

© Copyright. Not to be quoted or referred to without the permission of the author.

December, 1976

A Comment on the Propagation of the 'Scientific Temper'

by

V. Siddhartha⁺

Last November, as the nation was celebrating the birth anniversary of Jawaharlal Nehru, I happened to be in Delhi and listened to Prof. J.V. Narlikar of the Tata Institute of Fundamental Research deliver the tenth Nehru Memorial Lecture on 'The Role of (the) Scientific Outlook in the Development of Science and Society'. I also listened to a group of our leading scientist-administrators talking about Nehru and Science. Shortly afterwards, Prof. S. Ramaseshan of the National Aeronautical Laboratory spoke in Bangalore on 'Science and the Scientific Temper'; I was privileged to listen to him. In the same series Prof. Bhisam Sahni spoke on Science and Literature. With so much of worth being spoken on science and its relationship to our society, I doubt very much if I can say anything significantly new on the general theme underlying this section of the Symposium. I shall therefore attempt the simpler task of highlighting some of the issues that have emerged from these and other lectures and discussions and will try to derive some of their implications ^{for} the propagation of the Scientific Temper in our society and for science teaching in our schools and colleges. In attempting this task, I will be quoting rather extensively; not because I wish to attempt to over-awe you with the authority of the originators, but because I genuinely feel that there is little point in rephrasing something which has already been well put, merely for the sake of appearing different.

+ Systems Planning & Analysis Group, Indian Space Research Organisation (ISRO), Bangalore 560 009. The views expressed here are those of the author. They are not to be construed as being necessarily those of ISRO or of any other organisation.

"Do we", asked Prof. Ramaseshan, "teach our youth in schools and colleges the scientific method with its logic, its rationale and its insistence on the experimental method? We can categorically say that we do not We teach Science to our young, not as a process, or a method, but as a collection of formulations - whose logic they are not encouraged to understand but which they are required to learn by rote. To many of them mathematics is a form of magic which provides solutions to problems. Science to most of them is some form of mumbo-jumbo to be learnt "by heart" to be regurgitated at an examination."

"When a student is required to calculate the strength of a beam, he uses formula X on page Y in the prescribed text-book ... When he wants it to rain, he recites the formula A in canto B of the Varuna Shastra. To the student there is absolutely no difference between the two". We should all ponder this description of the situation. The students are, of course, not to blame for this tragedy where Science is willy-nilly projected as another ritual - more sophisticated perhaps than the others, but ritual none-the-less - in which the mantras are in english and mathematics rather than in sanskrit. Are the teachers to blame? Not at all; for they are only reciting the mantras from the text-book, as they have been told to do. Are the text-book writers to blame? Hardly; for they only copy the mantras from other books which themselves use foreign text-books as their models. (Would it not be better to simply reprint the foreign text-book - at least then the student will be spared the incomprehensible english, bad illustrations, typographical errors and incorrect 'worked examples'.)

Who then is to blame? But perhaps I am asking the wrong question, even an irrelevant one. What is this Science and Science Education that we are talking about when the Karnataka Government not so long ago ordered for prayers to be organised in order to bring rain? I venture to suggest that the existing social order has a vested interest in projecting science as a magic wand that transforms the pumpkin of poverty into the stage-coach of riches, provided God infuses the wand with an unknown magic ingredient. Science too must be subject to the divine will. How else are you going to explain its failure to deliver the goods? Of course, only certain people are allowed to use the wand -

the new priests called scientists. The mantras to be used with the wand are written in the Great Books. These are recited by those authorised to recite them - i.e. the new Brahmins, the scientist-priests. Never reveal the basis of the Great Books to the people at large lest they find out that there is no divine veto over the efficacy of the wand. When the wand fails, blame God and meanwhile make your pilgrimage to Cambridge or MIT or Stanford to learn some new, more potent mantras. When you come back (if you do) perform some counterfeit scientific magic, using Public money, to re-furbish your image and to re-establish your position in society.

I have exaggerated the picture, of course. But the idea that knowledge, and the privileges flowing from its use, are not to be widely shared is very deep-rooted in our culture; and the tendency to ascribe failure to extra-human agents is commonplace. Is it, therefore, any wonder that we have reduced science to something akin to yet another divine tool operated by His Authorised Agents on Earth subject to His Will?

How can all this be changed?

If the situation is anything like as I have described it, the process of change is going to be a long, slow and extraordinarily difficult one. Each time the stout-hearted try to initiate the propagation of the True Science, the System will rapidly convert it into a cartoon version, unrecognisable by the time it reaches the students in schools and colleges. To sustain the propagation of the True Science will require a revolution in the teaching of the humanities - in the sense of the study of Man. The speed of propagation will depend upon how well we teach the True Science, but the process itself cannot be sustained unless we re-cast our world of values. And I am sure you will agree that recasting the world of values is an extremely difficult task; requiring, as it does, political courage besides a continuous refinement of pedagogic technique.

Two matters must be recognised at the very outset; first, although science is a process of thought and a method always appealing to experiment which is followed by logical deduction, it is a process of thought of human beings. Science is a collective endeavour of

human beings engaged in a common pursuit. It is a corporate activity. The acceptability of hypothesis and the validation of theories depend upon human judgment and upon a certain important basic quasi-aesthetic value - the value which prefers the theory with one hypothesis rather than the one with two to explain the same phenomenon. This principle of economy is fundamental to the advancement of Science; without it choices between alternative explanatory schemes would be difficult, if not impossible to make. This principle is often used to discriminate between a cranky idea and a good one - an important distinction that is always being made in good science. Although I have not discussed this point with my peers, I believe that it will be very difficult to establish this value in our society which accepts a multiplicity of Gods and in which human conflict is avoided by allowing parallel ontologies rather than resolved by synthesis through a dialectic.

Secondly, as Herman Bondi has noted, science depends on human cooperation, it depends on people testing each other's work and it depends on people taking notice of each other. I would add that it also depends on scientists rewarding each other with recognition and acclaim regardless of social rank or age. How are we to establish such values as will sustain these needs of science when non-cooperation, jealousy and envy seem to govern our conduct to such a great extent; and in a society in which parents extol the virtues of Ekalavya who cut-off his finger at the behest of his jealous, aged teacher? There is a line in a marching song of the Bharat Scouts and Guides which transliterates as " At the name of our elders, we will be prepared to cut-off even our heads". It is clear that no Indian Scout can aspire to be a scientist, or he is liable to lose his head!

It is imperative that we de-mystify science. It is not a magic wand wielded by its Authorised Users. It is a process of thought and action that is accessible to all who submit to its rigours. We must ask our politicians to stop offering science as a kind of universal panacea that will be delivered by 'our scientists' - rather like the kings of not-so-long-ago promising a kingdom of plenty because they had ordered the priests to chant the appropriate mantras. When there is failure in science, it is due to the nature of science itself; when there is failure of science, it is not due to divine malaevolence but primarily due to the class nature of our society.

I must emphasise, at the risk of repetition, that ^{the} basic structure of Science does not have an independent existence outside the Society in which it is practised. It is not like petrol that you fill into a car to make it run - rather, it is the combination of driver, car and petrol. In the ultimate analysis science can only be defined as that activity that scientists are engaged in. It cannot be defined uniquely by reference to some external, universal standard; although, of course, its basic elements are common round the world. This commonality is not because there is some absolute standard against which the behaviour of scientists is checked. It is because scientists have learnt that in order to advance science you have to suppress private interests for the larger good; you have to be impartial, you have to be honest; you cannot perpetrate a scientific fraud because one day you will be found out and then nobody will ever forgive you. The sub-culture that governs scientists is the element that is truly international, not the subject-matter of their investigations. Every now and again some unscrupulous scientist will try to subvert this sub-culture by attempting a scientific fraud, by falsifying data. He is soon found out but the cost of undoing the damage he has wrought is often considerable; the time and energy of a number of scientists is wasted in trying to repeat his results. Occasionally the power apparatus of a State will try with the help of unscrupulous scientists to subvert this sub-culture as happened in the Soviet Union during the Stalin era. But that attempt also failed. The Soviet Union paid dearly for this crude attempt to remould a delicate fabric of customs and practices that governs the scientific community. The quality of science and the self-confidence of scientists is wholly dependent upon the nurturing of this sub-culture.

Jawaharlal Nehru says in his Discovery of India: "The scientific approach and temper are or should be, a way of life, a process of thinking, a method of acting and associating with our fellowmen ...". The propagation of the True Science is not only a matter of teaching better science in a better way; it is also a matter of learning and teaching a method of associating with our fellow-men. This I venture to suggest, is an even more difficult task as it requires a change in ourselves and our values.

I should like to end on a somewhat sombre note. Until now we have got away with murder, our entire industrial and scientific development has been based on imported technology and imported science. To be sure, in some spheres we have learnt the techniques of manipulation of this imported science and technology. But this is not the same thing as developing a scientific spirit, a scientific temper, a scientific way of life. The problems that our nation faces cannot be solved if we do not propagate the True Science. If the sub-culture of science and its full meaning are not taught in our schools and colleges now, I have no doubt that in less than ten years, our scientific enterprise - our space programme for example - will simply not be sustainable. Indeed it will lose all meaning.

We must teach ourselves and our students that the proper study for Man is Man - as Rabindranath Tagore said, and that the study of science is an integral part of this study, because science is an intensely human activity. Once we understand this and propagate this, we will begin a process of self-examination, dialectic and reform. This will then provide the environment in which True Science can be propagated. But, following this, we must also be prepared for some disruption in the home as parental values clash with those of their children; considerable disruption in the class-room as student values clash with those of teachers, and at least some disruption in society as the values of the ruling classes clash with those of the ruled as the consciousness of these latter is awakened by the essentially humanistic nature of science.

On Propagating Scientific Temper

V Siddhartha

THE eighth 'Fundamental Duty' enjoins every citizen 'to develop the scientific temper, humanism and the spirit of enquiry and reform'. In November, as the nation was celebrating the birth anniversary of Jawaharlal Nehru, J V Narlikar of the Tata Institute of Fundamental Research delivered the tenth Nehru Memorial Lecture on 'The Role of (the) Scientific Outlook in the Development of Science and Society'. A couple of days later, a group of our leading scientist-administrators talked about Nehru and Science. Shortly afterwards, S Ramaseshan of the National Aeronautical Laboratory spoke in Bangalore on 'Science and the Scientific Temper'. Thus, of late, there has been an upswelling of concern and interest in the matter of the propagation of the 'Scientific Temper' in our society. Here I wish to highlight some of the issues that seem to emerge from these and other lectures and discussions and try to derive some of their implications for the propagation of the Scientific Temper in our society and for science teaching in our schools and colleges. In attempting this, I will be quoting rather extensively; not to over-awe the reader with the authority of the originators, but because there is little point in re-phrasing something which has already been well put, merely for the sake of appearing different.

"Do we", asked Ramaseshan, "teach our youth in schools and colleges the scientific method with its logic, its rationale and its insistence on the experimental method? We can categorically say that we do not..... We teach Science to our young, not as a process, or a method, but as a collection of formulations — whose logic they are not encouraged to understand but which they are required to learn by rote. To many of them Mathematics is a form of magic which provides solutions to problems. Science to most of them is some form of mumbo-jumbo to be learnt 'by heart' to be regurgitated at an examination". "When a student is required to calculate the strength of a beam, he uses formula X on page Y in the prescribed text-book... When he wants it to rain, he recites the

formula A in canto B of the Varuna Shastra. To the student there is absolutely no difference between the two."

We should all ponder over this description of the situation. The students are, of course, not to blame for this tragedy where Science is willy-nilly, projected as another ritual — more sophisticated perhaps than the others, but ritual nonetheless — in which the mantras are in English and Mathematics rather than in Sanskrit. Are the teachers to blame? Not at all; for they are only reciting the mantras from the text-book, as they have been told to. Are the text-book, writers to blame? Hardly; for they only copy the mantras from other books which themselves use foreign text-books as their models. (Would it not be better to simply reprint the foreign text-book? The student will then at least be spared the incomprehensible English, bad illustrations, typographical errors and incorrect 'worked examples'.)

Who then is to blame? But the question is wrong, even irrelevant. What is this Science and Science Education that we are talking about when the Karnataka government not so long ago ordered for prayers to be organised in order to bring rain? I venture to suggest that the existing social order has a vested interest in projecting Science as a magic wand that transforms the pumpkin of poverty into the stage-coach of riches, provided God infuses the wand with an unknown magic ingredient. Science too must be subject to the Divine Will. How else are you going to explain its failure to deliver the goods? Of course, only certain people are allowed to use the wand — the new priests called scientists. The mantras to be used with the wand are written in the Great Books. These are recited by those authorised to recite them — the new Brahmins, the scientist-priests. Never reveal the basis of the Great Books to the people at large lest they find out that there is no divine veto over the efficacy of the wand. When the wand fails, blame God and meanwhile make your pilgrimage to Cambridge or MIT or Stanford or Moscow to learn some new, more potent mantras.

When you come back (if you do) perform some counterfeit scientific magic, using public money, to refurbish your image and to re-establish your position in society.

The picture is exaggerated, of course; but the idea that knowledge, and the privileges flowing from its use, are not to be widely shared is very deep-rooted in our culture; and the tendency to ascribe failure to extra-human agents is commonplace. Is it, therefore, any wonder that we have reduced Science to something akin to yet another divine tool operated by His Authorised Agents on Earth subject to His Will?

How can all this be changed?

If the situation is anything like as I have described, the process of change is going to be a long, slow and extraordinarily difficult one. Each time the stout-hearted try to initiate the propagation of the True Science, the 'System' will rapidly convert it into a cartoon version, unrecognisable by the time it reaches the students in schools and colleges. To sustain the propagation of the True Science will require a revolution in the teaching of the *humanities* — in the sense of the study of Man. The speed of propagation will depend upon how well we teach the True Science, but the process itself cannot be sustained unless we re-cast our world of values. And recasting the world of values is an extremely difficult task; requiring, as it does, political courage besides a continuous refinement of pedagogic technique.

Two things must be recognised at the very outset; first, although science is a process of thought and a method always appealing to experiment which is followed by logical deduction, it is a process of thought of *human beings*. Science is a collective endeavour of human beings engaged in a common pursuit. It is a corporate, 'communist', activity. The acceptability of hypotheses and the validation of theories depend upon human judgment and upon a certain important basic quasi-aesthetic value — the value which prefers the theory with one hypothesis rather than the one with two to explain the same phenomenon. This principle of economy is fundamental to the advancement of Science; without it, choices between alternative explanatory schemes would be difficult, if not impossible, to make. This principle is often used to discri-

minate between a cranky idea and a good one — an important distinction that is always being made in good science. I believe that it will be very difficult to establish this value in our society which accepts a multiplicity of Gods and in which human conflict is avoided by allowing parallel ontologies, rather than resolved by synthesis through a dialectic.

Secondly, as Herman Bondi has noted, science depends on human co-operation, it depends on people testing each other's work, and it depends on people taking notice of each other. I would add that it also depends on scientists rewarding each other with recognition and acclaim regardless of social rank or age. How are we to establish such values as will sustain these needs of science when non-co-operation, jealousy and envy seem to govern our conduct to such a great extent; and in a society in which parents extol the virtues of Ekalavya who cut-off his finger at the behest of his jealous, aged teacher? There is a line in a marching song of the Bharat Scouts and Guides which translates as ".....At the name of our elders, we will be prepared to cut-off even our heads". It is clear that no Indian Scout can aspire to be a scientist, or he is liable to lose his head!

It is imperative that we de-mystify Science. It is not a magic wand wielded by its Authorised Users. It is a process of thought and action that is accessible to all who submit to its rigours. We must ask our politicians (and our 'scientists') to stop offering science as a kind of universal panacea that will be delivered by 'our scientists' — rather like the kings of not-so-long-ago promising a kingdom of plenty because they had ordered the priests to chant the appropriate mantras. When there is failure *in* Science in a specific instance, it is due to the nature of Science itself; when there is failure *of* Science in a more general sense, it is not due to divine malevolence but primarily due to the class nature of our society.

I must emphasise, at the risk of repetition, that the basic structure of Science does not have an independent existence outside the society in which it is practised. It is not like petrol that you fill into a car to make it run; rather, it is the combination of driver, car and petrol. In the ultimate analysis Science can only be defined as that activity that scientists are engaged in. It cannot be defined uniquely by reference to some external, universal standard; although, of course, its basic elements are common round the world. This commonality is not because there is some absolute standard against which the behaviour of scientists is checked. It is because scientists have learnt that in order to advance Science you have to suppress private interests for the larger good; you have to be impartial, you have to be honest; you cannot perpetrate a scientific fraud because one day you will be found out and then nobody will ever forgive you. The sub-culture that governs scientists is the element that is truly international, not the subject matter of their investigations. Now and again some unscrupulous scientist will try to subvert this sub-culture by attempting a scientific fraud, by falsifying data. He is soon found out but the cost of undoing the damage he has wrought is often considerable; the time and energy of a number of scientists is wasted in trying to repeat his results. Occasionally the power apparatus of a State will try, with the help of unscrupulous scientists, to subvert this sub-culture as it happened in the Soviet Union during the Stalin era. But that attempt also failed. The Soviet Union paid dearly for this crude attempt to remould the delicate fabric of customs and practices that governs the scientific community. The quality of Science and the self-confidence of scientists is wholly dependent upon the nurturing of this sub-culture.

"The scientific approach and temper are, or should be, a way of life, a process of thinking, a method of *acting and associating with our fellowmen...*"

(Jawaharlal Nehru). The propagation of the True Science is not only a matter of teaching better science in a better way; it is also a matter of learning and teaching a method of acting and associating with our fellowmen. This is an even more difficult task as it requires a change in ourselves and our values.

Until now we have got away with murder, our entire industrial and scientific development has been based on imported technology and imported Science. To be sure, in some spheres we have learnt the techniques of manipulation of this imported Science and technology. But this is not the same thing as developing a scientific spirit, a scientific temper, a scientific way of life. The problems that our nation faces cannot be solved if we do not propagate the True Science. If the sub-culture of science and its full meaning are not taught in our schools and colleges now, and practised amongst the members of our emerging technocracy, I have no doubt that in less than ten years, our scientific enterprise — our space programme for example — will simply not be sustainable. Indeed it will lose all meaning.

We must teach ourselves and our students that the proper study for man is man, and that the study of Science is an integral part of the study, because Science is an intensely human activity. Once we understand this and propagate this, we will begin a process of self-examination, dialectic and reform. This will then provide the environment in which True Science can be propagated. But, following this, we must also be prepared for some disruption in the home as parental values clash with those of their children; considerable disruption in the class-room as student values clash with those of teachers, and at least some disruption in society as the values of the ruling classes clash with those of the ruled as the consciousness of these latter is awakened by the essentially humanistic nature of Science.