51 times. Do we give him credit? What if he is accurate 70 times? The statistician comes to our rescue here. He has devised tests to decide whether the success achieved in a particular experiment is purely due to chance or due to some other factor (e.g. the ability to predict correctly in the above case or the possibility of the coin being biased).

Likewise, tests have to be made of the above hypothesis concerning influence of planets. Such tests as have been conducted so far by scientists have shown negative results. But again, it is not always necessary to call upon the professional scientist to perform such tests. The educated common man can himself sift the evidence provided he adopts an objective outlook.

The Craze for Vastu-Shastra

An offshoot of the astrological superstition that has been gaining currency of late goes under the name of Vastushastra. It is an excellent example of how sound practical architectural rules can get mixed up in superstitions. Let us take a brief look at this scenario.

When you are building a house, there are certain local considerations that you may need to take heed of in orienting it, or, if you do not have that choice, of locating the various rooms in it. For example, in the northern high latitudes of the European countries, the Sun is mostly towards the South and, the climate there being generally on the colder side, attempt is made to have the windows of living room, dining room and bedrooms facing south. In Mumbai, or the Western Ghats, where the force of the monsoon winds and rain is terrific, windows in the south direction can be a hazard. In a big city, the location of the neighbouring buildings, the wind direction, disturbance of heavy traffic, etc. also play a role in the planning of a dwelling.

However, what do you say to the following type of advice which is today being given by vastu-shastries to the would-be house owners?

1. If the plot of land had a mongoose or a rabbit living on it, it will be a good plot for your house and will give you a brave son.
2. Your water tank should be in the East or Northeast direction as Gods like it and it will bring you prosperity. A tank sited in any other direction will lead to illness, enemies, loss of wealth, etc.
3. Windows in the North lead to gain of lot of money; if not there will always be a shortage of funds.
4. Kitchen should not be in the

Southwest as it leads to theft.

5. The staircase should have an odd number of steps such that their number when divided by three leaves a remainder of two; or else, there will be lot of difficulties and losses.

Again, I could go on and on : but these examples are sufficiently indicative.

There are no practical or scientific reasons linking the supposed effects to the causes in the above type of statements. There are no controlled experiments demonstrating the claimed effects. You are told , that you follow these rules, or else fact the consequences. The gullible ones feel, rather than take chances with destiny, let us play safe and follow the vastushastri. Even buildings already built have been demolished in order to subscribe to this advice. Think of the enormous waste of money involved and all for an unproven belief? The expense becomes inexcusable when it is charged to the public exchequer, as has been the case in several instances in the past.

Science Vs Anti-science

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 whether 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 have no relevance today. Some rituals had a symbolic meaning in the social ambience of several centuries ago : today they have become irrelevant. The question arises : what should one do in case of such a conflict arises?

Again the scientific outlook can help. Ask yourself rationally as to what is the purpose of the ritual. Is it going to serve the purpose for which it is being carried out? Or are you doing it because your elders did it before and they did it because their elders did it before them? Will you be prepared to examine what is presented to you as a miracle or will you take everything you see

on trust?

Despite the approaching end of the twentieth century, the miracle and godman industry is enjoying a boom in our country. It is instructive to learn from the Yiri Geller phenomenon in the west. His spoon-bending performance even fooled the scientists for a while until a professional magician called Randy stepped in and demonstrated how the so-called miracle could be performed by trickery common in professional magic shows.

In India too scientists and professional magicians can play a role debunking such miracles. The phoney godmen usually do not like to submit themselves to thorough scientific checking. But in the absence of that possibility, it is still worthwhile for a debunking team to perform these miracles on stage before audiences and then to explain how it is done. I have attended such performances by voluntary organizations devoted to eradication of superstitions. Indeed, eradication of superstitions is an important field of activities of some of our successful NGOs. There is of course, the need for more of them considering the enormous backlog of superstitions to be

cleared.

I think that such demonstrations should be concentrated on children more than the grown ups. The latter have now become set in their views and will be hard to persuade to think rationally. With children, however, we have a chance as they have open minds and can more easily appreciate what scientific reasoning means. Not only should they be able to judge what is real and what is fake, they should be able to bring this judgement to bear upon science itself, on how its products are being put to use.

I feel that we have already lost the first fifty years groping around in a muddled fashion. To survive in the increasingly competitive world, a proper strategy is needed in learning to live with the rapid growth of science and technology. This can only come about if we develop and nurture a scientific outlook. I am confident that if we neither blind ourselves by traditions nor dazzled by science and keep our visors open, our minds alert, we can take our country triumphantly into the twenty first century.

Prof. Jayant Narlikar grew up in an academic and scholarly environment at home and developed a liking for both Mathematics and Sanskrit. His father Vishnu Vasudeo Narlikar, was Professor and Head of Department of Mathematics at Benares University. His mother Sumatai Vishnu Narlikar was a Sanskrit Scholar.

After a distinguished career at Cambridge and then in TIFR, Dr. Narlikar became the Founder-Director of IUCAA in 1988, first in an honorary capacity and then as a full-time director since 1989, which he has been able to bring to international stature as a research centre as well as a place for pedagogical activities.

Narlikar has made important contributions to theoretical physics, astrophysics and cosmology. He is considered a leading expert and defender of the steady state cosmology against the more popular big bang cosmology. His work on conformal gravity theory with Fred Hoyle demonstrated how a synthesis could be achieved between Einstein's general theory of relativity and Mach's principle.

Dr. Narlikar has been honoured by several awards for his research. Apart from his research work, Jayant Narlikar has established a name in the field of science popularization. He has used the print and electronic media for this purpose, with English, Hindi and Marathi as languages for communication.
